2 Common Table Formats

TrueType Open consists of five tables: the Glyph Substitution table (GSUB), the Glyph Positioning table (GPOS), the Baseline table (BASE), the Justification table (JSTF), and the Glyph Definition table (GDEF). These tables use some of the same data formats. This chapter explains the conventions used in all TrueType Open tables, and it describes the common table formats. Separate chapters provide complete details about the GSUB, GPOS, BASE, JSTF, and GDEF tables.

Overview

The TrueType Open tables provide typographic information for properly positioning and substituting glyphs, operations that are required for accurate typography in many language environments. TrueType Open data is organized by script, language system, typographic feature, and lookup.

Scripts are defined at the top level. A *script* is a collection of glyphs used to represent one or more languages in written form (see Figure 2a). For instance, a single script—Latin—is used to write English, French, German, and many other languages. In contrast, three scripts—Hiragana, Katakana, and Kanji—are used to write Japanese. With TrueType Open, multiple scripts may be supported by a single font.

Figure 2a. Glyphs in the Latin, Kanji, and Arabic scripts

A *language system* may modify the functions or appearance of glyphs in a script to represent a particular language. For example, the eszet ligature is used in the German language system, but not in French or English (see Figure 2b). And the Arabic script contains different glyphs for writing the Farsi and Urdu languages. In TrueType Open, language systems are defined within scripts.

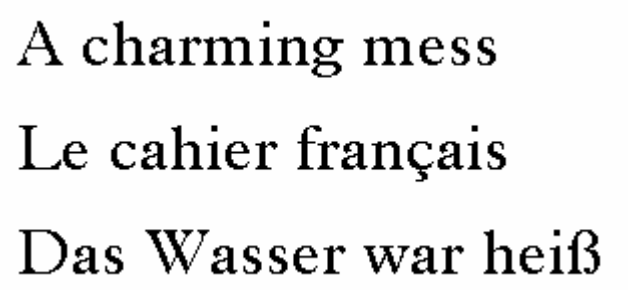


Figure 2b. Differences in the English, French, and German language systems

A language system defines *features*, which are typographic rules for using glyphs to represent a language. Sample features are a “vert” feature that substitutes vertical glyphs in Japanese, a “liga” feature for using ligatures in place of separate glyphs, and a “mark” feature that positions diacritical marks with respect to base glyphs in Arabic (see Figure 2c). In the absence of language-specific rules, default language system features apply to

the entire script. For instance, a default language system feature for the Arabic script substitutes initial, medial, and final glyph forms based on a glyph's position in a word.

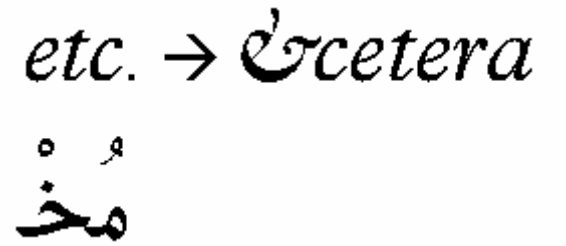


Figure 2c. A ligature glyph feature substitutes the <etc> ligature for individual glyphs, and a mark feature positions diacritical marks above an Arabic ligature glyph.

Features are implemented with lookup data that the text-processing client uses to substitute and position glyphs. *Lookups* describe the glyphs affected by an operation, the type of operation to be applied to these glyphs, and the resulting glyph output.

Table Organization

Two TrueType Open tables, GSUB and GPOS, use the same data formats to describe the typographic functions of glyphs and the languages and scripts that they support: a ScriptList table, a FeatureList table, and a LookupList table. In GSUB, the tables define glyph substitution data. In GPOS, they define glyph positioning data. This chapter describes these common table formats.

The ScriptList identifies the scripts in a font, each of which is represented by a Script table that contains script and language-system data. Language system tables reference features, which are defined in the FeatureList. Each feature table references the lookup data defined in the LookupList that describes how, when, and where to implement the feature.

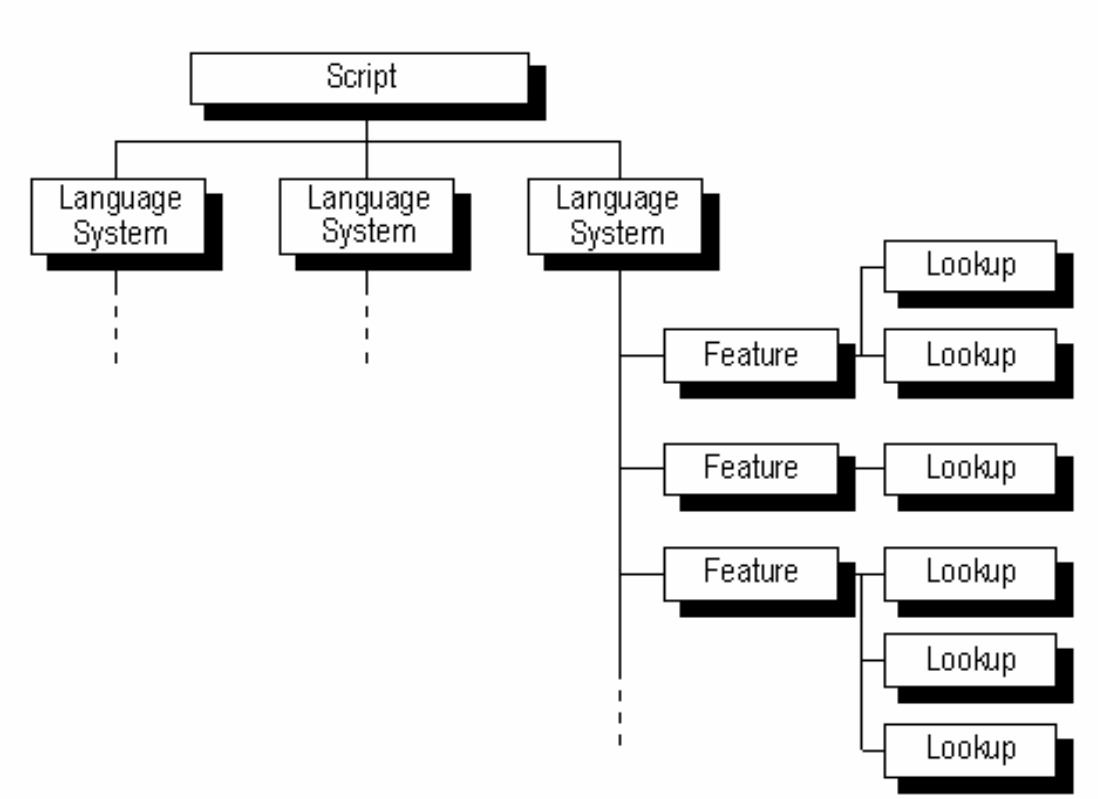


Figure 2d. The relationship of scripts, language systems, features, and lookups for substitution and positioning tables

> **Note:** The data in the BASE and JSTF tables also is organized by script and language system. However, the data formats differ from those in GSUB and GPOS, and they do not include a FeatureList or LookupList. The BASE and JSTF data formats are described in the BASE and JSTF chapters.

The information used to substitute and position glyphs is defined in Lookup subtables. Each subtable supplies one type of information, depending upon whether the lookup is part of a GSUB or GPOS table. For instance, a GSUB lookup might specify the glyphs to be substituted and the context in which a substitution occurs, and a GPOS lookup might specify glyph position adjustments for kerning. TrueType Open has five types of GSUB lookups (described in the GSUB chapter) and seven types of GPOS lookups (described in the GPOS chapter).

Each subtable includes a Coverage table that lists the “covered” glyphs that will result in a glyph substitution or positioning operation. The Coverage table formats are described in this chapter.

Some substitution or positioning operations may apply to groups, or classes, of glyphs. GSUB and GPOS Lookup subtables use the Class Definition table to assign glyphs to classes. This chapter includes a description of the Class Definition table formats.

Lookup subtables also may contain device tables, described in this chapter, to adjust scaled contour glyph coordinates for particular output sizes and resolutions. This chapter also describes the data types used in TrueType Open. Sample tables and lists that illustrate the common data formats are supplied at the end of this chapter.

Conventions

Many data types, listed below, are used in the TrueType Open table formats. As with all other TrueType data types, the TrueType Open tables store multi-byte values in "Motorola order," with the most significant byte first.

Data types

Type	Description
uint8	Unsigned character (length = 8 bits)
uint16	Unsigned integer (length = 16 bits)
int16	Signed integer (length = 16 bits)
uint32	Unsigned long integer (length = 32 bits)
fixed32	Fixed point 16.16 number (length = 32 bits)
Tag	Array of four uint8s (length = 32 bits) —used to identify a script, language system, feature, or baseline
GlyphID	Glyph index number, same as uint16 (length = 16 bits)
Offset	Offset to a table, same as uint16 (length = 16 bits) —NULL offset = 0x0000

Scripts and Languages

Three tables and their associated records apply to scripts and languages: the Script List table (ScriptList) and its script record (ScriptRecord), the Script table and its language system record (LangSysRecord), and the Language System table (LangSys).

Script List Table and Script Record

TrueType Open fonts may contain one or more groups of glyphs used to render various scripts, which are enumerated in a ScriptList table. Both the GSUB and GPOS tables define Script List tables (ScriptList):

- The GSUB table uses the ScriptList table to access the glyph substitution features that apply to a script. For details, see the chapter, The Glyph Substitution Table (GSUB).
- The GPOS table uses the ScriptList table to access the glyph positioning features that apply to a script. For details, see the chapter, The Glyph Positioning Table (GPOS).

A ScriptList table consists of a count of the scripts represented by the glyphs in the font (ScriptCount) and an array of records (ScriptRecord), one for each script for which the

font defines script-specific features (a script without script-specific features does not need a ScriptRecord).
The ScriptRecord array stores the records alphabetically by a ScriptTag that identifies the script. Each ScriptRecord consists of a ScriptTag and an offset to a Script table.
Example 1 at the end of this chapter shows a ScriptList table and ScriptRecords for a Japanese font that uses three scripts.

ScriptList table

Type	Name	Description
uint16	ScriptCount	Number of ScriptRecords
struct	ScriptRecord[ScriptCount]	Array of ScriptRecords —listed alphabetically by ScriptTag

ScriptRecord

Type	Name	Description
Tag	ScriptTag	4-byte ScriptTag identifier
Offset	⇨ Script	Offset to Script table —from beginning of ScriptList

Script Table and Language System Record

A Script table identifies each language system that defines how to use the glyphs in a script for a particular language. It also references a default language system that defines how to use the script's glyphs in the absence of language-specific knowledge.
A Script table begins with an offset to the Default Language System table (DefaultLangSys), which defines the set of features that regulate the default behavior of the script. Next, Language System Count (LangSysCount) defines the number of language systems (excluding the DefaultLangSys) that use the script. In addition, an array of Language System Records (LangSysRecord) defines each language system (excluding the default) with an identification tag (LangSysTag) and an offset to a Language System table (LangSys). The LangSysRecord array stores the records alphabetically by LangSysTag.
If no language-specific script behavior is defined, the LangSysCount is set to zero (0), and no LangSysRecords are allocated.

Script table

Type	Name	Description
Offset	⇨ DefaultLangSys	Offset to DefaultLangSys table —from beginning of Script table —may be NULL
uint16	LangSysCount	Number of LangSysRecords for this script —excluding the DefaultLangSys
struct	LangSysRecord [LangSysCount]	Array of LangSysRecords —listed alphabetically by LangSysTag

LangSysRecord

Type	Name	Description
Tag	LangSysTag	4-byte LangSysTag identifier
Offset	⇨ LangSys	Offset to LangSys table —from beginning of Script table

Language System Table

The Language System table (LangSys) identifies language-system features used to render the glyphs in a script. (The LookupOrder offset is reserved for future use.)

Optionally, a LangSys table may define a Required Feature Index (ReqFeatureIndex) to specify one feature as required within the context of a particular language system. For example, in the Cyrillic script, the Serbian language system always renders certain glyphs differently than the Russian language system.

Only one feature index value can be tagged as the ReqFeatureIndex. This is not a functional limitation, however, because the feature and lookup definitions in TrueType Open are structured so that one feature table can reference many glyph substitution and positioning lookups. When no required features are defined, then the ReqFeatureIndex is set to 0xFFFF.

All other features are optional. For each optional feature, a zero-based index value references a record (FeatureRecord) in the FeatureRecord array, which is stored in a Feature List table (FeatureList). The feature indices themselves (excluding the ReqFeatureIndex) are stored in arbitrary order in the FeatureIndex array. The FeatureCount specifies the total number of features listed in the FeatureIndex array. Features are specified in full in the FeatureList table, FeatureRecord, and Feature table, which are described later in this chapter.

Example 2 at the end of this chapter shows a Script table, LangSysRecord, and LangSys table used for contextual positioning in the Arabic script.

LangSys table

Type	Name	Description
Offset	⇨ LookupOrder	= NULL (reserved for an offset to a reordering table)
uint16	ReqFeatureIndex	Index of a feature required for this language system — if no required features = 0xFFFF
uint16	FeatureCount	Number of FeatureIndex values for this language system —excludes the required feature
uint16	FeatureIndex [FeatureCount]	Array of indices into the FeatureList —in arbitrary order

Features and Lookups

Features define the functionality of a TrueType Open font and they are named to convey meaning to the text-processing client. Consider a feature named “liga” to create ligatures. Because of its name, the client knows what the feature does and can decide whether to

apply it. A current list of TrueType Open registered features and their are listed in the TrueType Open Registry chapter at the end of this document. Font developers can use these features, as well as create their own.
After choosing which features to use, the client assembles all lookups from the selected features. Multiple lookups may be needed to define the data required for different substitution and positioning actions, as well as to control the sequencing and effects of those actions.
To implement features, a client applies the lookups in the order the lookup definitions occur in the LookupList. As a result, within the GSUB or GPOS table, lookups from several different features may be interleaved during text processing. A lookup is completed when the client locates a target glyph or glyph context and substitutes or positions a glyph.

> **Note:** The substitution (GSUB) lookups always occur before the positioning (GPOS) lookups. The lookup sequencing mechanism in TrueType relies on the font to determine the proper order of text-processing operations.

Lookup data is defined in one or more subtables that contain information about specific glyphs and the operations to be performed on them. Each type of lookup has one or more corresponding subtable definitions. The choice of a subtable format depends upon two factors: the precise content of the information being applied to an operation, and the required storage efficiency. (For complete definitions of all lookup types and subtables, see the the GSUB and GPOS chapters of this document.)
TrueType Open features define information that is specific to the layout of the glyphs in a font. They do not encode information that is constant within the conventions of a particular language or the typography of a particular script. Information that would be replicated across all fonts in a given language belongs in the text-processing application for that language, not in the fonts.

Feature List Table

The headers of the GSUB and GPOS tables contain offsets to Feature List tables (FeatureList) that enumerate all the features in a font. Features in a particular FeatureList are not limited to any single script. A FeatureList contains the entire list of either the GSUB or GPOS features that are used to render the glyphs in all the scripts in the font. The FeatureList table enumerates features in an array of records (FeatureRecord) and specifies the total number of features (FeatureCount). Every feature must have a FeatureRecord, which consists of a FeatureTag that identifies the feature and an offset to a Feature table (described next). The FeatureRecord array is arranged alphabetically by FeatureTag names.

> **Note:** The values stored in the FeatureIndex array of a LangSys table are used to locate records in the FeatureRecord array of a FeatureList table.

FeatureList table

Type	Name	Description
uint16	FeatureCount	Number of FeatureRecords in this table
struct	FeatureRecord [FeatureCount]	Array of FeatureRecords —zero-based (first feature has FeatureIndex = 0) —listed alphabetically by FeatureTag

FeatureRecord

Type	Name	Description
Tag	FeatureTag	4-byte feature identification tag
Offset	⇨ Feature	Offset to Feature table —from beginning of FeatureList

Feature Table

A Feature table defines a feature with one or more lookups. The client uses the lookups to substitute or position glyphs.

Feature tables defined within the GSUB table contain references to glyph substitution lookups, and feature tables defined within the GPOS table contain references to glyph positioning lookups. If a text-processing operation requires both glyph substitution and positioning, then both the GSUB and GPOS tables must each define a Feature table, and the tables must use the same FeatureTags.

A Feature table consists of an offset to a Feature Parameters (FeatureParams) table (currently reserved for future use and set to NULL), a count of the lookups listed for the feature (LookupCount), and an arbitrarily ordered array of indices into a LookupList (LookupListIndex). The LookupList indices are references into an array of offsets to Lookup tables.

To identify the features in a GSUB or GPOS table, a text-processing client reads the FeatureTag of each FeatureRecord referenced in a given LangSys table. Then the client selects the features it wants to implement and uses the LookupList to retrieve the Lookup indices of the chosen features. Next, the client arranges the indices in the LookupList order. Finally, the client applies the lookup data to substitute or position glyphs.

Example 3 at the end of this chapter shows the FeatureList and Feature tables used to substitute ligatures in two languages.

Feature table

Type	Name	Description
Offset	⇨ FeatureParams	= NULL (reserved for offset to FeatureParams)
uint16	LookupCount	Number of LookupList indices for this feature
uint16	LookupListIndex [LookupCount]	Array of LookupList indices for this feature —zero-based (first lookup is LookupListIndex = 0)

Lookup List Table

The headers of the GSUB and GPOS tables contain offsets to Lookup List tables (LookupList) for glyph substitution (GSUB table) and glyph positioning (GPOS table). The LookupList table contains an array of offsets to Lookup tables (Lookup). The font developer defines the Lookup sequence in the Lookup array to control the order in which a text-processing client applies lookup data to glyph substitution and positioning operations. LookupCount specifies the total number of Lookup table offsets in the array. Example 4 at the end of this chapter shows three ligature lookups in the LookupList table.

LookupList table

Type	Name	Description
uint16	LookupCount	Number of lookups in this table
Offset	⇨ Lookup[LookupCount]	Array of offsets to Lookup tables —from beginning of LookupList —zero based (first lookup is Lookup index = 0)

Lookup Table

A Lookup table (Lookup) defines the specific conditions, type, and results of a substitution or positioning action that is used to implement a feature. For example, a substitution operation requires a list of target glyph indices to be replaced, a list of replacement glyph indices, and a description of the type of substitution action.

Each Lookup table may contain only one type of information (LookupType), determined by whether the lookup is part of a GSUB or GPOS table. GSUB supports five LookupTypes, and GPOS supports seven LookupTypes (for details about LookupTypes, see the GSUB and GPOS chapters of the document).

Each LookupType is defined with one or more subtables, and each subtable definition provides a different representation format. The format is determined by the content of the information required for an operation and by required storage efficiency. When glyph information is best presented in more than one format, a single lookup may contain more than one subtable, as long as all the subtables are the same LookupType. For example, within a given lookup, a glyph index array format may best represent one set of target glyphs, whereas a glyph index range format may be better for another set of target glyphs.

During text processing, a client applies a lookup to each glyph in the string before moving to the next lookup. Once the client finds a target glyph index or context in a subtable and substitutes or positions the glyph, the lookup is completed for that glyph.

A Lookup table contains a LookupType, specified as an integer, that defines the type of information stored in the lookup. The LookupFlag specifies lookup qualifiers that assist a text-processing client in substituting or positioning glyphs. The SubTableCount specifies the total number of SubTables. The SubTable array specifies offsets, measured from the beginning of the Lookup table, to each SubTable enumerated in the SubTable array.

Lookup table

Type	Name	Description

uint16	LookupType	Different enumerations for GSUB and GPOS
uint16	LookupFlag	Lookup qualifiers
uint16	SubTableCount	Number of SubTables for this lookup
Offset	⇨ SubTable [SubTableCount]	Array of offsets to SubTables —from beginning of Lookup table

The LookupFlag uses four bits:

- The first bit, RightToLeft, is set when the text is written from right to left. This bit defines the order in which lookups specify glyph sequences.
- The next three bits—IgnoreBaseGlyphs, IgnoreLigatures, and IgnoreMarks—are set to specify additional instructions for applying a lookup to a glyph string.

LookupFlag bit enumeration

Mask	Name	Description
0x0001	RightToLeft	If set, implied glyph order is right to left —otherwise, glyph order is left to right
0x0002	IgnoreBaseGlyphs	If set, skips over base glyphs
0x0004	IgnoreLigatures	If set, skips over ligatures
0x0008	IgnoreMarks	If set, skips over combining marks
0xFFF0	Reserved	For future use

For example, in Arabic text, a character string might have the pattern <base character - mark character - base character>. That string could be converted into a ligature composed of two components, one for each base character, with the combining mark glyph over the first component. To produce this ligature, the font developer would set the IgnoreMarks bit to tell the client to ignore the mark, substitute the ligature glyph first, and then position the mark glyph over the ligature. Alternatively, a lookup which did not set the IgnoreMarks bit could be used to describe a three-component ligature glyph, composed of the first base glyph, the mark glyph, and the second base glyph.

Coverage Table

Each subtable in a lookup references a Coverage table (Coverage), which specifies all the glyphs affected by a substitution or positioning operation described in the subtable. The GSUB, GPOS, and GDEF tables rely on this notion of *coverage*. If a glyph does not appear in a Coverage table, the client can skip that subtable and move immediately to the next subtable.

A Coverage table identifies glyphs by glyph indices (GlyphIDs) either of two ways:

- As a list of individual glyph indices in the glyph set.
- As ranges of consecutive indices. The range format gives a number of start-glyph and end-glyph index pairs to denote the consecutive glyphs covered by the table.

In a Coverage table, a format code (CoverageFormat) specifies the format as an integer: 1 = lists, and 2 = ranges.
A Coverage table defines a unique index value (Coverage Index) for each covered glyph. This unique value specifies the position of the covered glyph in the Coverage table. The client uses the Coverage Index to look up values in the subtable for each glyph.

Coverage Format 1
Coverage Format 1 consists of a format code (CoverageFormat) and a count of covered glyphs (GlyphCount), followed by an array of glyph indices (GlyphArray). The glyph indices must be in numerical order for binary searching of the list. When a glyph is found in the Coverage table, its position in the GlyphArray determines the Coverage Index that is returned—the first glyph has a Coverage Index = 0, and the last glyph has a Coverage Index = GlyphCount -1.
Example 5 at the end of this chapter shows a Coverage table that uses Format 1 to list the GlyphIDs of all lowercase descender glyphs in a font.

CoverageFormat1 table: Individual glyph indices

Type	Name	Description
uint16	CoverageFormat	Format identifier —format = 1
uint16	GlyphCount	Number of glyphs in the GlyphArray
GlyphID	GlyphArray[GlyphCount]	Array of GlyphIDs —in numerical order

Coverage Format 2
Format 2 consists of a format code (CoverageFormat) and a count of glyph index ranges (RangeCount), followed by an array of records (RangeRecords). Each RangeRecord consists of a start glyph index (Start), an end glyph index (End), and the Coverage Index associated with the range's Start glyph. Ranges must be in GlyphID order, and they must be distinct, with no overlapping.
The Coverage Indexes for the first range begin with zero (0), and the Start Coverage Indexes for each succeeding range are determined by adding the length of the preceding range
(End GlyphID - Start GlyphID + 1) to the array Index. This allows for a quick calculation of the Coverage Index for any glyph in any range using the formula:
Coverage Index (GlyphID) = StartCoverageIndex + GlyphID - Start GlyphID.
Example 6 at the end of this chapter shows a Coverage table that uses Format 2 to identify a range of numeral glyphs in a font.

CoverageFormat2 table: Range of glyphs

Type	Name	Description
uint16	CoverageFormat	Format identifier —format = 2
uint16	RangeCount	Number of RangeRecords

struct	RangeRecord[RangeCount]	Array of glyph ranges —ordered by Start GlyphID

RangeRecord

Type	Name	Description
GlyphID	Start	First GlyphID in the range
GlyphID	End	Last GlyphID in the range
uint16	StartCoverageIndex	Coverage Index of first GlyphID in range

Class Definition Table

In TrueType Open, index values identify glyphs. For efficiency and ease of representation, a font developer can group glyph indices to form glyph classes. Class assignments vary in meaning from one lookup subtable to another. For example, in the GSUB and GPOS tables, classes are used to describe glyph contexts. GDEF tables also use the idea of glyph classes.

Consider a substitution action that replaces only the lowercase ascender glyphs in a glyph string. To more easily describe the appropriate context for the substitution, the font developer might divide the font's lowercase glyphs into two classes, one that contains the ascenders and one that contains the glyphs without ascenders.

A font developer can assign any glyph to any class, each identified with an integer called a class value. A Class Definition table (ClassDef) groups glyph indices by class, beginning with Class 1, then Class 2, and so on. All glyphs not assigned to a class fall into Class 0. Within a given class definition table, each glyph in the font belongs to exactly one class.

The ClassDef table can have either of two formats: one that assigns a range of consecutive glyph indices to different classes, or one that puts groups of consecutive glyph indices into the same class.

Class Definition Table Format 1

The first class definition format (ClassDefFormat1) specifies a range of consecutive glyph indices and a list of corresponding glyph class values. This table is useful for assigning each glyph to a different class because the glyph indices in each class are not grouped together.

A ClassDef Format 1 table begins with a format identifier (ClassFormat). The range of glyph indices (GlyphIDs) covered by the table is identified by two values: the GlyphID of the first glyph (StartGlyph), and the number of consecutive GlyphIDs (including the first one) that will be assigned class values (GlyphCount). The ClassValueArray lists the class value assigned to each GlyphID, starting with the class value for StartGlyph and following the same order as the GlyphIDs. Any glyph not included in the range of covered GlyphIDs automatically belongs to Class 0.

Example 7 at the end of this chapter uses Format 1 to assign class values to the lowercase, x-height, ascender, and descender glyphs in a font.

ClassDefFormat1 table: Class array

Type	Name	Description
uint16	ClassFormat	Format identifier —format = 1
GlyphID	StartGlyph	First GlyphID of the ClassValueArray
uint16	GlyphCount	Size of the ClassValueArray
uint16	ClassValueArray [GlyphCount]	Array of Class Values –one per GlyphID

Class Definition Table Format 2

The second class definition format (ClassDefFormat2) defines multiple groups of glyph indices that belong to the same class. Each group consists of a discrete range of glyph indices in consecutive order (ranges cannot overlap).

The ClassDef Format 2 table contains a format identifier (ClassFormat), a count of ClassRangeRecords that define the groups and assign class values (ClassRangeCount), and an array of ClassRangeRecords ordered by the GlyphID of the first glyph in each record (ClassRangeRecord).

Each ClassRangeRecord consists of a Start glyph index, an End glyph index, and a Class value. All GlyphIDs in a range, from Start to End inclusive, constitute the class identified by the Class value. Any glyph not covered by a ClassRangeRecord is assumed to belong to Class 0.

Example 8 at the end of this chapter uses Format 2 to assign class values to four types of glyphs in the Arabic script.

ClassDefFormat2 table: Class ranges

Type	Name	Description
uint16	ClassFormat	Format identifier —format = 2
uint16	ClassRangeCount	Number of ClassRangeRecords
struct	ClassRangeRecord [ClassRangeCount]	Array of ClassRangeRecords —ordered by Start GlyphID

ClassRangeRecord

Type	Name	Description
GlyphID	Start	First GlyphID in the range
GlyphID	End	Last GlyphID in the range
uint16	Class	Applied to all glyphs in the range

Device Tables

Glyphs in a font are defined in design units specified by the font developer. Font scaling increases or decreases a glyph's size and rounds it to the nearest whole pixel. However, precise glyph positioning often requires adjustment of these scaled and rounded values. Hinting, applied to points in the glyph outline, is an effective solution to this problem, but it may require the font developer to redesign or re-hint glyphs.

Another solution—used by the GPOS, BASE, JSTF, and GDEF tables—is to use a Device table to specify correction values to adjust the scaled design units. A Device table applies the correction values to the range of sizes identified by StartSize and EndSize, which specify the smallest and largest pixel-per-em (ppem) sizes needing adjustment. Because the adjustments often are very small (a pixel or two), the correction can be compressed into a 2-, 4-, or 8-bit representation per size. Two bits can represent a number in the range {-2, -1, 0, or 1}, four bits can represent a number in the range {-8 to 7}, and eight bits can represent a number in the range {-128 to 127}. The Device table identifies one of three data formats—signed 2-, 4,- or 8-bit values—for the adjustment values (DeltaFormat). A single Device table provides delta information for one coordinate at a range of sizes.

Format	Bits	Description
1	2	Signed 2-bit value, 8 values per uint16
2	4	Signed 4-bit value, 4 values per uint16
3	8	Signed 8-bit value, 2 values per uint16

The 2-, 4-, or 8-bit signed values are packed into uint16's most significant bits first. For example, using a DeltaFormat of 2 (4-bit values), an array of values equal to {1, 2, 3, -1} would be represented by the DeltaValue 0x123F.

The DeltaValue array lists the number of pixels to adjust specified points on the glyph, or the entire glyph, at each ppem size in the targeted range. In the array, the first index position specifies the number of pixels to add or subtract from the coordinate at the smallest ppem size that needs correction, the second index position specifies the number of pixels to add or subtract from the coordinate at the next ppem size, and so on for each ppem size in the range.

Example 9 at the end of this chapter uses a Device table to define the minimum extent value for a math script.

Device table

Type	Name	Description
uint16	StartSize	Smallest size to correct —in ppem
uint16	EndSize	Largest size to correct —in ppem
uint16	DeltaFormat	Format of DeltaValue array data: 1, 2, or 3
uint16	DeltaValue[ ]	Array of compressed data

Common Table Examples

The rest of this chapter describes and illustrates examples of all the common table formats. All the examples reflect unique parameters, but the samples provide a useful reference for building tables specific to other situations.
The examples have three columns showing hex data, source, and comments.

Example 1: ScriptList Table and ScriptRecords

Example 1 illustrates a ScriptList table and ScriptRecord definitions for a Japanese font with multiple scripts: Han Ideographic, Kana, and Latin. Each script has script-specific behavior.

Example 1

Hex Data	Source Comments
	ScriptList
	TheScriptList ;ScriptList table definition
0003	3 ;ScriptCount
	;ScriptRecord[0]
	; in alphabetical order by
	; ScriptTag
68616E69	"hani" ;ScriptTag
	; Han Ideographic script
0014	HanIScriptTable ;offset to Script table
	;ScriptRecord[1]
6B616E61	"kana" ;ScriptTag
	; Hiragana and Katakana scripts
0018	KanaScriptTable ;offset to Script table
	;ScriptRecord[2]
6C61746E	"latn" ;ScriptTag
	; Latin script
001C	LatinScriptTable ;offset to Script table

Example 2: Script Table, LangSysRecord, and LangSys Table

Example 2 illustrates the Script table, LangSysRecord, and LangSys table definitions for the Arabic script and the Urdu language system. The default LangSys table defines three default Arabic script features used to replace certain glyphs in words with their proper initial, medial, and final glyph forms. These contextual substitutions are invariant and occur in all language systems that use the Arabic script.
Many alternative glyphs in the Arabic script have language-specific uses. For instance, the Arabic, Farsi, and Urdu language systems use different glyphs for numerals. To maintain character-set compatibility, the Unicode standard includes separate character codes for the Arabic and Farsi numeral glyphs. However, the standard uses the same

character codes for Farsi and Urdu numerals, even though three of the Urdu glyphs (4, 6, and 7) differ from the Farsi glyphs. To access and display the proper glyphs for the Urdu numerals, users of the text-processing client must enter the character codes for the Farsi numerals. Then the text-processing client uses a required TrueType Open glyph substitution feature, defined in the Urdu LangSys table, to access the correct Urdu glyphs for the 4, 6, and 7 numerals.

Note that the Urdu LangSys table repeats the default script features. This repetition is necessary because the Urdu language system also uses alternative glyphs in the initial, medial, and final glyph positions in words.

Example 2

Hex Data	Source Comments
	Script
	ArabicScriptTable ;Script table definition
000A	DefLangSys ;offset to DefaultLangSys table
0001	1 ;LangSysCount
	;LangSysRecord[0]
	; in alphabetical order by
	; LangSysTag
55524420	"URD " ;LangSysTag
	; Urdu language
0016	UrduLangSys ;offset to LangSys table for
	; Urdu
	LangSys
	DefLangSys ;default LangSys table
	; definition
0000	NULL ;LookupOrder
	; reserved, null
FFFF	0xFFFF ;ReqFeatureIndex
	; no required features
0003	3 ;FeatureCount
0000	0 ;FeatureIndex[0]
	; in arbitrary order
	; "init" feature (initial
	; glyph)
0001	1 ;FeatureIndex[1]
	; "fina" feature (final glyph)
0002	2 ;FeatureIndex[2]
	; for "medi" feature (medial
	; glyph)
	LangSys
	UrduLangSys ;LangSys table definition
0000	NULL ;LookupOrder
	; reserved, null

```
0003                                    3       ;ReqFeatureIndex
                                                ;  numeral subsitution in
                                        Urdu
0003                                    3       ;FeatureCount
0000                                    0       ;FeatureIndex[0]
                                                ;  in arbitrary order
                                                ;  "init" feature (initial
                                                ;    glyph)
0001                                    1       ;FeatureIndex[1]
                                                ;  "fina" feature (final
                                        glyph)
0002                                    2       ;FeatureIndex[2]
                                                ;  "medi" feature (medial
                                        glyph)
```

Example 3: FeatureList Table and Feature Table

Example 3 shows the FeatureList and Feature table definitions for ligatures in the Latin script. The FeatureList has three features, all optional and named “liga.” One feature, also a default, implements ligatures in Latin if no language-specific feature specifies other ligatures. Two other features implement ligatures in the Turkish and German languages, respectively.

Three lookups define glyph substitutions for rendering ligatures in this font. The first lookup produces the “ffl,” “fl,” and “ff” ligatures; the second produces the “ffi” and “fi” ligatures; and the third produces the eszet ligature.

The ligatures that begin with an “f” are separated into two sets because Turkish has a dotless “i” glyph and so does not use “ffi” and “fi” ligatures. However, Turkish does use the “ffl,” “fl,” and “ff” ligatures, and the TurkishLigatures feature table lists this one lookup.

Only the German language system uses the eszet ligature, so the GermanLigatures feature table includes a lookup for rendering that ligature.

Because the Latin script can use both sets of ligatures, the DefaultLigatures feature table defines two LookupList indices: one for the “ffl,” “fl,” and “ff” ligatures, and one for the “ffi” and “fi” ligatures. If the text-processing client selects this feature, then the font applies both lookups.

Note that the TurkishLigatures and DefaultLigatures feature tables both list a LookupListIndex of zero (0) for the “ffl,” “fl,” and “ff” ligatures lookup. This is because language-specific lookups override all default language-system lookups, and a language-system feature table must explicitly list all lookups that apply to the language.

Example 3

Hex Data	Source Comments
	FeatureList
	TheFeatureList ;FeatureList table definition
0003	3 ;FeatureCount
	;FeatureRecord[0]
6C696761	"liga" ;FeatureTag
0014	TurkishLigatures ;offset to Feature table
	; FflFfFlLiga
	;FeatureRecord[1]
6C696761	"liga" ;FeatureTag
001A	DefaultLigatures ;offset to Feature table
	; FfiFiLiga, FflFfFlLiga
	;FeatureRecord[2]
6C696761	"liga" ;FeatureTag
0022	GermanLigatures ;offset to Feature table
	; EszetLiga
	Feature
	TurkishLigatures ;Feature table definition
0000	NULL ;FeatureParams
	; reserved, null
0001	1 ;LookupCount
0000	0 ;LookupListIndex[0]
	; ffl, fl, ff ligature
	; substitution Lookup
	Feature
	DefaultLigatures ;Feature table definition
0000	NULL ;FeatureParams - reserved, null
0002	2 ;LookupCount
0000	0 ;LookupListIndex[0]
	; in arbitrary order
	; ffl, fl, ff ligatures
0001	1 ;LookupListIndex[1]
	; ffi, fi ligature substitution
	; Lookup
	Feature
	GermanLigatures ;Feature table definition
0000	NULL ;FeatureParams - reserved, null
0001	3 ;LookupCount
0000	0 ;LookupListIndex[0]
	; in arbitrary order
	; ffl, fl, ff ligatures
0001	1 ;LookupListIndex[1]
	; ffi, fi ligature substitution
	; Lookup

```
0002                                    2      ;LookupListIndex[0]
                                               ;  eszet ligature
                                        substitution
                                               ;    Lookup
```

Example 4: LookupList Table and Lookup Table

A continuation of Example 3, Example 4 shows three ligature lookups in the LookupList table. The first generates the “ffl,” “fl,” and “ff” ligatures; the second produces the “ffi” and “fi” ligatures; and the third generates the eszet ligature. Each lookup table defines an offset to a subtable that contains data for the ligature substitution.

Example 4

Hex Data	Source Comments
	LookupList
	TheLookupList ;LookupList table definition
0003	3 ;LookupCount
0008	FflFlFfLookup ;offset to Lookup[0] table
	; in design order
0010	FfiFiLookup ;offset to Lookup[1] table
0018	EszetLookup ;offset to Lookup[2] table
	Lookup
	FflFlFfLookup ;Lookup[0] table definition
0004	4 ;LookupType
	; ligature subst
000C	0x000C ;LookupFlag
	; IgnoreLigatures, IgnoreMarks
0001	1 ;SubTableCount
0018	FflFlFfSubtable ;offset to FflFlFf ligature
	; substitution subtable
	Lookup
	FfiFiLookup ;Lookup[1] table definition
0004	4 ;LookupType
	; ligature subst
000C	0x000C ;LookupFlag
	; IgnoreLigatures, IgnoreMarks
0001	1 ;SubTableCount
0028	FfiFiSubtable ;offset to FfiFi ligature
	; substitution subtable
	Lookup
	EszetLookup ;Lookup[2] table definition
0004	4 ;LookupType
	; ligature subst
000C	0x000C ;LookupFlag
	; IgnoreLigatures, IgnoreMarks
0001	1 ;SubTableCount

```
0038                                    EszetSubtable;offset to Eszet
                                        ligature
                                              ;  substitution subtable
```

Example 5: CoverageFormat1 Table (GlyphID List)
Example 5 illustrates a Coverage table that lists the GlyphIDs of all lowercase descender glyphs in a font. The table uses the list format instead of the range format because the GlyphIDs for the descender glyphs are not consecutively ordered.

Example 5

Hex Data	Source Comments
	CoverageFormat1
	DescenderCoverage ;Coverage table definition
0001	1 ;CoverageFormat
	; lists
0005	5 ;GlyphCount
0038	gGlyphID ;GlyphArray[0]
	; in GlyphID order
003B	jGlyphID ;GlyphArray[1]
0041	pGlyphID ;GlyphArray[2]
0042	qGlyphID ;GlyphArray[3]
004A	yGlyphID ;GlyphArray[4]

Example 6: CoverageFormat2 Table (GlyphID Ranges)
Example 6 shows a Coverage table that defines ten numeral glyphs (0 through 9). The table uses the range format instead of the list format because the GlyphIDs are ordered consecutively in the font. The StartCoverageIndex of zero (0) indicates that the first GlyphID, for the zero glyph, returns a Coverage Index of 0. The second GlyphID, for the numeral one (1) glyph, returns a Coverage Index of 1, and so on.

Example 6

Hex Data	Source Comments
	CoverageFormat2
	NumeralCoverage ;Coverage table definition
0002	2 ;CoverageFormat
	; GlyphID ranges
0001	1 ;RangeCount
	;RangeRecord[0]
004E	0glyphID ;Start GlyphID
0057	9glyphID ;End GlyphID
0000	0 ;StartCoverageIndex
	; first CoverageIndex = 0

Example 7: ClassDefFormat1 Table (Class Array)
The ClassDef table in Example 7 assigns class values to the lowercase glyphs in a font. The x-height glyphs are in Class 0, the ascender glyphs are in Class 1, and the descender glyphs are in Class 2. The array begins with the index for the lowercase “a” glyph.
Example 7

Hex Data	Source	Comments
	ClassDefFormat1	
	LowercaseClassDef	;ClassDef table definition
0001	1	;ClassFormat
0032	aGlyphID	;StartGlyph
001A	26	;GlyphCount
0000	0	;aGlyph, Xheight Class 0
0001	1	;bGlyph, Ascender Class 1
0000	0	;cGlyph, Xheight Class 0
0001	1	;dGlyph, Ascender Class 1
0000	0	;eGlyph, Xheight Class 0
0001	1	;fGlyph, Ascender Class 1
0002	2	;gGlyph, Descender Class 2
0001	1	;hGlyph, Ascender Class 1
0000	0	;iGlyph, Ascender Class 1
0002	2	;jGlyph, Descender Class 2
0001	1	;kGlyph, Ascender Class 1
0001	1	;lGlyph, Ascender Class 1
0000	0	;mGlyph, Xheight Class 0
0000	0	;nGlyph, Xheight Class 0
0000	0	;oGlyph, Xheight Class 0
0002	2	;pGlyph, Descender Class 2
0002	2	;qGlyph, Descender Class 2
0000	0	;rGlyph, Xheight Class 0
0000	0	;sGlyph, Xheight Class 0
0001	1	;tGlyph, Ascender Class 1
0000	0	;uGlyph, Xheight Class 0
0000	0	;vGlyph, Xheight Class 0
0000	0	;wGlyph, Xheight Class 0
0000	0	;xGlyph, Xheight Class 0
0002	2	;yGlyph, Descender Class 2
0000	0	;zGlyph, Xheight Class 0

Example 8: ClassDefFormat2 Table (Class Ranges)
In Example 8, the ClassDef table assigns class values to four types of glyphs in the Arabic script: medium-height base glyphs, high base glyphs, very high base glyphs, and default mark glyphs. The table lists only Class 1, Class 2, and Class 3; all glyphs not explicitly assigned a class fall into Class 0.
The table uses the range format because the GlyphIDs in each class are ordered consecutively in the font. In the ClassRange array, ClassRange definitions are ordered by the Start glyph index in each range. The indices of the high base glyphs, defined in ClassRange[0], are first in the font and have a class value of 2. ClassRange[1] defines all the very high base glyphs and assigns a class value of 3. ClassRange[2] contains all

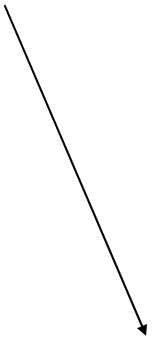
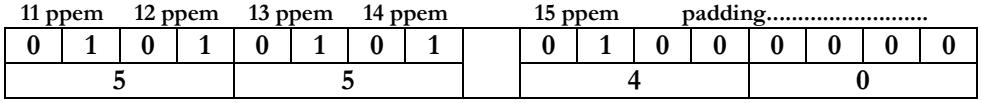
default mark glyphs; the class value is 1. Class 0 consists of all the medium-height base glyphs, which are not explicitly assigned a class value.

Example 8

Hex Data	Source Comments
	ClassDefFormat2
	GlyphHeightClassDef ;Class table definition
0002	2 ;Class Format
	; ranges
0003	3 ;ClassRangeCount
	;ClassRange[0]
	; ordered by StartGlyphID
0030	tahGlyphID ;Start
	; first GlyphID in the range
0031	dhahGlyphID ;End
	; Last GlyphID in the range
0002	2 ;Class
	; high base glyphs
	;ClassRange[1]
0040	cafGlyphID ;Start
	;first GlyphID in the range
0041	gafGlyphID ;End
	; Last GlyphID in the range
0003	3 ;Class
	; very high base glyphs
	;ClassRange[2]
00D2	fathatanDefaultGlyphID ;Start
	; first GlyphID in the range
00D3	dammatanDefaultGlyphID ;End
	; Last GlyphID in the range
0001	1 ;Class
	; default marks

Example 9: Device Table

Example 9 defines the minimum extent value for a math script, using a Device table to adjust the value according to the size of the output font. Here, the Device table defines single-pixel adjustments for font sizes from 11 ppem to 15 ppem. The DeltaFormat is 1, which signifies a packed array of signed 2-bit values, eight values per uint16.

Example 9

Hex Data	Source	Comments
	DeviceTableFormat1	
	MinCoordDeviceTable	;Device Table definition
000B	11	;StartSize, 11 ppem
000F	15	;EndSize, 15 ppem
0001	1	;DeltaFormat
		; signed 2 bit value, 8 values
		; per uint16
	1	;increase 11ppem by 1 pixel
	1	;increase 12ppem by 1 pixel
	1	;increase 13ppem by 1 pixel
	1	;increase 14ppem by 1 pixel
5540	1	;increase 15ppem by 1 pixel