

# File I

## Implementation

### 1 l3backend-basics Implementation

```
1 <*package>
```

Whilst there is a reasonable amount of code overlap between backends, it is much clearer to have the blocks more-or-less separated than run in together and DocStripped out in parts. As such, most of the following is set up on a per-backend basis, though there is some common code (again given in blocks not interspersed with other material).

All the file identifiers are up-front so that they come out in the right place in the files.

```
2 \ProvidesExplFile
3 <*dvipdfmx>
4   {l3backend-dvipdfmx.def}{2023-01-16}{}
5   {L3 backend support: dvipdfmx}
6 </dvipdfmx>
7 <*dvips>
8   {l3backend-dvips.def}{2023-01-16}{}
9   {L3 backend support: dvips}
10 </dvips>
11 <*dvisvgm>
12   {l3backend-dvisvgm.def}{2023-01-16}{}
13   {L3 backend support: dvisvgm}
14 </dvisvgm>
15 <*luatex>
16   {l3backend-luatex.def}{2023-01-16}{}
17   {L3 backend support: PDF output (LuaTeX)}
18 </luatex>
19 <*pdftex>
20   {l3backend-pdftex.def}{2023-01-16}{}
21   {L3 backend support: PDF output (pdfTeX)}
22 </pdftex>
23 <*xetex>
24   {l3backend-xetex.def}{2023-01-16}{}
25   {L3 backend support: XeTeX}
26 </xetex>
```

Check if the loaded kernel is at least enough to load this file. The kernel date has to be at least equal to `\ExplBackendFileDate` or later. If `\__kernel_dependency_version_check:Nn` doesn't exist we're loading in an older kernel, so it's an error anyway. With time, this test should vanish and only the dependency check should remain.

```
27 \cs_if_exist:NTF \__kernel_dependency_version_check:nn
28   {
29     \__kernel_dependency_version_check:nn {2021-02-18}
30 <dvipdfmx>   {l3backend-dvipdfmx.def}
31 <dvips>      {l3backend-dvips.def}
32 <dvisvgm>    {l3backend-dvisvgm.def}
33 <luatex>     {l3backend-luatex.def}
34 <pdftex>    {l3backend-pdftex.def}
35 <xetex>     {l3backend-xetex.def}
```

```

36 }
37 {
38   \cs_if_exist_use:cF { @latex@error } { \errmessage }
39   {
40     Mismatched-LaTeX-support-files~detected. \MessageBreak
41     Loading~aborted!
42   }
43   { \use:c { @ehd } }
44   \tex_endinput:D
45 }

```

The order of the backend code here is such that we get somewhat logical outcomes in terms of code sharing whilst keeping things readable. (Trying to mix all of the code by concept is almost unmanageable.) The key parts which are shared are

- Color support is either dvips-like or LuaTeX/pdfTeX-like.
- LuaTeX/pdfTeX and dvipdfmx/X<sub>Y</sub>TeX share drawing routines.
- X<sub>Y</sub>TeX is the same as dvipdfmx other than image size extraction so takes most of the same code.

`__kernel_backend_literal:e` The one shared function for all backends is access to the basic `\special` primitive: it has slightly odd expansion behaviour so a wrapper is provided.

```

__kernel_backend_literal:n
__kernel_backend_literal:x
46 \cs_new_eq:NN __kernel_backend_literal:e \tex_special:D
47 \cs_new_protected:Npn __kernel_backend_literal:n #1
48   { \__kernel_backend_literal:e { \exp_not:n {#1} } }
49 \cs_generate_variant:Nn __kernel_backend_literal:n { x }

```

*(End definition for `__kernel_backend_literal:e`.)*

`\kernel_backend_first_shipout:n` We need to write at first shipout in a few places. As we want to use the most up-to-date method,

```

50 \cs_if_exist:NTF \@ifl@t@r
51   {
52     \@ifl@t@r \fmtversion { 2020-10-01 }
53     {
54       \cs_new_protected:Npn __kernel_backend_first_shipout:n #1
55         { \hook_gput_code:nnn { shipout / firstpage } { l3backend } {#1} }
56     }
57     { \cs_new_eq:NN __kernel_backend_first_shipout:n \AtBeginDvi }
58   }
59   { \cs_new_eq:NN __kernel_backend_first_shipout:n \use:n }

```

*(End definition for `\kernel_backend_first_shipout:n`.)*

## 1.1 dvips backend

```

60 <*dvips>

```

`\kernel_backend_literal_postscript:n` Literal PostScript can be included using a few low-level formats. Here, we use the form with no positioning: this is overall more convenient as a wrapper. Note that this does require that where position is important, an appropriate wrapper is included.

```

61 \cs_new_protected:Npn __kernel_backend_literal_postscript:n #1
62   { \__kernel_backend_literal:n { ps:: #1 } }
63 \cs_generate_variant:Nn __kernel_backend_literal_postscript:n { x }

```

(End definition for `\_kernel_backend_literal_postscript:n`.)

`\_kernel_backend_postscript:n` PostScript data that does have positioning, and also applying a shift to `SDict` (which is not done automatically by `ps:` or `ps::`, in contrast to `!` or `"`).

```
64 \cs_new_protected:Npn \_kernel_backend_postscript:n #1
65   { \_kernel_backend_literal:n { ps: SDict ~ begin ~ #1 ~ end } }
66 \cs_generate_variant:Nn \_kernel_backend_postscript:n { x }
```

(End definition for `\_kernel_backend_postscript:n`.)

PostScript for the header: a small saving but makes the code clearer. This is held until the start of shipout such that a document with no actual output does not write anything.

```
67 \bool_if:NT \g__kernel_backend_header_bool
68   {
69     \_kernel_backend_first_shipout:n
70     { \_kernel_backend_literal:n { header = l3backend-dvips.pro } }
71   }
```

`\_kernel_backend_align_begin:` In `dvips` there is no built-in saving of the current position, and so some additional PostScript is required to set up the transformation matrix and also to restore it afterwards. Notice the use of the stack to save the current position “up front” and to move back to it at the end of the process. Notice that the `[begin]/[end]` pair here mean that we can use a run of PostScript statements in separate lines: not *required* but does make the code and output more clear.

```
72 \cs_new_protected:Npn \_kernel_backend_align_begin:
73   {
74     \_kernel_backend_literal:n { ps::[begin] }
75     \_kernel_backend_literal_postscript:n { currentpoint }
76     \_kernel_backend_literal_postscript:n { currentpoint~translate }
77   }
78 \cs_new_protected:Npn \_kernel_backend_align_end:
79   {
80     \_kernel_backend_literal_postscript:n { neg-exch~neg-exch~translate }
81     \_kernel_backend_literal:n { ps::[end] }
82   }
```

(End definition for `\_kernel_backend_align_begin:` and `\_kernel_backend_align_end:.`)

`\_kernel_backend_scope_begin:` Saving/restoring scope for general operations needs to be done with `dvips` positioning (try without to see this!). Thus we need the `ps:` version of the special here. As only the graphics state is ever altered within this pairing, we use the lower-cost `g-`versions.

```
83 \cs_new_protected:Npn \_kernel_backend_scope_begin:
84   { \_kernel_backend_literal:n { ps:gsave } }
85 \cs_new_protected:Npn \_kernel_backend_scope_end:
86   { \_kernel_backend_literal:n { ps:grestore } }
```

(End definition for `\_kernel_backend_scope_begin:` and `\_kernel_backend_scope_end:.`)

```
87 </dvips>
```

## 1.2 LuaTeX and pdfTeX backends

88 `<*luatex | pdftex>`

Both LuaTeX and pdfTeX write PDFs directly rather than via an intermediate file. Although there are similarities, the move of LuaTeX to have more code in Lua means we create two independent files using shared DocStrip code.

`\_kernel_backend_literal_pdf:n`  
`\_kernel_backend_literal_pdf:x`

This is equivalent to `\special{pdf:}` but the engine can track it. Without the `direct` keyword everything is kept in sync: the transformation matrix is set to the current point automatically. Note that this is still inside the text (BT ...ET block).

```
89 \cs_new_protected:Npn \_kernel_backend_literal_pdf:n #1
90 {
91 <*luatex>
92   \tex_pdfextension:D literal
93 </luatex>
94 <*pdftex>
95   \tex_pdfliteral:D
96 </pdftex>
97   { \exp_not:n {#1} }
98 }
99 \cs_generate_variant:Nn \_kernel_backend_literal_pdf:n { x }
```

(End definition for `\_kernel_backend_literal_pdf:n`.)

`\_kernel_backend_literal_page:n`

Page literals are pretty simple. To avoid an expansion, we write out by hand.

```
100 \cs_new_protected:Npn \_kernel_backend_literal_page:n #1
101 {
102 <*luatex>
103   \tex_pdfextension:D literal ~
104 </luatex>
105 <*pdftex>
106   \tex_pdfliteral:D
107 </pdftex>
108   page { \exp_not:n {#1} }
109 }
```

(End definition for `\_kernel_backend_literal_page:n`.)

`\_kernel_backend_scope_begin:`

Higher-level interfaces for saving and restoring the graphic state.

`\_kernel_backend_scope_end:`

```
110 \cs_new_protected:Npn \_kernel_backend_scope_begin:
111 {
112 <*luatex>
113   \tex_pdfextension:D save \scan_stop:
114 </luatex>
115 <*pdftex>
116   \tex_pdfsave:D
117 </pdftex>
118 }
119 \cs_new_protected:Npn \_kernel_backend_scope_end:
120 {
121 <*luatex>
122   \tex_pdfextension:D restore \scan_stop:
123 </luatex>
124 <*pdftex>
125   \tex_pdfrestore:D
```

```

126 </pdftex>
127 }

```

(End definition for `\_kernel_backend_scope_begin:` and `\_kernel_backend_scope_end:.`)

`\_kernel_backend_matrix:n` Here the appropriate function is set up to insert an affine matrix into the PDF. With `pdfTeX` and `LuaTeX` in direct PDF output mode there is a primitive for this, which only needs the rotation/scaling/skew part.

```

128 \cs_new_protected:Npn \_kernel_backend_matrix:n #1
129 {
130 <*luatex>
131 \tex_pdfextension:D setmatrix
132 </luatex>
133 <*pdftex>
134 \tex_pdfsetmatrix:D
135 </pdftex>
136 { \exp_not:n {#1} }
137 }
138 \cs_generate_variant:Nn \_kernel_backend_matrix:n { x }

```

(End definition for `\_kernel_backend_matrix:n.`)

```

139 </luatex | pdftex>

```

### 1.3 dvipdfmx backend

```

140 <*dvipdfmx | xetex>

```

The `dvipdfmx` shares code with the PDF mode one (using the common section to this file) but also with `XYTeX`. The latter is close to identical to `dvipdfmx` and so all of the code here is extracted for both backends, with some `clean up` for `XYTeX` as required.

`\_kernel_backend_literal_pdf:n` Undocumented but equivalent to `pdfTeX`'s `literal` keyword. It's similar to be not the same as the documented `contents` keyword as that adds a `q/Q` pair.

```

141 \cs_new_protected:Npn \_kernel_backend_literal_pdf:n #1
142 { \_kernel_backend_literal:n { pdf:literal~ #1 } }
143 \cs_generate_variant:Nn \_kernel_backend_literal_pdf:n { x }

```

(End definition for `\_kernel_backend_literal_pdf:n.`)

`\_kernel_backend_literal_page:n` Whilst the manual says this is like `literal direct` in `pdfTeX`, it closes the BT block!

```

144 \cs_new_protected:Npn \_kernel_backend_literal_page:n #1
145 { \_kernel_backend_literal:n { pdf:literal~direct~ #1 } }

```

(End definition for `\_kernel_backend_literal_page:n.`)

`\_kernel_backend_scope_begin:` Scoping is done using the backend-specific specials. We use the versions originally from `xdvipfmx (x:)` as these are well-tested “in the wild”.

```

146 \cs_new_protected:Npn \_kernel_backend_scope_begin:
147 { \_kernel_backend_literal:n { x:gsave } }
148 \cs_new_protected:Npn \_kernel_backend_scope_end:
149 { \_kernel_backend_literal:n { x:grestore } }

```

(End definition for `\_kernel_backend_scope_begin:` and `\_kernel_backend_scope_end:.`)

```

150 </dvipdfmx | xetex>

```

## 1.4 dvisvgm backend

151 `\*dvisvgm)`

`\_kernel_backend_literal_svg:n`  
`\_kernel_backend_literal_svg:x`

Unlike the other backends, the requirements for making SVG files mean that we can't conveniently transform all operations to the current point. That makes life a bit more tricky later as that needs to be accounted for. A new line is added after each call to help to keep the output readable for debugging.

152 `\cs_new_protected:Npn \_kernel_backend_literal_svg:n #1`  
 153 `{ \_kernel_backend_literal:n { dvisvgm:raw~ #1 { ?nl } } }`  
 154 `\cs_generate_variant:Nn \_kernel_backend_literal_svg:n { x }`

(End definition for `\_kernel_backend_literal_svg:n`.)

`\g__kernel_backend_scope_int`  
`\l__kernel_backend_scope_int`

In SVG, we need to track scope nesting as properties attach to scopes; that requires a pair of int registers.

155 `\int_new:N \g__kernel_backend_scope_int`  
 156 `\int_new:N \l__kernel_backend_scope_int`

(End definition for `\g__kernel_backend_scope_int` and `\l__kernel_backend_scope_int`.)

`\_kernel_backend_scope_begin:`  
`\_kernel_backend_scope_end:`  
`\_kernel_backend_scope_begin:n`  
`\_kernel_backend_scope_begin:x`  
`\_kernel_backend_scope:n`  
`\_kernel_backend_scope:x`

In SVG, the need to attach concepts to a scope means we need to be sure we will close all of the open scopes. That is easiest done if we only need an outer “wrapper” `begin/end` pair, and within that we apply operations as a simple scoped statements. To keep down the non-productive groups, we also have a `begin` version that does take an argument.

157 `\cs_new_protected:Npn \_kernel_backend_scope_begin:`  
 158 `{`  
 159 `\_kernel_backend_literal_svg:n { <g> }`  
 160 `\int_set_eq:NN`  
 161 `\l__kernel_backend_scope_int`  
 162 `\g__kernel_backend_scope_int`  
 163 `\group_begin:`  
 164 `\int_gset:Nn \g__kernel_backend_scope_int { 1 }`  
 165 `}`  
 166 `\cs_new_protected:Npn \_kernel_backend_scope_end:`  
 167 `{`  
 168 `\prg_replicate:nn`  
 169 `{ \g__kernel_backend_scope_int }`  
 170 `{ \_kernel_backend_literal_svg:n { </g> } }`  
 171 `\group_end:`  
 172 `\int_gset_eq:NN`  
 173 `\g__kernel_backend_scope_int`  
 174 `\l__kernel_backend_scope_int`  
 175 `}`  
 176 `\cs_new_protected:Npn \_kernel_backend_scope_begin:n #1`  
 177 `{`  
 178 `\_kernel_backend_literal_svg:n { <g ~ #1 > }`  
 179 `\int_set_eq:NN`  
 180 `\l__kernel_backend_scope_int`  
 181 `\g__kernel_backend_scope_int`  
 182 `\group_begin:`  
 183 `\int_gset:Nn \g__kernel_backend_scope_int { 1 }`  
 184 `}`  
 185 `\cs_generate_variant:Nn \_kernel_backend_scope_begin:n { x }`

```

186 \cs_new_protected:Npn \__kernel_backend_scope:n #1
187 {
188   \__kernel_backend_literal_svg:n { <g ~ #1 > }
189   \int_gincr:N \g__kernel_backend_scope_int
190 }
191 \cs_generate_variant:Nn \__kernel_backend_scope:n { x }

```

(End definition for \\_\_kernel\_backend\_scope\_begin: and others.)

```

192 </dvisvgm>
193 </package>

```

## 2 I3backend-box Implementation

```

194 <*package>
195 <@@=box>

```

### 2.1 dvips backend

```

196 <*dvips>

```

\\_\_box\_backend\_clip:N The `dvips` backend scales all absolute dimensions based on the output resolution selected and any `TeX` magnification. Thus for any operation involving absolute lengths there is a correction to make. See `normalscale` from `special.pro` for the variables, noting that here everything is saved on the stack rather than as a separate variable. Once all of that is done, the actual clipping is trivial.

```

197 \cs_new_protected:Npn \__box_backend_clip:N #1
198 {
199   \__kernel_backend_scope_begin:
200   \__kernel_backend_align_begin:
201   \__kernel_backend_literal_postscript:n { matrix-currentmatrix }
202   \__kernel_backend_literal_postscript:n
203     { Resolution~72~div~VResolution~72~div~scale }
204   \__kernel_backend_literal_postscript:n { DVImag-dup~scale }
205   \__kernel_backend_literal_postscript:x
206     {
207       0 ~
208       \dim_to_decimal_in_bp:n { \box_dp:N #1 } ~
209       \dim_to_decimal_in_bp:n { \box_wd:N #1 } ~
210       \dim_to_decimal_in_bp:n { -\box_ht:N #1 - \box_dp:N #1 } ~
211       rectclip
212     }
213   \__kernel_backend_literal_postscript:n { setmatrix }
214   \__kernel_backend_align_end:
215   \hbox_overlap_right:n { \box_use:N #1 }
216   \__kernel_backend_scope_end:
217   \skip_horizontal:n { \box_wd:N #1 }
218 }

```

(End definition for \\_\_box\_backend\_clip:N.)

\\_\_box\_backend\_rotate:Nn Rotating using `dvips` does not require that the box dimensions are altered and has a very convenient built-in operation. Zero rotation must be written as 0 not -0 so there is a quick test.

```

219 \cs_new_protected:Npn \__box_backend_rotate:Nn #1#2
220 { \exp_args:Nnf \__box_backend_rotate_aux:Nn #1 { \fp_eval:n {#2} } }
221 \cs_new_protected:Npn \__box_backend_rotate_aux:Nn #1#2
222 {
223   \__kernel_backend_scope_begin:
224   \__kernel_backend_align_begin:
225   \__kernel_backend_literal_postscript:x
226   {
227     \fp_compare:nNnTF {#2} = \c_zero_fp
228     { 0 }
229     { \fp_eval:n { round ( -(#2) , 5 ) } } } ~
230   rotate
231   }
232   \__kernel_backend_align_end:
233   \box_use:N #1
234   \__kernel_backend_scope_end:
235 }

```

(End definition for `\__box_backend_rotate:Nn` and `\__box_backend_rotate_aux:Nn`.)

`\__box_backend_scale:Nnn` The dvips backend once again has a dedicated operation we can use here.

```

236 \cs_new_protected:Npn \__box_backend_scale:Nnn #1#2#3
237 {
238   \__kernel_backend_scope_begin:
239   \__kernel_backend_align_begin:
240   \__kernel_backend_literal_postscript:x
241   {
242     \fp_eval:n { round ( #2 , 5 ) } ~
243     \fp_eval:n { round ( #3 , 5 ) } ~
244     scale
245   }
246   \__kernel_backend_align_end:
247   \hbox_overlap_right:n { \box_use:N #1 }
248   \__kernel_backend_scope_end:
249 }

```

(End definition for `\__box_backend_scale:Nnn`.)

250 `</dvips>`

## 2.2 LuaTeX and pdfTeX backends

251 `<*luatex | pdftex>`

`\__box_backend_clip:N` The general method is to save the current location, define a clipping path equivalent to the bounding box, then insert the content at the current position and in a zero width box. The “real” width is then made up using a horizontal skip before tidying up. There are other approaches that can be taken (for example using XForm objects), but the logic here shares as much code as possible and uses the same conversions (and so same rounding errors) in all cases.

```

252 \cs_new_protected:Npn \__box_backend_clip:N #1
253 {
254   \__kernel_backend_scope_begin:
255   \__kernel_backend_literal_pdf:x
256   {

```

```

257     0~
258     \dim_to_decimal_in_bp:n { -\box_dp:N #1 } ~
259     \dim_to_decimal_in_bp:n { \box_wd:N #1 } ~
260     \dim_to_decimal_in_bp:n { \box_ht:N #1 + \box_dp:N #1 } ~
261     re~W~n
262   }
263   \hbox_overlap_right:n { \box_use:N #1 }
264   \__kernel_backend_scope_end:
265   \skip_horizontal:n { \box_wd:N #1 }
266 }

```

(End definition for `\__box_backend_clip:N`.)

`\__box_backend_rotate:Nn` Rotations are set using an affine transformation matrix which therefore requires sine/cosine values not the angle itself. We store the rounded values to avoid rounding twice. There are also a couple of comparisons to ensure that `-0` is not written to the output, as this avoids any issues with problematic display programs. Note that numbers are compared to 0 after rounding.

```

267 \cs_new_protected:Npn \__box_backend_rotate:Nn #1#2
268 { \exp_args:Nnf \__box_backend_rotate_aux:Nn #1 { \fp_eval:n {#2} } }
269 \cs_new_protected:Npn \__box_backend_rotate_aux:Nn #1#2
270 {
271   \__kernel_backend_scope_begin:
272   \box_set_wd:Nn #1 { Opt }
273   \fp_set:Nn \l__box_backend_cos_fp { round ( cosd ( #2 ) , 5 ) }
274   \fp_compare:nNnT \l__box_backend_cos_fp = \c_zero_fp
275     { \fp_zero:N \l__box_backend_cos_fp }
276   \fp_set:Nn \l__box_backend_sin_fp { round ( sind ( #2 ) , 5 ) }
277   \__kernel_backend_matrix:x
278   {
279     \fp_use:N \l__box_backend_cos_fp \c_space_tl
280     \fp_compare:nNnTF \l__box_backend_sin_fp = \c_zero_fp
281       { 0~0 }
282     {
283       \fp_use:N \l__box_backend_sin_fp
284       \c_space_tl
285       \fp_eval:n { -\l__box_backend_sin_fp }
286     }
287     \c_space_tl
288     \fp_use:N \l__box_backend_cos_fp
289   }
290   \box_use:N #1
291   \__kernel_backend_scope_end:
292 }
293 \fp_new:N \l__box_backend_cos_fp
294 \fp_new:N \l__box_backend_sin_fp

```

(End definition for `\__box_backend_rotate:Nn` and others.)

`\__box_backend_scale:Nnn` The same idea as for rotation but without the complexity of signs and cosines.

```

295 \cs_new_protected:Npn \__box_backend_scale:Nnn #1#2#3
296 {
297   \__kernel_backend_scope_begin:
298   \__kernel_backend_matrix:x

```

```

299     {
300       \fp_eval:n { round ( #2 , 5 ) } ~
301       0~0~
302       \fp_eval:n { round ( #3 , 5 ) }
303     }
304     \hbox_overlap_right:n { \box_use:N #1 }
305     \__kernel_backend_scope_end:
306   }

```

(End definition for `\__box_backend_scale:Nnn`.)

```
307 </luatex | pdftex>
```

## 2.3 dvipdfmx/X<sub>Y</sub>TeX backend

```
308 <*dvipdfmx | xetex>
```

`\__box_backend_clip:N` The code here is identical to that for LuaTeX/pdfTeX: unlike rotation and scaling, there is no higher-level support in the backend for clipping.

```

309 \cs_new_protected:Npn \__box_backend_clip:N #1
310 {
311   \__kernel_backend_scope_begin:
312   \__kernel_backend_literal_pdf:x
313   {
314     0~
315     \dim_to_decimal_in_bp:n { -\box_dp:N #1 } ~
316     \dim_to_decimal_in_bp:n { \box_wd:N #1 } ~
317     \dim_to_decimal_in_bp:n { \box_ht:N #1 + \box_dp:N #1 } ~
318     re~W~n
319   }
320   \hbox_overlap_right:n { \box_use:N #1 }
321   \__kernel_backend_scope_end:
322   \skip_horizontal:n { \box_wd:N #1 }
323 }

```

(End definition for `\__box_backend_clip:N`.)

`\__box_backend_rotate:Nn` `\__box_backend_rotate_aux:Nn` Rotating in dvipdfmx/X<sub>Y</sub>TeX can be implemented using either PDF or backend-specific code. The former approach however is not “aware” of the content of boxes: this means that any embedded links would not be adjusted by the rotation. As such, the backend-native approach is preferred: the code therefore is similar (though not identical) to the dvips version (notice the rotation angle here is positive). As for dvips, zero rotation is written as 0 not -0.

```

324 \cs_new_protected:Npn \__box_backend_rotate:Nn #1#2
325 { \exp_args:Nnf \__box_backend_rotate_aux:Nn #1 { \fp_eval:n {#2} } }
326 \cs_new_protected:Npn \__box_backend_rotate_aux:Nn #1#2
327 {
328   \__kernel_backend_scope_begin:
329   \__kernel_backend_literal:x
330   {
331     x:rotate~
332     \fp_compare:nNnTF {#2} = \c_zero_fp
333     { 0 }
334     { \fp_eval:n { round ( #2 , 5 ) } } }
335   }

```

```

336     \box_use:N #1
337     \__kernel_backend_scope_end:
338 }

```

(End definition for `\__box_backend_rotate:Nn` and `\__box_backend_rotate_aux:Nn`.)

`\__box_backend_scale:Nnn` Much the same idea for scaling: use the higher-level backend operation to allow for box content.

```

339 \cs_new_protected:Npn \__box_backend_scale:Nnn #1#2#3
340 {
341     \__kernel_backend_scope_begin:
342     \__kernel_backend_literal:x
343     {
344         x:scale~
345         \fp_eval:n { round ( #2 , 5 ) } ~
346         \fp_eval:n { round ( #3 , 5 ) }
347     }
348     \hbox_overlap_right:n { \box_use:N #1 }
349     \__kernel_backend_scope_end:
350 }

```

(End definition for `\__box_backend_scale:Nnn`.)

```

351 </dviPDFmx | xetex>

```

## 2.4 dvisvgm backend

```

352 <*dvisvgm>

```

`\__box_backend_clip:N`  
`\g__kernel_clip_path_int`

Clipping in SVG is more involved than with other backends. The first issue is that the clipping path must be defined separately from where it is used, so we need to track how many paths have applied. The naming here uses `l3cp` as the namespace with a number following. Rather than use a rectangular operation, we define the path manually as this allows it to have a depth: easier than the alternative approach of shifting content up and down using scopes to allow for the depth of the  $\TeX$  box and keep the reference point the same!

```

353 \cs_new_protected:Npn \__box_backend_clip:N #1
354 {
355     \int_gincr:N \g__kernel_clip_path_int
356     \__kernel_backend_literal_svg:x
357     { < clipPath-id = " l3cp \int_use:N \g__kernel_clip_path_int " > }
358     \__kernel_backend_literal_svg:x
359     {
360         <
361         path ~ d =
362         "
363             M ~ 0 ~
364             \dim_to_decimal:n { -\box_dp:N #1 } ~
365             L ~ \dim_to_decimal:n { \box_wd:N #1 } ~
366             \dim_to_decimal:n { -\box_dp:N #1 } ~
367             L ~ \dim_to_decimal:n { \box_wd:N #1 } ~
368             \dim_to_decimal:n { \box_ht:N #1 + \box_dp:N #1 } ~
369             L ~ 0 ~
370             \dim_to_decimal:n { \box_ht:N #1 + \box_dp:N #1 } ~
371             Z

```

```

372         "
373         />
374     }
375     \__kernel_backend_literal_svg:n
376     { < /clipPath > }

```

In general the SVG set up does not try to transform coordinates to the current point. For clipping we need to do that, so have a transformation here to get us to the right place, and a matching one just before the  $\TeX$  box is inserted to get things back on track. The clip path needs to come between those two such that if lines up with the current point, as does the  $\TeX$  box.

```

377     \__kernel_backend_scope_begin:n
378     {
379         transform =
380         "
381             translate ( { ?x } , { ?y } ) ~
382             scale ( 1 , -1 )
383         "
384     }
385     \__kernel_backend_scope:x
386     {
387         clip-path =
388         "url ( \c_hash_str l3cp \int_use:N \g__kernel_clip_path_int ) "
389     }
390     \__kernel_backend_scope:n
391     {
392         transform =
393         "
394             scale ( -1 , 1 ) ~
395             translate ( { ?x } , { ?y } ) ~
396             scale ( -1 , -1 )
397         "
398     }
399     \box_use:N #1
400     \__kernel_backend_scope_end:
401 }
402 \int_new:N \g__kernel_clip_path_int

```

(End definition for  $\backslash\_box\_backend\_clip:N$  and  $\backslash\_g\_kernel\_clip\_path\_int$ .)

$\backslash\_box\_backend\_rotate:Nn$  Rotation has a dedicated operation which includes a centre-of-rotation optional pair. That can be picked up from the backend syntax, so there is no need to worry about the transformation matrix.

```

403 \cs_new_protected:Npn \__box_backend_rotate:Nn #1#2
404 {
405     \__kernel_backend_scope_begin:x
406     {
407         transform =
408         "
409             rotate
410             ( \fp_eval:n { round ( -(#2) , 5 ) } , ~ { ?x } , ~ { ?y } )
411         "
412     }
413     \box_use:N #1

```

```

414     \__kernel_backend_scope_end:
415 }

```

(End definition for \\_\_box\_backend\_rotate:Nn.)

\\_\_box\_backend\_scale:Nnn In contrast to rotation, we have to account for the current position in this case. That is done using a couple of translations in addition to the scaling (which is therefore done backward with a flip).

```

416 \cs_new_protected:Npn \__box_backend_scale:Nnn #1#2#3
417 {
418   \__kernel_backend_scope_begin:x
419   {
420     transform =
421     "
422       translate ( { ?x } , { ?y } ) ~
423       scale
424       (
425         \fp_eval:n { round ( -#2 , 5 ) } ,
426         \fp_eval:n { round ( -#3 , 5 ) }
427       ) ~
428       translate ( { ?x } , { ?y } ) ~
429       scale ( -1 )
430     "
431   }
432   \hbox_overlap_right:n { \box_use:N #1 }
433   \__kernel_backend_scope_end:
434 }

```

(End definition for \\_\_box\_backend\_scale:Nnn.)

```

435 </dvisvgm>

```

```

436 </package>

```

### 3 13backend-color Implementation

```

437 <*package>

```

```

438 <@@=color>

```

Color support is split into parts: collecting data from L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>, the color stack, general color, separations, and color for drawings. We have different approaches in each backend, and have some choices to make about dvipdfmx/X<sub>Y</sub>L<sub>A</sub>T<sub>E</sub>X in particular. Whilst it is in some ways convenient to use the same approach in multiple backends, the fact that dvipdfmx/X<sub>Y</sub>L<sub>A</sub>T<sub>E</sub>X is PDF-based means it (largely) sticks closer to direct PDF output.

#### 3.1 Collecting information from L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>

##### 3.1.1 dvips-style

```

439 <*dvisvgm | dvipdfmx | dvips | xetex>

```

\\_\_color\_backend\_pickup:N Allow for L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> color. Here, the possible input values are limited: dvips-style colors can be taken as-is. The x-type expansion is there to cover the case where xcolor is in use.

```

440 \cs_new_protected:Npn \__color_backend_pickup:N #1
441 {
442   \exp_args:NV \tl_if_head_is_space:nTF \current@color

```

```

443     {
444       \tl_set:Nn #1 { { gray } { 0 } }
445       \msg_warning:nxx { color } { unhandled }
446       { \current@color }
447     }
448     {
449       \exp_last_unbraced:Nx \_color_backend_pickup:w
450       { \current@color } \s__color_stop #1
451     }
452   }
453   \cs_new_protected:Npn \_color_backend_pickup:w #1 ~ #2 \s__color_stop #3
454   { \tl_set:Nn #3 { {#1} {#2} } }
(End definition for \_color_backend_pickup:N and \_color_backend_pickup:w.)
455 </dvisvgm | dvipdfmx | dvips | xetex>

```

### 3.1.2 LuaTeX and pdfTeX

```

456 <*luatex | pdftex>

```

Same ideas, but with a different backend-dependent format.

```

\_color_backend_pickup:N
\_color_backend_pickup:w

```

```

457 \cs_new_protected:Npn \_color_backend_pickup:N #1
458 {
459   \exp_last_unbraced:Nx \_color_backend_pickup:w
460   { \current@color } ~ 0 ~ 0 ~ 0 \s__color_stop #1
461 }
462 \cs_new_protected:Npn \_color_backend_pickup:w
463 #1 ~ #2 ~ #3 ~ #4 ~ #5 ~ #6 \s__color_stop #7
464 {
465   \str_if_eq:nnTF {#2} { g }
466   { \tl_set:Nn #7 { { gray } {#1} } }
467   {
468     \str_if_eq:nnTF {#4} { rg }
469     { \tl_set:Nn #7 { { rgb } { #1 ~ #2 ~ #3 } } }
470     {
471       \str_if_eq:nnTF {#5} { k }
472       { \tl_set:Nn #7 { { cmyk } { #1 ~ #2 ~ #3 ~ #4 } } }
473       {
474         \tl_set:Nn #1 { { gray } { 0 } }
475         \msg_warning:nxx { color } { unhandled }
476         { \current@color }
477       }
478     }
479   }
480 }
(End definition for \_color_backend_pickup:N and \_color_backend_pickup:w.)
481 </luatex | pdftex>

```

## 3.2 The color stack

For PDF-based engines, we have a color stack available inside the specials. This is used for concepts beyond color itself: it is needed to manage the graphics state generally. Although dvipdfmx/X<sub>Ǝ</sub>TeX have multiple color stacks in recent releases, the way these

interact with the original single stack and with other graphic state operations means that currently it is not feasible to use the multiple stacks.

### 3.2.1 Common code

```
482 <*luatex | pdftex>
```

```
\l__color_backend_stack_int
```

For tracking which stack is in use where multiple stacks are used: currently just pdfTeX/LuaTeX but at some future stage may also cover dvipdfmx/X<sub>Y</sub>TeX.

```
483 \int_new:N \l__color_backend_stack_int
```

(End definition for \l\_\_color\_backend\_stack\_int.)

```
484 </luatex | pdftex>
```

### 3.2.2 LuaTeX and pdfTeX

```
485 <*luatex | pdftex>
```

```
\__kernel_color_backend_stack_init:Nnn
```

```
486 \cs_new_protected:Npn \__kernel_color_backend_stack_init:Nnn #1#2#3
487 {
488   \int_const:Nn #1
489   {
490     <*luatex>
491     \tex_pdffeedback:D colorstackinit ~
492     </luatex>
493     <*pdftex>
494     \tex_pdfcolorstackinit:D
495     </pdftex>
496     \tl_if_blank:nF {#2} { #2 ~ }
497     {#3}
498   }
499 }
```

(End definition for \\_\_kernel\_color\_backend\_stack\_init:Nnn.)

```
\__kernel_color_backend_stack_push:nn
```

```
\__kernel_color_backend_stack_pop:n
```

```
500 \cs_new_protected:Npn \__kernel_color_backend_stack_push:nn #1#2
501 {
502   <*luatex>
503   \tex_pdfextension:D colorstack ~
504   </luatex>
505   <*pdftex>
506   \tex_pdfcolorstack:D
507   </pdftex>
508   \int_eval:n {#1} ~ push ~ {#2}
509 }
510 \cs_new_protected:Npn \__kernel_color_backend_stack_pop:n #1
511 {
512   <*luatex>
513   \tex_pdfextension:D colorstack ~
514   </luatex>
515   <*pdftex>
516   \tex_pdfcolorstack:D
517   </pdftex>
```

```

518     \int_eval:n {#1} ~ pop \scan_stop:
519   }

```

(End definition for `\__kernel_color_backend_stack_push:nn` and `\__kernel_color_backend_stack_pop:n`.)

```

520 </luatex | pdftex>

```

### 3.3 General color

#### 3.3.1 dvips-style

```

521 < *dvips | dvisvgm>

```

Push the data to the stack. In the case of dvips also saves the drawing color in raw PostScript. The spot model is for handling data in classical format.

```

\__color_backend_select_cmyk:n
\__color_backend_select_gray:n
\__color_backend_select_named:n
\__color_backend_select_rgb:n
\__color_backend_select:n
\__color_backend_reset:
color.sc
522 \cs_new_protected:Npn \__color_backend_select_cmyk:n #1
523   { \__color_backend_select:n { cmyk ~ #1 } }
524 \cs_new_protected:Npn \__color_backend_select_gray:n #1
525   { \__color_backend_select:n { gray ~ #1 } }
526 \cs_new_protected:Npn \__color_backend_select_named:n #1
527   { \__color_backend_select:n { ~ #1 } }
528 \cs_new_protected:Npn \__color_backend_select_rgb:n #1
529   { \__color_backend_select:n { rgb ~ #1 } }
530 \cs_new_protected:Npn \__color_backend_select:n #1
531   {
532     \__kernel_backend_literal:n { color~push~ #1 }
533   < *dvips>
534     \__kernel_backend_postscript:n { /color.sc ~ { } ~ def }
535   < /dvips>
536   }
537 \cs_new_protected:Npn \__color_backend_reset:
538   { \__kernel_backend_literal:n { color~pop } }

```

(End definition for `\__color_backend_select_cmyk:n` and others. This function is documented on page ??.)

```

539 < /dvips | dvisvgm>

```

#### 3.3.2 LuaTeX and pdfTeX

```

540 < *luatex | pdftex>

```

```

\l__color_backend_fill_tl
\l__color_backend_stroke_tl
541 \tl_new:N \l__color_backend_fill_tl
542 \tl_new:N \l__color_backend_stroke_tl

```

(End definition for `\l__color_backend_fill_tl` and `\l__color_backend_stroke_tl`.)

Store the values then pass to the stack.

```

\__color_backend_select_cmyk:n
\__color_backend_select_gray:n
\__color_backend_select_rgb:n
\__color_backend_select:nn
\__color_backend_reset:
543 \cs_new_protected:Npn \__color_backend_select_cmyk:n #1
544   { \__color_backend_select:nn { #1 ~ k } { #1 ~ K } }
545 \cs_new_protected:Npn \__color_backend_select_gray:n #1
546   { \__color_backend_select:nn { #1 ~ g } { #1 ~ G } }
547 \cs_new_protected:Npn \__color_backend_select_rgb:n #1
548   { \__color_backend_select:nn { #1 ~ rg } { #1 ~ RG } }
549 \cs_new_protected:Npn \__color_backend_select:nn #1#2

```

```

550 {
551   \tl_set:Nn \l__color_backend_fill_tl {#1}
552   \tl_set:Nn \l__color_backend_stroke_tl {#2}
553   \__kernel_color_backend_stack_push:nn \l__color_backend_stack_int { #1 ~ #2 }
554 }
555 \cs_new_protected:Npn \__color_backend_reset:
556 { \__kernel_color_backend_stack_pop:n \l__color_backend_stack_int }

```

(End definition for `\__color_backend_select_cmyk:n` and others.)

```
557 </luatex | pdftex>
```

### 3.3.3 dvipdfmx/X<sub>q</sub>T<sub>E</sub>X

These backends have the most possible approaches: it recognises both `dvips`-based color specials and its own format, plus one can include PDF statements directly. Recent releases also have a color stack approach similar to `pdfTEX`. Of the stack methods, the dedicated the most versatile is the latter as it can cover all of the use cases we have. However, at present this interacts problematically with any color on the original stack. We therefore stick to a single-stack approach here.

```
558 <*dvipdfmx | xetex>
```

```

\__color_backend_select:n Using the single stack is relatively easy as there is only one route.
  \__color_backend_select_cmyk:n 559 \cs_new_protected:Npn \__color_backend_select:n #1
  \__color_backend_select_gray:n 560 { \__kernel_backend_literal:n { pdf : bc ~ [ #1 ] } }
  \__color_backend_select_rgb:n 561 \cs_new_eq:NN \__color_backend_select_cmyk:n \__color_backend_select:n
\__color_backend_reset: 562 \cs_new_eq:NN \__color_backend_select_gray:n \__color_backend_select:n
563 \cs_new_eq:NN \__color_backend_select_rgb:n \__color_backend_select:n
564 \cs_new_protected:Npn \__color_backend_reset:
565 { \__kernel_backend_literal:n { pdf : ec } }

```

(End definition for `\__color_backend_select:n` and others.)

```

\__color_backend_select_named:n For classical named colors, the only value we should get is Black.
566 \cs_new_protected:Npn \__color_backend_select_named:n #1
567 {
568   \str_if_eq:nnTF {#1} { Black }
569     { \__color_backend_select_gray:n { 0 } }
570     { \msg_error:nnn { color } { unknown-named-color } {#1} }
571 }
572 \msg_new:nnn { color } { unknown-named-color }
573 { Named-color~'#1'~is~not~known. }

```

(End definition for `\__color_backend_select_named:n`.)

```
574 </dvipdfmx | xetex>
```

## 3.4 Separations

Here, life gets interesting and we need essentially one approach per backend.

```
575 <*dvipdfmx | luatex | pdftex | xetex | dvips>
```

But we start with some functionality needed for both PostScript and PDF based backends.

`\g_color_backend_colorant_prop`

```
576 \prop_new:N \g__color_backend_colorant_prop
```

(End definition for `\g__color_backend_colorant_prop`.)

`\__color_backend_devicen_colorants:n`

`\__color_backend_devicen_colorants:w`

```
577 \cs_new:Npx \__color_backend_devicen_colorants:n #1
```

```
578 {
```

```
579   \exp_not:N \tl_if_blank:nF {#1}
```

```
580   {
```

```
581     \c_space_tl
```

```
582     << ~
```

```
583     /Colorants ~
```

```
584     << ~
```

```
585     \exp_not:N \__color_backend_devicen_colorants:w #1 ~
```

```
586     \exp_not:N \q_recursion_tail \c_space_tl
```

```
587     \exp_not:N \q_recursion_stop
```

```
588     >> ~
```

```
589     >>
```

```
590   }
```

```
591 }
```

```
592 \cs_new:Npn \__color_backend_devicen_colorants:w #1 ~
```

```
593 {
```

```
594   \quark_if_recursion_tail_stop:n {#1}
```

```
595   \prop_if_in:NnT \g__color_backend_colorant_prop {#1}
```

```
596   {
```

```
597     #1 ~
```

```
598     \prop_item:Nn \g__color_backend_colorant_prop {#1} ~
```

```
599   }
```

```
600   \__color_backend_devicen_colorants:w
```

```
601 }
```

(End definition for `\__color_backend_devicen_colorants:n` and `\__color_backend_devicen_colorants:w`.)

```
602 </dvipdfmx | luatex | pdftex | xetex | dvips>
```

```
603 <*dvips>
```

`\__color_backend_select_separation:nn`

`\__color_backend_select_devicen:nn`

```
604 \cs_new_protected:Npn \__color_backend_select_separation:nn #1#2
```

```
605   { \__color_backend_select:n { separation ~ #1 ~ #2 } }
```

```
606 \cs_new_eq:NN \__color_backend_select_devicen:nn \__color_backend_select_separation:nn
```

(End definition for `\__color_backend_select_separation:nn` and `\__color_backend_select_devicen:nn`.)

`\__color_backend_select_iccbased:nn`

No support.

```
607 \cs_new_protected:Npn \__color_backend_select_iccbased:nn #1#2 { }
```

(End definition for `\__color_backend_select_iccbased:nn`.)

`\__color_backend_separation_init:nmnn`

`\__color_backend_separation_init:nxxnn`

`\__color_backend_separation_init_aux:nmnnnn`

`\__color_backend_separation_init_DeviceCMYK:nnn`

`\__color_backend_separation_init_DeviceGray:nnn`

`\__color_backend_separation_init_DeviceRGB:nnn`

```
608 \cs_new_protected:Npx \__color_backend_separation_init:nmnnn #1#2#3#4#5
```

```
609 {
```

`\__color_backend_separation_init_Device:Mn`

`\__color_backend_separation_init:nnm`

`\__color_backend_separation_init_count:n`

`\__color_backend_separation_init_count:w`

`\__color_backend_separation_init:nmnn`

`\__color_backend_separation_init:w`

`\__color_backend_separation_init:n`

`\__color_backend_separation_init:nw`

`\__color_backend_separation_init_CIELAB:nnm`

```

610 \bool_if:NT \g__kernel_backend_header_bool
611 {
612   \exp_args:Nx \__kernel_backend_first_shipout:n
613   {
614     \exp_not:N \__color_backend_separation_init_aux:nmnnnn
615     { \exp_not:N \int_use:N \g__color_model_int }
616     {#1} {#2} {#3} {#4} {#5}
617   }
618   \prop_gput:Nxx \exp_not:N \g__color_backend_colorant_prop
619   { / \exp_not:N \str_convert_pdfname:n {#1} }
620   {
621     << ~
622     /setcolorspace ~ {} ~
623     >> ~ begin ~
624     color \exp_not:N \int_use:N \g__color_model_int \c_space_tl
625     end
626   }
627 }
628 }
629 \cs_generate_variant:Nn \__color_backend_separation_init:nmnnnn { nxx }
630 \cs_new_protected:Npn \__color_backend_separation_init_aux:nmnnnn #1#2#3#4#5#6
631 {
632   \__kernel_backend_literal:e
633   {
634     !
635     TeXDict ~ begin ~
636     /color #1
637     {
638       [ ~
639       /Separation ~ ( \str_convert_pdfname:n {#2} ) ~
640       [ ~ #3 ~ ] ~
641       {
642         \cs_if_exist_use:cF { __color_backend_separation_init_ #3 :nnn }
643         { \__color_backend_separation_init:nmnnnn
644           {#4} {#5} {#6}
645         }
646       ] ~ setcolorspace
647     } ~ def ~
648     end
649   }
650 }
651 \cs_new:cpn { __color_backend_separation_init_ /DeviceCMYK :nnn } #1#2#3
652 { \__color_backend_separation_init_Device:Nn 4 {#3} }
653 \cs_new:cpn { __color_backend_separation_init_ /DeviceGray :nnn } #1#2#3
654 { \__color_backend_separation_init_Device:Nn 1 {#3} }
655 \cs_new:cpn { __color_backend_separation_init_ /DeviceRGB :nnn } #1#2#3
656 { \__color_backend_separation_init_Device:Nn 2 {#3} }
657 \cs_new:Npn \__color_backend_separation_init_Device:Nn #1#2
658 {
659   #2 ~
660   \prg_replicate:nn {#1}
661   { #1 ~ index ~ mul ~ #1 ~ 1 ~ roll ~ }
662   \int_eval:n { #1 + 1 } ~ -1 ~ roll ~ pop
663 }

```

For the generic case, we cannot use `/FunctionType 2` unfortunately, so we have to code that idea up in PostScript. Here, we will therefore assume that a range is *always* given. First, we count values in each argument: at the backend level, we can assume there are always well-behaved with spaces present.

```

664 \cs_new:Npn \__color_backend_separation_init:nnn #1#2#3
665 {
666   \exp_args:Ne \__color_backend_separation_init:nnnn
667   { \__color_backend_separation_init_count:n {#2} }
668   {#1} {#2} {#3}
669 }
670 \cs_new:Npn \__color_backend_separation_init_count:n #1
671 { \int_eval:n { 0 \__color_backend_separation_init_count:w #1 ~ \s__color_stop } }
672 \cs_new:Npn \__color_backend_separation_init_count:w #1 ~ #2 \s__color_stop
673 {
674   +1
675   \tl_if_blank:nF {#2}
676   { \__color_backend_separation_init_count:w #2 \s__color_stop }
677 }

```

Now we implement the algorithm. In the terms in the PostScript manual, we have  $\mathbf{N} = 1$  and  $\mathbf{Domain} = [0 \ 1]$ , with  $\mathbf{Range}$  as #2,  $\mathbf{C0}$  as #3 and  $\mathbf{C1}$  as #4, with the number of output components in #1. So all we have to do is implement  $y_i = \mathbf{C0}_i + x(\mathbf{C1}_i - \mathbf{C0}_i)$  with lots of stack manipulation, then check the ranges. That's done by adding everything to the stack first, then using the fact we know all of the offsets. As manipulating the stack is tricky, we start by re-formatting the  $\mathbf{C0}$  and  $\mathbf{C1}$  arrays to be interleaved, and add a 0 to each pair: this is used to keep the stack of constant length while we are doing the first pass of mathematics. We then working through that list, calculating from the last to the first value before tidying up by removing all of the input values. We do that by first copying all of the final  $y$  values to the end of the stack, then rolling everything so we can pop the now-unneeded material.

```

678 \cs_new:Npn \__color_backend_separation_init:nnnn #1#2#3#4
679 {
680   \__color_backend_separation_init:w #3 ~ \s__color_stop #4 ~ \s__color_stop
681   \prg_replicate:nn {#1}
682   {
683     pop ~ 1 ~ index ~ neg ~ 1 ~ index ~ add ~
684     \int_eval:n { 3 * #1 } ~ index ~ mul ~
685     2 ~ index ~ add ~
686     \int_eval:n { 3 * #1 } ~ #1 ~ roll ~
687   }
688   \int_step_function:nnnN {#1} { -1 } { 1 }
689   \__color_backend_separation_init:n
690   \int_eval:n { 4 * #1 + 1 } ~ #1 ~ roll ~
691   \prg_replicate:nn { 3 * #1 + 1 } { pop ~ }
692   \tl_if_blank:nF {#2}
693   { \__color_backend_separation_init:nw {#1} #2 ~ \s__color_stop }
694 }
695 \cs_new:Npn \__color_backend_separation_init:w
696 #1 ~ #2 \s__color_stop #3 ~ #4 \s__color_stop
697 {
698   #1 ~ #3 ~ 0 ~
699   \tl_if_blank:nF {#2}
700   { \__color_backend_separation_init:w #2 \s__color_stop #4 \s__color_stop }

```

```

701 }
702 \cs_new:Npn \__color_backend_separation_init:n #1
703 { \int_eval:n { #1 * 2 } ~ index ~ }

```

Finally, we deal with the range limit if required. This is handled by splitting the range into pairs. It's then just a question of doing the comparisons, this time dropping everything except the desired result.

```

704 \cs_new:Npn \__color_backend_separation_init:nw #1#2 ~ #3 ~ #4 \s__color_stop
705 {
706   #2 ~ #3 ~
707   2 ~ index ~ 2 ~ index ~ lt ~
708   { ~ pop ~ exch ~ pop ~ } ~
709   { ~
710     2 ~ index ~ 1 ~ index ~ gt ~
711     { ~ exch ~ pop ~ exch ~ pop ~ } ~
712     { ~ pop ~ pop ~ } ~
713     ifelse ~
714   }
715   ifelse ~
716   #1 ~ 1 ~ roll ~
717   \tl_if_blank:nF {#4}
718   { \__color_backend_separation_init:nw {#1} #4 \s__color_stop }
719 }

```

CIELAB support uses the detail from the PostScript reference, page 227; other than that block of PostScript, this is the same as for PDF-based routes.

```

720 \cs_new_protected:Npn \__color_backend_separation_init_CIELAB:nnn #1#2#3
721 {
722   \__color_backend_separation_init:nxxxnn
723   {#2}
724   {
725     /CIEBasedABC ~
726     << ~
727     /RangeABC ~ [ ~ \c__color_model_range_CIELAB_tl \c_space_tl ] ~
728     /DecodeABC ~
729     [ ~
730     { ~ 16 ~ add ~ 116 ~ div ~ } ~ bind ~
731     { ~ 500 ~ div ~ } ~ bind ~
732     { ~ 200 ~ div ~ } ~ bind ~
733     ] ~
734     /MatrixABC ~ [ ~ 1 ~ 1 ~ 1 ~ 1 ~ 0 ~ 0 ~ 0 ~ 0 ~ -1 ~ ] ~
735     /DecodeLMN ~
736     [ ~
737     { ~
738     dup ~ 6 ~ 29 ~ div ~ ge ~
739     { ~ dup ~ dup ~ mul ~ mul ~ ~ } ~
740     { ~ 4 ~ 29 ~ div ~ sub ~ 108 ~ 841 ~ div ~ mul ~ } ~
741     ifelse ~
742     0.9505 ~ mul ~
743     } ~ bind ~
744     { ~
745     dup ~ 6 ~ 29 ~ div ~ ge ~
746     { ~ dup ~ dup ~ mul ~ mul ~ } ~
747     { ~ 4 ~ 29 ~ div ~ sub ~ 108 ~ 841 ~ div ~ mul ~ } ~
748     ifelse ~

```

```

749         } ~ bind ~
750         { ~
751           dup ~ 6 ~ 29 ~ div ~ ge ~
752           { ~ dup ~ dup ~ mul ~ mul ~ } ~
753           { ~ 4 ~ 29 ~ div ~ sub ~ 108 ~ 841 ~ div ~ mul ~ } ~
754           ifelse ~
755           1.0890 ~ mul ~
756         } ~ bind
757       ] ~
758       /WhitePoint ~
759       [ ~ \tl_use:c { c__color_model_whitepoint_CIELAB_ #1 _tl } ~ ] ~
760       >>
761     }
762     { \c__color_model_range_CIELAB_tl }
763     { 100 ~ 0 ~ 0 }
764     {#3}
765   }

```

(End definition for `\__color_backend_separation_init:nnnnn` and others.)

`\__color_backend_devicen_init:nmn` Trivial as almost all of the work occurs in the shared code.

```

766 \cs_new_protected:Npn \__color_backend_devicen_init:nnn #1#2#3
767 {
768   \__kernel_backend_literal:e
769   {
770     !
771     TeXDict ~ begin ~
772     /color \int_use:N \g__color_model_int
773     {
774       [ ~
775         /DeviceN ~
776         [ ~ #1 ~ ] ~
777         #2 ~
778         { ~ #3 ~ } ~
779         \__color_backend_devicen_colorants:n {#1}
780       ] ~ setcolorspace
781     } ~ def ~
782   end
783 }
784 }

```

(End definition for `\__color_backend_devicen_init:nnn`.)

`\__color_backend_iccbased_init:nmn` No support at present.

```

785 \cs_new_protected:Npn \__color_backend_iccbased_init:nnn #1#2#3 { }

```

(End definition for `\__color_backend_iccbased_init:nnn`.)

```

786 </dvips>
787 <*dvisvgm>

```

`\__color_backend_select_separation:nn` No support at present.

```

\__color_backend_select_devicen:nn
788 \cs_new_protected:Npn \__color_backend_select_separation:nn #1#2 { }
789 \cs_new_eq:NN \__color_backend_select_devicen:nn \__color_backend_select_separation:nn

```

(End definition for `\_color_backend_select_separation:nn` and `\_color_backend_select_devicen:nn`.)

No support at present.

`\_color_backend_separation_init:nmmn`  
`\_color_backend_separation_init_CIELAB:nnn`

```
790 \cs_new_protected:Npn \_color_backend_separation_init:nmmn #1#2#3#4#5 { }
791 \cs_new_protected:Npn \_color_backend_separation_init_CIELAB:nnn #1#2#3 { }
```

(End definition for `\_color_backend_separation_init:nmmn` and `\_color_backend_separation_init_CIELAB:nnn`.)

`\_color_backend_select_iccbased:nn`

As detailed in <https://www.w3.org/TR/css-color-4/#at-profile>, we can apply a color profile using CSS. As we have a local file, we use a relative URL.

```
792 \cs_new_protected:Npn \_color_backend_select_iccbased:nn #1#2
793 {
794   \_kernel_backend_literal_svg:x
795   {
796     <style>
797       @color-profile ~
798       \str_if_eq:nnTF {#2} { cmyk }
799       { device-cmyk }
800       { --color \int_use:N \g_color_model_int }
801       \c_space_tl
802       {
803         src:("#1")
804       }
805     </style>
806   }
807 }
```

(End definition for `\_color_backend_select_iccbased:nn`.)

```
808 </dvisvgm>
809 <*dviPDFmx | luatex | pdftex | xetex>
```

`\_color_backend_select_separation:nn`  
`\_color_backend_select_devicen:nn`  
`\_color_backend_select_iccbased:nn`

```
810 <*dviPDFmx | xetex>
811 \cs_new_protected:Npn \_color_backend_select_separation:nn #1#2
812 { \_kernel_backend_literal:x { pdf : bc ~ \pdf_object_ref:n {#1} ~ [ #2 ] } }
813 </dviPDFmx | xetex>
814 <*luatex | pdftex>
815 \cs_new_protected:Npn \_color_backend_select_separation:nn #1#2
816 { \_color_backend_select:nn { /#1 ~ cs ~ #2 ~ scn } { /#1 ~ CS ~ #2 ~ SCN } }
817 </luatex | pdftex>
818 \cs_new_eq:NN \_color_backend_select_devicen:nn \_color_backend_select_separation:nn
819 \cs_new_eq:NN \_color_backend_select_iccbased:nn \_color_backend_select_separation:nn
```

(End definition for `\_color_backend_select_separation:nn`, `\_color_backend_select_devicen:nn`, and `\_color_backend_select_iccbased:nn`.)

`\_color_backend_init_resource:n`

Resource initiation comes up a few times. For `dviPDFmx/XqTeX`, we skip this as at present it's handled by the backend.

```
820 \cs_new_protected:Npn \_color_backend_init_resource:n #1
821 {
822 <*luatex | pdftex>
823   \bool_lazy_and:nnT
824   { \cs_if_exist_p:N \pdfmanagement_if_active_p: }

```

```

825     { \pdfmanagement_if_active_p: }
826     {
827       \use:x
828       {
829         \pdfmanagement_add:nnn
830         { Page / Resources / ColorSpace }
831         { #1 }
832         { \pdf_object_ref_last: }
833       }
834     }
835 </luatex | pdftex>
836   }

```

(End definition for `\_color_backend_init_resource:n`.)

```

\_color_backend_separation_init:nmnm
\_color_backend_separation_init:nn
\_color_backend_separation_init_CIELAB:nnm

```

Initialising the PDF structures needs two parts: creating an object containing the “real” name of the Separation, then adding a reference to that to each page. We use a separate object for the tint transformation following the model in the PDF reference. The object here for the color needs to be named as that way it’s accessible to `dvipdfmx/X4TEX`.

```

837 \cs_new_protected:Npn \_color_backend_separation_init:nmnm #1#2#3#4#5
838 {
839   \pdf_object_unnamed_write:nx { dict }
840   {
841     /FunctionType ~ 2
842     /Domain ~ [0 ~ 1]
843     \t1_if_blank:nF {#3} { /Range ~ [#3] }
844     /CO ~ [#4] ~
845     /C1 ~ [#5] /N ~ 1
846   }
847   \exp_args:Nx \_color_backend_separation_init:nn
848   { \str_convert_pdfname:n {#1} } {#2}
849   \_color_backend_init_resource:n { color \int_use:N \g_color_model_int }
850 }
851 \cs_new_protected:Npn \_color_backend_separation_init:nn #1#2
852 {
853   \use:x
854   {
855     \pdf_object_new:n { color \int_use:N \g_color_model_int }
856     \pdf_object_write:nnn { color \int_use:N \g_color_model_int } { array }
857     { /Separation /#1 ~ #2 ~ \pdf_object_ref_last: }
858   }
859   \prop_gput:Nnx \g_color_backend_colorant_prop { /#1 }
860   { \pdf_object_ref_last: }
861 }

```

For CIELAB colors, we need one object per document for the illuminant, plus initialisation of the color space referencing that object.

```

862 \cs_new_protected:Npn \_color_backend_separation_init_CIELAB:nnm #1#2#3
863 {
864   \pdf_object_if_exist:nF { \_color_illuminant_CIELAB_ #1 }
865   {
866     \pdf_object_new:n { \_color_illuminant_CIELAB_ #1 }
867     \pdf_object_write:nnx { \_color_illuminant_CIELAB_ #1 } { array }
868     {

```

```

869         /Lab ~
870         <<
871         /WhitePoint ~
872         [ \tl_use:c { c__color_model_whitepoint_CIELAB_ #1 _t1 } ]
873         /Range ~ [ \c__color_model_range_CIELAB_t1 ]
874         >>
875     }
876 }
877 \__color_backend_separation_init:nnnnn
878 {#2}
879 { \pdf_object_ref:n { __color_illuminant_CIELAB_ #1 } }
880 { \c__color_model_range_CIELAB_t1 }
881 { 100 ~ 0 ~ 0 }
882 {#3}
883 }

```

(End definition for \\_\_color\_backend\_separation\_init:nnnnn, \\_\_color\_backend\_separation\_init:nn, and \\_\_color\_backend\_separation\_init\_CIELAB:nnn.)

\\_\_color\_backend\_devicen\_init:nnn Similar to the Separations case, but with an arbitrary function for the alternative space  
 \\_\_color\_backend\_devicen\_init:w work.

```

884 \cs_new_protected:Npn \__color_backend_devicen_init:nnn #1#2#3
885 {
886   \pdf_object_unnamed_write:nx { stream }
887   {
888     {
889       /FunctionType ~ 4 ~
890       /Domain ~
891       [ ~
892         \prg_replicate:nn
893         { 0 \__color_backend_devicen_init:w #1 ~ \s__color_stop }
894         { 0 ~ 1 ~ }
895       ] ~
896       /Range ~
897       [ ~
898         \str_case:nn {#2}
899         {
900           { /DeviceCMYK } { 0 ~ 1 ~ 0 ~ 1 ~ 0 ~ 1 ~ 0 ~ 1 }
901           { /DeviceGray } { 0 ~ 1 }
902           { /DeviceRGB } { 0 ~ 1 ~ 0 ~ 1 ~ 0 ~ 1 }
903         } ~
904       ]
905     }
906     { {#3} }
907   }
908   \use:x
909   {
910     \pdf_object_new:n { color \int_use:N \g__color_model_int }
911     \pdf_object_write:nnn { color \int_use:N \g__color_model_int } { array }
912     {
913       /DeviceN ~
914       [ ~ #1 ~ ] ~
915       #2 ~
916       \pdf_object_ref_last:

```

```

917         \_color_backend_devicen_colorants:n {#1}
918     }
919 }
920 \_color_backend_init_resource:n { color \int_use:N \g_color_model_int }
921 }
922 \cs_new:Npn \_color_backend_devicen_init:w #1 ~ #2 \s_color_stop
923 {
924     + 1
925     \tl_if_blank:nF {#2}
926     { \_color_backend_devicen_init:w #2 \s_color_stop }
927 }

```

(End definition for \\_color\_backend\_devicen\_init:nnn and \\_color\_backend\_devicen\_init:w.)

\\_color\_backend\_iccbased\_init:nnn Lots of data to save here: we only want to do that once per file, so track it by name.

```

928 \cs_new_protected:Npn \_color_backend_iccbased_init:nnn #1#2#3
929 {
930     \pdf_object_if_exist:nF { __color_icc_ #1 }
931     {
932         \pdf_object_new:n { __color_icc_ #1 }
933         \pdf_object_write:nxx { __color_icc_ #1 } { fstream }
934         {
935             {
936                 /N ~ \exp_not:n { #2 } ~
937                 \tl_if_empty:nF { #3 } { /Range~[ #3 ] }
938             }
939             {#1}
940         }
941     }
942     \pdf_object_unnamed_write:nx { array }
943     { /ICCBased ~ \pdf_object_ref:n { __color_icc_ #1 } }
944     \_color_backend_init_resource:n { color \int_use:N \g_color_model_int }
945 }

```

(End definition for \\_color\_backend\_iccbased\_init:nnn.)

\\_color\_backend\_iccbased\_device:nnn This is very similar to setting up a color space: the only part we add to the page resources differently.

```

946 \cs_new_protected:Npn \_color_backend_iccbased_device:nnn #1#2#3
947 {
948     \pdf_object_if_exist:nF { __color_icc_ #1 }
949     {
950         \pdf_object_new:n { __color_icc_ #1 }
951         \pdf_object_write:nnn { __color_icc_ #1 } { fstream }
952         {
953             { /N ~ #3 }
954             {#1}
955         }
956     }
957     \pdf_object_unnamed_write:nx { array }
958     { /ICCBased ~ \pdf_object_ref:n { __color_icc_ #1 } }
959     \_color_backend_init_resource:n { Default #2 }
960 }

```

(End definition for \\_color\_backend\_iccbased\_device:nnn.)

```

961 </dviPDFmx | luatex | pdftex | xetex>

```

### 3.5 Fill and stroke color

Here, dvipdfmx/X<sub>Y</sub>TeX we write direct PDF specials for the fill, and only use the stack for the stroke color (see above for comments on why we cannot use multiple stacks with these backends). LuaTeX and pdfTeX have mutiple stacks that can deal with fill and stroke. For dvips we have to manage fill and stroke color ourselves. We also handle dvisvgm independently, as there we can create SVG directly.

962 <\*dvipdfmx | xetex>

```

  \_color_backend_fill:n
\_color_backend_fill_cmyk:n 963 \cs_new_protected:Npn \_color_backend_fill:n #1
\_color_backend_fill_gray:n 964 { \_kernel_backend_literal:n { pdf : bc ~ fill ~ [ #1 ] } }
\_color_backend_fill_rgb:n 965 \cs_new_eq:NN \_color_backend_fill_cmyk:n \_color_backend_fill:n
  \_color_backend_stroke:n 966 \cs_new_eq:NN \_color_backend_fill_gray:n \_color_backend_fill:n
    \_color_backend_stroke_cmyk:n 967 \cs_new_eq:NN \_color_backend_fill_rgb:n \_color_backend_fill:n
    \_color_backend_stroke_gray:n 968 \cs_new_protected:Npn \_color_backend_stroke:n #1
    \_color_backend_stroke_rgb:n 969 { \_kernel_backend_literal:n { pdf : bc ~ stroke ~ [ #1 ] } }
970 \cs_new_eq:NN \_color_backend_stroke_cmyk:n \_color_backend_stroke:n
971 \cs_new_eq:NN \_color_backend_stroke_gray:n \_color_backend_stroke:n
972 \cs_new_eq:NN \_color_backend_stroke_rgb:n \_color_backend_stroke:n

```

(End definition for \\_color\_backend\_fill:n and others.)

```

\_color_backend_fill_separation:nn
\_color_backend_stroke_separation:nn 973 \cs_new_protected:Npn \_color_backend_fill_separation:nn #1#2
  \_color_backend_fill_devicen:nn 974 {
  \_color_backend_stroke_devicen:nn 975 \_kernel_backend_literal:x
976 { pdf : bc ~ fill ~ \pdf_object_ref:n {#1} ~ [ #2 ] }
977 }
978 \cs_new_protected:Npn \_color_backend_stroke_separation:nn #1#2
979 {
980 \_kernel_backend_literal:x
981 { pdf : bc ~ stroke ~ \pdf_object_ref:n {#1} ~ [ #2 ] }
982 }
983 \cs_new_eq:NN \_color_backend_fill_devicen:nn \_color_backend_fill_separation:nn
984 \cs_new_eq:NN \_color_backend_stroke_devicen:nn \_color_backend_stroke_separation:nn

```

(End definition for \\_color\_backend\_fill\_separation:nn and others.)

```

\_color_backend_fill_reset:
  \_color_backend_stroke_reset: 985 \cs_new_eq:NN \_color_backend_fill_reset: \_color_backend_reset:
986 \cs_new_eq:NN \_color_backend_stroke_reset: \_color_backend_reset:

```

(End definition for \\_color\_backend\_fill\_reset: and \\_color\_backend\_stroke\_reset:.)

987 </dvipdfmx | xetex>

988 <\*luatex | pdftex>

```

\_color_backend_fill_cmyk:n
\_color_backend_fill_gray:n
\_color_backend_fill_rgb:n
  \_color_backend_fill:n
    \_color_backend_stroke_cmyk:n
    \_color_backend_stroke_gray:n
    \_color_backend_stroke_rgb:n
  \_color_backend_stroke:n

```

Drawing (fill/stroke) color is handled in dvipdfmx/X<sub>Y</sub>TeX in the same way as LuaTeX/pdfTeX. We use the same approach as earlier, except the color stack is not involved so the generic direct PDF operation is used. There is no worry about the nature of strokes: everything is handled automatically.

```

989 \cs_new_protected:Npn \_color_backend_fill_cmyk:n #1
990 { \_color_backend_fill:n { #1 ~ k } }

```

```

991 \cs_new_protected:Npn \__color_backend_fill_gray:n #1
992   { \__color_backend_fill:n { #1 ~ g } }
993 \cs_new_protected:Npn \__color_backend_fill_rgb:n #1
994   { \__color_backend_fill:n { #1 ~ rg } }
995 \cs_new_protected:Npn \__color_backend_fill:n #1
996   {
997     \tl_set:Nn \l__color_backend_fill_tl {#1}
998     \__kernel_color_backend_stack_push:nn \l__color_backend_stack_int
999     { #1 ~ \l__color_backend_stroke_tl }
1000  }
1001 \cs_new_protected:Npn \__color_backend_stroke_cmyk:n #1
1002   { \__color_backend_stroke:n { #1 ~ K } }
1003 \cs_new_protected:Npn \__color_backend_stroke_gray:n #1
1004   { \__color_backend_stroke:n { #1 ~ G } }
1005 \cs_new_protected:Npn \__color_backend_stroke_rgb:n #1
1006   { \__color_backend_stroke:n { #1 ~ RG } }
1007 \cs_new_protected:Npn \__color_backend_stroke:n #1
1008   {
1009     \tl_set:Nn \l__color_backend_stroke_tl {#1}
1010     \__kernel_color_backend_stack_push:nn \l__color_backend_stack_int
1011     { \l__color_backend_fill_tl \c_space_tl #1 }
1012  }

```

(End definition for `\__color_backend_fill_cmyk:n` and others.)

```

\__color_backend_fill_separation:nn
\__color_backend_stroke_separation:nn
\__color_backend_fill_devicen:nn
\__color_backend_stroke_devicen:nn
1013 \cs_new_protected:Npn \__color_backend_fill_separation:nn #1#2
1014   { \__color_backend_fill:n { /#1 ~ cs ~ #2 ~ scn } }
1015 \cs_new_protected:Npn \__color_backend_stroke_separation:nn #1#2
1016   { \__color_backend_stroke:n { /#1 ~ CS ~ #2 ~ SCN } }
1017 \cs_new_eq:NN \__color_backend_fill_devicen:nn \__color_backend_fill_separation:nn
1018 \cs_new_eq:NN \__color_backend_stroke_devicen:nn \__color_backend_stroke_separation:nn

```

(End definition for `\__color_backend_fill_separation:nn` and others.)

```

\__color_backend_fill_reset:
\__color_backend_stroke_reset:
1019 \cs_new_eq:NN \__color_backend_fill_reset: \__color_backend_reset:
1020 \cs_new_eq:NN \__color_backend_stroke_reset: \__color_backend_reset:

```

(End definition for `\__color_backend_fill_reset:` and `\__color_backend_stroke_reset:.`)

```
1021 </luatex | pdftex>
```

```
1022 <*dvips>
```

`\__color_backend_fill_cmyk:n` Fill color here is the same as general color *except* we skip the stroke part.

```

\__color_backend_fill_gray:n
\__color_backend_fill_rgb:n
\__color_backend_fill:n
\__color_backend_stroke_cmyk:n
\__color_backend_stroke_gray:n
\__color_backend_stroke_rgb:n
1023 \cs_new_protected:Npn \__color_backend_fill_cmyk:n #1
1024   { \__color_backend_fill:n { cmyk ~ #1 } }
1025 \cs_new_protected:Npn \__color_backend_fill_gray:n #1
1026   { \__color_backend_fill:n { gray ~ #1 } }
1027 \cs_new_protected:Npn \__color_backend_fill_rgb:n #1
1028   { \__color_backend_fill:n { rgb ~ #1 } }
1029 \cs_new_protected:Npn \__color_backend_fill:n #1
1030   {
1031     \__kernel_backend_literal:n { color~push~ #1 }
1032  }

```

```

1033 \cs_new_protected:Npn \__color_backend_stroke_cmyk:n #1
1034 { \__kernel_backend_postscript:n { /color.sc { #1 ~ setcmykcolor } def } }
1035 \cs_new_protected:Npn \__color_backend_stroke_gray:n #1
1036 { \__kernel_backend_postscript:n { /color.sc { #1 ~ setgray } def } }
1037 \cs_new_protected:Npn \__color_backend_stroke_rgb:n #1
1038 { \__kernel_backend_postscript:n { /color.sc { #1 ~ setrgbcolor } def } }

```

(End definition for \\_\_color\_backend\_fill\_cmyk:n and others.)

```

\__color_backend_fill_separation:nn
\__color_backend_stroke_separation:nn
\__color_backend_fill_devicen:nn
\__color_backend_stroke_devicen:nn
1039 \cs_new_protected:Npn \__color_backend_fill_separation:nn #1#2
1040 { \__color_backend_fill:n { separation ~ #1 ~ #2 } }
1041 \cs_new_protected:Npn \__color_backend_stroke_separation:nn #1#2
1042 { \__kernel_backend_postscript:n { /color.sc { separation ~ #1 ~ #2 } def } }
1043 \cs_new_eq:NN \__color_backend_fill_devicen:nn \__color_backend_fill_separation:nn
1044 \cs_new_eq:NN \__color_backend_stroke_devicen:nn \__color_backend_stroke_separation:nn

```

(End definition for \\_\_color\_backend\_fill\_separation:nn and others.)

```

\__color_backend_fill_reset:
\__color_backend_stroke_reset:

```

```

1045 \cs_new_eq:NN \__color_backend_fill_reset: \__color_backend_reset:
1046 \cs_new_protected:Npn \__color_backend_stroke_reset: { }

```

(End definition for \\_\_color\_backend\_fill\_reset: and \\_\_color\_backend\_stroke\_reset:.)

```

1047 </dvips>
1048 <*dvisvgm>

```

```

\__color_backend_fill_cmyk:n
\__color_backend_fill_gray:n
\__color_backend_fill_rgb:n
\__color_backend_fill:n

```

Fill color here is the same as general color *except* we skip the stroke part.

```

1049 \cs_new_protected:Npn \__color_backend_fill_cmyk:n #1
1050 { \__color_backend_fill:n { cmyk ~ #1 } }
1051 \cs_new_protected:Npn \__color_backend_fill_gray:n #1
1052 { \__color_backend_fill:n { gray ~ #1 } }
1053 \cs_new_protected:Npn \__color_backend_fill_rgb:n #1
1054 { \__color_backend_fill:n { rgb ~ #1 } }
1055 \cs_new_protected:Npn \__color_backend_fill:n #1
1056 {
1057   \__kernel_backend_literal:n { color~push~ #1 }
1058 }

```

(End definition for \\_\_color\_backend\_fill\_cmyk:n and others.)

```

\__color_backend_stroke_cmyk:n
\__color_backend_stroke_cmyk:w
\__color_backend_stroke_gray:n
\__color_backend_stroke_gray_aux:n
\__color_backend_stroke_rgb:n
\__color_backend_stroke_rgb:w
\__color_backend:nnn

```

For drawings in SVG, we use scopes for all stroke colors. That requires using RGB values, which luckily are easy to convert here (cmyk to RGB is a fixed function).

```

1059 \cs_new_protected:Npn \__color_backend_stroke_cmyk:n #1
1060 { \__color_backend_cmyk:w #1 \s__color_stop }
1061 \cs_new_protected:Npn \__color_backend_stroke_cmyk:w
1062 #1 ~ #2 ~ #3 ~ #4 \s__color_stop
1063 {
1064   \use:x
1065   {
1066     \__color_backend:nnn
1067     { \fp_eval:n { -100 * ( 1 - min ( 1 , #1 + #4 ) ) } }
1068     { \fp_eval:n { -100 * ( 1 - min ( 1 , #2 + #4 ) ) } }
1069     { \fp_eval:n { -100 * ( 1 - min ( 1 , #3 + #4 ) ) } }

```

```

1070     }
1071   }
1072   \cs_new_protected:Npn \__color_backend_stroke_gray:n #1
1073   {
1074     \use:x
1075     {
1076       \__color_backend_stroke_gray_aux:n
1077       { \fp_eval:n { 100 * (#1) } }
1078     }
1079   }
1080   \cs_new_protected:Npn \__color_backend_stroke_gray_aux:n #1
1081   { \__color_backend:nnn {#1} {#1} {#1} }
1082   \cs_new_protected:Npn \__color_backend_stroke_rgb:n #1
1083   { \__color_backend_rgb:w #1 \s__color_stop }
1084   \cs_new_protected:Npn \__color_backend_stroke_rgb:w
1085   #1 ~ #2 ~ #3 \s__color_stop
1086   {
1087     \use:x
1088     {
1089       \__color_backend:nnn
1090       { \fp_eval:n { 100 * (#1) } }
1091       { \fp_eval:n { 100 * (#2) } }
1092       { \fp_eval:n { 100 * (#3) } }
1093     }
1094   }
1095   \cs_new_protected:Npx \__color_backend:nnn #1#2#3
1096   {
1097     \__kernel_backend_scope:n
1098     {
1099       stroke =
1100       "
1101         rgb
1102         (
1103           #1 \c_percent_str ,
1104           #2 \c_percent_str ,
1105           #3 \c_percent_str
1106         )
1107       "
1108     }
1109   }

```

(End definition for \\_\_color\_backend\_stroke\_cmyk:n and others.)

At present, these are no-ops.

```

\__color_backend_fill_separation:nn
\__color_backend_stroke_separation:nn
\__color_backend_fill_devicen:nn
\__color_backend_stroke_devicen:nn
1110 \cs_new_protected:Npn \__color_backend_fill_separation:nn #1#2 { }
1111 \cs_new_protected:Npn \__color_backend_stroke_separation:nn #1#2 { }
1112 \cs_new_eq:NN \__color_backend_fill_devicen:nn \__color_backend_fill_separation:nn
1113 \cs_new_eq:NN \__color_backend_stroke_devicen:nn \__color_backend_stroke_separation:nn

```

(End definition for \\_\_color\_backend\_fill\_separation:nn and others.)

```

\__color_backend_fill_reset:
\__color_backend_stroke_reset:
1114 \cs_new_eq:NN \__color_backend_fill_reset: \__color_backend_reset:
1115 \cs_new_protected:Npn \__color_backend_stroke_reset: { }

```

(End definition for `\_color_backend_fill_reset:` and `\_color_backend_stroke_reset:`.)

`\_color_backend_devicen_init:nnn` No support at present.

```
\_color_backend_iccbased_init:nnn 1116 \cs_new_protected:Npn \_color_backend_devicen_init:nnn #1#2#3 { }  
1117 \cs_new_protected:Npn \_color_backend_iccbased_init:nnn #1#2#3 { }
```

(End definition for `\_color_backend_devicen_init:nnn` and `\_color_backend_iccbased_init:nnn`.)

```
1118 \end{dvipsvm}
```

```
1119 \end{package}
```

## 4 I3backend-draw Implementation

```
1120 \*package
```

```
1121 \@@=draw
```

### 4.1 dvips backend

```
1122 \*dvips
```

`\_draw_backend_literal:n` The same as literal PostScript: same arguments about positioning apply her.

```
\_draw_backend_literal:x 1123 \cs_new_eq:NN \_draw_backend_literal:n \_kernel_backend_literal_postscript:n  
1124 \cs_generate_variant:Nn \_draw_backend_literal:n { x }
```

(End definition for `\_draw_backend_literal:n`.)

`\_draw_backend_begin:` The `ps::[begin]` special here deals with positioning but allows us to continue on to a matching `ps::[end]`: contrast with `ps:`, which positions but where we can't split material between separate calls. The `@beginspecial/@endspecial` pair are from `special.pro` and correct the scale and  $y$ -axis direction. In contrast to `pgf`, we don't save the current point: discussion with Tom Rokici suggested a better way to handle the necessary translations (see `\_draw_backend_box_use:Nnnnn`). (Note that `@beginspecial/@endspecial` forms a backend scope.) The `[begin]/[end]` lines are handled differently from the rest as they are conceptually different: not really drawing literals but instructions to `dvips` itself.

```
1125 \cs_new_protected:Npn \_draw_backend_begin:  
1126 {  
1127   \_kernel_backend_literal:n { ps::[begin] }  
1128   \_draw_backend_literal:n { @beginspecial }  
1129 }  
1130 \cs_new_protected:Npn \_draw_backend_end:  
1131 {  
1132   \_draw_backend_literal:n { @endspecial }  
1133   \_kernel_backend_literal:n { ps::[end] }  
1134 }
```

(End definition for `\_draw_backend_begin:` and `\_draw_backend_end:`.)

`\_draw_backend_scope_begin:` Scope here may need to contain saved definitions, so the entire memory rather than just the graphic state has to be sent to the stack.

```
\_draw_backend_scope_end: 1135 \cs_new_protected:Npn \_draw_backend_scope_begin:  
1136 { \_draw_backend_literal:n { save } }  
1137 \cs_new_protected:Npn \_draw_backend_scope_end:  
1138 { \_draw_backend_literal:n { restore } }
```

(End definition for `\_draw_backend_scope_begin:` and `\_draw_backend_scope_end:`)

`\_draw_backend_moveto:nn` Path creation operations mainly resolve directly to PostScript primitive steps, with only  
`\_draw_backend_lineto:nn` the need to convert to bp. Notice that x-type expansion is included here to ensure that  
`\_draw_backend_rectangle:nmmn` any variable values are forced to literals before any possible caching. There is no native  
`\_draw_backend_curveto:nnmmnn` rectangular path command (without also clipping, filling or stroking), so that task is  
done using a small amount of PostScript.

```

1139 \cs_new_protected:Npn \_draw_backend_moveto:nn #1#2
1140   {
1141     \_draw_backend_literal:x
1142     {
1143       \dim_to_decimal_in_bp:n {#1} ~
1144       \dim_to_decimal_in_bp:n {#2} ~ moveto
1145     }
1146   }
1147 \cs_new_protected:Npn \_draw_backend_lineto:nn #1#2
1148   {
1149     \_draw_backend_literal:x
1150     {
1151       \dim_to_decimal_in_bp:n {#1} ~
1152       \dim_to_decimal_in_bp:n {#2} ~ lineto
1153     }
1154   }
1155 \cs_new_protected:Npn \_draw_backend_rectangle:nmmn #1#2#3#4
1156   {
1157     \_draw_backend_literal:x
1158     {
1159       \dim_to_decimal_in_bp:n {#4} ~ \dim_to_decimal_in_bp:n {#3} ~
1160       \dim_to_decimal_in_bp:n {#1} ~ \dim_to_decimal_in_bp:n {#2} ~
1161       moveto-dup-0~rlineto-exch-0~exch~rlineto-neg-0~rlineto~closepath
1162     }
1163   }
1164 \cs_new_protected:Npn \_draw_backend_curveto:nnmmnn #1#2#3#4#5#6
1165   {
1166     \_draw_backend_literal:x
1167     {
1168       \dim_to_decimal_in_bp:n {#1} ~ \dim_to_decimal_in_bp:n {#2} ~
1169       \dim_to_decimal_in_bp:n {#3} ~ \dim_to_decimal_in_bp:n {#4} ~
1170       \dim_to_decimal_in_bp:n {#5} ~ \dim_to_decimal_in_bp:n {#6} ~
1171       curveto
1172     }
1173   }

```

(End definition for `\_draw_backend_moveto:nn` and others.)

`\_draw_backend_evenodd_rule:` The even-odd rule here can be implemented as a simply switch.  
`\_draw_backend_nonzero_rule:` 1174 `\cs_new_protected:Npn \_draw_backend_evenodd_rule:`  
`\g__draw_draw_eor_bool` 1175 `{ \bool_gset_true:N \g__draw_draw_eor_bool }`  
1176 `\cs_new_protected:Npn \_draw_backend_nonzero_rule:`  
1177 `{ \bool_gset_false:N \g__draw_draw_eor_bool }`  
1178 `\bool_new:N \g__draw_draw_eor_bool`

(End definition for `\_draw_backend_evenodd_rule:`, `\_draw_backend_nonzero_rule:`, and `\g__draw_draw_eor_bool:`.)

`\_draw_backend_closepath:` Unlike PDF, PostScript doesn't track separate colors for strokes and other elements. It is  
`\_draw_backend_stroke:` also desirable to have the `clip` keyword after a stroke or fill. To achieve those outcomes,  
`\_draw_backend_closestroke:` there is some work to do. For color, the stroke color is simple but the fill one has to be  
`\_draw_backend_fill:` inserted by hand. For clipping, the required ordering is achieved using a  $\TeX$  switch.  
`\_draw_backend_fillstroke:` All of the operations end with a new path instruction as they do not terminate (again in  
`\_draw_backend_clip:` contrast to PDF).  
`\_draw_backend_discardpath:`

```

1179 \cs_new_protected:Npn \_draw_backend_closepath:
1180 { \_draw_backend_literal:n { closepath } }
1181 \cs_new_protected:Npn \_draw_backend_stroke:
1182 {
1183   \_draw_backend_literal:n { gsave }
1184   \_draw_backend_literal:n { color.sc }
1185   \_draw_backend_literal:n { stroke }
1186   \_draw_backend_literal:n { grestore }
1187   \bool_if:NT \g__draw_draw_clip_bool
1188     {
1189       \_draw_backend_literal:x
1190       {
1191         \bool_if:NT \g__draw_draw_eor_bool { eo }
1192         clip
1193       }
1194     }
1195   \_draw_backend_literal:n { newpath }
1196   \bool_gset_false:N \g__draw_draw_clip_bool
1197 }
1198 \cs_new_protected:Npn \_draw_backend_closestroke:
1199 {
1200   \_draw_backend_closepath:
1201   \_draw_backend_stroke:
1202 }
1203 \cs_new_protected:Npn \_draw_backend_fill:
1204 {
1205   \_draw_backend_literal:x
1206   {
1207     \bool_if:NT \g__draw_draw_eor_bool { eo }
1208     fill
1209   }
1210   \bool_if:NT \g__draw_draw_clip_bool
1211   {
1212     \_draw_backend_literal:x
1213     {
1214       \bool_if:NT \g__draw_draw_eor_bool { eo }
1215       clip
1216     }
1217   }
1218   \_draw_backend_literal:n { newpath }
1219   \bool_gset_false:N \g__draw_draw_clip_bool
1220 }
1221 \cs_new_protected:Npn \_draw_backend_fillstroke:
1222 {
1223   \_draw_backend_literal:x
1224   {
1225     \bool_if:NT \g__draw_draw_eor_bool { eo }

```

```

1226         fill
1227     }
1228     \_draw_backend_literal:n { gsave }
1229     \_draw_backend_literal:n { color.sc }
1230     \_draw_backend_literal:n { stroke }
1231     \_draw_backend_literal:n { grestore }
1232     \bool_if:NT \g__draw_draw_clip_bool
1233     {
1234         \_draw_backend_literal:x
1235         {
1236             \bool_if:NT \g__draw_draw_eor_bool { eo }
1237             clip
1238         }
1239     }
1240     \_draw_backend_literal:n { newpath }
1241     \bool_gset_false:N \g__draw_draw_clip_bool
1242 }
1243 \cs_new_protected:Npn \_draw_backend_clip:
1244 { \bool_gset_true:N \g__draw_draw_clip_bool }
1245 \bool_new:N \g__draw_draw_clip_bool
1246 \cs_new_protected:Npn \_draw_backend_discardpath:
1247 {
1248     \bool_if:NT \g__draw_draw_clip_bool
1249     {
1250         \_draw_backend_literal:x
1251         {
1252             \bool_if:NT \g__draw_draw_eor_bool { eo }
1253             clip
1254         }
1255     }
1256     \_draw_backend_literal:n { newpath }
1257     \bool_gset_false:N \g__draw_draw_clip_bool
1258 }

```

(End definition for `\_draw_backend_closepath:` and others.)

`\_draw_backend_dash_pattern:nn` Converting paths to output is again a case of mapping directly to PostScript operations.

```

1259 \cs_new_protected:Npn \_draw_backend_dash_pattern:nn #1#2
1260 {
1261     \_draw_backend_literal:x
1262     {
1263         [
1264             \exp_args:Nf \use:n
1265             { \clist_map_function:nN {#1} \_draw_backend_dash:n }
1266         ] ~
1267         \dim_to_decimal_in_bp:n {#2} ~ setdash
1268     }
1269 }
1270 \cs_new:Npn \_draw_backend_dash:n #1
1271 { ~ \dim_to_decimal_in_bp:n {#1} }
1272 \cs_new_protected:Npn \_draw_backend_linewidth:n #1
1273 {
1274     \_draw_backend_literal:x
1275     { \dim_to_decimal_in_bp:n {#1} ~ setlinewidth }

```

```

1276 }
1277 \cs_new_protected:Npn \__draw_backend_miterlimit:n #1
1278 { \__draw_backend_literal:n { #1 ~ setmiterlimit } }
1279 \cs_new_protected:Npn \__draw_backend_cap_but:
1280 { \__draw_backend_literal:n { 0 ~ setlinecap } }
1281 \cs_new_protected:Npn \__draw_backend_cap_round:
1282 { \__draw_backend_literal:n { 1 ~ setlinecap } }
1283 \cs_new_protected:Npn \__draw_backend_cap_rectangle:
1284 { \__draw_backend_literal:n { 2 ~ setlinecap } }
1285 \cs_new_protected:Npn \__draw_backend_join_miter:
1286 { \__draw_backend_literal:n { 0 ~ setlinejoin } }
1287 \cs_new_protected:Npn \__draw_backend_join_round:
1288 { \__draw_backend_literal:n { 1 ~ setlinejoin } }
1289 \cs_new_protected:Npn \__draw_backend_join_bevel:
1290 { \__draw_backend_literal:n { 2 ~ setlinejoin } }

```

(End definition for `\__draw_backend_dash_pattern:nn` and others.)

`\__draw_backend_cm:nmmm` In `dvips`, keeping the transformations in line with the engine is unfortunately not possible for scaling and rotations: even if we decompose the matrix into those operations, there is still no backend tracking (cf. `dvipdfmx/XYTeX`). Thus we take the shortest path available and simply dump the matrix as given.

```

1291 \cs_new_protected:Npn \__draw_backend_cm:nmmm #1#2#3#4
1292 {
1293   \__draw_backend_literal:n
1294   { [ #1 ~ #2 ~ #3 ~ #4 ~ 0 ~ 0 ] ~ concat }
1295 }

```

(End definition for `\__draw_backend_cm:nmmm`.)

`\__draw_backend_box_use:Nmmmm` Inside a picture `@beginspecial/@endspecial` are active, which is normally a good thing but means that the position and scaling would be off if the box was inserted directly. To deal with that, there are a number of possible approaches. The implementation here was suggested by Tom Rokici (author of `dvips`). We end the current special placement, then set the current point with a literal `[begin]`. As for general literals, we then use the stack to store the current point and move to it. To insert the required transformation, we have to flip the  $y$ -axis, once before and once after it. Then we get back to the `TeX` reference point to insert our content. The clean up has to happen in the right places, hence the `[begin]/[end]` pair around `restore`. Finally, we can return to “normal” drawing mode. Notice that the set up here is very similar to that in `\__draw_align_currentpoint_...`, but the ordering of saving and restoring is different (intermixed).

```

1296 \cs_new_protected:Npn \__draw_backend_box_use:Nmmmm #1#2#3#4#5
1297 {
1298   \__draw_backend_literal:n { @endspecial }
1299   \__draw_backend_literal:n { [end] }
1300   \__draw_backend_literal:n { [begin] }
1301   \__draw_backend_literal:n { save }
1302   \__draw_backend_literal:n { currentpoint }
1303   \__draw_backend_literal:n { currentpoint~translate }
1304   \__draw_backend_cm:nmmm { 1 } { 0 } { 0 } { -1 }
1305   \__draw_backend_cm:nmmm {#2} {#3} {#4} {#5}
1306   \__draw_backend_cm:nmmm { 1 } { 0 } { 0 } { -1 }
1307   \__draw_backend_literal:n { neg~exch~neg~exch~translate }

```

```

1308     \_draw_backend_literal:n { [end] }
1309     \hbox_overlap_right:n { \box_use:N #1 }
1310     \_draw_backend_literal:n { [begin] }
1311     \_draw_backend_literal:n { restore }
1312     \_draw_backend_literal:n { [end] }
1313     \_draw_backend_literal:n { [begin] }
1314     \_draw_backend_literal:n { @beginspecial }
1315 }

```

(End definition for `\_draw_backend_box_use:Nnnnn`.)

```

1316 </dvips>

```

## 4.2 LuaTeX, pdfTeX, dvipdfmx and XeTeX

LuaTeX, pdfTeX, dvipdfmx and XeTeX directly produce PDF output and understand a shared set of specials for drawing commands.

```

1317 <*dvipdfmx | luatex | pdftex | xetex>

```

### 4.2.1 Drawing

`\_draw_backend_literal:n` Pass data through using a dedicated interface.

```

\_draw_backend_literal:x
1318 \cs_new_eq:NN \_draw_backend_literal:n \_kernel_backend_literal_pdf:n
1319 \cs_generate_variant:Nn \_draw_backend_literal:n { x }

```

(End definition for `\_draw_backend_literal:n`.)

`\_draw_backend_begin:` No special requirements here, so simply set up a drawing scope.

```

\_draw_backend_end:
1320 \cs_new_protected:Npn \_draw_backend_begin:
1321 { \_draw_backend_scope_begin: }
1322 \cs_new_protected:Npn \_draw_backend_end:
1323 { \_draw_backend_scope_end: }

```

(End definition for `\_draw_backend_begin:` and `\_draw_backend_end:.`)

`\_draw_backend_scope_begin:` Use the backend-level scope mechanisms.

```

\_draw_backend_scope_end:
1324 \cs_new_eq:NN \_draw_backend_scope_begin: \_kernel_backend_scope_begin:
1325 \cs_new_eq:NN \_draw_backend_scope_end: \_kernel_backend_scope_end:

```

(End definition for `\_draw_backend_scope_begin:` and `\_draw_backend_scope_end:.`)

`\_draw_backend_moveto:nn` Path creation operations all resolve directly to PDF primitive steps, with only the need to convert to bp.

```

\_draw_backend_lineto:nn
  \_draw_backend_curveto:nnnnn
  \_draw_backend_rectangle:nnnn
1326 \cs_new_protected:Npn \_draw_backend_moveto:nn #1#2
1327 {
1328   \_draw_backend_literal:x
1329   { \dim_to_decimal_in_bp:n {#1} ~ \dim_to_decimal_in_bp:n {#2} ~ m }
1330 }
1331 \cs_new_protected:Npn \_draw_backend_lineto:nn #1#2
1332 {
1333   \_draw_backend_literal:x
1334   { \dim_to_decimal_in_bp:n {#1} ~ \dim_to_decimal_in_bp:n {#2} ~ l }
1335 }
1336 \cs_new_protected:Npn \_draw_backend_curveto:nnnnn #1#2#3#4#5#6
1337 {

```

```

1338   \__draw_backend_literal:x
1339   {
1340     \dim_to_decimal_in_bp:n {#1} ~ \dim_to_decimal_in_bp:n {#2} ~
1341     \dim_to_decimal_in_bp:n {#3} ~ \dim_to_decimal_in_bp:n {#4} ~
1342     \dim_to_decimal_in_bp:n {#5} ~ \dim_to_decimal_in_bp:n {#6} ~
1343     c
1344   }
1345 }
1346 \cs_new_protected:Npn \__draw_backend_rectangle:nnnn #1#2#3#4
1347 {
1348   \__draw_backend_literal:x
1349   {
1350     \dim_to_decimal_in_bp:n {#1} ~ \dim_to_decimal_in_bp:n {#2} ~
1351     \dim_to_decimal_in_bp:n {#3} ~ \dim_to_decimal_in_bp:n {#4} ~
1352     re
1353   }
1354 }

```

(End definition for `\__draw_backend_moveto:nn` and others.)

`\__draw_backend_evenodd_rule:` The even-odd rule here can be implemented as a simply switch.  
`\__draw_backend_nonzero_rule:`  
`\g__draw_draw_eor_bool`

```

1355 \cs_new_protected:Npn \__draw_backend_evenodd_rule:
1356   { \bool_gset_true:N \g__draw_draw_eor_bool }
1357 \cs_new_protected:Npn \__draw_backend_nonzero_rule:
1358   { \bool_gset_false:N \g__draw_draw_eor_bool }
1359 \bool_new:N \g__draw_draw_eor_bool

```

(End definition for `\__draw_backend_evenodd_rule:`, `\__draw_backend_nonzero_rule:`, and `\g__draw_draw_eor_bool`.)

`\__draw_backend_closepath:` Converting paths to output is again a case of mapping directly to PDF operations.

```

\__draw_backend_stroke: 1360 \cs_new_protected:Npn \__draw_backend_closepath:
\__draw_backend_closestroke: 1361   { \__draw_backend_literal:n { h } }
\__draw_backend_fill: 1362 \cs_new_protected:Npn \__draw_backend_stroke:
\__draw_backend_fillstroke: 1363   { \__draw_backend_literal:n { S } }
\__draw_backend_clip: 1364 \cs_new_protected:Npn \__draw_backend_closestroke:
\__draw_backend_discardpath: 1365   { \__draw_backend_literal:n { s } }
1366 \cs_new_protected:Npn \__draw_backend_fill:
1367   {
1368     \__draw_backend_literal:x
1369     { f \bool_if:NT \g__draw_draw_eor_bool * }
1370   }
1371 \cs_new_protected:Npn \__draw_backend_fillstroke:
1372   {
1373     \__draw_backend_literal:x
1374     { B \bool_if:NT \g__draw_draw_eor_bool * }
1375   }
1376 \cs_new_protected:Npn \__draw_backend_clip:
1377   {
1378     \__draw_backend_literal:x
1379     { W \bool_if:NT \g__draw_draw_eor_bool * }
1380   }
1381 \cs_new_protected:Npn \__draw_backend_discardpath:
1382   { \__draw_backend_literal:n { n } }

```

(End definition for `\_draw_backend_closepath`: and others.)

Converting paths to output is again a case of mapping directly to PDF operations.

```

\__draw_backend_dash_pattern:nn
\__draw_backend_dash:n      1383 \cs_new_protected:Npn \__draw_backend_dash_pattern:nn #1#2
\__draw_backend_linewidth:n 1384 {
\__draw_backend_miterlimit:n 1385   \__draw_backend_literal:x
\__draw_backend_cap_but:    1386   {
\__draw_backend_cap_round:  1387     [
\__draw_backend_cap_rectangle: 1388     \exp_args:Nf \use:n
\__draw_backend_join_miter:  1389     { \clist_map_function:nN {#1} \__draw_backend_dash:n }
\__draw_backend_join_round:  1390     ] ~
\__draw_backend_join_bevel:  1391     \dim_to_decimal_in_bp:n {#2} ~ d
1392   }
1393 }
1394 \cs_new:Npn \__draw_backend_dash:n #1
1395   { ~ \dim_to_decimal_in_bp:n {#1} }
1396 \cs_new_protected:Npn \__draw_backend_linewidth:n #1
1397   {
1398     \__draw_backend_literal:x
1399     { \dim_to_decimal_in_bp:n {#1} ~ w }
1400   }
1401 \cs_new_protected:Npn \__draw_backend_miterlimit:n #1
1402   { \__draw_backend_literal:x { #1 ~ M } }
1403 \cs_new_protected:Npn \__draw_backend_cap_but:
1404   { \__draw_backend_literal:n { 0 ~ J } }
1405 \cs_new_protected:Npn \__draw_backend_cap_round:
1406   { \__draw_backend_literal:n { 1 ~ J } }
1407 \cs_new_protected:Npn \__draw_backend_cap_rectangle:
1408   { \__draw_backend_literal:n { 2 ~ J } }
1409 \cs_new_protected:Npn \__draw_backend_join_miter:
1410   { \__draw_backend_literal:n { 0 ~ j } }
1411 \cs_new_protected:Npn \__draw_backend_join_round:
1412   { \__draw_backend_literal:n { 1 ~ j } }
1413 \cs_new_protected:Npn \__draw_backend_join_bevel:
1414   { \__draw_backend_literal:n { 2 ~ j } }

```

(End definition for `\_draw_backend_dash_pattern:nn` and others.)

`\_draw_backend_cm:nnnn` Another split here between LuaTeX/pdfTeX and dvipdfmx/X<sub>q</sub>TeX. In the former, we have a direct method to maintain alignment: the backend can use a matrix itself. For dvipdfmx/X<sub>q</sub>TeX, we can to decompose the matrix into rotations and a scaling, then use those operations as they are handled by the backend. (There is backend support for matrix operations in dvipdfmx/X<sub>q</sub>TeX, but as a matched pair so not suitable for the “stand alone” transformation set up here.) The specials used here are from xdvipdfmx originally: they are well-tested, but probably equivalent to the pdf: versions!

```

1415 \cs_new_protected:Npn \__draw_backend_cm:nnnn #1#2#3#4
1416   {
1417     <*luatex | pdftex>
1418     \__kernel_backend_matrix:n { #1 ~ #2 ~ #3 ~ #4 }
1419     </luatex | pdftex>
1420     <*dvipdfmx | xetex>
1421     \__draw_backend_cm_decompose:nnnnN {#1} {#2} {#3} {#4}
1422     \__draw_backend_cm_aux:nnnn
1423     </dvipdfmx | xetex>

```

```

1424 }
1425 <*dvipdfmx|xetex>
1426 \cs_new_protected:Npn \__draw_backend_cm_aux:nnnn #1#2#3#4
1427 {
1428   \__kernel_backend_literal:x
1429   {
1430     x:rotate~
1431     \fp_compare:nNnTF {#1} = \c_zero_fp
1432     { 0 }
1433     { \fp_eval:n { round ( -#1 , 5 ) } }
1434   }
1435   \__kernel_backend_literal:x
1436   {
1437     x:scale~
1438     \fp_eval:n { round ( #2 , 5 ) } ~
1439     \fp_eval:n { round ( #3 , 5 ) }
1440   }
1441   \__kernel_backend_literal:x
1442   {
1443     x:rotate~
1444     \fp_compare:nNnTF {#4} = \c_zero_fp
1445     { 0 }
1446     { \fp_eval:n { round ( -#4 , 5 ) } }
1447   }
1448 }
1449 </dvipdfmx|xetex>

```

(End definition for `\__draw_backend_cm:nnnn` and `\__draw_backend_cm_aux:nnnn`.)

```

\__draw_backend_cm_decompose:nnnnN
\__draw_backend_cm_decompose_auxi:nnnnN
\__draw_backend_cm_decompose_auxii:nnnnN
\__draw_backend_cm_decompose_auxiii:nnnnN

```

Internally, transformations for drawing are tracked as a matrix. Not all engines provide a way of dealing with this: if we use a raw matrix, the engine loses track of positions (for example for hyperlinks), and this is not desirable. They do, however, allow us to track rotations and scalings. Luckily, we can decompose any (two-dimensional) matrix into two rotations and a single scaling:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} \cos \beta & \sin \beta \\ -\sin \beta & \cos \beta \end{bmatrix} \begin{bmatrix} w_1 & 0 \\ 0 & w_2 \end{bmatrix} \begin{bmatrix} \cos \gamma & \sin \gamma \\ -\sin \gamma & \cos \gamma \end{bmatrix}$$

The parent matrix can be converted to

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} E & H \\ -H & E \end{bmatrix} + \begin{bmatrix} F & G \\ G & -F \end{bmatrix}$$

From these, we can find that

$$\begin{aligned} \frac{w_1 + w_2}{2} &= \sqrt{E^2 + H^2} \\ \frac{w_1 - w_2}{2} &= \sqrt{F^2 + G^2} \\ \gamma - \beta &= \tan^{-1}(G/F) \\ \gamma + \beta &= \tan^{-1}(H/E) \end{aligned}$$

at which point we just have to do various pieces of re-arrangement to get all of the values. (See J. Blinn, *IEEE Comput. Graph. Appl.*, 1996, **16**, 82–88.) There is one wrinkle: the

PostScript (and PDF) way of specifying a transformation matrix exchanges where one would normally expect  $B$  and  $C$  to be.

```

1450 <*dviptdpmx|xetex>
1451 \cs_new_protected:Npn \__draw_backend_cm_decompose:nnnnN #1#2#3#4#5
1452 {
1453   \use:x
1454   {
1455     \__draw_backend_cm_decompose_auxi:nnnnN
1456     { \fp_eval:n { (#1 + #4) / 2 } }
1457     { \fp_eval:n { (#1 - #4) / 2 } }
1458     { \fp_eval:n { (#3 + #2) / 2 } }
1459     { \fp_eval:n { (#3 - #2) / 2 } }
1460   }
1461   #5
1462 }
1463 \cs_new_protected:Npn \__draw_backend_cm_decompose_auxi:nnnnN #1#2#3#4#5
1464 {
1465   \use:x
1466   {
1467     \__draw_backend_cm_decompose_auxii:nnnnN
1468     { \fp_eval:n { 2 * sqrt ( #1 * #1 + #4 * #4 ) } }
1469     { \fp_eval:n { 2 * sqrt ( #2 * #2 + #3 * #3 ) } }
1470     { \fp_eval:n { atand ( #3 , #2 ) } }
1471     { \fp_eval:n { atand ( #4 , #1 ) } }
1472   }
1473   #5
1474 }
1475 \cs_new_protected:Npn \__draw_backend_cm_decompose_auxii:nnnnN #1#2#3#4#5
1476 {
1477   \use:x
1478   {
1479     \__draw_backend_cm_decompose_auxiii:nnnnN
1480     { \fp_eval:n { ( #4 - #3 ) / 2 } }
1481     { \fp_eval:n { ( #1 + #2 ) / 2 } }
1482     { \fp_eval:n { ( #1 - #2 ) / 2 } }
1483     { \fp_eval:n { ( #4 + #3 ) / 2 } }
1484   }
1485   #5
1486 }
1487 \cs_new_protected:Npn \__draw_backend_cm_decompose_auxiii:nnnnN #1#2#3#4#5
1488 {
1489   \fp_compare:nNnTF { abs( #2 ) } > { abs ( #3 ) }
1490   { #5 {#1} {#2} {#3} {#4} }
1491   { #5 {#1} {#3} {#2} {#4} }
1492 }
1493 </dviptdpmx|xetex>

```

(End definition for `\__draw_backend_cm_decompose:nnnnN` and others.)

`\__draw_backend_box_use:Nnnn` Inserting a  $\text{T}_\text{E}\text{X}$  box transformed to the requested position and using the current matrix is done using a mixture of  $\text{T}_\text{E}\text{X}$  and low-level manipulation. The offset can be handled by  $\text{T}_\text{E}\text{X}$ , so only any rotation/skew/scaling component needs to be done using the matrix operation. As this operation can never be cached, the scope is set directly not using the `draw` version.

```

1494 \cs_new_protected:Npn \__draw_backend_box_use:Nnnnn #1#2#3#4#5
1495 {
1496   \__kernel_backend_scope_begin:
1497   <*luatex | pdftex>
1498   \__draw_backend_cm:nnnn {#2} {#3} {#4} {#5}
1499   </luatex | pdftex>
1500   <*dviptdvmx | xetex>
1501   \__kernel_backend_literal:n
1502   { pdf:btrans~matrix~ #2 ~ #3 ~ #4 ~ #5 ~ 0 ~ 0 }
1503   </dviptdvmx | xetex>
1504   \hbox_overlap_right:n { \box_use:N #1 }
1505   <*dviptdvmx | xetex>
1506   \__kernel_backend_literal:n { pdf:etrans }
1507   </dviptdvmx | xetex>
1508   \__kernel_backend_scope_end:
1509 }

```

(End definition for \\_\_draw\_backend\_box\_use:Nnnnn.)

```

1510 </dviptdvmx | luatex | pdftex | xetex>

```

### 4.3 dvisvgm backend

```

1511 <*dvisvgm>

```

\\_\_draw\_backend\_literal:n The same as the more general literal call.

\\_\_draw\_backend\_literal:x

```

1512 \cs_new_eq:NN \__draw_backend_literal:n \__kernel_backend_literal_svg:n
1513 \cs_generate_variant:Nn \__draw_backend_literal:n { x }

```

(End definition for \\_\_draw\_backend\_literal:n.)

\\_\_draw\_backend\_scope\_begin:

Use the backend-level scope mechanisms.

\\_\_draw\_backend\_scope\_end:

```

1514 \cs_new_eq:NN \__draw_backend_scope_begin: \__kernel_backend_scope_begin:
1515 \cs_new_eq:NN \__draw_backend_scope_end: \__kernel_backend_scope_end:

```

(End definition for \\_\_draw\_backend\_scope\_begin: and \\_\_draw\_backend\_scope\_end:.)

\\_\_draw\_backend\_begin:

A drawing needs to be set up such that the co-ordinate system is translated. That is done inside a scope, which as described below

\\_\_draw\_backend\_end:

```

1516 \cs_new_protected:Npn \__draw_backend_begin:
1517 {
1518   \__kernel_backend_scope_begin:
1519   \__kernel_backend_scope:n { transform="translate({?x},{?y})~scale(1,-1)" }
1520 }
1521 \cs_new_eq:NN \__draw_backend_end: \__kernel_backend_scope_end:

```

(End definition for \\_\_draw\_backend\_begin: and \\_\_draw\_backend\_end:.)

\\_\_draw\_backend\_moveto:nn

Once again, some work is needed to get path constructs correct. Rather than write the values as they are given, the entire path needs to be collected up before being output

\\_\_draw\_backend\_lineto:nn

in one go. For that we use a dedicated storage routine, which adds spaces as required. Since paths should be fully expanded there is no need to worry about the internal x-type expansion.

\\_\_draw\_backend\_rectangle:nnnn

\\_\_draw\_backend\_curveto:nnnnnn

\\_\_draw\_backend\_add\_to\_path:n

\g\_\_draw\_backend\_path\_tl

```

1522 \cs_new_protected:Npn \__draw_backend_moveto:nn #1#2
1523 {

```

```

1524     \_draw_backend_add_to_path:n
1525     { M ~ \dim_to_decimal:n {#1} ~ \dim_to_decimal:n {#2} }
1526   }
1527 \cs_new_protected:Npn \_draw_backend_lineto:nn #1#2
1528   {
1529     \_draw_backend_add_to_path:n
1530     { L ~ \dim_to_decimal:n {#1} ~ \dim_to_decimal:n {#2} }
1531   }
1532 \cs_new_protected:Npn \_draw_backend_rectangle:nnnn #1#2#3#4
1533   {
1534     \_draw_backend_add_to_path:n
1535     {
1536       M ~ \dim_to_decimal:n {#1} ~ \dim_to_decimal:n {#2}
1537       h ~ \dim_to_decimal:n {#3} ~
1538       v ~ \dim_to_decimal:n {#4} ~
1539       h ~ \dim_to_decimal:n { -#3 } ~
1540       Z
1541     }
1542   }
1543 \cs_new_protected:Npn \_draw_backend_curveto:nnnnn #1#2#3#4#5#6
1544   {
1545     \_draw_backend_add_to_path:n
1546     {
1547       C ~
1548       \dim_to_decimal:n {#1} ~ \dim_to_decimal:n {#2} ~
1549       \dim_to_decimal:n {#3} ~ \dim_to_decimal:n {#4} ~
1550       \dim_to_decimal:n {#5} ~ \dim_to_decimal:n {#6}
1551     }
1552   }
1553 \cs_new_protected:Npn \_draw_backend_add_to_path:n #1
1554   {
1555     \tl_gset:Nx \g__draw_backend_path_tl
1556     {
1557       \g__draw_backend_path_tl
1558       \tl_if_empty:NF \g__draw_backend_path_tl { \c_space_tl }
1559       #1
1560     }
1561   }
1562 \tl_new:N \g__draw_backend_path_tl

```

(End definition for \\_draw\_backend\_moveto:nn and others.)

\\_draw\_backend\_evenodd\_rule: The fill rules here have to be handled as scopes.

```

\_draw_backend_nonzero_rule: 1563 \cs_new_protected:Npn \_draw_backend_evenodd_rule:
1564   { \_kernel_backend_scope:n { fill-rule="evenodd" } }
1565 \cs_new_protected:Npn \_draw_backend_nonzero_rule:
1566   { \_kernel_backend_scope:n { fill-rule="nonzero" } }

```

(End definition for \\_draw\_backend\_evenodd\_rule: and \\_draw\_backend\_nonzero\_rule:.)

```

\_draw_backend_path:n
\_draw_backend_closepath:
\_draw_backend_stroke:
\_draw_backend_closestroke:
\_draw_backend_fill:
\_draw_backend_fillstroke:
\_draw_backend_clip:
\_draw_backend_discardpath:
\g__draw_draw_clip_bool
\g__draw_draw_path_int

```

Setting fill and stroke effects and doing clipping all has to be done using scopes. This means setting up the various requirements in a shared auxiliary which deals with the bits and pieces. Clipping paths are reused for path drawing: not essential but avoids constructing them twice. Discarding a path needs a separate function as it's not quite the same.

```

1567 \cs_new_protected:Npn \__draw_backend_closepath:
1568   { \__draw_backend_add_to_path:n { Z } }
1569 \cs_new_protected:Npn \__draw_backend_path:n #1
1570   {
1571     \bool_if:NTF \g__draw_draw_clip_bool
1572     {
1573       \int_gincr:N \g__kernel_clip_path_int
1574       \__draw_backend_literal:x
1575       {
1576         < clipPath~id = " l3cp \int_use:N \g__kernel_clip_path_int " >
1577         { ?nl }
1578         <path~d=" \g__draw_backend_path_tl "/> { ?nl }
1579         < /clipPath > { ? nl }
1580         <
1581         use~xlink:href =
1582         "\c_hash_str l3path \int_use:N \g__draw_backend_path_int " ~
1583         #1
1584         />
1585       }
1586       \__kernel_backend_scope:x
1587       {
1588         clip-path =
1589         "url( \c_hash_str l3cp \int_use:N \g__kernel_clip_path_int)"
1590       }
1591     }
1592     {
1593       \__draw_backend_literal:x
1594       { <path ~ d=" \g__draw_backend_path_tl " ~ #1 /> }
1595     }
1596     \tl_gclear:N \g__draw_backend_path_tl
1597     \bool_gset_false:N \g__draw_draw_clip_bool
1598   }
1599 \int_new:N \g__draw_backend_path_int
1600 \cs_new_protected:Npn \__draw_backend_stroke:
1601   { \__draw_backend_path:n { style="fill:none" } }
1602 \cs_new_protected:Npn \__draw_backend_closestroke:
1603   {
1604     \__draw_backend_closepath:
1605     \__draw_backend_stroke:
1606   }
1607 \cs_new_protected:Npn \__draw_backend_fill:
1608   { \__draw_backend_path:n { style="stroke:none" } }
1609 \cs_new_protected:Npn \__draw_backend_fillstroke:
1610   { \__draw_backend_path:n { } }
1611 \cs_new_protected:Npn \__draw_backend_clip:
1612   { \bool_gset_true:N \g__draw_draw_clip_bool }
1613 \bool_new:N \g__draw_draw_clip_bool
1614 \cs_new_protected:Npn \__draw_backend_discardpath:
1615   {
1616     \bool_if:NT \g__draw_draw_clip_bool
1617     {
1618       \int_gincr:N \g__kernel_clip_path_int
1619       \__draw_backend_literal:x
1620       {

```

```

1621         < clipPath~id = " l3cp \int_use:N \g__kernel_clip_path_int " >
1622             { ?nl }
1623         <path~d=" \g__draw_backend_path_tl "/> { ?nl }
1624         < /clipPath >
1625     }
1626     \__kernel_backend_scope:x
1627     {
1628         clip-path =
1629         "url( \c_hash_str l3cp \int_use:N \g__kernel_clip_path_int)"
1630     }
1631 }
1632 \tl_gclear:N \g__draw_path_tl
1633 \bool_gset_false:N \g__draw_draw_clip_bool
1634 }

```

(End definition for \\_draw\_backend\_path:n and others.)

\\_draw\_backend\_dash\_pattern:nn All of these ideas are properties of scopes in SVG. The only slight complexity is converting the dash array properly (doing any required maths).

```

\_draw_backend_dash:n
\_draw_backend_dash_aux:nn 1635 \cs_new_protected:Npn \_draw_backend_dash_pattern:nn #1#2
\_draw_backend_linewidth:n 1636 {
\_draw_backend_miterlimit:n 1637     \use:x
\_draw_backend_cap_but: 1638     {
\_draw_backend_cap_round: 1639         \_draw_backend_dash_aux:nn
    \_draw_backend_cap_rectangle: 1640         { \clist_map_function:nN {#1} \_draw_backend_dash:n }
    \_draw_backend_join_miter: 1641         { \dim_to_decimal:n {#2} }
    \_draw_backend_join_round: 1642     }
    \_draw_backend_join_bevel: 1643 }
1644 \cs_new:Npn \_draw_backend_dash:n #1
1645 { , \dim_to_decimal_in_bp:n {#1} }
1646 \cs_new_protected:Npn \_draw_backend_dash_aux:nn #1#2
1647 {
1648     \__kernel_backend_scope:x
1649     {
1650         stroke-dasharray =
1651         "
1652             \tl_if_empty:nTF {#1}
1653             { none }
1654             { \use_none:n #1 }
1655         " ~
1656         stroke-offset=" #2 "
1657     }
1658 }
1659 \cs_new_protected:Npn \_draw_backend_linewidth:n #1
1660 { \__kernel_backend_scope:x { stroke-width=" \dim_to_decimal:n {#1} " } }
1661 \cs_new_protected:Npn \_draw_backend_miterlimit:n #1
1662 { \__kernel_backend_scope:x { stroke-miterlimit=" #1 " } }
1663 \cs_new_protected:Npn \_draw_backend_cap_but:
1664 { \__kernel_backend_scope:n { stroke-linecap="butt" } }
1665 \cs_new_protected:Npn \_draw_backend_cap_round:
1666 { \__kernel_backend_scope:n { stroke-linecap="round" } }
1667 \cs_new_protected:Npn \_draw_backend_cap_rectangle:
1668 { \__kernel_backend_scope:n { stroke-linecap="square" } }
1669 \cs_new_protected:Npn \_draw_backend_join_miter:

```

```

1670 { \__kernel_backend_scope:n { stroke-linejoin="miter" } }
1671 \cs_new_protected:Npn \__draw_backend_join_round:
1672 { \__kernel_backend_scope:n { stroke-linejoin="round" } }
1673 \cs_new_protected:Npn \__draw_backend_join_bevel:
1674 { \__kernel_backend_scope:n { stroke-linejoin="bevel" } }

```

(End definition for \\_\_draw\_backend\_dash\_pattern:nn and others.)

\\_\_draw\_backend\_cm:nnnn The four arguments here are floats (the affine matrix), the last two are a displacement vector.

```

1675 \cs_new_protected:Npn \__draw_backend_cm:nnnn #1#2#3#4
1676 {
1677   \__kernel_backend_scope:n
1678   {
1679     transform =
1680     " matrix ( #1 , #2 , #3 , #4 , Opt , Opt ) "
1681   }
1682 }

```

(End definition for \\_\_draw\_backend\_cm:nnnn.)

\\_\_draw\_backend\_box\_use:Nnnnn No special savings can be made here: simply displace the box inside a scope. As there is nothing to re-box, just make the box passed of zero size.

```

1683 \cs_new_protected:Npn \__draw_backend_box_use:Nnnnn #1#2#3#4#5
1684 {
1685   \__kernel_backend_scope_begin:
1686   \__draw_backend_cm:nnnn {#2} {#3} {#4} {#5}
1687   \__kernel_backend_literal_svg:n
1688   {
1689     < g~
1690     stroke="none"~
1691     transform="scale(-1,1)~translate({?x},{?y})~scale(-1,-1)"
1692     >
1693   }
1694   \box_set_wd:Nn #1 { Opt }
1695   \box_set_ht:Nn #1 { Opt }
1696   \box_set_dp:Nn #1 { Opt }
1697   \box_use:N #1
1698   \__kernel_backend_literal_svg:n { </g> }
1699   \__kernel_backend_scope_end:
1700 }

```

(End definition for \\_\_draw\_backend\_box\_use:Nnnnn.)

```
1701 </divisvgm>
```

```
1702 </package>
```

## 5 l3backend-graphics Implementation

```

1703 <*package>
1704 <@=graphics>

```

\\_\_graphics\_backend\_loaded:n To deal with file load ordering. Plain users are on their own.

```
1705 \cs_new_protected:Npn \__graphics_backend_loaded:n #1
```

```

1706 {
1707   \cs_if_exist:NTF \hook_gput_code:nnn
1708   {
1709     \hook_gput_code:nnn
1710     { file / l3graphics.sty / after }
1711     { backend }
1712     {#1}
1713   }
1714   {#1}
1715 }

```

(End definition for `\__graphics_backend_loaded:n`.)

## 5.1 dvips backend

```
1716 <dvips>
```

`\l_graphics_search_ext_seq`

```

1717 \__graphics_backend_loaded:n
1718 { \seq_set_from_clist:Nn \l_graphics_search_ext_seq { .eps , .ps } }

```

(End definition for `\l_graphics_search_ext_seq`. This variable is documented on page ??.)

`\__graphics_backend_getbb_eps:n`  
`\__graphics_backend_getbb_ps:n`

Simply use the generic function.

```

1719 \__graphics_backend_loaded:n
1720 {
1721   \cs_new_eq:NN \__graphics_backend_getbb_eps:n \__graphics_read_bb:n
1722   \cs_new_eq:NN \__graphics_backend_getbb_ps:n \__graphics_read_bb:n
1723 }

```

(End definition for `\__graphics_backend_getbb_eps:n` and `\__graphics_backend_getbb_ps:n`.)

`\__graphics_backend_include_eps:n`  
`\__graphics_backend_include_ps:n`

The special syntax is relatively clear here: remember we need PostScript sizes here.

```

1724 \cs_new_protected:Npn \__graphics_backend_include_eps:n #1
1725 {
1726   \__kernel_backend_literal:x
1727   {
1728     PSfile = #1 \c_space_tl
1729     llx = \dim_to_decimal_in_bp:n \l__graphics_llx_dim \c_space_tl
1730     lly = \dim_to_decimal_in_bp:n \l__graphics_lly_dim \c_space_tl
1731     urx = \dim_to_decimal_in_bp:n \l__graphics_urx_dim \c_space_tl
1732     ury = \dim_to_decimal_in_bp:n \l__graphics_ury_dim
1733   }
1734 }
1735 \cs_new_eq:NN \__graphics_backend_include_ps:n \__graphics_backend_include_eps:n

```

(End definition for `\__graphics_backend_include_eps:n` and `\__graphics_backend_include_ps:n`.)

`\__graphics_backend_get_pagecount:n`

```

1736 \__graphics_backend_loaded:n
1737 { \cs_new_eq:NN \__graphics_backend_get_pagecount:n \__graphics_get_pagecount:n }

```

(End definition for `\__graphics_backend_get_pagecount:n`.)

```
1738 </dvips>
```

## 5.2 LuaTeX and pdfTeX backends

1739 `\*luatex | pdftex`

`\l_graphics_search_ext_seq`

```
1740 \__graphics_backend_loaded:n
1741 {
1742   \seq_set_from_clist:Nn
1743   \l_graphics_search_ext_seq
1744   { .pdf , .eps , .ps , .png , .jpg , .jpeg }
1745 }
```

(End definition for `\l_graphics_search_ext_seq`. This variable is documented on page ??.)

`\l_graphics_graphics_attr_tl`

In PDF mode, additional attributes of an graphic (such as page number) are needed both to obtain the bounding box and when inserting the graphic: this occurs as the graphic dictionary approach means they are read as part of the bounding box operation. As such, it is easier to track additional attributes using a dedicated `tl` rather than build up the same data twice.

```
1746 \tl_new:N \l__graphics_graphics_attr_tl
```

(End definition for `\l__graphics_graphics_attr_tl`.)

`\_graphics_backend_getbb_jpg:n`

`\_graphics_backend_getbb_jpeg:n`

`\_graphics_backend_getbb_pdf:n`

`\_graphics_backend_getbb_png:n`

`\_graphics_backend_getbb_auxi:n`

`\_graphics_backend_getbb_auxii:n`

`\_graphics_backend_getbb_auxiii:n`

`\_graphics_backend_dequote:w`

Getting the bounding box here requires us to box up the graphic and measure it. To deal with the difference in feature support in bitmap and vector graphics but keeping the common parts, there is a little work to do in terms of auxiliaries. The key here is to notice that we need two forms of the attributes: a “short” set to allow us to track for caching, and the full form to pass to the primitive.

```
1747 \cs_new_protected:Npn \__graphics_backend_getbb_jpg:n #1
```

```
1748 {
1749   \int_zero:N \l__graphics_page_int
1750   \tl_clear:N \l__graphics_pagebox_tl
1751   \tl_set:Nx \l__graphics_graphics_attr_tl
1752   {
1753     \tl_if_empty:NF \l__graphics_decodearray_str
1754     { :D \l__graphics_decodearray_str }
1755     \bool_if:NT \l__graphics_interpolate_bool
1756     { :I }
1757   }
1758   \tl_clear:N \l__graphics_graphics_attr_tl
1759   \__graphics_backend_getbb_auxi:n {#1}
1760 }
```

```
1761 \cs_new_eq:NN \__graphics_backend_getbb_jpeg:n \__graphics_backend_getbb_jpg:n
```

```
1762 \cs_new_eq:NN \__graphics_backend_getbb_png:n \__graphics_backend_getbb_jpg:n
```

```
1763 \cs_new_protected:Npn \__graphics_backend_getbb_pdf:n #1
```

```
1764 {
1765   \tl_clear:N \l__graphics_decodearray_str
1766   \bool_set_false:N \l__graphics_interpolate_bool
1767   \tl_set:Nx \l__graphics_graphics_attr_tl
1768   {
1769     : \l__graphics_pagebox_tl
1770     \int_compare:nNnT \l__graphics_page_int > 1
1771     { :P \int_use:N \l__graphics_page_int }
1772   }
```

```

1773   \__graphics_backend_getbb_auxi:n {#1}
1774 }
1775 \cs_new_protected:Npn \__graphics_backend_getbb_auxi:n #1
1776 {
1777   \__graphics_bb_restore:xF { #1 \l__graphics_graphics_attr_tl }
1778   { \__graphics_backend_getbb_auxii:n {#1} }
1779 }

```

Measuring the graphic is done by boxing up: for PDF graphics we could use `\tex_pdfximagebbox:D`, but it doesn't work for other types. As the box always starts at (0,0) there is no need to worry about the lower-left position. Quotes need to be *removed* as LuaTeX does not like them here.

```

1780 \cs_new_protected:Npn \__graphics_backend_getbb_auxii:n #1
1781 {
1782   \exp_args:Ne \__graphics_backend_getbb_auxiii:n
1783   { \__graphics_backend_dequote:w #1 " #1 " \s__graphics_stop }
1784   \int_const:cn { c__graphics_ #1 \l__graphics_graphics_attr_tl _int }
1785   { \tex_the:D \tex_pdflastximage:D }
1786   \__graphics_bb_save:x { #1 \l__graphics_graphics_attr_tl }
1787 }
1788 \cs_new_protected:Npn \__graphics_backend_getbb_auxiii:n #1
1789 {
1790   \tex_immediate:D \tex_pdfximage:D
1791   \bool_lazy_or:nnT
1792   { \l__graphics_interpolate_bool }
1793   { ! \tl_if_empty_p:N \l__graphics_decodearray_str }
1794   {
1795     attr ~
1796     {
1797       \tl_if_empty:NF \l__graphics_decodearray_str
1798       { /Decode~[ \l__graphics_decodearray_str ] }
1799       \bool_if:NT \l__graphics_interpolate_bool
1800       { /Interpolate~true }
1801     }
1802   }
1803   \int_compare:nNnT \l__graphics_page_int > 0
1804   { page ~ \int_use:N \l__graphics_page_int }
1805   \tl_if_empty:NF \l__graphics_pagebox_tl
1806   { \l__graphics_pagebox_tl }
1807   {#1}
1808   \hbox_set:Nn \l__graphics_internal_box
1809   { \tex_pdfrefximage:D \tex_pdflastximage:D }
1810   \dim_set:Nn \l__graphics_urx_dim { \box_wd:N \l__graphics_internal_box }
1811   \dim_set:Nn \l__graphics_ury_dim { \box_ht:N \l__graphics_internal_box }
1812 }
1813 \cs_new:Npn \__graphics_backend_dequote:w #1 " #2 " #3 \s__graphics_stop {#2}

```

(End definition for `\__graphics_backend_getbb_jpg:n` and others.)

```

\__graphics_backend_include_jpg:n
\__graphics_backend_include_jpeg:n
\__graphics_backend_include_pdf:n
\__graphics_backend_include_png:n

```

Images are already loaded for the measurement part of the code, so inclusion is straightforward, with only any attributes to worry about. The latter carry through from determination of the bounding box.

```

1814 \cs_new_protected:Npn \__graphics_backend_include_jpg:n #1
1815 {

```

```

1816 \tex_pdfrefximage:D
1817 \int_use:c { c__graphics_ #1 \l__graphics_graphics_attr_tl _int }
1818 }
1819 \cs_new_eq:NN \__graphics_backend_include_jpeg:n \__graphics_backend_include_jpg:n
1820 \cs_new_eq:NN \__graphics_backend_include_pdf:n \__graphics_backend_include_jpg:n
1821 \cs_new_eq:NN \__graphics_backend_include_png:n \__graphics_backend_include_jpg:n

```

(End definition for \\_\_graphics\_backend\_include\_jpg:n and others.)

EPS graphics may be included in LuaTeX/pdfTeX by conversion to PDF: this requires restricted shell escape. Modelled on the `epstopdf LATEX 2ε` package, but simplified, conversion takes place here if we have shell access.

```

\__graphics_backend_getbb_eps:n
\__graphics_backend_getbb_ps:n
\__graphics_backend_getbb_eps:nm
\__graphics_backend_include_eps:n
\__graphics_backend_include_ps:n
\l__graphics_backend_dir_str
\l__graphics_backend_name_str
\l__graphics_backend_ext_str
1822 \sys_if_shell:T
1823 {
1824 \str_new:N \l__graphics_backend_dir_str
1825 \str_new:N \l__graphics_backend_name_str
1826 \str_new:N \l__graphics_backend_ext_str
1827 \cs_new_protected:Npn \__graphics_backend_getbb_eps:n #1
1828 {
1829 \file_parse_full_name:nNNN {#1}
1830 \l__graphics_backend_dir_str
1831 \l__graphics_backend_name_str
1832 \l__graphics_backend_ext_str
1833 \exp_args:Nx \__graphics_backend_getbb_eps:nn
1834 {
1835 \exp_args:Ne \__kernel_file_name_quote:n
1836 {
1837 \l__graphics_backend_name_str
1838 - \str_tail:N \l__graphics_backend_ext_str
1839 -converted-to.pdf
1840 }
1841 }
1842 {#1}
1843 }
1844 \cs_new_eq:NN \__graphics_backend_getbb_ps:n \__graphics_backend_getbb_eps:n
1845 \cs_new_protected:Npn \__graphics_backend_getbb_eps:nn #1#2
1846 {
1847 \file_compare_timestamp:nNnT {#2} > {#1}
1848 {
1849 \sys_shell_now:n
1850 { repstopdf ~ #2 ~ #1 }
1851 }
1852 \tl_set:Nn \l__graphics_final_name_str {#1}
1853 \__graphics_backend_getbb_pdf:n {#1}
1854 }
1855 \cs_new_protected:Npn \__graphics_backend_include_eps:n #1
1856 {
1857 \file_parse_full_name:nNNN {#1}
1858 \l__graphics_backend_dir_str \l__graphics_backend_name_str \l__graphics_backend_ext_str
1859 \exp_args:Nx \__graphics_backend_include_pdf:n
1860 {
1861 \exp_args:Ne \__kernel_file_name_quote:n
1862 {
1863 \l__graphics_backend_name_str

```

```

1864         - \str_tail:N \l__graphics_backend_ext_str
1865         -converted-to.pdf
1866     }
1867 }
1868 }
1869 \cs_new_eq:NN \__graphics_backend_include_ps:n \__graphics_backend_include_eps:n
1870 }

```

(End definition for `\__graphics_backend_getbb_eps:n` and others.)

`\__graphics_backend_get_pagecount:n` Simply load and store.

```

1871 \cs_new_protected:Npn \__graphics_backend_get_pagecount:n #1
1872 {
1873     \tex_pdfximage:D {#1}
1874     \int_const:cn { c__graphics_ #1 _pages_int }
1875     { \int_use:N \tex_pdflastximagepages:D }
1876 }

```

(End definition for `\__graphics_backend_get_pagecount:n`.)

```
1877 </luatex | pdftex>
```

### 5.3 dvipdfmx backend

```
1878 <*dvipdfmx | xetex>
```

`\l_graphics_search_ext_seq`

```

1879 \__graphics_backend_loaded:n
1880 {
1881     \seq_set_from_clist:Nn \l_graphics_search_ext_seq
1882     { .pdf , .eps , .ps , .png , .jpg , .jpeg , .bmp }
1883 }

```

(End definition for `\l_graphics_search_ext_seq`. This variable is documented on page ??.)

`\__graphics_backend_getbb_eps:n` Simply use the generic functions: only for dvipdfmx in the extraction cases.

```

\__graphics_backend_getbb_ps:n 1884 \__graphics_backend_loaded:n
\__graphics_backend_getbb_jpg:n 1885 {
\__graphics_backend_getbb_jpeg:n 1886     \cs_new_eq:NN \__graphics_backend_getbb_eps:n \__graphics_read_bb:n
\__graphics_backend_getbb_pdf:n 1887     \cs_new_eq:NN \__graphics_backend_getbb_ps:n \__graphics_read_bb:n
\__graphics_backend_getbb_png:n 1888 }
\__graphics_backend_getbb_bmp:n 1889 <*dvipdfmx>
1890 \cs_new_protected:Npn \__graphics_backend_getbb_jpg:n #1
1891 {
1892     \int_zero:N \l__graphics_page_int
1893     \tl_clear:N \l__graphics_pagebox_tl
1894     \__graphics_extract_bb:n {#1}
1895 }
1896 \cs_new_eq:NN \__graphics_backend_getbb_jpeg:n \__graphics_backend_getbb_jpg:n
1897 \cs_new_eq:NN \__graphics_backend_getbb_png:n \__graphics_backend_getbb_jpg:n
1898 \cs_new_eq:NN \__graphics_backend_getbb_bmp:n \__graphics_backend_getbb_jpg:n
1899 \cs_new_protected:Npn \__graphics_backend_getbb_pdf:n #1
1900 {
1901     \tl_clear:N \l__graphics_decodearray_str
1902     \bool_set_false:N \l__graphics_interpolate_bool

```

```

1903     \_graphics_extract_bb:n {#1}
1904   }
1905 </dviPDFfmX>

```

(End definition for `\_graphics_backend_getbb_eps:n` and others.)

`\g__graphics_track_int` Used to track the object number associated with each graphic.

```

1906 \int_new:N \g__graphics_track_int

```

(End definition for `\g__graphics_track_int`.)

The special syntax depends on the file type. There is a difference in how PDF graphics are best handled between `dviPDFfmX` and `XYTeX`: for the latter it is better to use the primitive route. The relevant code for that is included later in this file.

```

\_graphics_backend_include_eps:n
\_graphics_backend_include_ps:n
\_graphics_backend_include_jpg:n
\_graphics_backend_include_jpeg:n
\_graphics_backend_include_pdf:n
\_graphics_backend_include_png:n
\_graphics_backend_include_bmp:n
\_graphics_backend_include_auxi:nn
\_graphics_backend_include_auxii:nnn
\_graphics_backend_include_auxiii:nnn
1907 \cs_new_protected:Npn \_graphics_backend_include_eps:n #1
1908 {
1909   \_kernel_backend_literal:x
1910   {
1911     PSfile = #1 \c_space_tl
1912     llx = \dim_to_decimal_in_bp:n \l__graphics_llx_dim \c_space_tl
1913     lly = \dim_to_decimal_in_bp:n \l__graphics_lly_dim \c_space_tl
1914     urx = \dim_to_decimal_in_bp:n \l__graphics_urx_dim \c_space_tl
1915     ury = \dim_to_decimal_in_bp:n \l__graphics_ury_dim
1916   }
1917 }
1918 \cs_new_eq:NN \_graphics_backend_include_ps:n \_graphics_backend_include_eps:n
1919 \cs_new_protected:Npn \_graphics_backend_include_jpg:n #1
1920 { \_graphics_backend_include_auxi:nn {#1} { image } }
1921 \cs_new_eq:NN \_graphics_backend_include_jpeg:n \_graphics_backend_include_jpg:n
1922 \cs_new_eq:NN \_graphics_backend_include_png:n \_graphics_backend_include_jpg:n
1923 \cs_new_eq:NN \_graphics_backend_include_bmp:n \_graphics_backend_include_jpg:n
1924 <*dviPDFfmX>
1925 \cs_new_protected:Npn \_graphics_backend_include_pdf:n #1
1926 { \_graphics_backend_include_auxi:nn {#1} { epdf } }
1927 </dviPDFfmX>

```

Graphic inclusion is set up to use the fact that each image is stored in the PDF as an XObject. This means that we can include repeated images only once and refer to them. To allow that, track the nature of each image: much the same as for the direct PDF mode case.

```

1928 \cs_new_protected:Npn \_graphics_backend_include_auxi:nn #1#2
1929 {
1930   \_graphics_backend_include_auxii:nnn
1931   {
1932     \tl_if_empty:NF \l__graphics_pagebox_tl
1933     { : \l__graphics_pagebox_tl }
1934     \int_compare:nNnT \l__graphics_page_int > 1
1935     { :P \int_use:N \l__graphics_page_int }
1936     \tl_if_empty:NF \l__graphics_decodearray_str
1937     { :D \l__graphics_decodearray_str }
1938     \bool_if:NT \l__graphics_interpolate_bool
1939     { :I }
1940   }
1941   {#1} {#2}

```

```

1942 }
1943 \cs_new_protected:Npn \__graphics_backend_include_auxii:nnn #1#2#3
1944 {
1945   \int_if_exist:cTF { c__graphics_ #2#1 _int }
1946   {
1947     \__kernel_backend_literal:x
1948     { pdf:useobj~@graphic \int_use:c { c__graphics_ #2#1 _int } }
1949   }
1950   { \__graphics_backend_include_auxiii:nnn {#2} {#1} {#3} }
1951 }
1952 \cs_generate_variant:Nn \__graphics_backend_include_auxii:nnn { x }

```

Inclusion using the specials is relatively straight-forward, but there is one wrinkle. To get the `pagebox` correct for PDF graphics in all cases, it is necessary to provide both that information and the `bbox` argument: odd things happen otherwise!

```

1953 \cs_new_protected:Npn \__graphics_backend_include_auxiii:nnn #1#2#3
1954 {
1955   \int_gincr:N \g__graphics_track_int
1956   \int_const:cn { c__graphics_ #1#2 _int } { \g__graphics_track_int }
1957   \__kernel_backend_literal:x
1958   {
1959     pdf:#3~
1960     @graphic \int_use:c { c__graphics_ #1#2 _int } ~
1961     \int_compare:nNnT \l__graphics_page_int > 1
1962     { page ~ \int_use:N \l__graphics_page_int \c_space_tl }
1963     \tl_if_empty:NF \l__graphics_pagebox_tl
1964     {
1965       pagebox ~ \l__graphics_pagebox_tl \c_space_tl
1966       bbox ~
1967         \dim_to_decimal_in_bp:n \l__graphics_llx_dim \c_space_tl
1968         \dim_to_decimal_in_bp:n \l__graphics_lly_dim \c_space_tl
1969         \dim_to_decimal_in_bp:n \l__graphics_urx_dim \c_space_tl
1970         \dim_to_decimal_in_bp:n \l__graphics_ury_dim \c_space_tl
1971     }
1972     (#1)
1973     \bool_lazy_or:nnT
1974     { \l__graphics_interpolate_bool }
1975     { ! \tl_if_empty_p:N \l__graphics_decodearray_str }
1976     {
1977       <<
1978         \tl_if_empty:NF \l__graphics_decodearray_str
1979         { /Decode~[ \l__graphics_decodearray_str ] }
1980         \bool_if:NT \l__graphics_interpolate_bool
1981         { /Interpolate~true> }
1982       >>
1983     }
1984   }
1985 }

```

(End definition for `\__graphics_backend_include_eps:n` and others.)

`\__graphics_backend_get_pagecount:n`

```

1986 < *dvipdfmx >
1987 \__graphics_backend_loaded:n
1988 { \cs_new_eq:NN \__graphics_backend_get_pagecount:n \__graphics_get_pagecount:n }

```

```
1989 </dviptfm>
```

(End definition for `\_graphics_backend_get_pagecount:n`.)

```
1990 </dviptfm | xetex>
```

## 5.4 X<sub>Y</sub>T<sub>E</sub>X backend

```
1991 <*xetex>
```

For X<sub>Y</sub>T<sub>E</sub>X, there are two primitives that allow us to obtain the bounding box without needing `extractbb`. The only complexity is passing the various minor variations to a common core process. The X<sub>Y</sub>T<sub>E</sub>X primitive omits the text box from the page box specification, so there is also some “trimming” to do here.

```
1992 \cs_new_protected:Npn \_graphics_backend_getbb_jpg:n #1
1993 {
1994   \int_zero:N \l__graphics_page_int
1995   \tl_clear:N \l__graphics_pagebox_tl
1996   \_graphics_backend_getbb_auxi:nN {#1} \tex_XeTeXpicfile:D
1997 }
1998 \cs_new_eq:NN \_graphics_backend_getbb_jpeg:n \_graphics_backend_getbb_jpg:n
1999 \cs_new_eq:NN \_graphics_backend_getbb_png:n \_graphics_backend_getbb_jpg:n
2000 \cs_new_eq:NN \_graphics_backend_getbb_bmp:n \_graphics_backend_getbb_jpg:n
2001 \cs_new_protected:Npn \_graphics_backend_getbb_pdf:n #1
2002 {
2003   \tl_clear:N \l__graphics_decodearray_str
2004   \bool_set_false:N \l__graphics_interpolate_bool
2005   \_graphics_backend_getbb_auxi:nN {#1} \tex_XeTeXpdffile:D
2006 }
2007 \cs_new_protected:Npn \_graphics_backend_getbb_auxi:nN #1#2
2008 {
2009   \int_compare:nNnTF \l__graphics_page_int > 1
2010     { \_graphics_backend_getbb_auxii:VnN \l__graphics_page_int {#1} #2 }
2011     { \_graphics_backend_getbb_auxiii:nNnn {#1} #2 { :P 1 } { page 1 } }
2012 }
2013 \cs_new_protected:Npn \_graphics_backend_getbb_auxii:nnN #1#2#3
2014 { \_graphics_backend_getbb_auxiii:nNnn {#2} #3 { :P #1 } { page #1 } }
2015 \cs_generate_variant:Nn \_graphics_backend_getbb_auxii:nnN { V }
2016 \cs_new_protected:Npn \_graphics_backend_getbb_auxiii:nNnn #1#2#3#4
2017 {
2018   \tl_if_empty:NTF \l__graphics_pagebox_tl
2019     { \_graphics_backend_getbb_auxiv:VnNnn \l__graphics_pagebox_tl }
2020     { \_graphics_backend_getbb_auxv:nNnn }
2021     {#1} #2 {#3} {#4}
2022 }
2023 \cs_new_protected:Npn \_graphics_backend_getbb_auxiv:nnNnn #1#2#3#4#5
2024 {
2025   \use:x
2026   {
2027     \_graphics_backend_getbb_auxv:nNnn {#2} #3 { : #1 #4 }
2028     {
2029       #5
2030       \tl_if_blank:nF {#1}
2031         { \c_space_tl \_graphics_backend_getbb_pagebox:w #1 }
2032     }
2033   }
```

```

2033     }
2034   }
2035   \cs_generate_variant:Nn \__graphics_backend_getbb_auxiv:nnNnn { V }
2036   \cs_new_protected:Npn \__graphics_backend_getbb_auxv:nNnn #1#2#3#4
2037     {
2038       \__graphics_bb_restore:nF {#1#3}
2039       { \__graphics_backend_getbb_auxvi:nNnn {#1} #2 {#3} {#4} }
2040     }
2041   \cs_new_protected:Npn \__graphics_backend_getbb_auxvi:nNnn #1#2#3#4
2042     {
2043       \hbox_set:Nn \l__graphics_internal_box { #2 #1 ~ #4 }
2044       \dim_set:Nn \l__graphics_urx_dim { \box_wd:N \l__graphics_internal_box }
2045       \dim_set:Nn \l__graphics_ury_dim { \box_ht:N \l__graphics_internal_box }
2046       \__graphics_bb_save:n {#1#3}
2047     }
2048   \cs_new:Npn \__graphics_backend_getbb_pagebox:w #1 box {#1}

```

(End definition for \\_\_graphics\_backend\_getbb\_jpg:n and others.)

\\_\_graphics\_backend\_include\_pdf:n For PDF graphics, properly supporting the pagebox concept in X<sub>Y</sub>TeX is best done using the \tex\_XeTeXpdffile:D primitive. The syntax here is the same as for the graphic measurement part, although we know at this stage that there must be some valid setting for \l\_\_graphics\_pagebox\_tl.

```

2049   \cs_new_protected:Npn \__graphics_backend_include_pdf:n #1
2050     {
2051       \tex_XeTeXpdffile:D #1 ~
2052       \int_compare:nNnT \l__graphics_page_int > 0
2053         { page ~ \int_use:N \l__graphics_page_int \c_space_tl }
2054       \exp_after:wN \__graphics_backend_getbb_pagebox:w \l__graphics_pagebox_tl
2055     }

```

(End definition for \\_\_graphics\_backend\_include\_pdf:n.)

\\_\_graphics\_backend\_get\_pagecount:n Very little to do here other than cover the case of a non-PDF file.

```

2056   \cs_new_protected:Npn \__graphics_backend_get_pagecount:n #1
2057     {
2058       \int_const:cn { c__graphics_#1 _pages_int }
2059       {
2060         \int_max:nn
2061           { \int_use:N \tex_XeTeXpdfpagecount:D #1 ~ }
2062           { 1 }
2063       }
2064     }

```

(End definition for \\_\_graphics\_backend\_get\_pagecount:n.)

2065 </xetex>

## 5.5 dvisvgm backend

2066 <\*dvisvgm>

\l\_graphics\_search\_ext\_seq

```

2067   \__graphics_backend_loaded:n
2068     {

```

```

2069 \seq_set_from_clist:Nn
2070 \l_graphics_search_ext_seq
2071 { .svg , .pdf , .eps , .ps , .png , .jpg , .jpeg }
2072 }

```

(End definition for `\l_graphics_search_ext_seq`. This variable is documented on page ??.)

```

\_graphics_backend_getbb_svg:n
\_graphics_backend_getbb_svg_auxi:nNn
\_graphics_backend_getbb_svg_auxii:w
\_graphics_backend_getbb_svg_auxiii:Nw
\_graphics_backend_getbb_svg_auxiv:Nw
\_graphics_backend_getbb_svg_auxv:Nw
\_graphics_backend_getbb_svg_auxvi:Nn
\_graphics_backend_getbb_svg_auxvii:w

```

This is relatively similar to reading bounding boxes for `.eps` files. Life is though made more tricky as we cannot pick a single line for the data. So we have to loop until we collect up both height and width. To do that, we can use a marker value. We also have to allow for the default units of the lengths: they are big points and may be omitted.

```

2073 \cs_new_protected:Npn \_graphics_backend_getbb_svg:n #1
2074 {
2075   \__graphics_bb_restore:nF {#1}
2076   {
2077     \ior_open:Nn \l__graphics_internal_ior {#1}
2078     \ior_if_eof:NTF \l__graphics_internal_ior
2079       { \msg_error:nnn { graphics } { graphic-not-found } {#1} }
2080     {
2081       \dim_zero:N \l__graphics_llx_dim
2082       \dim_zero:N \l__graphics_lly_dim
2083       \dim_set:Nn \l__graphics_urx_dim { -\c_max_dim }
2084       \dim_set:Nn \l__graphics_ury_dim { -\c_max_dim }
2085       \ior_str_map_inline:Nn \l__graphics_internal_ior
2086         {
2087           \dim_compare:nNnT \l__graphics_urx_dim = { -\c_max_dim }
2088             {
2089               \_graphics_backend_getbb_svg_auxi:nNn
2090                 { width } \l__graphics_urx_dim {##1}
2091             }
2092           \dim_compare:nNnT \l__graphics_ury_dim = { -\c_max_dim }
2093             {
2094               \_graphics_backend_getbb_svg_auxi:nNn
2095                 { height } \l__graphics_ury_dim {##1}
2096             }
2097           \bool_lazy_and:nnF
2098             { \dim_compare_p:nNn \l__graphics_urx_dim = { -\c_max_dim } }
2099             { \dim_compare_p:nNn \l__graphics_ury_dim = { -\c_max_dim } }
2100             { \ior_map_break: }
2101         }
2102       \__graphics_bb_save:n {#1}
2103     }
2104     \ior_close:N \l__graphics_internal_ior
2105   }
2106 }
2107 \cs_new_protected:Npn \_graphics_backend_getbb_svg_auxi:nNn #1#2#3
2108 {
2109   \use:x
2110   {
2111     \cs_set_protected:Npn \_graphics_backend_getbb_svg_auxii:w
2112       ###1 \tl_to_str:n {#1} = ####2 \tl_to_str:n {#1} = ####3
2113     \s__graphics_stop
2114   }
2115 }

```

```

2116     \tl_if_blank:nF {##2}
2117     {
2118         \peek_remove_spaces:n
2119         {
2120             \peek_meaning:NTF ' % '
2121             { \__graphics_backend_getbb_svg_auxiii:Nw #2 }
2122             {
2123                 \peek_meaning:NTF " % "
2124                 { \__graphics_backend_getbb_svg_auxiv:Nw #2 }
2125                 { \__graphics_backend_getbb_svg_auxv:Nw #2 }
2126             }
2127         }
2128         ##2 \s__graphics_stop
2129     }
2130 }
2131 \use:x
2132 {
2133     \__graphics_backend_getbb_svg_auxii:w #3
2134     \tl_to_str:n {#1} = \tl_to_str:n {#1} =
2135     \s__graphics_stop
2136 }
2137 }
2138 \cs_new_protected:Npn \__graphics_backend_getbb_svg_auxii:w { }
2139 \cs_new_protected:Npn \__graphics_backend_getbb_svg_auxiii:Nw #1 ' #2 ' #3 \s__graphics_stop
2140 { \__graphics_backend_getbb_svg_auxvi:Nn #1 {#2} }
2141 \cs_new_protected:Npn \__graphics_backend_getbb_svg_auxiv:Nw #1 " #2 " #3 \s__graphics_stop
2142 { \__graphics_backend_getbb_svg_auxvi:Nn #1 {#2} }
2143 \cs_new_protected:Npn \__graphics_backend_getbb_svg_auxv:Nw #1 #2 ~ #3 \s__graphics_stop
2144 { \__graphics_backend_getbb_svg_auxvi:Nn #1 {#2} }
2145 \cs_new_protected:Npn \__graphics_backend_getbb_svg_auxvi:Nn #1#2
2146 {
2147     \tex_afterassignment:D \__graphics_backend_getbb_svg_auxvii:w
2148     \l__graphics_internal_dim #2 bp \scan_stop:
2149     \dim_set_eq:NN #1 \l__graphics_internal_dim
2150 }
2151 \cs_new_protected:Npn \__graphics_backend_getbb_svg_auxvii:w #1 \scan_stop: { }

```

(End definition for `\__graphics_backend_getbb_svg:n` and others.)

`\__graphics_backend_getbb_eps:n` Simply use the generic function.

```

\__graphics_backend_getbb_ps:n
2152 \__graphics_backend_loaded:n
2153 {
2154     \cs_new_eq:NN \__graphics_backend_getbb_eps:n \__graphics_read_bb:n
2155     \cs_new_eq:NN \__graphics_backend_getbb_ps:n \__graphics_read_bb:n
2156 }

```

(End definition for `\__graphics_backend_getbb_eps:n` and `\__graphics_backend_getbb_ps:n`.)

`\__graphics_backend_getbb_png:n` These can be included by extracting the bounding box data.

```

\__graphics_backend_getbb_jpg:n
\__graphics_backend_getbb_jpeg:n
2157 \cs_new_protected:Npn \__graphics_backend_getbb_jpg:n #1
2158 {
2159     \int_zero:N \l__graphics_page_int
2160     \tl_clear:N \l__graphics_pagebox_tl
2161     \__graphics_extract_bb:n {#1}
2162 }

```

```

2163 \cs_new_eq:NN \__graphics_backend_getbb_jpeg:n \__graphics_backend_getbb_jpg:n
2164 \cs_new_eq:NN \__graphics_backend_getbb_png:n \__graphics_backend_getbb_jpg:n

```

(End definition for \\_\_graphics\_backend\_getbb\_png:n, \\_\_graphics\_backend\_getbb\_jpg:n, and \\_\_graphics\_backend\_getbb\_jpeg:n.)

\\_\_graphics\_backend\_getbb\_pdf:n Same as for dvipdfmx: use the generic function

```

2165 \cs_new_protected:Npn \__graphics_backend_getbb_pdf:n #1
2166 {
2167   \tl_clear:N \l__graphics_decodearray_str
2168   \bool_set_false:N \l__graphics_interpolate_bool
2169   \__graphics_extract_bb:n {#1}
2170 }

```

(End definition for \\_\_graphics\_backend\_getbb\_pdf:n.)

\\_\_graphics\_backend\_include\_eps:n \\_\_graphics\_backend\_include\_ps:n \\_\_graphics\_backend\_include\_pdf:n \\_\_graphics\_backend\_include\_nn The special syntax is relatively clear here: remember we need PostScript sizes here. (This is the same as the dvips code.)

```

2171 \cs_new_protected:Npn \__graphics_backend_include_eps:n #1
2172 { \__graphics_backend_include:nn { PSfile } {#1} }
2173 \cs_new_eq:NN \__graphics_backend_include_ps:n \__graphics_backend_include_eps:n
2174 \cs_new_protected:Npn \__graphics_backend_include_pdf:n #1
2175 { \__graphics_backend_include:nn { pdffile } {#1} }
2176 \cs_new_protected:Npn \__graphics_backend_include:nn #1#2
2177 {
2178   \__kernel_backend_literal:x
2179   {
2180     #1 = #2 \c_space_tl
2181     llx = \dim_to_decimal_in_bp:n \l__graphics_llx_dim \c_space_tl
2182     lly = \dim_to_decimal_in_bp:n \l__graphics_lly_dim \c_space_tl
2183     urx = \dim_to_decimal_in_bp:n \l__graphics_urx_dim \c_space_tl
2184     ury = \dim_to_decimal_in_bp:n \l__graphics_ury_dim
2185   }
2186 }

```

(End definition for \\_\_graphics\_backend\_include\_eps:n and others.)

\\_\_graphics\_backend\_include\_svg:n \\_\_graphics\_backend\_include\_png:n \\_\_graphics\_backend\_include\_jpg:n \\_\_graphics\_backend\_include\_jpeg:n \\_\_graphics\_backend\_include\_dequote:w The backend here has built-in support for basic graphic inclusion (see dvisvgm.def for a more complex approach, needed if clipping, etc., is covered at the graphic backend level). We have to deal with the fact that the image reference point is at the top, so there is a need for a vertical shift to put it in the right place. The other issue is that #1 must be quote-corrected. The dvisvgm:img operation quotes the file name, but if it is already quoted (contains spaces) then we have an issue: we simply strip off any quotes as a result.

```

2187 \cs_new_protected:Npn \__graphics_backend_include_svg:n #1
2188 {
2189   \box_move_up:nn { \l__graphics_ury_dim }
2190   {
2191     \hbox:n
2192     {
2193       \__kernel_backend_literal:x
2194       {
2195         dvisvgm:img~
2196         \dim_to_decimal:n { \l__graphics_urx_dim } ~
2197         \dim_to_decimal:n { \l__graphics_ury_dim } ~

```

```

2198         \_graphics_backend_include_dequote:w #1 " #1 " \s__graphics_stop
2199     }
2200 }
2201 }
2202 }
2203 \cs_new_eq:NN \_graphics_backend_include_png:n \_graphics_backend_include_svg:n
2204 \cs_new_eq:NN \_graphics_backend_include_jpeg:n \_graphics_backend_include_svg:n
2205 \cs_new_eq:NN \_graphics_backend_include_jpg:n \_graphics_backend_include_svg:n
2206 \cs_new:Npn \_graphics_backend_include_dequote:w #1 " #2 " #3 \s__graphics_stop
2207     {#2}

```

(End definition for `\_graphics_backend_include_svg:n` and others.)

`\_graphics_backend_get_pagecount:n`

```

2208 \_graphics_backend_loaded:n
2209 { \cs_new_eq:NN \_graphics_backend_get_pagecount:n \_graphics_get_pagecount:n }

```

(End definition for `\_graphics_backend_get_pagecount:n`.)

```

2210 </dvisvgm>
2211 </package>

```

## 6 I3backend-pdf Implementation

```

2212 <*package>
2213 <@=pdf>

```

Setting up PDF resources is a complex area with only limited documentation in the engine manuals. The following code builds heavily on existing ideas from `hyperref` work by Sebastian Rahtz and Heiko Oberdiek, and significant contributions by Alexander Grahn, in addition to the specific code referenced a various points.

### 6.1 Shared code

A very small number of items that belong at the backend level but which are common to all backends.

`\l__pdf_internal_box`

```

2214 \box_new:N \l__pdf_internal_box

```

(End definition for `\l__pdf_internal_box`.)

### 6.2 dvips backend

```

2215 <*dvips>

```

`\_pdf_backend_pdfmark:n` Used often enough it should be a separate function.

```

\_pdf_backend_pdfmark:x
2216 \cs_new_protected:Npn \_pdf_backend_pdfmark:n #1
2217     { \_kernel_backend_postscript:n { mark #1 ~ pdfmark } }
2218 \cs_generate_variant:Nn \_pdf_backend_pdfmark:n { x }

```

(End definition for `\_pdf_backend_pdfmark:n`.)

## 6.2.1 Catalogue entries

```
\_pdf_backend_catalog_gput:nn
\_pdf_backend_info_gput:nn 2219 \cs_new_protected:Npn \_pdf_backend_catalog_gput:nn #1#2
2220 { \_pdf_backend_pdfmark:n { { Catalog } << /#1 ~ #2 >> /PUT } }
2221 \cs_new_protected:Npn \_pdf_backend_info_gput:nn #1#2
2222 { \_pdf_backend_pdfmark:n { /#1 ~ #2 /DOCINFO } }

(End definition for \_pdf_backend_catalog_gput:nn and \_pdf_backend_info_gput:nn.)
```

## 6.2.2 Objects

```
\g__pdf_backend_object_int For tracking objects.
2223 \int_new:N \g__pdf_backend_object_int

(End definition for \g__pdf_backend_object_int.)

\_pdf_backend_object_new:n
\_pdf_backend_object_ref:n 2224 \cs_new_protected:Npn \_pdf_backend_object_new:n #1
2225 {
2226   \int_gincr:N \g__pdf_backend_object_int
2227   \int_const:cn
2228     { c__pdf_object_ \tl_to_str:n {#1} _int }
2229     { \g__pdf_backend_object_int }
2230 }
2231 \cs_new:Npn \_pdf_backend_object_ref:n #1
2232 { { pdf.obj \int_use:c { c__pdf_object_ \tl_to_str:n {#1} _int } } }

(End definition for \_pdf_backend_object_new:n and \_pdf_backend_object_ref:n.)
```

```
\_pdf_backend_object_write:nnn This is where we choose the actual type: some work to get things right. To allow code
\_pdf_backend_object_write:nnx sharing with the anonymous version, we use an auxiliary.
\_pdf_backend_object_write_aux:nnn 2233 \cs_new_protected:Npn \_pdf_backend_object_write:nnn #1#2#3
\_pdf_backend_object_write_array:nn 2234 {
\_pdf_backend_object_write_dict:nn 2235   \_pdf_backend_object_write_aux:nnn
\_pdf_backend_object_write_fstream:nn 2236   { \_pdf_backend_object_ref:n {#1} }
\_pdf_backend_object_write_stream:nn 2237   {#2} {#3}
\_pdf_backend_object_write_stream:nnn 2238 }
2239 \cs_generate_variant:Nn \_pdf_backend_object_write:nnn { nnx }
2240 \cs_new_protected:Npn \_pdf_backend_object_write_aux:nnn #1#2#3
2241 {
2242   \_pdf_backend_pdfmark:x
2243   {
2244     /_objdef ~ #1
2245     /type
2246     \str_case:nn {#2}
2247     {
2248       { array } { /array }
2249       { dict } { /dict }
2250       { fstream } { /stream }
2251       { stream } { /stream }
2252     }
2253     /OBJ
2254   }
2255   \use:c { __pdf_backend_object_write_ #2 :nn } {#1} {#3}
```

```

2256 }
2257 \cs_new_protected:Npn \__pdf_backend_object_write_array:nn #1#2
2258 {
2259   \__pdf_backend_pdfmark:x
2260   { #1 ~0~ [ ~ \exp_not:n {#2} ~ ] ~ /PUTINTERVAL }
2261 }
2262 \cs_new_protected:Npn \__pdf_backend_object_write_dict:nn #1#2
2263 {
2264   \__pdf_backend_pdfmark:x
2265   { #1 << \exp_not:n {#2} >> /PUT }
2266 }
2267 \cs_new_protected:Npn \__pdf_backend_object_write_fstream:nn #1#2
2268 {
2269   \exp_args:Nx
2270   \__pdf_backend_object_write_fstream:nnn {#1} #2
2271 }
2272 \cs_new_protected:Npn \__pdf_backend_object_write_fstream:nnn #1#2#3
2273 {
2274   \__kernel_backend_postscript:n
2275   {
2276     SDict ~ begin ~
2277     mark ~ #1 ~ << #2 >> /PUT ~ pdfmark ~
2278     mark ~ #1 ~ ( #3 )~ ( r )~ file ~ /PUT ~ pdfmark ~
2279     end
2280   }
2281 }
2282 \cs_new_protected:Npn \__pdf_backend_object_write_stream:nn #1#2
2283 {
2284   \exp_args:Nx
2285   \__pdf_backend_object_write_stream:nnn {#1} #2
2286 }
2287 \cs_new_protected:Npn \__pdf_backend_object_write_stream:nnn #1#2#3
2288 {
2289   \__kernel_backend_postscript:n
2290   {
2291     mark ~ #1 ~ ( #3 ) /PUT ~ pdfmark ~
2292     mark ~ #1 ~ << #2 >> /PUT ~ pdfmark
2293   }
2294 }

```

(End definition for \\_\_pdf\_backend\_object\_write:nnn and others.)

\\_\_pdf\_backend\_object\_now:nn No anonymous objects, so things are done manually.

```

\__pdf_backend_object_now:nx
2295 \cs_new_protected:Npn \__pdf_backend_object_now:nn #1#2
2296 {
2297   \int_gincr:N \g__pdf_backend_object_int
2298   \__pdf_backend_object_write_aux:nnn
2299   { { pdf.obj \int_use:N \g__pdf_backend_object_int } }
2300   {#1} {#2}
2301 }
2302 \cs_generate_variant:Nn \__pdf_backend_object_now:nn { nx }

```

(End definition for \\_\_pdf\_backend\_object\_now:nn.)

`\_pdf_backend_object_last:` Much like the annotation version.

```

2303 \cs_new:Npn \_pdf_backend_object_last:
2304   { { pdf.obj \int_use:N \g_pdf_backend_object_int } }

```

(End definition for `\_pdf_backend_object_last:`.)

`\_pdf_backend_pageobject_ref:n` Page references are easy in dvips.

```

2305 \cs_new:Npn \_pdf_backend_pageobject_ref:n #1
2306   { { Page #1 } }

```

(End definition for `\_pdf_backend_pageobject_ref:n`.)

### 6.2.3 Annotations

In dvips, annotations have to be constructed manually. As such, we need the object code above for some definitions.

`\l_pdf_backend_content_box` The content of an annotation.

```

2307 \box_new:N \l_pdf_backend_content_box

```

(End definition for `\l_pdf_backend_content_box`.)

`\l_pdf_backend_model_box` For creating model sizing for links.

```

2308 \box_new:N \l_pdf_backend_model_box

```

(End definition for `\l_pdf_backend_model_box`.)

`\g_pdf_backend_annotation_int` Needed as objects which are not annotations could be created.

```

2309 \int_new:N \g_pdf_backend_annotation_int

```

(End definition for `\g_pdf_backend_annotation_int`.)

`\_pdf_backend_annotation:nnnn` Annotations are objects, but we track them separately. Notably, they are not in the object data lists. Here, to get the co-ordinates of the annotation, we need to have the data collected at the PostScript level. That requires a bit of box trickery (effectively a L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> picture of zero size). Once the data is collected, use it to set up the annotation border.

```

2310 \cs_new_protected:Npn \_pdf_backend_annotation:nnnn #1#2#3#4
2311   {
2312     \exp_args:Nf \_pdf_backend_annotation_aux:nnnn
2313       { \dim_eval:n {#1} } {#2} {#3} {#4}
2314   }
2315 \cs_new_protected:Npn \_pdf_backend_annotation_aux:nnnn #1#2#3#4
2316   {
2317     \box_move_down:nn {#3}
2318     { \hbox:n { \_kernel_backend_postscript:n { pdf.save.ll } } }
2319     \box_move_up:nn {#2}
2320     {
2321       \hbox:n
2322         {
2323           \_kernel_kern:n {#1}
2324           \_kernel_backend_postscript:n { pdf.save.ur }
2325           \_kernel_kern:n { -#1 }
2326         }

```

```

2327     }
2328     \int_gincr:N \g__pdf_backend_object_int
2329     \int_gset_eq:NN \g__pdf_backend_annotation_int \g__pdf_backend_object_int
2330     \__pdf_backend_pdfmark:x
2331     {
2332         /_objdef { pdf.obj \int_use:N \g__pdf_backend_object_int }
2333         pdf.rect
2334         #4 ~
2335         /ANN
2336     }
2337 }

```

(End definition for \\_\_pdf\_backend\_annotation:nnnn.)

\\_\_pdf\_backend\_annotation\_last: Provide the last annotation we created: could get tricky of course if other packages are loaded.

```

2338 \cs_new:Npn \__pdf_backend_annotation_last:
2339   { { pdf.obj \int_use:N \g__pdf_backend_annotation_int } }

```

(End definition for \\_\_pdf\_backend\_annotation\_last:.)

\g\_\_pdf\_backend\_link\_int To track annotations which are links.

```

2340 \int_new:N \g__pdf_backend_link_int

```

(End definition for \g\_\_pdf\_backend\_link\_int.)

\g\_\_pdf\_backend\_link\_dict\_tl To pass information to the end-of-link function.

```

2341 \tl_new:N \g__pdf_backend_link_dict_tl

```

(End definition for \g\_\_pdf\_backend\_link\_dict\_tl.)

\g\_\_pdf\_backend\_link\_sf\_int Needed to save/restore space factor, which is needed to deal with the face we need a box.

```

2342 \int_new:N \g__pdf_backend_link_sf_int

```

(End definition for \g\_\_pdf\_backend\_link\_sf\_int.)

\g\_\_pdf\_backend\_link\_math\_bool Needed to save/restore math mode.

```

2343 \bool_new:N \g__pdf_backend_link_math_bool

```

(End definition for \g\_\_pdf\_backend\_link\_math\_bool.)

\g\_\_pdf\_backend\_link\_bool Track link formation: we cannot nest at all.

```

2344 \bool_new:N \g__pdf_backend_link_bool

```

(End definition for \g\_\_pdf\_backend\_link\_bool.)

\l\_\_pdf\_breaklink\_pdfmark\_tl Swappable content for link breaking.

```

2345 \tl_new:N \l__pdf_breaklink_pdfmark_tl
2346 \tl_set:Nn \l__pdf_breaklink_pdfmark_tl { pdfmark }

```

(End definition for \l\_\_pdf\_breaklink\_pdfmark\_tl.)

\\_\_pdf\_breaklink\_postscript:n To allow dropping material unless link breaking is active.

```

2347 \cs_new_protected:Npn \__pdf_breaklink_postscript:n #1 { }

```

(End definition for \\_\_pdf\_breaklink\_postscript:n.)

`\_pdf_breaklink_usebox:N` Swappable box unpacking or use.

```
2348 \cs_new_eq:NN \_pdf_breaklink_usebox:N \box_use:N
```

(End definition for `\_pdf_breaklink_usebox:N`.)

```
\_pdf_backend_link_begin_goto:nnw
```

```
\_pdf_backend_link_begin_user:nnw
```

```
\_pdf_backend_link:nw
```

```
\_pdf_backend_link_aux:nw
```

```
\_pdf_backend_link_end:
```

```
\_pdf_backend_link_end_aux:
```

```
\_pdf_backend_link_minima:
```

```
\_pdf_backend_link_outerbox:n
```

```
\_pdf_backend_link_sf_save:
```

```
\_pdf_backend_link_sf_restore:
```

```
pdf.linkdp.pad
```

```
pdf.linkht.pad
```

```
pdf.llx
```

```
pdf.lly
```

```
pdf.ury
```

```
pdf.link.dict
```

```
pdf.outerbox
```

```
pdf.baselineskip
```

Links are crated like annotations but with dedicated code to allow for adjusting the size of the rectangle. In contrast to `hyperref`, we grab the link content as a box which can then `unbox`: this allows the same interface as for `pdfTeX`.

Notice that the link setup here uses `/Action` not `/A`. That is because Distiller *requires* this trigger word, rather than a “raw” PDF dictionary key (Ghostscript can handle either form).

Taking the idea of `evenboxes` from `hypdvips`, we implement a minimum box height and depth for link placement. This means that “underlining” with a hyperlink will generally give an even appearance. However, to ensure that the full content is always above the link border, we do not allow this to be negative (contrast `hypdvips` approach).

The result should be similar to `pdfTeX` in the vast majority of foreseeable cases.

The object number for a link is saved separately from the rest of the dictionary as this allows us to insert it just once, at either an unbroken link or only in the first line of a broken one. That makes the code clearer but also avoids a low-level PostScript error with the code as taken from `hypdvips`.

Getting the outer dimensions of the text area may be better using a two-pass approach and `\tex_savepos:D`. That plus generic mode are still to re-examine.

```
2349 \cs_new_protected:Npn \_pdf_backend_link_begin_goto:nnw #1#2
2350 {
2351   \_pdf_backend_link_begin:nw
2352   { #1 /Subtype /Link /Action << /S /GoTo /D ( #2 ) >> }
2353 }
2354 \cs_new_protected:Npn \_pdf_backend_link_begin_user:nnw #1#2
2355 { \_pdf_backend_link_begin:nw {#1#2} }
2356 \cs_new_protected:Npn \_pdf_backend_link_begin:nw #1
2357 {
2358   \bool_if:NF \g__pdf_backend_link_bool
2359   { \_pdf_backend_link_begin_aux:nw {#1} }
2360 }
```

The definition of `pdf.link.dict` here is needed as there is code in the PostScript headers for breaking links, and that can only work with this available.

```
2361 \cs_new_protected:Npn \_pdf_backend_link_begin_aux:nw #1
2362 {
2363   \bool_gset_true:N \g__pdf_backend_link_bool
2364   \_kernel_backend_postscript:n
2365   { /pdf.link.dict ( #1 ) def }
2366   \tl_gset:Nn \g__pdf_backend_link_dict_tl {#1}
2367   \_pdf_backend_link_sf_save:
2368   \mode_if_math:TF
2369   { \bool_gset_true:N \g__pdf_backend_link_math_bool }
2370   { \bool_gset_false:N \g__pdf_backend_link_math_bool }
2371   \hbox_set:Nw \l__pdf_backend_content_box
2372   \_pdf_backend_link_sf_restore:
2373   \bool_if:NT \g__pdf_backend_link_math_bool
2374   { \c_math_toggle_token }
2375 }
2376 \cs_new_protected:Npn \_pdf_backend_link_end:
```

```

2377 {
2378   \bool_if:NT \g__pdf_backend_link_bool
2379   { \__pdf_backend_link_end_aux: }
2380 }
2381 \cs_new_protected:Npn \__pdf_backend_link_end_aux:
2382 {
2383   \bool_if:NT \g__pdf_backend_link_math_bool
2384   { \c_math_toggle_token }
2385   \__pdf_backend_link_sf_save:
2386   \hbox_set_end:
2387   \__pdf_backend_link_minima:
2388   \hbox_set:Nn \l__pdf_backend_model_box { Gg }
2389   \exp_args:Nx \__pdf_backend_link_outerbox:n
2390   {
2391     \int_if_odd:nTF { \value { page } }
2392     { \oddsidemargin }
2393     { \evensidemargin }
2394   }
2395   \box_move_down:nn { \box_dp:N \l__pdf_backend_content_box }
2396   { \hbox:n { \__kernel_backend_postscript:n { pdf.save.linkll } } }
2397   \__pdf_breaklink_postscript:n { pdf.bordertracking.begin }
2398   \__pdf_breaklink_usebox:N \l__pdf_backend_content_box
2399   \__pdf_breaklink_postscript:n { pdf.bordertracking.end }
2400   \box_move_up:nn { \box_ht:N \l__pdf_backend_content_box }
2401   {
2402     \hbox:n
2403     { \__kernel_backend_postscript:n { pdf.save.linkur } }
2404   }
2405   \int_gincr:N \g__pdf_backend_object_int
2406   \int_gset_eq:NN \g__pdf_backend_link_int \g__pdf_backend_object_int
2407   \__kernel_backend_postscript:x
2408   {
2409     mark
2410     /_objdef { pdf.obj \int_use:N \g__pdf_backend_link_int }
2411     \g__pdf_backend_link_dict_tl \c_space_tl
2412     pdf.rect
2413     /ANN ~ \l__pdf_breaklink_pdfmark_tl
2414   }
2415   \__pdf_backend_link_sf_restore:
2416   \bool_gset_false:N \g__pdf_backend_link_bool
2417 }
2418 \cs_new_protected:Npn \__pdf_backend_link_minima:
2419 {
2420   \hbox_set:Nn \l__pdf_backend_model_box { Gg }
2421   \__kernel_backend_postscript:x
2422   {
2423     /pdf.linkdp.pad ~
2424     \dim_to_decimal:n
2425     {
2426       \dim_max:nn
2427       {
2428         \box_dp:N \l__pdf_backend_model_box
2429         - \box_dp:N \l__pdf_backend_content_box
2430       }

```

```

2431         { Opt }
2432     } ~
2433     pdf.pt.dvi ~ def
2434 /pdf.linkht.pad ~
2435 \dim_to_decimal:n
2436 {
2437     \dim_max:nn
2438     {
2439         \box_ht:N \l__pdf_backend_model_box
2440         - \box_ht:N \l__pdf_backend_content_box
2441     }
2442     { Opt }
2443 } ~
2444 pdf.pt.dvi ~ def
2445 }
2446 }
2447 \cs_new_protected:Npn \__pdf_backend_link_outerbox:n #1
2448 {
2449     \__kernel_backend_postscript:x
2450     {
2451         /pdf.outerbox
2452         [
2453             \dim_to_decimal:n {#1} ~
2454             \dim_to_decimal:n { -\box_dp:N \l__pdf_backend_model_box } ~
2455             \dim_to_decimal:n { #1 + \textwidth } ~
2456             \dim_to_decimal:n { \box_ht:N \l__pdf_backend_model_box }
2457         ]
2458         [ exch { pdf.pt.dvi } forall ] def
2459         /pdf.baselineskip ~
2460         \dim_to_decimal:n { \tex_baselineskip:D } ~ dup ~ 0 ~ gt
2461         { pdf.pt.dvi ~ def }
2462         { pop ~ pop }
2463         ifelse
2464     }
2465 }
2466 \cs_new_protected:Npn \__pdf_backend_link_sf_save:
2467 {
2468     \int_gset:Nn \g__pdf_backend_link_sf_int
2469     {
2470         \mode_if_horizontal:TF
2471         { \tex_spacefactor:D }
2472         { 0 }
2473     }
2474 }
2475 \cs_new_protected:Npn \__pdf_backend_link_sf_restore:
2476 {
2477     \mode_if_horizontal:T
2478     {
2479         \int_compare:nNnT \g__pdf_backend_link_sf_int > { 0 }
2480         { \int_set_eq:NN \tex_spacefactor:D \g__pdf_backend_link_sf_int }
2481     }
2482 }

```

(End definition for `\__pdf_backend_link_begin_goto:nw` and others. These functions are documented on page ??.)

`\@makecol@hook` Hooks to allow link breaking: something will be needed in format mode at some stage. At present this code is disabled as there is an open question about the name of the hook: to be resolved at the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> end.

```

2483 \use_none:n
2484 {
2485   \cs_if_exist:NT \@makecol@hook
2486     {
2487       \tl_put_right:Nn \@makecol@hook
2488         {
2489           \box_if_empty:NF \@cclv
2490             {
2491               \vbox_set:Nn \@cclv
2492                 {
2493                   \__kernel_backend_postscript:n
2494                     {
2495                       pdf.globaldict /pdf.brokenlink.rect ~ known
2496                         { pdf.bordertracking.continue }
2497                       if
2498                     }
2499                   \vbox_unpack_drop:N \@cclv
2500                   \__kernel_backend_postscript:n
2501                     { pdf.bordertracking.endpage }
2502                 }
2503             }
2504         }
2505       \tl_set:Nn \l__pdf_breaklink_pdfmark_tl { pdf.pdfmark }
2506       \cs_set_eq:NN \__pdf_breaklink_postscript:n \__kernel_backend_postscript:n
2507       \cs_set_eq:NN \__pdf_breaklink_usebox:N \hbox_unpack:N
2508     }
2509 }

```

*(End definition for \@makecol@hook. This function is documented on page ??.)*

`\__pdf_backend_link_last:` The same as annotations, but with a custom integer.

```

2510 \cs_new:Npn \__pdf_backend_link_last:
2511   { { pdf.obj \int_use:N \g__pdf_backend_link_int } }

```

*(End definition for \\_\_pdf\_backend\_link\_last:.)*

`\__pdf_backend_link_margin:n` Convert to big points and pass to PostScript.

```

2512 \cs_new_protected:Npn \__pdf_backend_link_margin:n #1
2513   {
2514     \__kernel_backend_postscript:x
2515       {
2516         /pdf.linkmargin { \dim_to_decimal:n {#1} ~ pdf.pt.dvi } def
2517       }
2518   }

```

*(End definition for \\_\_pdf\_backend\_link\_margin:n.)*

`\__pdf_backend_destination:nn` Here, we need to turn the zoom into a scale. We also need to know where the current anchor point actually is: worked out in PostScript. For the rectangle version, we have a bit more PostScript: we need two points. fitr without rule spec doesn't work, so it falls back to /Fit here.

`\__pdf_backend_destination:nmnn`

`\__pdf_backend_destination_aux:nmnn`

```

2519 \cs_new_protected:Npn \__pdf_backend_destination:nn #1#2
2520 {
2521   \__kernel_backend_postscript:n { pdf.dest.anchor }
2522   \__pdf_backend_pdfmark:x
2523   {
2524     /View
2525     [
2526       \str_case:nnF {#2}
2527       {
2528         { xyz } { /XYZ ~ pdf.dest.point ~ null }
2529         { fit } { /Fit }
2530         { fitb } { /FitB }
2531         { fitbh } { /FitBH ~ pdf.dest.y }
2532         { fitbv } { /FitBV ~ pdf.dest.x }
2533         { fith } { /FitH ~ pdf.dest.y }
2534         { fitv } { /FitV ~ pdf.dest.x }
2535         { fitr } { /Fit }
2536       }
2537       {
2538         /XYZ ~ pdf.dest.point ~ \fp_eval:n { (#2) / 100 }
2539       }
2540     ]
2541     /Dest ( \exp_not:n {#1} ) cvn
2542     /DEST
2543   }
2544 }
2545 \cs_new_protected:Npn \__pdf_backend_destination:nmmm #1#2#3#4
2546 {
2547   \exp_args:Ne \__pdf_backend_destination_aux:nmmm
2548   { \dim_eval:n {#2} } {#1} {#3} {#4}
2549 }
2550 \cs_new_protected:Npn \__pdf_backend_destination_aux:nmmm #1#2#3#4
2551 {
2552   \vbox_to_zero:n
2553   {
2554     \__kernel_kern:n {#4}
2555     \hbox:n { \__kernel_backend_postscript:n { pdf.save.ll } }
2556     \tex_vss:D
2557   }
2558   \__kernel_kern:n {#1}
2559   \vbox_to_zero:n
2560   {
2561     \__kernel_kern:n { -#3 }
2562     \hbox:n { \__kernel_backend_postscript:n { pdf.save.ur } }
2563     \tex_vss:D
2564   }
2565   \__kernel_kern:n { -#1 }
2566   \__pdf_backend_pdfmark:n
2567   {
2568     /View
2569     [
2570       /FitR ~
2571       pdf.llx ~ pdf.lly ~ pdf.dest2device ~
2572       pdf.urx ~ pdf.ury ~ pdf.dest2device

```

```

2573     ]
2574     /Dest ( #2 ) cvn
2575     /DEST
2576   }
2577 }

```

(End definition for `\_pdf_backend_destination:nn`, `\_pdf_backend_destination:nnnn`, and `\_pdf_backend_destination_aux:nnnn`.)

## 6.2.4 Structure

Doable for the usual ps2pdf method.

```

\_pdf_backend_compresslevel:n
\_pdf_backend_compress_objects:n
2578 \cs_new_protected:Npn \_pdf_backend_compresslevel:n #1
2579 {
2580   \int_compare:nNnT {#1} = 0
2581   {
2582     \__kernel_backend_literal_postscript:n
2583     {
2584       /setdistillerparams ~ where
2585       { pop << /CompressPages ~ false >> setdistillerparams }
2586       if
2587     }
2588   }
2589 }
2590 \cs_new_protected:Npn \_pdf_backend_compress_objects:n #1
2591 {
2592   \bool_if:nF {#1}
2593   {
2594     \__kernel_backend_literal_postscript:n
2595     {
2596       /setdistillerparams ~ where
2597       { pop << /CompressStreams ~ false >> setdistillerparams }
2598       if
2599     }
2600   }
2601 }

```

(End definition for `\_pdf_backend_compresslevel:n` and `\_pdf_backend_compress_objects:n`.)

```

\_pdf_backend_version_major_gset:n
\_pdf_backend_version_minor_gset:n
2602 \cs_new_protected:Npn \_pdf_backend_version_major_gset:n #1
2603 {
2604   \cs_gset:Npx \_pdf_backend_version_major: { \int_eval:n {#1} }
2605 }
2606 \cs_new_protected:Npn \_pdf_backend_version_minor_gset:n #1
2607 {
2608   \cs_gset:Npx \_pdf_backend_version_minor: { \int_eval:n {#1} }
2609 }

```

(End definition for `\_pdf_backend_version_major_gset:n` and `\_pdf_backend_version_minor_gset:n`.)

`\_pdf_backend_version_major:` Data not available!

```

\_pdf_backend_version_minor:
2610 \cs_new:Npn \_pdf_backend_version_major: { -1 }
2611 \cs_new:Npn \_pdf_backend_version_minor: { -1 }

```

(End definition for `\_pdf_backend_version_major:` and `\_pdf_backend_version_minor:.`)

## 6.2.5 Marked content

`\_pdf_backend_bdc:nn` Simple wrappers.  
`\_pdf_backend_emc:`

```
2612 \cs_new_protected:Npn \_pdf_backend_bdc:nn #1#2
2613   { \_pdf_backend_pdfmark:n { /#1 ~ #2 /BDC } }
2614 \cs_new_protected:Npn \_pdf_backend_emc:
2615   { \_pdf_backend_pdfmark:n { /EMC } }

(End definition for \_pdf_backend_bdc:nn and \_pdf_backend_emc:.)

2616 </dvips>
```

## 6.3 LuaTeX and pdfTeX backend

```
2617 < *luatex | pdftex >
```

### 6.3.1 Annotations

`\_pdf_backend_annotation:nnnn` Simply pass the raw data through, just dealing with evaluation of dimensions.

```
2618 \cs_new_protected:Npn \_pdf_backend_annotation:nnnn #1#2#3#4
2619   {
2620     < *luatex >
2621     \tex_pdfextension:D annot ~
2622     < /luatex >
2623     < *pdftex >
2624     \tex_pdfannot:D
2625     < /pdftex >
2626     width ~ \dim_eval:n {#1} ~
2627     height ~ \dim_eval:n {#2} ~
2628     depth ~ \dim_eval:n {#3} ~
2629     {#4}
2630   }
```

(End definition for `\_pdf_backend_annotation:nnnn`.)

`\_pdf_backend_annotation_last:` A tiny amount of extra data gets added here; we use x-type expansion to get the space in the right place and form. The “extra” space in the LuaTeX version is *required* as it is consumed in finding the end of the keyword.

```
2631 \cs_new:Npx \_pdf_backend_annotation_last:
2632   {
2633     \exp_not:N \int_value:w
2634     < *luatex >
2635     \exp_not:N \tex_pdffeedback:D lastannot ~
2636     < /luatex >
2637     < *pdftex >
2638     \exp_not:N \tex_pdflastannot:D
2639     < /pdftex >
2640     \c_space_tl 0 ~ R
2641   }
```

(End definition for `\_pdf_backend_annotation_last:`.)

`\_pdf_backend_link_begin_goto:nnw` Links are all created using the same internals.

```
\_pdf_backend_link_begin_user:nnw
\_pdf_backend_link_begin:nnnw
\_pdf_backend_link_end:
2642 \cs_new_protected:Npn \_pdf_backend_link_begin_goto:nnw #1#2
2643   { \_pdf_backend_link_begin:nnnw {#1} { goto~name } {#2} }
2644 \cs_new_protected:Npn \_pdf_backend_link_begin_user:nnw #1#2
```

```

2645 { \_pdf_backend_link_begin:nnw {#1} { user } {#2} }
2646 \cs_new_protected:Npn \_pdf_backend_link_begin:nnw #1#2#3
2647 {
2648 <*luatex>
2649   \tex_pdfextension:D startlink ~
2650 </luatex>
2651 <*pdftex>
2652   \tex_pdfstartlink:D
2653 </pdftex>
2654   attr {#1}
2655   #2 {#3}
2656 }
2657 \cs_new_protected:Npn \_pdf_backend_link_end:
2658 {
2659 <*luatex>
2660   \tex_pdfextension:D endlink \scan_stop:
2661 </luatex>
2662 <*pdftex>
2663   \tex_pdfendlink:D
2664 </pdftex>
2665 }

```

(End definition for \\_pdf\_backend\_link\_begin\_goto:nnw and others.)

\\_pdf\_backend\_link\_last: Formatted for direct use.

```

2666 \cs_new:Npx \_pdf_backend_link_last:
2667 {
2668   \exp_not:N \int_value:w
2669 <*luatex>
2670   \exp_not:N \tex_pdffeedback:D lastlink ~
2671 </luatex>
2672 <*pdftex>
2673   \exp_not:N \tex_pdflastlink:D
2674 </pdftex>
2675   \c_space_tl 0 ~ R
2676 }

```

(End definition for \\_pdf\_backend\_link\_last:.)

\\_pdf\_backend\_link\_margin:n A simple task: pass the data to the primitive.

```

2677 \cs_new_protected:Npn \_pdf_backend_link_margin:n #1
2678 {
2679 <*luatex>
2680   \tex_pdfvariable:D linkmargin
2681 </luatex>
2682 <*pdftex>
2683   \tex_pdflinkmargin:D
2684 </pdftex>
2685   \dim_eval:n {#1} \scan_stop:
2686 }

```

(End definition for \\_pdf\_backend\_link\_margin:n.)

`\_pdf_backend_destination:nn`  
`\_pdf_backend_destination:nnnn`

A simple task: pass the data to the primitive. The `\scan_stop:` deals with the danger of an unterminated keyword. The zoom given here is a percentage, but we need to pass it as *per mille*. The rectangle version is also easy as everything is build in.

```

2687 \cs_new_protected:Npn \_pdf_backend_destination:nn #1#2
2688 {
2689 <*luatex>
2690   \tex_pdfextension:D dest ~
2691 </luatex>
2692 <*pdftex>
2693   \tex_pdfdest:D
2694 </pdftex>
2695   name {#1}
2696   \str_case:nnF {#2}
2697   {
2698     { xyz } { xyz }
2699     { fit } { fit }
2700     { fitb } { fitb }
2701     { fitbh } { fitbh }
2702     { fitbv } { fitbv }
2703     { fith } { fith }
2704     { fitv } { fitv }
2705     { fitr } { fitr }
2706   }
2707   { xyz ~ zoom \fp_eval:n { #2 * 10 } }
2708   \scan_stop:
2709 }
2710 \cs_new_protected:Npn \_pdf_backend_destination:nnnn #1#2#3#4
2711 {
2712 <*luatex>
2713   \tex_pdfextension:D dest ~
2714 </luatex>
2715 <*pdftex>
2716   \tex_pdfdest:D
2717 </pdftex>
2718   name {#1}
2719   fitr ~
2720   width \dim_eval:n {#2} ~
2721   height \dim_eval:n {#3} ~
2722   depth \dim_eval:n {#4} \scan_stop:
2723 }

```

(End definition for `\_pdf_backend_destination:nn` and `\_pdf_backend_destination:nnnn`.)

### 6.3.2 Catalogue entries

`\_pdf_backend_catalog_gput:nn`  
`\_pdf_backend_info_gput:nn`

```

2724 \cs_new_protected:Npn \_pdf_backend_catalog_gput:nn #1#2
2725 {
2726 <*luatex>
2727   \tex_pdfextension:D catalog
2728 </luatex>
2729 <*pdftex>
2730   \tex_pdfcatalog:D
2731 </pdftex>

```

```

2732     { / #1 ~ #2 }
2733   }
2734   \cs_new_protected:Npn \__pdf_backend_info_gput:nn #1#2
2735     {
2736     \*luatex
2737       \tex_pdfextension:D info
2738     \*pdfTeX
2739     \*pdfTeX
2740     \tex_pdfinfo:D
2741     \*pdfTeX
2742     { / #1 ~ #2 }
2743   }

```

(End definition for \\_\_pdf\_backend\_catalog\_gput:nn and \\_\_pdf\_backend\_info\_gput:nn.)

### 6.3.3 Objects

\g\_\_pdf\_backend\_object\_prop For tracking objects to allow finalisation.

```

2744 \prop_new:N \g__pdf_backend_object_prop

```

(End definition for \g\_\_pdf\_backend\_object\_prop.)

\\_\_pdf\_backend\_object\_new:n Declaring objects means reserving at the PDF level plus starting tracking.

\\_\_pdf\_backend\_object\_ref:n

```

2745 \cs_new_protected:Npn \__pdf_backend_object_new:n #1
2746   {
2747   \*luatex
2748     \tex_pdfextension:D obj ~
2749   \*pdfTeX
2750   \*pdfTeX
2751   \tex_pdfobj:D
2752   \*pdfTeX
2753     reserveobjnum ~
2754     \int_const:cn
2755     { c__pdf_object_ \tl_to_str:n {#1} _int }
2756   \*luatex
2757     { \tex_pdffeedback:D lastobj }
2758   \*pdfTeX
2759   \*pdfTeX
2760     { \tex_pdflastobj:D }
2761   \*pdfTeX
2762   }

```

```

2763 \cs_new:Npn \__pdf_backend_object_ref:n #1
2764   { \int_use:c { c__pdf_object_ \tl_to_str:n {#1} _int } ~ 0 ~ R }

```

(End definition for \\_\_pdf\_backend\_object\_new:n and \\_\_pdf\_backend\_object\_ref:n.)

\\_\_pdf\_backend\_object\_write:nnn Writing the data needs a little information about the structure of the object.

\\_\_pdf\_backend\_object\_write:nnx

\\_\_pdf\_backend\_object\_write:nn

\\_\_pdf\_exp\_not\_i:nn

\\_\_pdf\_exp\_not\_ii:nn

```

2765 \cs_new_protected:Npn \__pdf_backend_object_write:nnn #1#2#3
2766   {
2767   \*luatex
2768     \tex_immediate:D \tex_pdfextension:D obj ~
2769   \*pdfTeX
2770   \*pdfTeX
2771     \tex_immediate:D \tex_pdfobj:D
2772   \*pdfTeX

```

```

2773     useobjnum ~
2774     \int_use:c
2775     { c__pdf_object_ \tl_to_str:n {#1} _int }
2776     \__pdf_backend_object_write:nn {#2} {#3}
2777   }
2778 \cs_new:Npn \__pdf_backend_object_write:nn #1#2
2779 {
2780   \str_case:nn {#1}
2781   {
2782     { array } { { [ ~ \exp_not:n {#2} ~ ] } }
2783     { dict } { { << ~ \exp_not:n {#2} ~ >> } }
2784     { fstream }
2785     {
2786       stream ~ attr ~ { \__pdf_exp_not_i:nn #2 } ~
2787       file ~ { \__pdf_exp_not_ii:nn #2 }
2788     }
2789     { stream }
2790     {
2791       stream ~ attr ~ { \__pdf_exp_not_i:nn #2 } ~
2792       { \__pdf_exp_not_ii:nn #2 }
2793     }
2794   }
2795 }
2796 \cs_generate_variant:Nn \__pdf_backend_object_write:nnn { nnx }
2797 \cs_new:Npn \__pdf_exp_not_i:nn #1#2 { \exp_not:n {#1} }
2798 \cs_new:Npn \__pdf_exp_not_ii:nn #1#2 { \exp_not:n {#2} }

```

(End definition for \\_\_pdf\_backend\_object\_write:nnn and others.)

\\_\_pdf\_backend\_object\_now:nn Much like writing, but direct creation.

```

\__pdf_backend_object_now:nx
2799 \cs_new_protected:Npn \__pdf_backend_object_now:nn #1#2
2800 {
2801   \*luatex
2802   \tex_immediate:D \tex_pdfextension:D obj ~
2803   \*luatex
2804   \*pdftex
2805   \tex_immediate:D \tex_pdfobj:D
2806   \*pdftex
2807   \__pdf_backend_object_write:nn {#1} {#2}
2808 }
2809 \cs_generate_variant:Nn \__pdf_backend_object_now:nn { nx }

```

(End definition for \\_\_pdf\_backend\_object\_now:nn.)

\\_\_pdf\_backend\_object\_last: Much like annotation.

```

2810 \cs_new:Npx \__pdf_backend_object_last:
2811 {
2812   \exp_not:N \int_value:w
2813   \*luatex
2814   \exp_not:N \tex_pdffeedback:D lastobj ~
2815   \*luatex
2816   \*pdftex
2817   \exp_not:N \tex_pdflastobj:D
2818   \*pdftex
2819   \c_space_tl 0 ~ R

```

```
2820 }
(End definition for \_pdf_backend_object_last:.)
```

\\_pdf\_backend\_pageobject\_ref:n The usual wrapper situation; the three spaces here are essential.

```
2821 \cs_new:Npx \_pdf_backend_pageobject_ref:n #1
2822 {
2823   \exp_not:N \int_value:w
2824   <*luatex>
2825     \exp_not:N \tex_pdffeedback:D pageref
2826   </luatex>
2827   <*pdftex>
2828     \exp_not:N \tex_pdfpageref:D
2829   </pdftex>
2830   \c_space_tl #1 \c_space_tl \c_space_tl \c_space_tl 0 ~ R
2831 }
```

(End definition for \\_pdf\_backend\_pageobject\_ref:n.)

### 6.3.4 Structure

\\_pdf\_backend\_compresslevel:n Simply pass data to the engine.

```
\_pdf_backend_compresslevel:n
\_pdf_backend_compress_objects:n
\_pdf_backend_objcompresslevel:n
2832 \cs_new_protected:Npn \_pdf_backend_compresslevel:n #1
2833 {
2834   \tex_global:D
2835   <*luatex>
2836     \tex_pdfvariable:D compresslevel
2837   </luatex>
2838   <*pdftex>
2839     \tex_pdfcompresslevel:D
2840   </pdftex>
2841     \int_value:w \int_eval:n {#1} \scan_stop:
2842 }
2843 \cs_new_protected:Npn \_pdf_backend_compress_objects:n #1
2844 {
2845   \bool_if:nTF {#1}
2846     { \_pdf_backend_objcompresslevel:n { 2 } }
2847     { \_pdf_backend_objcompresslevel:n { 0 } }
2848 }
2849 \cs_new_protected:Npn \_pdf_backend_objcompresslevel:n #1
2850 {
2851   \tex_global:D
2852   <*luatex>
2853     \tex_pdfvariable:D objcompresslevel
2854   </luatex>
2855   <*pdftex>
2856     \tex_pdfobjcompresslevel:D
2857   </pdftex>
2858     #1 \scan_stop:
2859 }
```

(End definition for \\_pdf\_backend\_compresslevel:n, \\_pdf\_backend\_compress\_objects:n, and \\_pdf\_backend\_objcompresslevel:n.)

`\_pdf_backend_version_major_gset:n`  
`\_pdf_backend_version_minor_gset:n`

The availability of the primitive is not universal, so we have to test at load time.

```
2860 \cs_new_protected:Npx \_pdf_backend_version_major_gset:n #1
2861 {
2862 <*luatex>
2863   \int_compare:nNnT \tex luatexversion:D > { 106 }
2864   {
2865     \exp_not:N \tex_global:D \tex_pdfvariable:D majorversion
2866     \exp_not:N \int_eval:n {#1} \scan_stop:
2867   }
2868 </luatex>
2869 <*pdftex>
2870   \cs_if_exist:NT \tex_pdfmajorversion:D
2871   {
2872     \exp_not:N \tex_global:D \tex_pdfmajorversion:D
2873     \exp_not:N \int_eval:n {#1} \scan_stop:
2874   }
2875 </pdftex>
2876 }
2877 \cs_new_protected:Npn \_pdf_backend_version_minor_gset:n #1
2878 {
2879   \tex_global:D
2880 <*luatex>
2881   \tex_pdfvariable:D minorversion
2882 </luatex>
2883 <*pdftex>
2884   \tex_pdfminorversion:D
2885 </pdftex>
2886   \int_eval:n {#1} \scan_stop:
2887 }
```

(End definition for `\_pdf_backend_version_major_gset:n` and `\_pdf_backend_version_minor_gset:n`.)

`\_pdf_backend_version_major:`  
`\_pdf_backend_version_minor:`

As above.

```
2888 \cs_new:Npx \_pdf_backend_version_major:
2889 {
2890 <*luatex>
2891   \int_compare:nNnTF \tex luatexversion:D > { 106 }
2892   { \exp_not:N \tex_the:D \tex_pdfvariable:D majorversion }
2893   { 1 }
2894 </luatex>
2895 <*pdftex>
2896   \cs_if_exist:NTF \tex_pdfmajorversion:D
2897   { \exp_not:N \tex_the:D \tex_pdfmajorversion:D }
2898   { 1 }
2899 </pdftex>
2900 }
2901 \cs_new:Npn \_pdf_backend_version_minor:
2902 {
2903   \tex_the:D
2904 <*luatex>
2905   \tex_pdfvariable:D minorversion
2906 </luatex>
2907 <*pdftex>
2908   \tex_pdfminorversion:D
```

```

2909 </pdftex>
2910 }

```

(End definition for `\_pdf_backend_version_major:` and `\_pdf_backend_version_minor:`.)

### 6.3.5 Marked content

`\_pdf_backend_bdc:nn` Simple wrappers. May need refinement: see <https://chat.stackexchange.com/transcript/message/49970158#49970158>.

```

2911 \cs_new_protected:Npn \_pdf_backend_bdc:nn #1#2
2912 { \_kernel_backend_literal_page:n { /#1 ~ #2 ~ BDC } }
2913 \cs_new_protected:Npn \_pdf_backend_emc:
2914 { \_kernel_backend_literal_page:n { EMC } }

```

(End definition for `\_pdf_backend_bdc:nn` and `\_pdf_backend_emc:`.)

```

2915 </luatex | pdftex>

```

## 6.4 dvipdfmx backend

```

2916 <*dvipdfmx | xetex>

```

`\_pdf_backend:n` A generic function for the backend PDF specials: used where we can.

```

\_pdf_backend:n
\_pdf_backend:x
2917 \cs_new_protected:Npx \_pdf_backend:n #1
2918 { \_kernel_backend_literal:n { pdf: #1 } }
2919 \cs_generate_variant:Nn \_pdf_backend:n { x }

```

(End definition for `\_pdf_backend:n`.)

### 6.4.1 Catalogue entries

```

\_pdf_backend_catalog_gput:nn
\_pdf_backend_info_gput:nn
2920 \cs_new_protected:Npn \_pdf_backend_catalog_gput:nn #1#2
2921 { \_pdf_backend:n { put ~ @catalog << /#1 ~ #2 >> } }
2922 \cs_new_protected:Npn \_pdf_backend_info_gput:nn #1#2
2923 { \_pdf_backend:n { docinfo << /#1 ~ #2 >> } }

```

(End definition for `\_pdf_backend_catalog_gput:nn` and `\_pdf_backend_info_gput:nn`.)

### 6.4.2 Objects

`\g__pdf_backend_object_int` For tracking objects to allow finalisation.

```

\g__pdf_backend_object_int
\g__pdf_backend_object_prop
2924 \int_new:N \g__pdf_backend_object_int
2925 \prop_new:N \g__pdf_backend_object_prop

```

(End definition for `\g__pdf_backend_object_int` and `\g__pdf_backend_object_prop`.)

`\_pdf_backend_object_new:n` Objects are tracked at the macro level, but we don't have to do anything at this stage.

```

\_pdf_backend_object_ref:n
2926 \cs_new_protected:Npn \_pdf_backend_object_new:n #1
2927 {
2928   \int_gincr:N \g__pdf_backend_object_int
2929   \int_const:cn
2930   { c__pdf_object_ \tl_to_str:n {#1} _int }
2931   { \g__pdf_backend_object_int }
2932 }
2933 \cs_new:Npn \_pdf_backend_object_ref:n #1
2934 { @pdf.obj \int_use:c { c__pdf_object_ \tl_to_str:n {#1} _int } }

```

(End definition for `\_pdf_backend_object_new:n` and `\_pdf_backend_object_ref:n`.)

This is where we choose the actual type.

```
\_pdf_backend_object_write:nnn
\_pdf_backend_object_write:nnx
\_pdf_backend_object_write_array:nn
\_pdf_backend_object_write_dict:nn
\_pdf_backend_object_write_fstream:nn
\_pdf_backend_object_write_stream:nn
\_pdf_backend_object_write_stream:nnnn
2935 \cs_new_protected:Npn \_pdf_backend_object_write:nnn #1#2#3
2936 {
2937   \use:c { \_pdf_backend_object_write_ #2 :nn }
2938   { \_pdf_backend_object_ref:n {#1} } {#3}
2939 }
2940 \cs_generate_variant:Nn \_pdf_backend_object_write:nnn { nnx }
2941 \cs_new_protected:Npn \_pdf_backend_object_write_array:nn #1#2
2942 {
2943   \_pdf_backend:x
2944   { obj ~ #1 ~ [ ~ \exp_not:n {#2} ~ ] }
2945 }
2946 \cs_new_protected:Npn \_pdf_backend_object_write_dict:nn #1#2
2947 {
2948   \_pdf_backend:x
2949   { obj ~ #1 ~ << ~ \exp_not:n {#2} ~ >> }
2950 }
2951 \cs_new_protected:Npn \_pdf_backend_object_write_fstream:nn #1#2
2952 { \_pdf_backend_object_write_stream:nnnn { f } {#1} #2 }
2953 \cs_new_protected:Npn \_pdf_backend_object_write_stream:nn #1#2
2954 { \_pdf_backend_object_write_stream:nnnn { } {#1} #2 }
2955 \cs_new_protected:Npn \_pdf_backend_object_write_stream:nnnn #1#2#3#4
2956 {
2957   \_pdf_backend:x
2958   {
2959     #1 stream ~ #2 ~
2960     ( \exp_not:n {#4} ) ~ << \exp_not:n {#3} >>
2961   }
2962 }
```

(End definition for `\_pdf_backend_object_write:nnn` and others.)

No anonymous objects with dvipdfmx so we have to give an object name.

```
\_pdf_backend_object_now:nn
\_pdf_backend_object_now:nx
2963 \cs_new_protected:Npn \_pdf_backend_object_now:nn #1#2
2964 {
2965   \int_gincr:N \g__pdf_backend_object_int
2966   \exp_args:Nnx \use:c { \_pdf_backend_object_write_ #1 :nn }
2967   { @pdf.obj \int_use:N \g__pdf_backend_object_int }
2968   {#2}
2969 }
2970 \cs_generate_variant:Nn \_pdf_backend_object_now:nn { nx }
```

(End definition for `\_pdf_backend_object_now:nn`.)

`\_pdf_backend_object_last:`

```
2971 \cs_new:Npn \_pdf_backend_object_last:
2972 { @pdf.obj \int_use:N \g__pdf_backend_object_int }
```

(End definition for `\_pdf_backend_object_last:.`)

`\_pdf_backend_pageobject_ref:n` Page references are easy in dvipdfmx/X<sub>q</sub>TeX.

```
2973 \cs_new:Npn \_pdf_backend_pageobject_ref:n #1
2974 { @page #1 }
```

(End definition for `\_pdf_backend_pageobject_ref:n`.)

### 6.4.3 Annotations

`\g_pdf_backend_annotation_int` Needed as objects which are not annotations could be created.

```
2975 \int_new:N \g_pdf_backend_annotation_int
```

(End definition for `\g_pdf_backend_annotation_int`.)

`\_pdf_backend_annotation:nmmn` Simply pass the raw data through, just dealing with evaluation of dimensions.

```
2976 \cs_new_protected:Npn \_pdf_backend_annotation:nmmn #1#2#3#4
```

```
2977 {
2978   \int_gincr:N \g_pdf_backend_object_int
2979   \int_gset_eq:NN \g_pdf_backend_annotation_int \g_pdf_backend_object_int
2980   \_pdf_backend:x
2981   {
2982     ann ~ @pdf.obj \int_use:N \g_pdf_backend_object_int \c_space_tl
2983     width ~ \dim_eval:n {#1} ~
2984     height ~ \dim_eval:n {#2} ~
2985     depth ~ \dim_eval:n {#3} ~
2986     << /Type /Annot #4 >>
2987   }
2988 }
```

(End definition for `\_pdf_backend_annotation:nmmn`.)

`\_pdf_backend_annotation_last:`

```
2989 \cs_new:Npn \_pdf_backend_annotation_last:
2990 { @pdf.obj \int_use:N \g_pdf_backend_annotation_int }
```

(End definition for `\_pdf_backend_annotation_last:`.)

`\g_pdf_backend_link_int` To track annotations which are links.

```
2991 \int_new:N \g_pdf_backend_link_int
```

(End definition for `\g_pdf_backend_link_int`.)

`\_pdf_backend_link_begin_goto:nmw` All created using the same internals.

`\_pdf_backend_link_begin_user:nmw`

```
2992 \cs_new_protected:Npn \_pdf_backend_link_begin_goto:nmw #1#2
```

```
2993 { \_pdf_backend_link_begin:n { #1 /Subtype /Link /A << /S /GoTo /D ( #2 ) >> } }
```

`\_pdf_backend_link_begin:n`

```
2994 \cs_new_protected:Npn \_pdf_backend_link_begin_user:nmw #1#2
```

```
2995 { \_pdf_backend_link_begin:n { #1#2 } }
```

`\_pdf_backend_link_end:`

```
2996 \cs_new_protected:Npx \_pdf_backend_link_end:n #1
```

```
2997 {
2998   \exp_not:N \int_gincr:N \exp_not:N \g_pdf_backend_link_int
2999   \_pdf_backend:x
3000   {
3001     bann ~
3002     @pdf.lnk
3003     \exp_not:N \int_use:N \exp_not:N \g_pdf_backend_link_int
3004     \c_space_tl
3005     <<
3006     /Type /Annot
3007     #1
3008     >>
3009   }
3010 }
3011 \cs_new_protected:Npn \_pdf_backend_link_end:
3012 { \_pdf_backend:n { eann } }
```

(End definition for `\_pdf_backend_link_begin_goto:nw` and others.)

`\_pdf_backend_link_last:` Available using the backend mechanism with a suitably-recent version.

```
3013 \cs_new:Npn \_pdf_backend_link_last:
3014   { @pdf.lnk \int_use:N \g_pdf_backend_link_int }
```

(End definition for `\_pdf_backend_link_last:.`)

`\_pdf_backend_link_margin:n` Pass to `dvipdfmx`.

```
3015 \cs_new_protected:Npn \_pdf_backend_link_margin:n #1
3016   { \_kernel_backend_literal:x { dvipdfmx.config-g~ \dim_eval:n {#1} } }
```

(End definition for `\_pdf_backend_link_margin:n`.)

`\_pdf_backend_destination:nn`  
`\_pdf_backend_destination:nmnn`  
`\_pdf_backend_destination_aux:nmnn`

Here, we need to turn the zoom into a scale. The method for `FitR` is from Alexander Grahn: the idea is to avoid needing to do any calculations in `TeX` by using the backend data for `@xpos` and `@ypos`. `/FitR` without rule spec doesn't work, so it falls back to `/Fit` here.

```
3017 \cs_new_protected:Npn \_pdf_backend_destination:nn #1#2
3018   {
3019     \_pdf_backend:x
3020     {
3021       dest ~ ( \exp_not:n {#1} )
3022       [
3023         @thispage
3024         \str_case:nmF {#2}
3025         {
3026           { xyz } { /XYZ ~ @xpos ~ @ypos ~ null }
3027           { fit } { /Fit }
3028           { fitb } { /FitB }
3029           { fitbh } { /FitBH }
3030           { fitbv } { /FitBV ~ @xpos }
3031           { fith } { /FitH ~ @ypos }
3032           { fitv } { /FitV ~ @xpos }
3033           { fitr } { /Fit }
3034         }
3035         { /XYZ ~ @xpos ~ @ypos ~ \fp_eval:n { (#2) / 100 } }
3036       ]
3037     }
3038   }
3039 \cs_new_protected:Npn \_pdf_backend_destination:nmnn #1#2#3#4
3040   {
3041     \exp_args:Ne \_pdf_backend_destination_aux:nmnn
3042     { \dim_eval:n {#2} } {#1} {#3} {#4}
3043   }
3044 \cs_new_protected:Npn \_pdf_backend_destination_aux:nmnn #1#2#3#4
3045   {
3046     \vbox_to_zero:n
3047     {
3048       \_kernel_kern:n {#4}
3049       \hbox:n
3050       {
3051         \_pdf_backend:n { obj ~ @pdf_ #2 _llx ~ @xpos }
3052         \_pdf_backend:n { obj ~ @pdf_ #2 _lly ~ @ypos }
```

```

3053     }
3054     \tex_vss:D
3055   }
3056   \__kernel_kern:n {#1}
3057   \vbox_to_zero:n
3058   {
3059     \__kernel_kern:n { -#3 }
3060     \hbox:n
3061     {
3062       \__pdf_backend:n
3063       {
3064         dest ~ (#2)
3065         [
3066           @thispage
3067           /FitR ~
3068           @pdf_ #2 _llx ~ @pdf_ #2 _lly ~
3069           @xpos ~ @ypos
3070         ]
3071       }
3072     }
3073     \tex_vss:D
3074   }
3075   \__kernel_kern:n { -#1 }
3076 }

```

(End definition for `\__pdf_backend_destination:nn`, `\__pdf_backend_destination:nnnn`, and `\__pdf_backend_destination_aux:nnnn`.)

#### 6.4.4 Structure

`\__pdf_backend_compresslevel:n` Pass data to the backend: these are a one-shot.  
`\__pdf_backend_compress_objects:n`

```

3077 \cs_new_protected:Npn \__pdf_backend_compresslevel:n #1
3078 { \__kernel_backend_literal:x { dvipdfmx:config~z~ \int_eval:n {#1} } }
3079 \cs_new_protected:Npn \__pdf_backend_compress_objects:n #1
3080 {
3081   \bool_if:nF {#1}
3082   { \__kernel_backend_literal:n { dvipdfmx:config~C~0x40 } }
3083 }

```

(End definition for `\__pdf_backend_compresslevel:n` and `\__pdf_backend_compress_objects:n`.)

`\__pdf_backend_version_major_gset:n` We start with the assumption that the default is active.  
`\__pdf_backend_version_minor_gset:n`

```

3084 \cs_new_protected:Npn \__pdf_backend_version_major_gset:n #1
3085 {
3086   \cs_gset:Npx \__pdf_backend_version_major: { \int_eval:n {#1} }
3087   \__kernel_backend_literal:x { pdf:majorversion~ \__pdf_backend_version_major: }
3088 }
3089 \cs_new_protected:Npn \__pdf_backend_version_minor_gset:n #1
3090 {
3091   \cs_gset:Npx \__pdf_backend_version_minor: { \int_eval:n {#1} }
3092   \__kernel_backend_literal:x { pdf:minorversion~ \__pdf_backend_version_minor: }
3093 }

```

(End definition for `\__pdf_backend_version_major_gset:n` and `\__pdf_backend_version_minor_gset:n`.)

```

\_pdf_backend_version_major: We start with the assumption that the default is active.
\_pdf_backend_version_minor: 3094 \cs_new:Npn \_pdf_backend_version_major: { 1 }
                             3095 \cs_new:Npn \_pdf_backend_version_minor: { 5 }

(End definition for \_pdf_backend_version_major: and \_pdf_backend_version_minor:.)

```

#### 6.4.5 Marked content

```

\_pdf_backend_bdc:nn Simple wrappers. May need refinement: see https://chat.stackexchange.com/transcript/message/49970158#49970158.
\_pdf_backend_emc:
3096 \cs_new_protected:Npn \_pdf_backend_bdc:nn #1#2
3097 { \_kernel_backend_literal_page:n { /#1 ~ #2 ~ BDC } }
3098 \cs_new_protected:Npn \_pdf_backend_emc:
3099 { \_kernel_backend_literal_page:n { EMC } }

(End definition for \_pdf_backend_bdc:nn and \_pdf_backend_emc:.)
3100 </dviPDFmx | xetex>

```

### 6.5 dvisvgm backend

```
3101 <*dvisvgm>
```

#### 6.5.1 Annotations

```

\_pdf_backend_annotation:nmmn
3102 \cs_new_protected:Npn \_pdf_backend_annotation:nmmn #1#2#3#4 { }

(End definition for \_pdf_backend_annotation:nmmn.)

```

```

\_pdf_backend_annotation_last:
3103 \cs_new:Npn \_pdf_backend_annotation_last: { }

(End definition for \_pdf_backend_annotation_last:.)

```

```

\_pdf_backend_link_begin_goto:nmw
\_pdf_backend_link_begin_user:nmmn
\_pdf_backend_link_begin:nmmnw
\_pdf_backend_link_end:
3104 \cs_new_protected:Npn \_pdf_backend_link_begin_goto:nmw #1#2 { }
3105 \cs_new_protected:Npn \_pdf_backend_link_begin_user:nmmn #1#2 { }
3106 \cs_new_protected:Npn \_pdf_backend_link_begin:nmmnw #1#2#3 { }
3107 \cs_new_protected:Npn \_pdf_backend_link_end: { }

(End definition for \_pdf_backend_link_begin_goto:nmw and others.)

```

```

\_pdf_backend_link_last:
3108 \cs_new:Npx \_pdf_backend_link_last: { }

(End definition for \_pdf_backend_link_last:.)

```

```

\_pdf_backend_link_margin:n A simple task: pass the data to the primitive.
3109 \cs_new_protected:Npn \_pdf_backend_link_margin:n #1 { }

(End definition for \_pdf_backend_link_margin:n.)

```

```

\_pdf_backend_destination:nn
\_pdf_backend_destination:nmmn
3110 \cs_new_protected:Npn \_pdf_backend_destination:nn #1#2 { }
3111 \cs_new_protected:Npn \_pdf_backend_destination:nmmn #1#2#3#4 { }

(End definition for \_pdf_backend_destination:nn and \_pdf_backend_destination:nmmn.)

```

## 6.5.2 Catalogue entries

No-op.

```
\_pdf_backend_catalog_gput:nn
\__pdf_backend_info_gput:nn 3112 \cs_new_protected:Npn \_pdf_backend_catalog_gput:nn #1#2 { }
3113 \cs_new_protected:Npn \_pdf_backend_info_gput:nn #1#2 { }
```

(End definition for \\_pdf\_backend\_catalog\_gput:nn and \\_pdf\_backend\_info\_gput:nn.)

## 6.5.3 Objects

All no-ops here.

```
\_pdf_backend_object_new:n
\__pdf_backend_object_ref:n 3114 \cs_new_protected:Npn \_pdf_backend_object_new:nn #1 { }
\_pdf_backend_object_write:mn 3115 \cs_new:Npn \_pdf_backend_object_ref:n #1 { }
\_pdf_backend_object_write:nx 3116 \cs_new_protected:Npn \_pdf_backend_object_write:nnn #1#2#3 { }
\_pdf_backend_object_now:nn 3117 \cs_new_protected:Npn \_pdf_backend_object_write:nxx #1#2#3 { }
\_pdf_backend_object_now:nx 3118 \cs_new_protected:Npn \_pdf_backend_object_now:nn #1#2 { }
\_pdf_backend_object_last: 3119 \cs_new_protected:Npn \_pdf_backend_object_now:nx #1#2 { }
\_pdf_backend_pageobject_ref:n 3120 \cs_new:Npn \_pdf_backend_object_last: { }
3121 \cs_new:Npn \_pdf_backend_pageobject_ref:n #1 { }
```

(End definition for \\_pdf\_backend\_object\_new:n and others.)

## 6.5.4 Structure

These are all no-ops.

```
\_pdf_backend_compresslevel:n
\_pdf_backend_compress_objects:n 3122 \cs_new_protected:Npn \_pdf_backend_compresslevel:n #1 { }
3123 \cs_new_protected:Npn \_pdf_backend_compress_objects:n #1 { }
```

(End definition for \\_pdf\_backend\_compresslevel:n and \\_pdf\_backend\_compress\_objects:n.)

Data not available!

```
\_pdf_backend_version_major_gset:n
\_pdf_backend_version_minor_gset:n 3124 \cs_new_protected:Npn \_pdf_backend_version_major_gset:n #1 { }
3125 \cs_new_protected:Npn \_pdf_backend_version_minor_gset:n #1 { }
```

(End definition for \\_pdf\_backend\_version\_major\_gset:n and \\_pdf\_backend\_version\_minor\_gset:n.)

Data not available!

```
\_pdf_backend_version_major:
\_pdf_backend_version_minor: 3126 \cs_new:Npn \_pdf_backend_version_major: { -1 }
3127 \cs_new:Npn \_pdf_backend_version_minor: { -1 }
```

(End definition for \\_pdf\_backend\_version\_major: and \\_pdf\_backend\_version\_minor:.)

More no-ops.

```
\__pdf_backend_bdc:nn
\_pdf_backend_emc: 3128 \cs_new_protected:Npn \_pdf_backend_bdc:nn #1#2 { }
3129 \cs_new_protected:Npn \_pdf_backend_emc: { }
```

(End definition for \\_pdf\_backend\_bdc:nn and \\_pdf\_backend\_emc:.)

```
3130 </dvisvgm>
```

## 6.6 PDF Page size (media box)

For setting the media box, the split between backends is somewhat different to other areas, thus we approach this separately. The code here assumes a recent L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>: that is ensured at the level above.

```
3131 <*dvipdfmx | dvips>
```

`\_pdf_backend_pagesize_gset:nn` This is done as a backend literal, so we deal with it using the shipout hook.

```
3132 \cs_new_protected:Npn \_pdf_backend_pagesize_gset:nn #1#2
3133 {
3134   \__kernel_backend_first_shipout:n
3135   {
3136     \__kernel_backend_literal:e
3137     {
3138       <*dvipdfmx>
3139         pdf:pagesize ~
3140         width ~ \dim_eval:n {#1} ~
3141         height ~ \dim_eval:n {#2}
3142       </dvipdfmx>
3143       <*dvips>
3144         papersize = \dim_eval:n {#1} , \dim_eval:n {#2}
3145       </dvips>
3146     }
3147   }
3148 }
```

*(End definition for \\_pdf\_backend\_pagesize\_gset:nn.)*

```
3149 </dvipdfmx | dvips>
```

```
3150 <*luatex | pdftex | xetex>
```

`\_pdf_backend_pagesize_gset:nn` Pass to the primitives.

```
3151 \cs_new_protected:Npn \_pdf_backend_pagesize_gset:nn #1#2
3152 {
3153   \dim_gset:Nn \tex_pagewidth:D {#1}
3154   \dim_gset:Nn \tex_pageheight:D {#2}
3155 }
```

*(End definition for \\_pdf\_backend\_pagesize\_gset:nn.)*

```
3156 </luatex | pdftex | xetex>
```

```
3157 <*dvisvgm>
```

`\_pdf_backend_pagesize_gset:nn` A no-op.

```
3158 \cs_new_protected:Npn \_pdf_backend_pagesize_gset:nn #1#2 { }
```

*(End definition for \\_pdf\_backend\_pagesize\_gset:nn.)*

```
3159 </dvisvgm>
```

```
3160 </package>
```

## 7 I3backend-opacity Implementation

```
3161 (*package)
3162 (@@=opacity)
```

Although opacity is not color, it needs to be managed in a somewhat similar way: using a dedicated stack if possible. Depending on the backend, that may not be possible. There is also the need to cover fill/stroke setting as well as more general running opacity. It is easiest to describe the value used in terms of opacity, although commonly this is referred to as transparency.

```
3163 (*dvips)
```

No stack so set values directly. The need to deal with Distiller and Ghostscript separately means we use a common auxiliary: the two systems require different PostScript for transparency. This is of course not quite as efficient as doing one test for setting all transparency, but it keeps things clearer here. Thanks to Alex Grahn for the detail on testing for GhostScript.

```

3164 \cs_new_protected:Npn \__opacity_backend_select:n #1
3165 {
3166   \exp_args:Nx \__opacity_backend_select_aux:n
3167   { \fp_eval:n { min(max(0,#1),1) } }
3168 }
3169 \cs_new_protected:Npn \__opacity_backend_select_aux:n #1
3170 {
3171   \__opacity_backend:nnn {#1} { fill } { ca }
3172   \__opacity_backend:nnn {#1} { stroke } { CA }
3173 }
3174 \cs_new_protected:Npn \__opacity_backend_fill:n #1
3175 {
3176   \__opacity_backend:xnn
3177   { \fp_eval:n { min(max(0,#1),1) } }
3178   { fill }
3179   { ca }
3180 }
3181 \cs_new_protected:Npn \__opacity_backend_stroke:n #1
3182 {
3183   \__opacity_backend:xnn
3184   { \fp_eval:n { min(max(0,#1),1) } }
3185   { stroke }
3186   { CA }
3187 }
3188 \cs_new_protected:Npn \__opacity_backend:nnn #1#2#3
3189 {
3190   \__kernel_backend_postscript:n
3191   {
3192     product ~ (Ghostscript) ~ search
3193     {
3194       pop ~ pop ~ pop ~
3195       #1 ~ .set #2 constantalpha
3196     }
3197     {
3198       pop ~
3199       mark ~
3200       /#3 ~ #1

```

```

3201         /SetTransparency ~
3202         pdfmark
3203     }
3204     ifelse
3205 }
3206 }
3207 \cs_generate_variant:Nn \_opacity_backend:nnn { x }

```

(End definition for \\_opacity\_backend\_select:n and others.)

```

3208 </dvips>
3209 <*dvipdfmx | luatex | pdftex | xetex>

```

\c\_opacity\_backend\_stack\_int Set up a stack, where that is applicable.

```

3210 \bool_lazy_and:nnT
3211 { \cs_if_exist_p:N \pdfmanagement_if_active_p: }
3212 { \pdfmanagement_if_active_p:}
3213 {
3214 <*luatex | pdftex>
3215     \_kernel_color_backend_stack_init:Nnn \c_opacity_backend_stack_int
3216     { page ~ direct } { /opacity 1 ~ gs }
3217 </luatex | pdftex>
3218     \pdfmanagement_add:nnn { Page / Resources / ExtGState }
3219     { opacity 1 } { << /ca ~ 1 /CA ~ 1 >> }
3220 }

```

(End definition for \c\_opacity\_backend\_stack\_int.)

\l\_\_opacity\_backend\_fill\_tl We use tl here for speed: at the backend, this should be reasonable.

```

\l__opacity_backend_stroke_tl
3221 \tl_new:N \l__opacity_backend_fill_tl
3222 \tl_new:N \l__opacity_backend_stroke_tl

```

(End definition for \l\_\_opacity\_backend\_fill\_tl and \l\_\_opacity\_backend\_stroke\_tl.)

\\_opacity\_backend\_select:n Other than the need to evaluate the opacity as an fp, much the same as color.

```

\_opacity_backend_select_aux:n
\_opacity_backend_reset:
3223 \cs_new_protected:Npn \_opacity_backend_select:n #1
3224 {
3225     \exp_args:Nx \_opacity_backend_select_aux:n
3226     { \fp_eval:n { min(max(0,#1),1) } }
3227 }
3228 \cs_new_protected:Npn \_opacity_backend_select_aux:n #1
3229 {
3230     \tl_set:Nn \l__opacity_backend_fill_tl {#1}
3231     \tl_set:Nn \l__opacity_backend_stroke_tl {#1}
3232     \pdfmanagement_add:nnn { Page / Resources / ExtGState }
3233     { opacity #1 }
3234     { << /ca ~ #1 /CA ~ #1 >> }
3235 <*dvipdfmx | xetex>
3236     \_kernel_backend_literal_pdf:n
3237 </dvipdfmx | xetex>
3238 <*luatex | pdftex>
3239     \_kernel_color_backend_stack_push:nm \c_opacity_backend_stack_int
3240 </luatex | pdftex>
3241     { /opacity #1 ~ gs }
3242     \group_insert_after:N \_opacity_backend_reset:

```

```

3243 }
3244 \bool_lazy_and:nnF
3245 { \cs_if_exist_p:N \pdfmanagement_if_active_p: }
3246 { \pdfmanagement_if_active_p:}
3247 {
3248   \cs_gset_protected:Npn \__opacity_backend_select_aux:n #1 { }
3249 }
3250 \cs_new_protected:Npn \__opacity_backend_reset:
3251 {
3252   <*dvipdfmx | xetex>
3253   \__kernel_backend_literal_pdf:n
3254   { /opacity1 ~ gs }
3255   </dvipdfmx | xetex>
3256   <*luatex | pdftex>
3257   \__kernel_color_backend_stack_pop:n \c__opacity_backend_stack_int
3258   </luatex | pdftex>
3259   }

```

(End definition for \\_\_opacity\_backend\_select:n, \\_\_opacity\_backend\_select\_aux:n, and \\_\_opacity\_backend\_reset:.)

\\_\_opacity\_backend\_fill:n For separate fill and stroke, we need to work out if we need to do more work or if we can  
 \\_\_opacity\_backend\_stroke:n stick to a single setting.

```

\__opacity_backend_fillstroke:mn 3260 \cs_new_protected:Npn \__opacity_backend_fill:n #1
\__opacity_backend_fillstroke:xx 3261 {
3262   \__opacity_backend_fill_stroke:xx
3263   { \fp_eval:n { min(max(0,#1),1) } }
3264   \l__opacity_backend_stroke_tl
3265 }
3266 \cs_new_protected:Npn \__opacity_backend_stroke:n #1
3267 {
3268   \__opacity_backend_fill_stroke:xx
3269   \l__opacity_backend_fill_tl
3270   { \fp_eval:n { min(max(0,#1),1) } }
3271 }
3272 \cs_new_protected:Npn \__opacity_backend_fill_stroke:nn #1#2
3273 {
3274   \str_if_eq:nnTF {#1} {#2}
3275   { \__opacity_backend_select_aux:n {#1} }
3276   {
3277     \tl_set:Nn \l__opacity_backend_fill_tl {#1}
3278     \tl_set:Nn \l__opacity_backend_stroke_tl {#2}
3279     \pdfmanagement_add:nnn { Page / Resources / ExtGState }
3280     { opacity.fill #1 }
3281     { << /ca ~ #1 >> }
3282     \pdfmanagement_add:nnn { Page / Resources / ExtGState }
3283     { opacity.stroke #1 }
3284     { << /CA ~ #2 >> }
3285   }
3286   <*dvipdfmx | xetex>
3287   \__kernel_backend_literal_pdf:n
3288   </dvipdfmx | xetex>
3289   <*luatex | pdftex>
3290   \__kernel_color_backend_stack_push:nn \c__opacity_backend_stack_int
3291   </luatex | pdftex>

```

```

3291         { /opacity.fill #1 ~ gs /opacity.stroke #2 ~ gs }
3292         \group_insert_after:N \_opacity_backend_reset:
3293     }
3294 }
3295 \cs_generate_variant:Nn \_opacity_backend_fill_stroke:nn { xx }

(End definition for \_opacity_backend_fill:n, \_opacity_backend_stroke:n, and \_opacity_backend_fillstroke:nn.)

3296 </dviptfm | luatex | pdftex | xetex>
3297 <*dvisvgm>

```

`\_opacity_backend_select:n` Once again, we use a scope here. There is a general opacity function for SVG, but that is of course not set up using the stack.

```

\opacity_backend_fill:n
\opacity_backend_stroke:n
\opacity_backend:nn
3298 \cs_new_protected:Npn \_opacity_backend_select:n #1
3299   { \_opacity_backend:nn {#1} { } }
3300 \cs_new_protected:Npn \_opacity_backend_fill:n #1
3301   { \_opacity_backend:nn {#1} { fill- } }
3302 \cs_new_protected:Npn \_opacity_backend_stroke:n #1
3303   { \_opacity_backend:nn {#1} { stroke- } }
3304 \cs_new_protected:Npn \_opacity_backend:nn #1#2
3305   { \_kernel_backend_scope:x { #2 opacity = " \fp_eval:n { min(max(0,#1),1) } " } }

(End definition for \_opacity_backend_select:n and others.)

3306 </dvisvgm>
3307 </package>

```

## 8 l3backend-header Implementation

```
3308 <*dvips & header>
```

`color.sc` Empty definition for color at the top level.

```
3309 /color.sc { } def
```

(End definition for `color.sc`. This function is documented on page ??.)

`TeXcolorseparation` Support for separation/spot colors: this strange naming is so things work with the color stack.

`separation`

```
3310 TeXDict begin
3311 /TeXcolorseparation { setcolor } def
3312 end
```

(End definition for `TeXcolorseparation` and `separation`. These functions are documented on page ??.)

`pdf.globaldict` A small global dictionary for backend use.

```
3313 true setglobal
3314 /pdf.globaldict 4 dict def
3315 false setglobal
```

(End definition for `pdf.globaldict`. This function is documented on page ??.)

pdf.cvs Small utilities for PostScript manipulations. Conversion to DVI dimensions is done here to allow for Resolution. The total height of a rectangle (an array) needs a little maths, in contrast to simply extracting a value.

```

pdf.dvi.pt
pdf.pt.dvi
pdf.rect.ht
3316 /pdf.cvs { 65534 string cvs } def
3317 /pdf.dvi.pt { 72.27 mul Resolution div } def
3318 /pdf.pt.dvi { 72.27 div Resolution mul } def
3319 /pdf.rect.ht { dup 1 get neg exch 3 get add } def

```

(End definition for pdf.cvs and others. These functions are documented on page ??.)

pdf.linkmargin Settings which are defined up-front in SDict.

```

pdf.linkdp.pad 3320 /pdf.linkmargin { 1 pdf.pt.dvi } def
pdf.linkht.pad 3321 /pdf.linkdp.pad { 0 } def
3322 /pdf.linkht.pad { 0 } def

```

(End definition for pdf.linkmargin, pdf.linkdp.pad, and pdf.linkht.pad. These functions are documented on page ??.)

pdf.rect Functions for marking the limits of an annotation/link, plus drawing the border. We separate links for generic annotations to support adding a margin and setting a minimal size.

```

pdf.save.ll
pdf.save.ur
pdf.save.linkll 3323 /pdf.rect
pdf.save.linkur 3324 { /Rect [ pdf.llx pdf.lly pdf.urx pdf.ury ] } def
pdf.llx 3325 /pdf.save.ll
pdf.lly 3326 {
pdf.urx 3327 currentpoint
pdf.ury 3328 /pdf.lly exch def
3329 /pdf.llx exch def
3330 }
3331 def
3332 /pdf.save.ur
3333 {
3334 currentpoint
3335 /pdf.ury exch def
3336 /pdf.urx exch def
3337 }
3338 def
3339 /pdf.save.linkll
3340 {
3341 currentpoint
3342 pdf.linkmargin add
3343 pdf.linkdp.pad add
3344 /pdf.lly exch def
3345 pdf.linkmargin sub
3346 /pdf.llx exch def
3347 }
3348 def
3349 /pdf.save.linkur
3350 {
3351 currentpoint
3352 pdf.linkmargin sub
3353 pdf.linkht.pad sub
3354 /pdf.ury exch def
3355 pdf.linkmargin add

```

```

3356     /pdf.urx  exch def
3357   }
3358   def

```

*(End definition for pdf.rect and others. These functions are documented on page ??.)*

`pdf.dest.anchor` For finding the anchor point of a destination link. We make the use case a separate function as it comes up a lot, and as this makes it easier to adjust if we need additional effects. We also need a more complex approach to convert a co-ordinate pair correctly when defining a rectangle: this can otherwise be out when using a landscape page. (Thanks to Alexander Grahn for the approach here.)

```

pdf.dev.x 3359 /pdf.dest.anchor
pdf.dev.y 3360 {
pdf.tmpa 3361   currentpoint exch
pdf.tmpb 3362   pdf.dvi.pt 72 add
pdf.tmpc 3363   /pdf.dest.x exch def
pdf.tmpd 3364   pdf.dvi.pt
3365   vsize 72 sub exch sub
3366   /pdf.dest.y exch def
3367 }
3368 def
3369 /pdf.dest.point
3370 { pdf.dest.x pdf.dest.y } def
3371 /pdf.dest2device
3372 {
3373   /pdf.dest.y exch def
3374   /pdf.dest.x exch def
3375   matrix currentmatrix
3376   matrix defaultmatrix
3377   matrix invertmatrix
3378   matrix concatmatrix
3379   cvx exec
3380   /pdf.dev.y exch def
3381   /pdf.dev.x exch def
3382   /pdf.tmpd exch def
3383   /pdf.tmpc exch def
3384   /pdf.tmpb exch def
3385   /pdf.tmpa exch def
3386   pdf.dest.x pdf.tmpa mul
3387   pdf.dest.y pdf.tmpc mul add
3388   pdf.dev.x add
3389   pdf.dest.x pdf.tmpb mul
3390   pdf.dest.y pdf.tmpd mul add
3391   pdf.dev.y add
3392 }
3393 def

```

*(End definition for pdf.dest.anchor and others. These functions are documented on page ??.)*

`pdf.bordertracking` To know where a breakable link can go, we need to track the boundary rectangle. That can be done by hooking into `a` and `x` operations: those names have to be retained. The boundary is stored at the end of the operation. Special effort is needed at the start and end of pages (or rather galleys), such that everything works properly.

```

pdf.bordertracking 3394 /pdf.bordertracking false def
pdf.bordertracking.begin
pdf.bordertracking.end
pdf.leftboundary
pdf.rightboundary
pdf.brokenlink.rect
pdf.brokenlink.skip
pdf.brokenlink.dict
pdf.bordertracking.endpage
pdf.bordertracking.continue
pdf.originx
pdf.originy

```

```

3395 /pdf.bordertracking.begin
3396 {
3397   SDict /pdf.bordertracking true put
3398   SDict /pdf.leftboundary undef
3399   SDict /pdf.rightboundary undef
3400   /a where
3401     {
3402       /a
3403       {
3404         currentpoint pop
3405         SDict /pdf.rightboundary known dup
3406         {
3407           SDict /pdf.rightboundary get 2 index lt
3408             { not }
3409             if
3410           }
3411         if
3412           { pop }
3413           { SDict exch /pdf.rightboundary exch put }
3414         ifelse
3415         moveto
3416         currentpoint pop
3417         SDict /pdf.leftboundary known dup
3418         {
3419           SDict /pdf.leftboundary get 2 index gt
3420             { not }
3421             if
3422           }
3423         if
3424           { pop }
3425           { SDict exch /pdf.leftboundary exch put }
3426         ifelse
3427       }
3428     } put
3429   }
3430   if
3431 }
3432 def
3433 /pdf.bordertracking.end
3434 {
3435   /a where { /a { moveto } put } if
3436   /x where { /x { 0 exch rmoveto } put } if
3437   SDict /pdf.leftboundary known
3438     { pdf.outerbox 0 pdf.leftboundary put }
3439   if
3440   SDict /pdf.rightboundary known
3441     { pdf.outerbox 2 pdf.rightboundary put }
3442   if
3443   SDict /pdf.bordertracking false put
3444 }
3445 def
3446 /pdf.bordertracking.endpage
3447 {
3448   pdf.bordertracking

```

```

3449 {
3450 pdf.bordertracking.end
3451 true setglobal
3452 pdf.globaldict
3453 /pdf.brokenlink.rect [ pdf.outerbox aload pop ] put
3454 pdf.globaldict
3455 /pdf.brokenlink.skip pdf.baselineskip put
3456 pdf.globaldict
3457 /pdf.brokenlink.dict
3458 pdf.link.dict pdf.cvs put
3459 false setglobal
3460 mark pdf.link.dict cvx exec /Rect
3461 [
3462 pdf.llx
3463 pdf.lly
3464 pdf.outerbox 2 get pdf.linkmargin add
3465 currentpoint exch pop
3466 pdf.outerbox pdf.rect.ht sub pdf.linkmargin sub
3467 ]
3468 /ANN pdf.pdfmark
3469 }
3470 if
3471 }
3472 def
3473 /pdf.bordertracking.continue
3474 {
3475 /pdf.link.dict pdf.globaldict
3476 /pdf.brokenlink.dict get def
3477 /pdf.outerbox pdf.globaldict
3478 /pdf.brokenlink.rect get def
3479 /pdf.baselineskip pdf.globaldict
3480 /pdf.brokenlink.skip get def
3481 pdf.globaldict dup dup
3482 /pdf.brokenlink.dict undef
3483 /pdf.brokenlink.skip undef
3484 /pdf.brokenlink.rect undef
3485 currentpoint
3486 /pdf.originy exch def
3487 /pdf.originx exch def
3488 /a where
3489 {
3490 /a
3491 {
3492 moveto
3493 SDict
3494 begin
3495 currentpoint pdf.originy ne exch
3496 pdf.originx ne or
3497 {
3498 pdf.save.linkll
3499 /pdf.lly
3500 pdf.lly pdf.outerbox 1 get sub def
3501 pdf.bordertracking.begin
3502 }

```

```

3503         if
3504         end
3505     }
3506     put
3507 }
3508 if
3509 /x where
3510 {
3511     /x
3512     {
3513         0 exch rmoveto
3514         SDict
3515         begin
3516         currentpoint
3517         pdf.originy ne exch pdf.originx ne or
3518         {
3519             pdf.save.linkll
3520             /pdf.lly
3521             pdf.lly pdf.outerbox 1 get sub def
3522             pdf.bordertracking.begin
3523         }
3524         if
3525         end
3526     }
3527     put
3528 }
3529 if
3530 }
3531 def

```

(End definition for pdf.bordertracking and others. These functions are documented on page ??.)

pdf.breaklink Dealing with link breaking itself has multiple stage. The first step is to find the Rect entry  
pdf.breaklink.write in the dictionary, looping over key–value pairs. The first line is handled first, adjusting  
pdf.count the rectangle to stay inside the text area. The second phase is a loop over the height of  
pdf.currentrect the bulk of the link area, done on the basis of a number of baselines. Finally, the end of  
the link area is tidied up, again from the boundary of the text area.

```

3532 /pdf.breaklink
3533 {
3534     pop
3535     counttomark 2 mod 0 eq
3536     {
3537         counttomark /pdf.count exch def
3538         {
3539             pdf.count 0 eq { exit } if
3540             counttomark 2 roll
3541             1 index /Rect eq
3542             {
3543                 dup 4 array copy
3544                 dup dup
3545                 1 get
3546                 pdf.outerbox pdf.rect.ht
3547                 pdf.linkmargin 2 mul add sub
3548                 3 exch put

```

```

3549     dup
3550     pdf.outerbox 2 get
3551     pdf.linkmargin add
3552     2 exch put
3553     dup dup
3554     3 get
3555     pdf.outerbox pdf.rect.ht
3556     pdf.linkmargin 2 mul add add
3557     1 exch put
3558     /pdf.currentrect exch def
3559     pdf.breaklink.write
3560     {
3561     pdf.currentrect
3562     dup
3563     pdf.outerbox 0 get
3564     pdf.linkmargin sub
3565     0 exch put
3566     dup
3567     pdf.outerbox 2 get
3568     pdf.linkmargin add
3569     2 exch put
3570     dup dup
3571     1 get
3572     pdf.baselineskip add
3573     1 exch put
3574     dup dup
3575     3 get
3576     pdf.baselineskip add
3577     3 exch put
3578     /pdf.currentrect exch def
3579     pdf.breaklink.write
3580     }
3581     1 index 3 get
3582     pdf.linkmargin 2 mul add
3583     pdf.outerbox pdf.rect.ht add
3584     2 index 1 get sub
3585     pdf.baselineskip div round cvi 1 sub
3586     exch
3587     repeat
3588     pdf.currentrect
3589     dup
3590     pdf.outerbox 0 get
3591     pdf.linkmargin sub
3592     0 exch put
3593     dup dup
3594     1 get
3595     pdf.baselineskip add
3596     1 exch put
3597     dup dup
3598     3 get
3599     pdf.baselineskip add
3600     3 exch put
3601     dup 2 index 2 get 2 exch put
3602     /pdf.currentrect exch def

```

```

3603         pdf.breaklink.write
3604         SDict /pdf.pdfmark.good false put
3605         exit
3606     }
3607     { pdf.count 2 sub /pdf.count exch def }
3608     ifelse
3609 }
3610 loop
3611 }
3612 if
3613 /ANN
3614 }
3615 def
3616 /pdf.breaklink.write
3617 {
3618     counttomark 1 sub
3619     index /_objdef eq
3620     {
3621         counttomark -2 roll
3622         dup wcheck
3623         {
3624             readonly
3625             counttomark 2 roll
3626         }
3627         { pop pop }
3628     } ifelse
3629 }
3630 if
3631 counttomark 1 add copy
3632 pop pdf.currentrect
3633 /ANN pdfmark
3634 }
3635 def

```

*(End definition for pdf.breaklink and others. These functions are documented on page ??.)*

pdf.pdfmark The business end of breaking links starts by hooking into pdfmarks. Unlike hypdvips, pdf.pdfmark.good we avoid altering any links we have not created by using a copy of the core pdfmarks pdf.outerbox function. Only mark types which are known are altered. At present, this is purely ANN pdf.baselineskip marks, which are measured relative to the size of the baseline skip. If they are more than pdf.pdfmark.dict one apparent line high, breaking is applied.

```

3636 /pdf.pdfmark
3637 {
3638     SDict /pdf.pdfmark.good true put
3639     dup /ANN eq
3640     {
3641         pdf.pdfmark.store
3642         pdf.pdfmark.dict
3643         begin
3644             Subtype /Link eq
3645             currentdict /Rect known and
3646             SDict /pdf.outerbox known and
3647             SDict /pdf.baselineskip known and
3648             {

```

```

3649         Rect 3 get
3650         pdf.linkmargin 2 mul add
3651         pdf.outerbox pdf.rect.ht add
3652         Rect 1 get sub
3653         pdf.baselineskip div round cvi 0 gt
3654         { pdf.breaklink }
3655         if
3656     }
3657     if
3658     end
3659     SDict /pdf.outerbox undef
3660     SDict /pdf.baselineskip undef
3661     currentdict /pdf.pdfmark.dict undef
3662 }
3663 if
3664 pdf.pdfmark.good
3665 { pdfmark }
3666 { cleartomark }
3667 ifelse
3668 }
3669 def
3670 /pdf.pdfmark.store
3671 {
3672     /pdf.pdfmark.dict 65534 dict def
3673     counttomark 1 add copy
3674     pop
3675     {
3676         dup mark eq
3677         {
3678             pop
3679             exit
3680         }
3681         {
3682             pdf.pdfmark.dict
3683             begin def end
3684         }
3685     } ifelse
3686 }
3687 loop
3688 }
3689 def

```

(End definition for pdf.pdfmark and others. These functions are documented on page ??.)

```
3690 </dvips & header>
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