The Type 42 Font Format Specification

Adobe Developer Support

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1 Introduction

This document describes the PostScript® Type 42 font format which can be used to download TrueType® fonts to PostScript printers (or PostScript compatible printers) that contain a TrueType rasterizer. This method yields better print quality than can be achieved by converting a TrueType font to a Type 1 or Type 3 font. Performance may also be improved for large Chinese, Japanese, or Korean (CJK) fonts when the print driver takes advantage of glyph subsetting and incremental downloading.

A Type 42 font dictionary contains the TrueType font embedded as a string value for the **sfnts** keyword. For single-byte Roman TrueType fonts, the **sfnts** array typically contains the complete TrueType font. This was first supported in PostScript version 2010 for printers that contain the optional TrueType rasterizer. Other entries in the Type 42 font dictionary permit the PostScript interpreter to handle the font in a manner similar to a Type 1 font, and to make the TrueType font data available to the TrueType rasterizer.

This version of this document, dated June 1998, adds a description of how to convert multi-byte TrueType fonts into **CIDFontType** 2 CID fonts. This takes advantage of the CID format's ability to encode the large number of glyphs needed for most CJK fonts. Both permanent downloading to a printer's hard disk, and font embedding for a print job are explained.

Support for multi-byte CJK TrueType fonts was added in version 2015 of the PostScript interpreter by providing a mechanism for subsetting and incremental downloading of large fonts. Recent updates for version 3011 support further optimizations to improve printing performance.

This document only describes the format of a Type 42 font program and how it may be created from a TrueType font. The TrueType specification from Apple Computer is available at the following URL:

< http://fonts.apple.com/TTRefMan/index.html >

Microsoft's TrueType specification is available at the following URL:

< http://www.microsoft.com/typography/tt/tt.htm >

Additional information on Type 42 fonts can be found in: The PostScript Language Reference Manual Supplements for versions 2015, 3010, and 3011. Also, see Adobe Technical Note #5213, “PostScript Language Extensions for CID-Keyed Fonts (PostScript Software Version 2015).”

2 The Type 42 Font Format

The TrueType font format was originally developed by Apple Computer, and is the native font format used by the Macintosh and Windows operating environments. Until recently, Macintosh print drivers would download either the TrueType font and the TrueType rasterizer to interpreters with 680X0-class controllers, or convert the font into a PostScript Type 1 (unhinted) font program. Windows print drivers would either convert to Type 1 or Type 3, or rasterize the TrueType font on the host, and download a bitmap Type 3 or Type 32 font. All of these methods have disadvantages: the TrueType rasterizer is large; conversion to Type 1 format loses the hint information and the translation of TrueType quadratic to PostScript Bézier curves cannot be exact; and bitmap fonts cannot be scaled for multiple resolutions retain the necessary quality.

Many PostScript interpreters, beginning with version 2013, now include a TrueType rasterizer; they can be identified from the PostScript Printer Description (PPD) file (see section 3). For a TrueType font to be recognized by a PostScript interpreter, it must be enclosed in a PostScript font dictionary with **FontType** 42, or as a CID font with **CIDFontType** 2 and **FontType** 42.

FontType 42 and **CIDFontType** 2 are standard part of LanguageLevel 3; all version 3010 and greater interpreters support them. However, the version 3011 extensions are not part of LanguageLevel 3.

Note *Although the keyword name* **sfnts** *is derived from the Macintosh resource type used for TrueType fonts, TrueType fonts from the Windows environment can be converted in an identical manner.*

A Type 42 font is a base font and shares all the properties of base fonts as documented in the *PostScript Language Reference Manual, second edition*. In particular, presence of an unique identifier such as an **XUID** facilitates bitmap caching for a Type 42 font just as it does for any other type of base font. When Type 42 fonts are permanently downloaded to a hard disk connected to a PostScript printer, only the *charstrings* actually referenced in the print job will be read into VM, thus saving memory (see section 4.2). Also, glyphs can be modified or added to the Type 42 font by using user-defined PostScript language procedures (See section 5.6.3 in *The PostScript Language Reference Manual*, second edition.).

2.1 Type 42 Font Comment Lines

The first line of a Type 42 font program shall be:

%!PS-TrueTypeFont-*TTVersion-MfrRevision*

where *TTVersion is the TrueType version number of the font (specified in the header); MfrRevision* is the font manufacturer's revision number of the font. This line helps downloaders to easily identify TrueType Type 42 fonts on the printer's hard disk.

The first portion of the comment line: *%!PS-TrueTypeFont*, is required for disk-based Type 42 fonts on any interpreter that supports Type 42. If the font has the required portion of the comment line and it conforms to the requirements listed in section 4.2, the embedded TrueType glyph data will be accessed from disk on demand rather than reading the entire font into VM.

Another useful and recommended comment line specifies the VM usage:

%%VMusage: *MinMemory MaxMemory*

where *MinMemory* and *MaxMemory* specify the minimum memory needed for the font and how much is needed if the font is downloaded first (these numbers are not necessarily the same; see *The Adobe Type 1 Font Format, version 1.1*, Addison Wesley, 1990). This comment is not used by the PostScript interpreter, but is useful for application programs. The PostScript operator **resourcestatus** can be used to obtain the VM requirements for a font resource.

The values for the **VMusage** comment can be derived from a TrueType font which contains a post table (which contains information useful for PostScript printing). For downloading purposes, the size of the font can be used as an estimate for the values for **VMusage**. However, a properly constructed Type 42 font on a printer's hard disk will generally require only a percentage of the VM required for the downloadable version of the font.

2.2 The Type 42 Font Dictionary

Table 1 lists entries common to all types of font dictionaries. Table 2 lists additional key-value pairs that are meaningful in all *base* fonts. Table 3 lists additional key-value pairs that are meaningful in Type 42 fonts. See the corresponding tables 5.1 through 5.3 in *The PostScript Language Reference Manual, second edition.*

Table 1 *Entries in all types of font dictionaries*

Key	*Type*	*Description*
FontType	integer	(*Required*) Value must be *42*.
FontMatrix	array[6]	(*Required*) Transforms the glyph coordinate system into the user coordinate system. Type 42 fonts, unlike Type 1 fonts, are usually defined in terms of an identity transform, so the value of **FontMatrix** should be [1 0 0 1 0 0]. See section 2.3 for a discussion of the implications of this choice of coordinate system. **FontMatrix** must be a literal array.
FontName	name	(*Optional*) The font program's PostScript font name, derived from the TrueType name table.
FontInfo	dictionary	(*Optional*) See *The PostScript Language Reference Manual, second edition*, Table 5.4, page 268.

Table 2 *Additional entries in all base fonts (***FontType** *not 0)*

Key	*Type*	*Description*
Encoding	array[256]	(*Required*) An array of 256 glyph names ordered by glyph code value. The encoding is most likely to be either the Apple standard encoding or the Windows ANSI encoding, but other encodings will occur. See section 4.4, "Generating the Encoding Vector." **Encoding** must be a literal array.
FontBBox	array[4]	(*Required*) See description in *The PostScript Language Reference Manual, second edition*, Table 5.2. Derived from the TrueType head table. See also section 2.3, "Implications of The Glyph Coordinate System."
UniqueID	integer	(*Optional*) See section 4.6, "Generating Unique Identifiers."
XUID	array	(*Optional*) Array of integers that uniquely identifies this font or any variant of it. See section 5.8 of *The PostScript Language Reference Manual, second edition*. **XUID** must be a literal array.

Table 3 *Additional and modified entries in Type 42 fonts*

Key	*Type*	*Description*
PaintType	integer	(*Required*) 0 for filled glyphs; 2 for stroked glyphs.

StrokeWidth	number	(*Optional*) The width of the line used to stroke outline fonts (**PaintType** = 2), in glyph coordinates. This number is interpreted in glyph space; see section 2.3, “Implications of The Glyph Coordinate System.”
Metrics	dictionary	(*Optional*) Width and sidebearing information for writing mode 0. Not normally present in the original definition of a font; adding this dictionary to a font overrides the widths and sidebearings encoded in the glyph definitions in the TrueType font. This dictionary will only affect Type 42 fonts in version number 2013 and greater of the PostScript interpreter. The values in this dictionary are interpreted in glyph space; see section 2.3, “Implications of The Glyph Coordinate System.”
Metrics2	dictionary	(*Optional*) Width and sidebearing information for writing mode 1. In general this dictionary is only interpreted by LanguageLevel 1 devices with composite font extensions and all LanguageLevel 2 devices; for Type 42 fonts it is only recognized by PostScript interpreter version 2013 and greater. The values in this dictionary are interpreted in glyph space; see section 2.3, “Implications of The Glyph Coordinate System.”
CDevProc	procedure	Algorithmically derives global changes to a font’s metrics. See *The PostScript Language Reference Manual, second edition*, p. 277. **CDevProc** works the same in a Type 42 font as in a Type 1 font, aside from the different glyph coordinate system; see section 2.3, “Implications of The Glyph Coordinate System.”
CharStrings	dictionary	(*Required*) Associates glyph names with glyph descriptions. If an entry’s value is an integer, it is used as an index into the TrueType loca table, which contains the byte offsets of glyph definitions in the glyf table. If the value is a procedure (executable array or packed array), it is interpreted as described in section 5.6.3 of *The PostScript Language Reference Manual, second edition*. This dictionary must have an entry whose key is .notdef.
sfnts	array	(*Required*) An array of one or more PostScript language string objects containing the binary TrueType font. (see section 4.2 for information on the constraints and format).
CIDMap	array, string, integer, or dictionary	(*Required*) Maps CIDs to glyph indices. If **CIDMap** is a string, it is treated as an array of glyph index values, each of which is **GDBytes** long, stored high-order byte first. If **CIDMap** is an array of strings, the strings are logically concatenated; each must be a multiple of **GDBytes** long. If **CIDMap** is a dictionary, its keys are CIDs and its values are integers representing glyph indices. If **CIDMap** is an integer, it is simply added to the CID to yield a glyph index. See Section 5.4, “Changes to CIDMap.”

GDBytes	**integer**	(Required if **CIDMap** is a string or array) Number of bytes representing each glyph index in the **CIDMap**.
GlyphDirectory	array or dictionary	(*Optional*) See Section 5.5, “GlyphDirectory.”
MetricsCount	integer	*(Optional)* 0, 2, or 4. Default value: 0 See Section 5.7, “MetricsCount.”

2.3 Implications of The Glyph Coordinate System

As indicated in Table 1, a Type 42 font’s glyph coordinate system is typically defined as an identity transform. This is in contrast to a Type 1 font, whose glyph coordinate system is typically defined at a 1000 unit scale relative to user space.

This difference has implications regarding the interpretation of font dictionary entries whose values are defined in glyph space. If a PostScript program adds or changes such entries in a font dictionary, it must choose values that are appropriate for the font’s glyph coordinate system. In particular, values that would be appropriate for a Type 1 font will be 1000 times too large for a Type 42 font.

The font dictionary entries for which this issue arises include:

- The value of **StrokeWidth** (when **PaintType** has been set to 2);
- The contents of the **Metrics** and **Metrics2** dictionaries;
- The operands and results of the **CDevProc** procedure;
- The values of **UnderlinePosition** and **UnderlineThickness** in the **FontInfo** dictionary.
- The values in the **FontBBox** array.

3 Identifying Interpreters with TrueType Rasterizers

PostScript interpreters with TrueType rasterizers can be identified from the following entry in the device’s PPD file (version 4.1 of the specification):

```
*TTRasterizer: RasterizerOption
```

where *RasterizerOption* can be any of the following:

None	No TrueType rasterizer is present, and the device is not capable of receiving a downloadable rasterizer. To use a TrueType font on this interpreter, it must be converted to a Type 1 or Type 3 font.
Accept68K	No TrueType rasterizer is built-in, but the device has a 680X0-based controller and enough memory to accept a downloadable TrueType rasterizer. (The code to accomplish this is proprietary to Apple Computer, and is not generally available).
Type42	The device has a Type 42 TrueType rasterizer in ROM.

A PostScript program can determine whether a LanguageLevel 2 or 3 device supports Type 42 fonts (no LanguageLevel 1 devices support Type 42) by executing:

```
42 /FontType resourcestatus {pop pop true} {false} ifelse
```

which pushes *true* or *false* on the stack depending on whether Type 42 font support is present.

4 Conversion Issues

The following sections discuss issues related to converting a TrueType font into a Type 42 font.

4.1 The FontInfo Dictionary

The optional **FontInfo** dictionary may be constructed from entries in the name and post tables in the TrueType font. It is not used by the PostScript interpreter, but some PostScript programs may utilize entries such as **UnderlinePosition** and **UnderlineThickness**.

4.2 The sfnts Array

In VM, a TrueType font is represented as an array named **sfnts** consists of PostScript string objects which, when concatenated, represent the entire TrueType font. Multiple strings may be required due to the PostScript language implementation limit of 65535 bytes in a string.

When a TrueType font is divided into multiple strings, for compatibility with pre-2013 interpreters, the strings must begin at TrueType table boundaries, or at individual glyph boundaries within the glyf table. The TrueType file format requires that tables begin at 4-byte boundaries and that individual glyph

descriptions begin at 2-byte boundaries. Therefore, each string will contain an even number of bytes of TrueType data. There is a practical limit of 64 K on the size of tables (except for the glyf table), until PostScript version 3011.

For compatibility with Type 42 implementations in PostScript interpreter versions prior to 2013, each string must have one additional padding byte appended by adding “00” to the hex data in the file. That is, the length of each string must be odd. The last byte is not logically part of the TrueType font data and is ignored by the interpreter.

The **sfnts** array is expressed as a series of strings:

```
/sfnts [ <string1> <string2> … <stringN> ] def
```

In the font file, the strings are made up of lines of hexadecimal characters. The characters in each line may be preceded, followed, and divided by an arbitrary (but consistent) number of white space or control characters (see the additional compatibility constraint in the bullet list below for fonts downloaded to a hard disk).

For Type 42 fonts to be downloaded to a printer’s disk (or other file system hardware), there are specific additional constraints on the text representation of that array in the file. Observing these constraints and beginning the file with the correct comment line (see section 2.1) enables the PostScript interpreter to have dynamic access to the font file on an as-needed basis, which has significant implications for saving VM. If a Type 42 font has the correct initial comment line but does not conform to the constraints listed below, the result will be an invalidfont error on some interpreters.

Although newer versions of the PostScript interpreter are likely to have fewer restrictions on the format of the **sfnts** array, the following constraints should be used, for backward compatibility purposes, to enable dynamic access to a disk-based font file:

- There may be whitespace and/or control characters between the **/sfnts**, the ‘[’, and the ‘<’, and between any string’s ‘>’ and the next string’s ‘<’.

- The string should be subdivided into lines of a constant *n* characters in length and which may be divided by *m* characters of white space and/or control characters. The numbers *n* and *m* must be constant for the entire **sfnts** array, although it may vary from font to font. Line lengths should also satisfy the Document Structuring Convention (DSC) constraint: $0 < n \leq 255$ (see Appendix G of *The PostScript Language Reference Manual, second edition).*

- The data encoding technique used in the **sfnts** array, for example, either ASCII-Hex or binary (see below) must be the same for all strings in a particular font, but may vary among fonts.

The strings in the **sfnts** array may be represented in binary in the same way as may be used for Type 1 charstrings (see section 2.4 in the *Adobe Type 1 Font Format* book). However, fonts using this representation cannot be installed on disk in PostScript interpreter versions prior to 2013. Also, they cannot be safely transmitted across non-binary channels, so fonts in this format should not be embedded in documents. Use of this format should be limited to disk font installer utilities that know something about the capabilities of the PostScript interpreter being accessed.

To represent a string in a binary representation, a PostScript language procedure must be defined with the following code:

```
/RD {string currentfile exch readstring pop} executeonly def
```

Each use of RD is followed by exactly one blank character followed by a sequence of binary bytes that are the string contents:

```
n RD ~binary~bytes~ {noaccess def} executeonly def
```

RD itself is preceded by an integer *n* which is the number of binary bytes following the RD (not including the single blank that follows the RD).

The following is an example of a two-element **sfnts** array encoded in this way:

```
/sfnts [
   62135 RD ~62135~binary~bytes~
   12093 RD ~12093~binary~bytes~
   ] def
```

Each string contains an even number of bytes of TrueType data, followed by one byte of padding which the PostScript interpreter ignores.

4.3 Generating The CharStrings Dictionary

The **CharStrings** dictionary for a Type 42 font is a standard dictionary of *key/value* pairs, where the *key* is the glyph's name (derived from the TrueType font's cmap table), and the *value* is an index number into the TrueType font's loca (glyph offsets) table. The value in the key/value pair may also be a PostScript language procedure (executable array or packed array); see section 5.6.3 of the *The PostScript Language Reference Manual, second edition.*

4.4 Generating the Encoding Vector

Note The **/Encoding** vector associates a code point with a glyph name. The glyph name is used to look up the glyph's glyph id in the **Charstrings** dictionary. Glyph names can either be inferred by the encoding used by the font, or can be derived from glyph names in the font's post table—if the font's post table is of a version that allows glyph names.

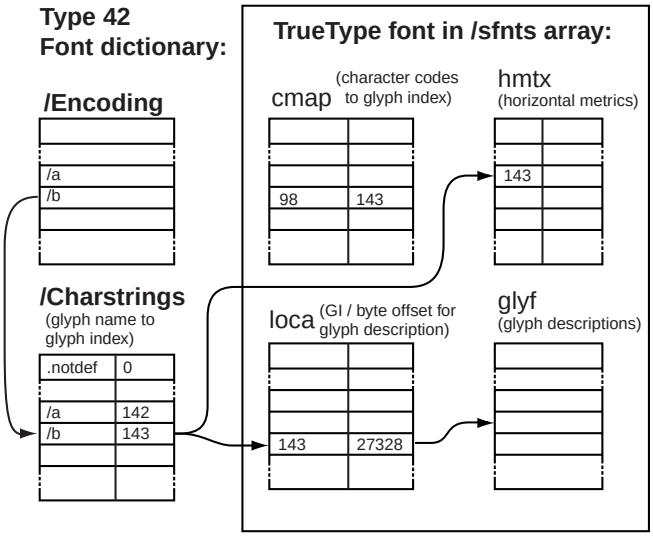
TrueType fonts used in the Windows or Macintosh environments will generally use the encoding specific to that system, such as ANSI for Windows and the Apple encoding for the Macintosh. The platform-specific encoding can be determined by the platform ID number in a subtable of the cmap table. The post table lists glyph names that differ from the platform's standard encoding. Only versions 1.0, 2.0, and 2.5 of the post table allow the inclusion of glyph names. Formats 3.0 (the one used in most TrueType fonts), and 4.0, do not contain glyph names. If there is no post table in a TrueType font in the Windows environment, the Windows ANSI encoding can be assumed.

When downloading and installing a Type 42 font on a printer's hard disk, it is essential that the software use a naming convention that is consistent with that used by software on any host system that might be connected to the printer.

4.5 Glyph Mapping and Metrics Access

Figure 1 illustrates how TrueType glyph descriptions and metrics are referenced by character codes and names in a Type 42 font dictionary.

Figure 1 *Type 42 Font Glyph Mapping*



When a printer driver builds a Type 42 font, it uses the TrueType cmap table to map character codes to glyph indices, which enables it to build the **/Charstrings** dictionary (which associates PostScript character names with TrueType glyph indices). However, the cmap table is not used by the PostScript interpreter, so it need not be downloaded.

The PostScript interpreter uses the /**Encoding** array to look up the character name, which is then used to access the /**Charstrings** entry with that name. The value of that entry is the glyph index, which is then used to retrieve the glyph description's byte offset in the loca table. The glyph index is also used

to get metrics from the hmtx. As of PostScript interpreter version 3011, the glyph index can also be used to get vertical metrics from the vmtx table (see section 5.6, “Vertical Writing Mode”).

4.6 Generating Unique Identifiers

The Type 42 font may contain an unique identifier which allows the glyph bitmaps to be cached across print jobs (see also section 5.8 of *The PostScript Language Reference Manual, second edition*). This entry is optional but highly desirable since many users may use the same fonts in every print job.

Bitmaps generated from TrueType fonts in Type 42 format use the same caching system as is used for Type 1 fonts. When a glyph bitmap is needed from a Type 42 font, the glyph cache is checked first. If the bitmap has not been cached, the bitmap is produced from the outline font program.

TrueType fonts do not contain any type of unique number which either corresponds to the PostScript language **UniqueID** entry or could be used for such. Using something like a checksum number as a **UniqueID** value devices would not be advisable since it does not assure uniqueness. Although this approach would work in many situations, there is an increased and unacceptable risk when, as at a service bureau, bitmaps are cached on a hard disk for a potentially long period of time. Hence, the performance gain resulting from caching does not offset the danger of a user getting incorrect bitmaps from the cache.

Since TrueType rasterizers only exist in LanguageLevel 2 interpreters, the **XUID** operator offers a safer opportunity to cache bitmaps. The **XUID** (extended unique ID) is an array of integers which provides for distributed, hierarchical management of **UniqueID** numbers. The goal is to have a mechanism for generating an **XUID** array of values, on-the-fly, which are unique for every font, yet exactly repeatable since a TrueType font in a user’s system may be converted multiple times to a Type 42 for printing.

A recommended method for generating a number for a given font which is both more likely to be unique than a simple checksum and exactly repeatable, is to use the MD5 algorithm from RSA Data Security, Incorporated. Their software can be copied and freely distributed if it is properly identified. The code for this algorithm is readily available from:

RSA Data Security, Inc.
100 Marine Parkway
Redwood City, CA 94065

The goal is to generate an **XUID** array of five elements, with the first having the value of 42 (decimal). This value has been registered in the Adobe **XUID** registry for use by software in creating Type 42 fonts. The MD5 algorithm

can then be used to generate a 128-bit number, using the font file as input. This number can then be divided into four 32-bit integers to make the other four elements of the array. Some optimization of the algorithm code may be necessary to enhance performance.

4.7 Required TrueType Tables

In creating a Type 42 font from a TrueType font, only a subset of all potential tables in the original font are actually used by the rasterizer in the PostScript interpreter. The following tables are the set of tables that are used by the TrueType rasterizer. Not all of these tables are required for every configuration of a Type 42 font.

head	prep	cvt_
hhea	fpgm	maxp
hmtx	vhea	vmtx
loca	glyf	

The tables vhea and vmtx are *only* supported in version 3011 or higher, and only when **MetricsCount** has a value of 0 or 2, or if the **MetricsCount** keyword is not included. Also, for compatibility reasons, **CDevProc** should be included for vertical writing mode.

Since a significant number of tables may be included in a TrueType font (including potentially large kerning and metrics tables), performance may be improved by including in the downloadable Type 42 font only the tables actually used by the TrueType rasterizer.

5 CIDFontType 2 CID Fonts

Version 2015 of the PostScript interpreter introduced support for large Chinese, Japanese, and Korean (CJK) multi-byte TrueType fonts by supporting the use of CID fonts that contain TrueType glyphs. The CID font format allows thousands of glyphs to be encoded and accessed. The CID font must have the keyword/values **CIDFontType** 2, and **FontType** 42. For information on the CID format, see Technical Note #5014, *Adobe CMap and CIDFont Files Specification*.

For downloading and installing a **CIDFontType** 2 CID font to a printer's hard disk, the font should contain the TrueType font embedded in the **sfnts** array. The number of tables included can be limited to only those tables used by the rasterizer (see section 4.7, "Required TrueType Tables"). The inclusion of other tables depends on the desired optimizations for printing speed, or whether the font is to be permanently downloaded to a printer's hard disk. For example, for vertical writing, a **GlyphDirectory** may be included in the

PostScript portion of the font if the font is to be subsetted or incrementally downloaded; but for disk-based fonts, including the vhea and vmtx tables in the **sfnts** array gives better performance.

A large CJK TrueType font may have 35,000 glyphs, as well as a number of very large data tables. For a **CIDFontType** 2 CID font that is to be downloaded for printing a specific document, a number of optimizations can be made to limit the amount of data that must be downloaded. For example, the font can be subsetted to include only the glyphs needed in the document, and those glyphs can be downloaded incrementally on an as-needed basis. These optimizations can improve performance as well as save VM, which helps to ensure that a document will print when memory is low.

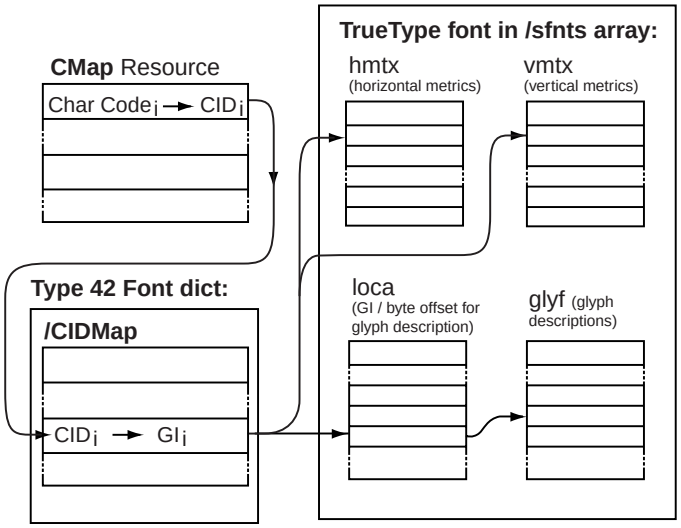
5.1 Complete Font Downloading

When downloading a TrueType font to a printer's hard disk, the optimizations for subsetting and incremental downloading are not used because the full font must be available.

Figure 2 shows the configuration for glyph mapping for TrueType fonts to be permanently downloaded to a printer's hard disk. It is desirable to have a full **CIDMap**, as well as full hmtx, vmtx, loca, and glyf tables. The TrueType cmap table is not shown because it is not needed by the rasterizer, but it is used initially by the driver software to get the glyph indices for building the **/Charstrings** dictionary.

The interpreter maps a character code to a CID number, and uses the CID to get the TrueType glyph index from **CIDMap**. The glyph index is then used to get horizontal or vertical metrics from the hmtx or vmtx tables, respectively. A glyph description is obtained from the glyf table by getting its byte offset from the loca table.

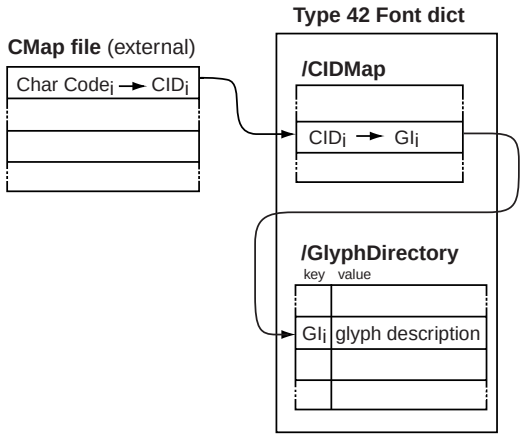
Figure 2 *CID Type 42 Font for Disk Installation*



5.2 Incremental Font Downloading

Figure 3 shows an example of how glyphs are accessed for **CIDFontType** 2 CID fonts that use a **GlyphDirectory** for subsetting and incremental downloading. The **CMap** resource is used to map the character code to a CID number, and the **CIDMap** maps CIDs to glyph indices. If a special **CMap** can be constructed which makes **CIDMap** an identity mapping, then downloading the identity **CIDMap** is wasteful and unnecessary. In this case, **CIDMap** can simply be defined as an integer. The glyph index is then used to access the glyph description in **GlyphDirectory**.

Figure 3 CIDFontType *2 CID Glyph Mapping for Downloading*



5.3 CMap Resources for CIDFontType 2 CID Fonts

CIDFontType 2 fonts must have an associated **CMap** resource. Since the original TrueType font does not have a CMap file, the driver or downloader software must create one.

The **CMap** resource (maps character codes to CIDs) can be constructed so that the mapping in **CIDMap** (CIDs to glyph indices) is an *identity* mapping, such that:

$$GI_i = CID_i$$

Because the resulting **CIDMap** uses an identity mapping, it is not necessary to download **CIDMap** as a dictionary or array, thus saving a significant amount of VM. Although **CIDMap** is a required entry, it can be defined as having an integer value (see “Defining CIDMap as an Integer” in section 5.4). In the general case, the value of the integer would be zero.

A CID-keyed font must reference the **/Registry**, **/Ordering**, and **/Supplement** specified in the **CMap** resource. Hence, both the CIDFont and the CMap must be built to reflect that relationship (see Adobe Technical Note #5014, *Adobe CMap and CIDFont Files Specification*).

5.4 Changes to CIDMap

Prior to interpreter version 3011, a **CIDMap** could be either a string or an array of strings, and was interpreted as a mapping of CIDs to glyph indices. The resulting glyph index is then used to access glyphs in either the glyf table or the **GlyphDirectory**, as well as metrics data in the hmtx or vmtx tables in the TrueType font.

For large multi-byte fonts, **CIDMap**s tend to be fairly large, and if only a fraction of the font's glyphs are needed for a particular document, storage space can be wasted. For example, the Windows Simplified Chinese font SimHei has about 25 K glyphs and its **CIDMap** requires about 50 KB of file size and VM. The following sections explain how to define **CIDMap** as a dictionary or an integer, so only a subset of all glyph mappings need to be downloaded. Alternatively, it can be defined as an integer, so that the **CIDMap** need not be downloaded at all (except as a single value).

Defining CIDMap as a Dictionary

Defining **CIDMap** as a dictionary facilitates incremental downloading of glyphs by allowing the downloading of only the mapping entries needed by the current document. This can save a significant amount of both file and VM space.

Defining CIDMap as an Integer

CIDMap can be defined as having a single integer value:

```
/CIDMap integer
```

where *integer* is interpreted as an offset that is added to the CID obtained from the **CMap** resource, to map to the corresponding glyph index value:

GI = integer + CID

For the general case, the value of the integer will be zero. It may also sometimes be necessary to create a **CIDMap** in which there is an offset from the Identity mapping. For example, if it is attempted to download a TrueType font with 20,000 glyphs to a printer's hard disk, the large loca table (20K x 4 bytes/entry) will not be interpreted correctly if it is split into multiple **sfnts** strings. The font can be downloaded as two CIDFonts, one with the glyph's from 0 to n–1; and the other with glyphs from n to 20K–1 (being careful not to split composite glyphs across two fonts). Hence, a glyph index used in a host document can be looked up using the CMap (where GI = CID) to decide which CIDFont to use when printing.

5.5 GlyphDirectory

Both Type 42 and **CIDFontType** 2 CID fonts may be created with a **GlyphDirectory** array or dictionary, which allows font subsetting and incremental downloading.

For a **CIDFontType** 2 font, if **GlyphDirectory** is a dictionary, each key is an integer glyph index, and the value is a string containing the TrueType glyph description. If **GlyphDirectory** is an array, its length must be greater than the

highest glyph index in the font. Each array element can be either null (indicating an empty element), or a string containing the TrueType glyph description.

Starting with PostScript version 2015, the interpreter checks for the existence of a gdir table in the **sfnts** array, and if found, uses **GlyphDirectory** in place of the loca and glyf tables. This table, which is not in the TrueType font format specification, must be inserted by the software that builds the **CIDFontType** 2 font. The size and offset of the gdir table must be zero, it is only used to specify the use of the **GlyphDirectory** entry in the font dictionary.

The loca or hmtx tables are of the order of magnitude of 4 bytes × numGlyphs. Thus, for incrementally downloaded or subset fonts, the choice to use **GlyphDirectory** avoids the need to download a large and mostly unused loca table, and saves the corresponding space in VM. For PostScript versions before 3011, for these same small fonts, the large and mostly unused hmtx table must still be downloaded. In 3011, the horizontal and vertical metrics may be included in the **GlyphDirectory**, making it unnecessary to download the additional tables (see section 5.7, “MetricsCount”).

For large **CIDFontType** 2 CID fonts that are to be permanently downloaded in full to a PostScript file system, **GlyphDirectory** should not be used because it is less efficient than using the loca and glyf table method. In addition, for compatibility with earlier PostScript versions, some font downloading applications may choose to download the hmtx table (and, now, vmtx table) rather than a **GlyphDirectory**, in order to provide compatibility with interpreters before 3011.

Once a **GlyphDirectory** array or dictionary is defined, a PostScript program may insert entries containing new glyph descriptions by replacing null array elements with strings or inserting new dictionary entries. It may not replace entries that are not null; due to font caching, any attempts to do so will yield unpredictable results. If a glyph is added to **GlyphDirectory** between **save** and **restore** operations, the **restore** operator will remove it, since this is equivalent to replacing an entry that is not null. To avoid this problem, the driver must download the same glyph definition again before the next attempt to perform a **show** operation on that glyph.

As is true for all CID fonts, an attempt to perform a **show** operation on a glyph whose CID selects a null or missing entry in the **CMap** resource, the CMap will be consulted to see if there is a .notdef CID for that character code. If there is, it will be used; otherwise a CID of 0 will be used. The **GlyphDirectory** entry for CID 0 must be present and not null, or an **invalidfont** error will occur.

If **GlyphDirectory** is an array, it must be allocated with enough entries to store the highest CID or glyph index that is expected. Any unused entries in the array will be wasted space. An array of a given length consumes about 40

percent of the memory used by a dictionary of the same length. Thus, the dictionary representation is advisable only for a sparsely populated font containing less than 40 percent of the total glyphs in the font.

5.6 Vertical Writing Mode

CJK fonts are typically used in either horizontal or vertical typographic modes. For vertical layout, the metrics data is available in the host font's vmtx table (advance height and top side bearing). It is up to the print driver to decide whether both horizontal and vertical metrics need to be included in the **CIDFontType** 2 CID font that is to be downloaded.

/**WMode** 1 indicates that the renderer should use vertical metrics. Thus, if **MetricsCount** is 0 or 2 (see section 5.7, "MetricsCount" below) the metrics data is found in the vmtx table, which must be provided. If **MetricsCount** is missing (the default value is 0, which indicates that no metrics are contained in **GlyphDirectory)**, it is up to the creator to provide the metrics using **CDevProc** or **Metrics2**, or both. If **MetricsCount** is 4, the data is found in the first through fourth bytes at the start of the glyph description.

5.7 MetricsCount

The addition of the **MetricsCount** key in 3011 allows the inclusion of metrics data in the **GlyphDirectory** dictionary or array. This has the advantage that only the metrics for the subsetted characters need be included, rather than having to download complete hmtx and vmtx tables.

When a key **/MetricsCount** is found in a CIDFont with **CIDFontType** 2, it must be an integer with values 0, 2, or 4.

Prior to 3011, the TrueType rasterizer in a PostScript interpreter ignored metrics specified for vertical writing mode in the vmtx table, and vertical metrics had to be supplied using a **Metrics2** dictionary. For a full font downloaded to PostScript file system, the full **Metrics2** dictionary is large and takes up a large amount of VM. Even for a font which is incrementally downloaded or subsetted, the **Metrics2** overhead is inefficient. With 3011, the vertical metrics can be supplied using a vmtx table, or they can be embedded in the **GlyphDirectory** entries for incremental downloading.

Table 4 shows where the metrics data is located, based on the value of **MetricsCount**.

Table 4 *Metrics Location based on MetricsCount Value*

MetricsCount	Number of metrics data bytes	Horizontal Metrics	Vertical Metrics
0	0	hmtx or **Metrics** dictionary	vmtx, **Metrics2** dictionary, or **CDevProc**
2	4	**GlyphDirectory** (4 bytes preceding the glyph description)	vmtx, **Metrics2**, or **CDevProc**
4	8	**GlyphDirectory** (second set of four bytes preceding the glyph description)	**GlyphDirectory** (first set of four bytes preceding the glyph description—see Table 5)

MetricsCount may have a value of 0, 2, or 4. A value of 0 indicates that no metrics data is included in the **GlyphDirectory**, and hmtx and/or vmtx tables are included in the font. If **MetricsCount** is missing, a value of 0 is implied.

If **MetricsCount** is 2 or 4, it specifies that horizontal, or vertical and horizontal metrics, respectively, precede the glyph description in the **GlyphDirectory** dictionary or array. These metrics values are copied directly from the TrueType glyph description, without any conversion or translation.

In all cases, the glyph description will begin (2 × **MetricsCount**) bytes from the beginning of the string. If **MetricsCount** has a value of 2, the four bytes of data will be the horizontal advance width and left sidebearing. If **MetricsCount** has a value of 4, then there will be eight bytes of metrics data: the vertical advance height and top sidebearing, followed by the horizontal advance width and sidebearing, with the first byte of each pair being the high order byte.

Table 5 *Metrics Data in Glyph Directory*

MetricsCount	byte #	semantics
2	0,1	horizontal advance width
	2,3	left sidebearing

Table 5 *Metrics Data in Glyph Directory*

MetricsCount	byte #	semantics
4	0,1	vertical advance width
	2, 3	top sidebearing
	4, 5	horizontal advance width
	6, 7	left sidebearing

6 Known Bugs

There is a known bug in the TrueType rasterizer included in versions of the PostScript interpreter previous to version 2013. The problem is that the translation components of the **FontMatrix**, as used as an argument to the **definefont** or **makefont** operators, are ignored. Translation of user space is not affected by this bug.

7 Example Type 42 single-byte font program

```
%!PS-TrueTypeFont-65536-65536-1
   11 dict begin
   /FontName /Chicago def
   /Encoding 256 array
   0 1 255{1 index exch/.notdef put}for
   dup 0 /.null put
   dup 1 /option put
   dup 2 /control put
   %
   %... many Encoding array entries omitted...
   %
   dup 253 /hungarumlaut put
   dup 254 /ogonek put
   dup 255 /caron put
   readonly def
   /PaintType 0 def
   /FontMatrix [1 0 0 1 0 0] def
   /FontBBox[-190 -283 1164 1090] def
   /FontType 42 def
   /XUID [42 16#7880BE99 16#AC616C9D 16#D021DE98 16#1F9CD56E] def
   %
   % Optional FontInfo dictionary may be inserted here
   %
   /sfnts[<
   000100000009000900090009
   637674202B194DE00000009C00000290
   6670676D31773E000000032C000003B6
   %
   %...many sfnts lines omitted...
   %
   58B0FF1D594569534273737373737373737474737345684400
   00>]def
   /CharStrings 279 dict dup begin
   /.notdef 0 def/.null 1 def/nonmarkingreturn 2 def
   /space 3 def/exclam 4 def /quotedbl 5 def/numbersign 6 def
   /dollar 7 def/percent 8 def/ampersand 9 def
   %
```

```
%...many CharStrings entries omitted...
%
/checkmark 273 def/linebreakltor 274 def
/linebreakrtol 275 def /markingnobreakspace 276 def
/diamond 277 def/appleoutline 278 def end readonly def
FontName currentdict end definefont pop
```

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