Abstract

Application protocols using Unicode characters in protocol strings need to properly prepare such strings in order to perform valid comparison operations (e.g., for purposes of authentication or authorization). This document defines a framework enabling application protocols to perform the preparation and comparison of internationalized strings ("PRECIS") in a way that depends on the properties of Unicode characters and thus is agile with respect to versions of Unicode. As a result, this framework provides a more sustainable approach to the handling of internationalized strings than the previous framework, known as Stringprep (RFC 3454). This document obsoletes RFC 3454.

Status of This Memo

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1. Introduction

As described in the problem statement for the preparation and comparison of internationalized strings ("PRECIS") [RFC6885], many IETF protocols have used the Stringprep framework [RFC3454] as the basis for preparing and comparing protocol strings that contain Unicode characters [UNICODE] outside the ASCII range [RFC20]. The Stringprep framework was developed during work on the original technology for internationalized domain names (IDNs), here called "IDNA2003" [RFC3490], and Nameprep [RFC3491] was the Stringprep profile for IDNs. At the time, Stringprep was designed as a general framework so that other application protocols could define their own Stringprep profiles for the preparation and comparison of strings and identifiers. Indeed, a number of application protocols defined such profiles.

After the publication of [RFC3454] in 2002, several significant issues arose with the use of Stringprep in the IDN case, as documented in the IAB’s recommendations regarding IDNs [RFC4690] (most significantly, Stringprep was tied to Unicode version 3.2). Therefore, the newer IDNA specifications, here called "IDNA2008" ([RFC5890], [RFC5891], [RFC5892], [RFC5893], [RFC5894]), no longer use Stringprep and Nameprep. This migration away from Stringprep for IDNs has prompted other "customers" of Stringprep to consider new approaches to the preparation and comparison of internationalized strings, as described in [RFC6885].

This document defines a framework for a post-Stringprep approach to the preparation and comparison of internationalized strings in application protocols, based on several principles:
1. Define a small set of string classes that specify the Unicode characters (i.e., specific "code points") appropriate for common application protocol constructs.

2. Define each PRECIS string class in terms of Unicode code points and their properties so that an algorithm can be used to determine whether each code point or character category is (a) valid, (b) allowed in certain contexts, (c) disallowed, or (d) unassigned.

3. Use an "inclusion model" such that a string class consists only of code points that are explicitly allowed, with the result that any code point not explicitly allowed is forbidden.

4. Enable application protocols to define profiles of the PRECIS string classes, addressing matters such as width mapping, case folding and other forms of character mapping, Unicode normalization, directionality, and further excluded code points or character categories.

Whereas the string classes define the "baseline" code points for a range of applications, profiling enables application protocols to further restrict the allowable code points beyond those specified for the relevant string class (e.g., characters with special or reserved meaning, such as "@" and "/" when used as separators within identifiers) and to apply the string classes in ways that are appropriate for constructs such as usernames and passwords [I-D.ietf-precis-saslprep-bis], nicknames [I-D.ietf-precis-nickname], the localsparts of instant messaging addresses [I-D.ietf-xmpp-6122-bis], and free-form strings [I-D.ietf-xmpp-6122-bis]. Profiles are responsible for defining the handling of right-to-left characters as well as various mapping operations of the kind also discussed for IDNs in [RFC5895], such as case preservation or lowercasing, Unicode normalization, mapping of certain characters to other characters or to nothing, and mapping of full-width and half-width characters.

When an application applies a profile of a PRECIS string class, it can achieve the following objectives:

a. Determine if a given string conforms to the profile (e.g. to determine if it is allowed for use in the relevant "slot" specified by an application protocol).

b. Determine if any two given strings are equivalent (e.g., to make an access decision for purposes of authentication or authorization as further described in [RFC6943]).
It is expected that this framework will yield the following benefits:

- Application protocols will be agile with regard to Unicode versions.
- Implementers will be able to share code point tables and software code across application protocols, most likely by means of software libraries.
- End users will be able to acquire more accurate expectations about the characters that are acceptable in various contexts. Given this more uniform set of string classes, it is also expected that copy/paste operations between software implementing different application protocols will be more predictable and coherent.

Although this framework is similar to IDNA2008 and borrows some of the character categories defined in [RFC5892], it defines additional character categories to meet the needs of common application protocols.

The character categories and calculation rules defined under Section 7 and Section 8 are normative and apply to all Unicode code points. The code point table provided under Appendix A is non-normative and merely shows, for illustrative purposes, the consequences of the character categories and calculation rules, as well as the resulting property values.

2. Terminology

Many important terms used in this document are defined in [RFC5890], [RFC6365], [RFC6885], and [UNICODE]. The terms "left-to-right" (LTR) and "right-to-left" (RTL) are defined in Unicode Standard Annex #9 [UAX9].

As of the date of writing, the version of Unicode published by the Unicode Consortium is 6.3; however, PRECIS is not tied to a specific version of Unicode.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. String Classes
3.1. Overview

Starting in 2010, various "customers" of Stringprep began to discuss the need to define a post-Stringprep approach to the preparation and comparison of internationalized strings other than IDNs. This community analyzed the existing Stringprep profiles and also weighed the costs and benefits of defining a relatively small set of Unicode characters that would minimize the potential for user confusion caused by visually similar characters (and thus be relatively "safe") vs. defining a much larger set of Unicode characters that would maximize the potential for user creativity (and thus be relatively "expressive"). As a result, the community concluded that most existing uses could be addressed by two string classes:

IdentifierClass: a sequence of letters, numbers, and some symbols that is used to identify or address a network entity such as a user account, a venue (e.g., a chatroom), an information source (e.g., a data feed), or a collection of data (e.g., a file); the intent is that this class will minimize user confusion in a wide variety of application protocols, with the result that safety has been prioritized over expressiveness for this class.

FreeformClass: a sequence of letters, numbers, symbols, spaces, and other characters that is used for free-form strings, including passwords as well as display elements such as human-friendly nicknames in chatrooms; the intent is that this class will allow nearly any Unicode character, with the result that expressiveness has been prioritized over safety for this class (e.g., protocol designers, application developers, service providers, and end users might not understand or be able to enter all of the characters that can be included in the FreeformClass).

Future specifications might define additional PRECIS string classes, such as a class that falls somewhere between the IdentifierClass and the FreeformClass. At this time, it is not clear how useful such a class would be. In any case, because application developers are able to define profiles of PRECIS string classes, a protocol needing a construct between the IdentifierClass and the FreeformClass could define a restricted profile of the FreeformClass if needed.

The following subsections discuss the IdentifierClass and FreeformClass in more detail, with reference to the dimensions described in Section 3 of [RFC6885]. Each string class is defined by the following behavioral rules:

Valid: Defines which code points and character categories are treated as valid input to the string.
Contextual Rule Required: Defines which code points and character categories are treated as allowed only if the requirements of a contextual rule are met (i.e., either CONTEXTJ or CONTEXTO).

Disallowed: Defines which code points and character categories need to be excluded from the string.

Unassigned: Defines application behavior in the presence of code points that are unknown (i.e., not yet designated) for the version of Unicode used by the application.

This document defines the valid, contextual rule required, disallowed, and unassigned rules for the IdentifierClass and FreeformClass. As described under Section 4, profiles of these string classes are responsible for defining the width mapping, additional mappings, case mapping, normalization, directionality, and exclusion rules.

3.2. IdentifierClass

Most application technologies need strings that can be used to refer to, include, or communicate protocol strings like usernames, file names, data feed identifiers, and chatroom names. We group such strings into a class called "IdentifierClass" having the following features.

3.2.1. Valid

- Code points traditionally used as letters and numbers in writing systems, i.e., the LetterDigits ("A") category first defined in [RFC5892] and listed here under Section 7.1.

- Code points in the range U+0021 through U+007E, i.e., the (printable) ASCII7 ("K") rule defined under Section 7.11. These code points are "grandfathered" into PRECIS and thus are valid even if they would otherwise be disallowed according to the property-based rules specified in the next section.

Note: Although the PRECIS IdentifierClass re-uses the LetterDigits category from IDNA2008, the range of characters allowed in the IdentifierClass is wider than the range of characters allowed in IDNA2008. The main reason is that IDNA2008 applies the Unstable category before the LetterDigits category, thus disallowing uppercase characters, whereas the IdentifierClass does not apply the Unstable category.
3.2.2. Contextual Rule Required

- A number of characters from the Exceptions ("F") category defined under Section 7.6 (see Section 7.6 for a full list).
- Joining characters, i.e., the JoinControl ("H") category defined under Section 7.8.

3.2.3. Disallowed

- Old Hangul Jamo characters, i.e., the OldHangulJamo ("I") category defined under Section 7.9.
- Control characters, i.e., the Controls ("L") category defined under Section 7.12.
- Ignorable characters, i.e., the PrecisIgnorableProperties ("M") category defined under Section 7.13.
- Space characters, i.e., the Spaces ("N") category defined under Section 7.14.
- Symbol characters, i.e., the Symbols ("O") category defined under Section 7.15.
- Punctuation characters, i.e., the Punctuation ("P") category defined under Section 7.16.
- Any character that has a compatibility equivalent, i.e., the HasCompat ("Q") category defined under Section 7.17. These code points are disallowed even if they would otherwise be valid according to the property-based rules specified in the previous section.
- Letters and digits other than the "traditional" letters and digits allowed in IDNs, i.e., the OtherLetterDigits ("R") category defined under Section 7.18.

3.2.4. Unassigned

Any code points that are not yet designated in the Unicode character set are considered Unassigned for purposes of the IdentifierClass, and such code points are to be treated as Disallowed.
3.2.5. Examples

As described in the Introduction to this document, the string classes do not handle all issues related to string preparation and comparison (such as case mapping); instead, such issues are handled at the level of profiles. Examples for two profiles of the IdentifierClass can be found in [I-D.ietf-precis-saslprepbis] (the UsernameIdentifierClass profile) and in [I-D.ietf-xmpp-6122bis] (the JIDlocalIdentifierClass profile).

3.3. FreeformClass

Some application technologies need strings that can be used in a free-form way, e.g., as a password in an authentication exchange (see [I-D.ietf-precis-saslprepbis] or a nickname in a chatroom (see [I-D.ietf-precis-nickname]). We group such things into a class called "FreeformClass" having the following features.

Security Warning: Consult Section 10.6 for relevant security considerations when strings conforming to the FreeformClass, or a profile thereof, are used as passwords.

3.3.1. Valid

- Traditional letters and numbers, i.e., the LetterDigits ("A") category first defined in [RFC5892] and listed here under Section 7.1.
- Letters and digits other than the "traditional" letters and digits allowed in IDNs, i.e., the OtherLetterDigits ("R") category defined under Section 7.18.
- Code points in the range U+0021 through U+007E, i.e., the (printable) ASCII7 ("K") rule defined under Section 7.11.
- Any character that has a compatibility equivalent, i.e., the HasCompat ("Q") category defined under Section 7.17.
- Space characters, i.e., the Spaces ("N") category defined under Section 7.14.
- Symbol characters, i.e., the Symbols ("O") category defined under Section 7.15.
- Punctuation characters, i.e., the Punctuation ("P") category defined under Section 7.16.
3.3.2. Contextual Rule Required

- A number of characters from the Exceptions ("F") category defined under Section 7.6 (see Section 7.6 for a full list).

- Joining characters, i.e., the JoinControl ("H") category defined under Section 7.8.

3.3.3. Disallowed

- Old Hangul Jamo characters, i.e., the OldHangulJamo ("I") category defined under Section 7.9.

- Control characters, i.e., the Controls ("L") category defined under Section 7.12.

- Ignorable characters, i.e., the PrecisIgnoreableProperties ("M") category defined under Section 7.13.

3.3.4. Unassigned

Any code points that are not yet designated in the Unicode character set are considered Unassigned for purposes of the FreeformClass, and such code points are to be treated as Disallowed.

3.3.5. Examples

As described in the Introduction to this document, the string classes do not handle all issues related to string preparation and comparison (such as case mapping); instead, such issues are handled at the level of profiles. Examples for two profiles of the FreeformClass can be found in [I-D.ietf-precis-nickname] (the NicknameFreeformClass profile) and in [I-D.ietf-xmpp-6122bis] (the JIDresourceIdentifierClass profile).

4. Profiles

4.1. Principles

This framework document defines the valid, contextual-rule-required, disallowed, and unassigned rules for the IdentifierClass and the FreeformClass. A profile of a PRECIS string class MUST define the width mapping, additional mappings (if any), case mapping, normalization, directionality, and exclusion rules. A profile MAY also restrict the allowable characters above and beyond the definition of the relevant PRECIS string class (but MUST NOT add as valid any code points or character categories that are disallowed by
the relevant PRECIS string class). These matters are discussed in the following subsections.

Profiles of the PRECIS string classes are registered with the IANA as described under Section 9.3. The naming convention for profile names is that they of the form "ProfilenameBaseClass", where the "Profilename" string is a differentiator and "BaseClass" is the name of the PRECIS string class being profiled; for example, the profile of the IdentifierClass used for localparts of Jabber IDs in the Extensible Messaging and Presence Protocol (XMPP) is named "JIDlocalIdentifierClass" [I-D.ietf-xmpp-6122bis].

4.1.1. Width Mapping

The width mapping rule of a profile specifies whether width mapping is performed on fullwidth and halfwidth characters, and how the mapping is done. Typically such mapping consists of mapping fullwidth and halfwidth characters, i.e., code points with a Decomposition Type of Wide or Narrow, to their decomposition mappings; as an example, FULLWIDTH DIGIT ZERO (U+FF10) would be mapped to DIGIT ZERO (U+0030).

The normalization form specified by a profile (see below) has an impact on the need for width mapping. Because width mapping is performed as a part of compatibility decomposition, a profile employing either normalization form KD (NFKD) or normalization form KC (NFKC) does not need to specify width mapping. However, if Unicode normalization form C (NFC) is used then the profile needs to specify whether to apply width mapping; in this case, width mapping is in general RECOMMENDED because allowing fullwidth and halfwidth characters to remain unmapped to their compatibility variants would violate the principle of least user surprise. For more information about the concept of width in East Asian scripts within Unicode, see Unicode Standard Annex #11 [UAX11].

4.1.2. Additional Mappings

The additional mappings rule of a profile specifies whether additional mappings are to be applied, such as mapping of delimiter characters and mapping of special characters (e.g., non-ASCII space characters to ASCII space or certain characters to nothing).

4.1.3. Case Mapping

The case mapping rule of a profile specifies whether case mapping is performed (instead of case preservation) on uppercase and titlecase characters, and how the mapping is done (e.g., mapping uppercase and titlecase characters to their lowercase equivalents).
If case mapping is desired (instead of case preservation), it is RECOMMENDED to use Unicode Default Case Folding as defined in Chapter 3 of the Unicode Standard [UNICODE].

Note: Unicode Default Case Folding is not designed to handle various localization issues (such as so-called "dotless i" in several Turkic languages). The PRECIS mappings document [I-D.ietf-precis-mappings] describes these issues in greater detail and defines a "local case mapping" method that handles some locale-dependent and context-dependent mappings.

In order to maximize entropy and minimize the potential for false positives, it is NOT RECOMMENDED for application protocols to map uppercase and titlecase code points to their lowercase equivalents when strings conforming to the FreeformClass, or a profile thereof, are used in passwords; instead, it is RECOMMENDED to preserve the case of all code points contained in such strings and then perform case-sensitive comparison. See also the related discussion in [I-D.ietf-precis-saslprepbis].

4.1.4. Normalization

The normalization rule of a profile specifies which Unicode normalization form (D, KD, C, or KC) is to be applied (see Unicode Standard Annex #15 [UAX15] for background information).

In accordance with [RFC5198], normalization form C (NFC) is RECOMMENDED.

4.1.5. Directionality

The directionality rule of a profile specifies which strings are to be considered left-to-right (LTR) and right-to-left (RTL), and the allowable sequences of characters in LTR and RTL strings (see Unicode Standard Annex #9 [UAX9]). Possible rules include, but are not limited to, (a) considering any string that contains a right-to-left code point to be a right-to-left string, or (b) applying the "Bidi Rule" from [RFC5893].

Mixed-direction strings are not directly supported by the PRECIS framework itself, since there is currently no widely accepted and implemented solution for the processing and safe display of mixed-direction strings. An application protocol that uses the PRECIS framework (or an extension to the framework) could define methods for handling mixed-direction strings; however, such methods are outside the scope of the framework.
4.1.6. Exclusions

The exclusions rule of a profile specifies whether the profile excludes additional code points or character categories above and beyond those excluded by the string class being profiled. That is, a profile MAY do either of the following:

1. Exclude specific code points that are allowed by the relevant string class.

2. Exclude characters matching certain Unicode properties (e.g., math symbols) that are included in the relevant PRECIS string class.

As a result of such exclusions, code points that are defined as valid for the PRECIS string class being profiled will be defined as disallowed for the profile.

4.2. Building Application-Layer Constructs

Sometimes, an application-layer construct does not map in a straightforward manner to one of the PRECIS string classes or a profile thereof. Consider, for example, the "simple user name" construct in the Simple Authentication and Security Layer (SASL) [RFC4422]. Depending on the deployment, a simple user name might take the form of a user’s full name (e.g., the user’s personal name followed by a space and then the user’s family name). Such a simple user name cannot be defined as an instance of the IdentifierClass or a profile thereof, since space characters are not allowed in the IdentifierClass; however, it could be defined using a space-separated sequence of IdentifierClass instances, as in the following pseudo-ABNF [RFC5234]:

```
fullname = namepart *(1*SP namepart)
namepart = 1*idpoint
```

; an "idpoint" is a UTF-8 encoded Unicode code point
; that conforms to the PRECIS IdentifierClass

Similar techniques could be used to define many application-layer constructs, say of the form "user@domain" or "path/to/file".

4.3. A Note about Spaces

With regard to the IdentifierClass, the consensus of the PRECIS Working Group was that spaces are problematic for many reasons, including:
Many Unicode characters are confusable with ASCII space.

Even if non-ASCII space characters are mapped to ASCII space (U+0020), space characters are often not rendered in user interfaces, leading to the possibility that a human user might consider a string containing spaces to be equivalent to the same string without spaces.

In some locales, some devices are known to generate a character other than ASCII space (such as ZERO WIDTH JOINER, U+200D) when a user performs an action like hit the space bar on a keyboard.

One consequence of disallowing space characters in the IdentifierClass might be to effectively discourage their use within identifiers created in newer application protocols; given the challenges involved in properly handling space characters (especially non-ASCII space characters) in identifiers and other protocol strings, the Working Group considered this to be a feature, not a bug.

However, the FreeformClass does allow spaces, which enables application protocols to define profiles of the FreeformClass that are more flexible than any profiles of the IdentifierClass. In addition, as explained in the previous section, application protocols can also define application-layer constructs containing spaces.

5. Order of Operations

To ensure proper comparison, the following order of operations is REQUIRED:

1. Width mapping

2. Optionally, additional mappings such as mapping of delimiters (e.g., characters such as '@', ':', '/', '+', and '-') and special handling of certain characters or classes of characters (e.g., mapping of non-ASCII spaces to ASCII space or mapping of control characters to nothing); the PRECIS mappings document [I-D.ietf-precis-mappings] describes such mappings in more detail

3. Case mapping as described under Section 4.1.3 of this document

4. Normalization

5. Behavioral rules for determining whether a code point is valid, allowed under a contextual rule, disallowed, or unassigned
As already described, the width mapping, additional mappings, case mapping, and normalization operations are specified for each profile, whereas the behavioral rules are specified for each string class. Some of the logic behind this order is provided under Section 4.1.1 (see also the PRECIS mappings document [I-D.ietf-precis-mappings]).

6. Code Point Properties

In order to implement the string classes described above, this document does the following:

1. Reviews and classifies the collections of code points in the Unicode character set by examining various code point properties.

2. Defines an algorithm for determining a derived property value, which can vary depending on the string class being used by the relevant application protocol.

This document is not intended to specify precisely how derived property values are to be applied in protocol strings. That information is the responsibility of the protocol specification that uses or profiles a PRECIS string class from this document.

The value of the property is to be interpreted as follows.

- **PROTOCOL VALID** Those code points that are allowed to be used in any PRECIS string class (currently, IdentifierClass and FreeformClass). Code points with this property value are permitted for general use in any string class. The abbreviated term "PVALID" is used to refer to this value in the remainder of this document.

- **SPECIFIC CLASS PROTOCOL VALID** Those code points that are allowed to be used in specific string classes. Code points with this property value are permitted for use in specific string classes. In the remainder of this document, the abbreviated term *_PVAL is used, where * = (ID | FREE), i.e., either "FREE_PVAL" or "ID_PVAL".

- **CONTEXTUAL RULE REQUIRED** Some characteristics of the character, such as its being invisible in certain contexts or problematic in others, require that it not be used in labels unless specific other characters or properties are present. As in IDNA2008, there are two subdivisions of CONTEXTUAL RULE REQUIRED, the first for Join_controls (called "CONTEXTJ") and the second for other characters (called "CONTEXTO"). A character with the derived property value CONTEXTJ or CONTEXTO MUST NOT be used unless an appropriate rule has been established and the context of the
character is consistent with that rule. The most notable of the
CONTEXTUAL RULE REQUIRED characters are the Join Control
characters U+200D ZERO WIDTH JOINER and U+200C ZERO WIDTH NON-
JOINER, which have a derived property value of CONTEXTJ. See
Appendix A of [RFC5892] for more information.

DISALLOWED Those code points that are not permitted in any PRECIS
string class.

SPECIFIC CLASS DISALLOWED Those code points that are not to be
included in a specific string class. Code points with this
property value are not permitted in one of the string classes but
might be permitted in others. In the remainder of this document,
the abbreviated term *_DIS is used, where * = (ID | FREE), i.e.,
either "FREE_DIS" or "ID_DIS".

UNASSIGNED Those code points that are not designated (i.e. are
unassigned) in the Unicode Standard.

The mechanisms described here allow determination of the value of the
property for future versions of Unicode (including characters added
after Unicode 5.2 or 6.3 depending on the category, since some
categories in this document are reused from IDNA2008 and therefore
were defined at the time of Unicode 5.2). Changes in Unicode
properties that do not affect the outcome of this process therefore
do not affect this framework. For example, a character can have its
Unicode General_Category value [UNICODE] change from So to Sm, or
from Lo to Ll, without affecting the algorithm results. Moreover,
even if such changes were to result, the BackwardCompatible list
(Section 7.7) can be adjusted to ensure the stability of the results.

7. Category Definitions Used to Calculate Derived Property

The derived property obtains its value based on a two-step procedure:

1. Characters are placed in one or more character categories either
   (1) based on core properties defined by the Unicode Standard or
   (2) by treating the code point as an exception and addressing the
   code point based on its code point value. These categories are
   not mutually exclusive.

2. Set operations are used with these categories to determine the
   values for a property specific to a given string class. These
   operations are specified under Section 8.

Note: Unicode property names and property value names might have
short abbreviations, such as "gc" for the General_Category
property and "Ll" for the Lowercase_Letter property value of the gc property.

In the following specification of character categories, the operation that returns the value of a particular Unicode character property for a code point is designated by using the formal name of that property (from the Unicode PropertyAliases.txt [1]) followed by '(cp)' for "code point". For example, the value of the General_Category property for a code point is indicated by General_Category(cp).

The first ten categories (A-J) shown below were previously defined for IDNA2008 and are copied directly from [RFC5892]. Some of these categories are reused in PRECIS and some of them are not; however, the lettering of categories is retained to prevent overlap and to ease implementation of both IDNA2008 and PRECIS in a single software application. The next eight categories (K-R) are specific to PRECIS.

7.1. LetterDigits (A)

Note: This category is defined in [RFC5892] and copied here for use in PRECIS.

A: General_Category(cp) is in {Ll, Lu, Lm, Lo, Mn, Mc, Nd}

These rules identify characters commonly used in mnemonics and often informally described as "language characters".

For more information, see Chapter 4 of the Unicode Standard [UNICODE].

The categories used in this rule are:

- Ll - Lowercase_Letter
- Lu - Uppercase_Letter
- Lm - Modifier_Letter
- Lo - Other_Letter
- Mn - Nonspacing_Mark
- Mc - Spacing_Mark
- Nd - Decimal_Number
7.2. Unstable (B)

Note: This category is defined in [RFC5892] but not used in PRECIS.

7.3. IgnorableProperties (C)

Note: This category is defined in [RFC5892] but not used in PRECIS. See the "PrecisIgnorableProperties (M)" category below for a more inclusive category used in PRECIS identifiers.

7.4. IgnorableBlocks (D)

Note: This category is defined in [RFC5892] but not used in PRECIS.

7.5. LDH (E)

Note: This category is defined in [RFC5892] but not used in PRECIS. See the "ASCII7 (K)" category below for a more inclusive category used in PRECIS identifiers.

7.6. Exceptions (F)

Note: This category is defined in [RFC5892] and used in PRECIS to ensure consistent treatment of the relevant code points.

F: cp is in \{00B7, 00DF, 0375, 03C2, 05F3, 05F4, 0640, 0660, 0661, 0662, 0663, 0664, 0665, 0666, 0667, 0668, 0669, 06F0, 06F1, 06F2, 06F3, 06F4, 06F5, 06F6, 06F7, 06F8, 06F9, 06FD, 06FE, 07FA, 0F0B, 3007, 302E, 302F, 3031, 3032, 3033, 3034, 3035, 303B, 30FA\}

This category explicitly lists code points for which the category cannot be assigned using only the core property values that exist in the Unicode Standard. The values are according to the table below:

PVALID -- Would otherwise have been DISALLOWED

00DF; PVALID # LATIN SMALL LETTER SHARP S
03C2; PVALID # GREEK SMALL LETTER FINAL SIGMA
06FD; PVALID # ARABIC SIGN SINDHI AMPERSAND
06FE; PVALID # ARABIC SIGN SINDHI POSTPOSITION MEN
0F0B; PVALID # TIBETAN MARK INTERSYLLABIC TSHEG
3007; PVALID # IDEOGRAPHIC NUMBER ZERO

CONTEXTO -- Would otherwise have been DISALLOWED

00B7; CONTEXTO # MIDDLE DOT
7.7. BackwardCompatible (G)

Note: This category is defined in [RFC5892] and copied here for use in PRECIS. Because of how the PRECIS string classes are defined, only changes that would result in code points being added to or removed from the LetterDigits ("A") category would result in
backward-incompatible modifications to code point assignments. Therefore, management of this category is handled via the processes specified in [RFC5892].

G: cp is in {}

This category includes the code points for which property values in versions of Unicode after 5.2 have changed in such a way that the derived property value would no longer be PVALID or DISALLOWED. If changes are made to future versions of Unicode so that code points might change property value from PVALID or DISALLOWED, then this table can be updated and keep special exception values so that the property values for code points stay stable.

7.8. JoinControl (H)

Note: This category is defined in [RFC5892] and copied here for use in PRECIS.

H: Join_Control(cp) = True

This category consists of Join Control characters (i.e., they are not in LetterDigits (Section 7.1) but are still required in strings under some circumstances).

7.9. OldHangulJamo (I)

Note: This category is defined in [RFC5892] and copied here for use in PRECIS.

I: Hangul_Syllable_Type(cp) is in {L, V, T}

This category consists of all conjoining Hangul Jamo (Leading Jamo, Vowel Jamo, and Trailing Jamo).

Elimination of conjoining Hangul Jamos from the set of PVALID characters results in restricting the set of Korean PVALID characters just to preformed, modern Hangul syllable characters. Old Hangul syllables, which are spelled with sequences of conjoining Hangul Jamos, are not PVALID for string classes.

7.10. Unassigned (J)

Note: This category is defined in [RFC5892] and copied here for use in PRECIS.

J: General_Category(cp) is in {Cn} and Noncharacter_Code_Point(cp) = False
This category consists of code points in the Unicode character set that are not (yet) designated. Implementers might want to keep in mind that the Unicode Standard distinguishes between ‘unassigned code points’ and ‘unassigned characters’. The unassigned code points are all but (Cn - Noncharacters), whereas the unassigned characters are all but (Cn + Cs).

7.11. ASCII7 (K)

This PRECIS-specific category consists of all printable, non-space characters from the 7-bit ASCII range. By applying this category, the algorithm specified under Section 8 exempts these characters from other rules that might be applied during PRECIS processing, on the assumption that these code points are in such wide use that disallowing them would be counter-productive.

K: cp is in {0021..007E}

7.12. Controls (L)

L: Control(cp) = True

7.13. PrecisIgnorableProperties (M)

This PRECIS-specific category is used to group code points that are discouraged from use in PRECIS string classes.

M: Default_Ignorable_Code_Point(cp) = True or Noncharacter_Code_Point(cp) = True

The definition for Default_Ignorable_Code_Point can be found in the DerivedCoreProperties.txt [2] file, and at the time of Unicode 6.3 is as follows:

- Other_Default_Ignorable_Code_Point
- Cf (Format characters)
- Variation_Selector
- White_Space
- FFF9..FFFF (Annotation Characters)
- 0600..0604, 06DD, 070F, 110BD (exceptional Cf characters that should be visible)

7.14. Spaces (N)

This PRECIS-specific category is used to group code points that are space characters.

N: General_Category(cp) is in {Zs}
7.15. Symbols (O)

This PRECIS-specific category is used to group code points that are symbols.

O: General_Category(cp) is in \{Sm, Sc, Sk, So\}

7.16. Punctuation (P)

This PRECIS-specific category is used to group code points that are punctuation characters.

P: General_Category(cp) is in \{Pc, Pd, Ps, Pe, Pi, Pf, Po\}

7.17. HasCompat (Q)

This PRECIS-specific category is used to group code points that have compatibility equivalents as explained in Chapter 2 and Chapter 3 of the Unicode Standard [UNICODE].

Q: toNFKC(cp) \neq cp

The toNFKC() operation returns the code point in normalization form KC. For more information, see Section 5 of Unicode Standard Annex #15 [UAX15].

7.18. OtherLetterDigits (R)

This PRECIS-specific category is used to group code points that are letters and digits other than the "traditional" letters and digits grouped under the LetterDigits (A) class (see Section 7.1).

R: General_Category(cp) is in \{Lt, Nl, No, Me\}

8. Calculation of the Derived Property

Possible values of the derived property are:

- PVALID
- ID_PVAL
- FREE_PVAL
- CONTEXTJ
- CONTEXTO
Note: The value of the derived property calculated can depend on the string class; for example, if an identifier used in an application protocol is defined as profiling the PRECIS IdentifierClass then a space character such as U+0020 would be assigned to ID_DIS, whereas if an identifier is defined as profiling the PRECIS FreeformClass then the character would be assigned to FREE_PVAL. For the sake of brevity, the designation "FREE_PVAL" is used in the code point tables, instead of the longer designation "ID_DIS or FREE_PVAL". In practice, the derived properties ID_PVAL and FREE_DIS are not used in this specification, since every ID_PVAL code point is PVALID and every FREE_DIS code point is DISALLOWED.

The algorithm to calculate the value of the derived property is as follows:

If .cp. .in. Exceptions Then Exceptions(cp);
Else If .cp. .in. BackwardCompatibility Then BackwardCompatible(cp);
Else If .cp. .in. Unassigned Then UNASSIGNED;
Else If .cp. .in. ASCII7 Then PVALID;
Else If .cp. .in. JoinControl Then CONTEXTJ;
Else If .cp. .in. OldHangulJamo Then DISALLOWED;
Else If .cp. .in. PrecisIgnorableProperties Then DISALLOWED;
Else If .cp. .in. Controls Then DISALLOWED;
Else If .cp. .in. HasCompat Then ID_DIS or FREE_PVAL;
Else If .cp. .in. LetterDigits Then PVALID;
Else If .cp. .in. OtherLetterDigits Then ID_DIS or FREE_PVAL;
Else If .cp. .in. Spaces Then ID_DIS or FREE_PVAL;
Else If .cp. .in. Symbols Then ID_DIS or FREE_PVAL;
Else If .cp. .in. Punctuation Then ID_DIS or FREE_PVAL;
Else DISALLOWED;

Note: Use of the name of a rule (such as "Exceptions") implies the set of code points that the rule defines, whereas the same name as a function call (such as "Exceptions(cp)") implies the value that the code point has in the Exceptions table.
9. IANA Considerations

9.1. PRECIS Derived Property Value Registry

IANA is requested to create a PRECIS-specific registry with the Derived Properties for the versions of Unicode that are released after (and including) version 6.3. The derived property value is to be calculated in cooperation with a designated expert [RFC5226] according to the rules specified under Section 7 and Section 8, not by copying the non-normative table found under Appendix A.

The IESG is to be notified if backward-incompatible changes to the table of derived properties are discovered or if other problems arise during the process of creating the table of derived property values or during expert review. Changes to the rules defined under Section 7 and Section 8 require IETF Review.

9.2. PRECIS Base Classes Registry

IANA is requested to create a registry of PRECIS string classes. In accordance with [RFC5226], the registration policy is "RFC Required".

The registration template is as follows:

Base Class: [the name of the PRECIS string class]

Description: [a brief description of the PRECIS string class and its intended use, e.g., "A sequence of letters, numbers, and symbols that is used to identify or address a network entity."]

Specification: [the RFC number]

The initial registrations are as follows:

Base Class: FreeformClass.
Description: A sequence of letters, numbers, symbols, spaces, and other code points that is used for free-form strings.
Specification: Section 3.3 of this document.
[Note to RFC Editor: please change "this document" to the RFC number issued for this specification.]

Base Class: IdentifierClass.
Description: A sequence of letters, numbers, and symbols that is used to identify or address a network entity.
Specification: Section 3.3 of this document.
[Note to RFC Editor: please change "this document" to the RFC number issued for this specification.]
9.3. PRECIS Profiles Registry

IANA is requested to create a registry of profiles that use the PRECIS string classes. In accordance with [RFC5226], the registration policy is "Expert Review". This policy was chosen in order to ease the burden of registration while ensuring that "customers" of PRECIS receive appropriate guidance regarding the sometimes complex and subtle internationalization issues related to profiles of PRECIS string classes.

The registration template is as follows:

Name:  [the name of the profile]

Applicability:  [the specific protocol elements to which this profile applies, e.g., "Localparts in XMPP addresses."]

Base Class:  [which PRECIS string class is being profiled]

Replaces:  [the Stringprep profile that this PRECIS profile replaces, if any]

Width Mapping:  [the behavioral rule for handling of width, e.g., "Map fullwidth and halfwidth characters to their compatibility variants."]

Additional Mappings:  [any additional mappings are required or recommended, e.g., "Map non-ASCII space characters to ASCII space."]

Case Mapping:  [the behavioral rule for handling of case, e.g., "Unicode Default Case Folding"]

Normalization:  [which Unicode normalization form is applied, e.g., "NFC"]

Directionality:  [the behavioral rule for handling of right-to-left code points, e.g., "The ‘Bidi Rule’ defined in RFC 5893 applies."]

Exclusions:  [a brief description of the specific code points or characters categories are excluded, e.g., "Eight legacy characters in the ASCII range" or "Any character that has a compatibility equivalent, i.e., the HasCompat category"]

Enforcement:  [which entities enforce the rules, and when that enforcement occurs during protocol operations]
In order to request a review, the registrant shall send a completed template to the precis@ietf.org list or its designated successor.

Factors to focus on while defining profiles and reviewing profile registrations include the following:

- Is the problem being addressed by this profile well-defined?
- Does the specification define what kinds of applications are involved and the protocol elements to which this profile applies?
- Would an existing PRECIS string class or profile solve the problem?
- Is the profile clearly defined?
- Is the profile based on an appropriate dividing line between user interface (culture, context, intent, locale, device limitations, etc.) and the use of conformant strings in protocol elements?
- Are the width mapping, case mapping, additional mappings, normalization, exclusion, and directionality rules appropriate for the intended use?
- Does the profile explain which entities enforce the rules, and when such enforcement occurs during protocol operations?
- Does the profile reduce the degree to which human users could be surprised or confused by application behavior (the "principle of least user surprise")?
- Does the profile introduce any new security concerns such as those described under Section 10 of this document (e.g., false positives for authentication or authorization)?

10. Security Considerations

10.1. General Issues

The security of applications that use this framework can depend in part on the proper preparation and comparison of internationalized strings. For example, such strings can be used to make authentication and authorization decisions, and the security of an application could be compromised if an entity providing a given
Specifications of application protocols that use this framework are encouraged to describe how internationalized strings are used in the protocol, including the security implications of any false positives and false negatives that might result from various comparison operations. For some helpful guidelines, refer to [RFC6943], [RFC5890], [UTR36], and [UTS39].

10.2. Use of the IdentifierClass

Strings that conform to the IdentifierClass and any profile thereof are intended to be relatively safe for use in a broad range of applications, primarily because they include only letters, digits, and "grandfathered" non-space characters from the ASCII range; thus they exclude spaces, characters with compatibility equivalents, and almost all symbols and punctuation marks. However, because such strings can still include so-called confusable characters (see Section 10.5), protocol designers and implementers are encouraged to pay close attention to the security considerations described elsewhere in this document.

10.3. Use of the FreeformClass

Strings that conform to the FreeformClass and many profiles thereof can include virtually any Unicode character. This makes the FreeformClass quite expressive, but also problematic from the perspective of possible user confusion. Protocol designers are hereby warned that the FreeformClass contains codepoints they might not understand, and are encouraged to profile the IdentifierClass wherever feasible; however, if an application protocol requires more code points than are allowed by the IdentifierClass, protocol designers are encouraged to define a profile of the FreeformClass that restricts the allowable code points as tightly as possible. (The PRECIS Working Group considered the option of allowing superclasses as well as profiles of PRECIS string classes, but decided against allowing superclasses to reduce the likelihood of security and interoperability problems.)

10.4. Local Character Set Issues

When systems use local character sets other than ASCII and Unicode, this specification leaves the problem of converting between the local character set and Unicode up to the application or local system. If different applications (or different versions of one application) implement different rules for conversions among coded character sets, they could interpret the same name differently and contact different
application servers or other network entities. This problem is not solved by security protocols, such as Transport Layer Security (TLS) [RFC5246] and the Simple Authentication and Security Layer (SASL) [RFC4422], that do not take local character sets into account.

10.5. Visually Similar Characters

Some characters are visually similar and thus can cause confusion among humans. Such characters are often called "confusable characters" or "confusables".

The problem of confusable characters is not necessarily caused by the use of Unicode code points outside the ASCII range. For example, in some presentations and to some individuals the string "juliet" (spelled with DIGIT ONE, U+0031, as the third character) might appear to be the same as "juliet" (spelled with LATIN SMALL LETTER L, U+006C), especially on casual visual inspection. This phenomenon is sometimes called "typejacking".

However, the problem is made more serious by introducing the full range of Unicode code points into protocol strings. For example, the characters U+13DA U+13A2 U+13B5 U+13AC U+13A2 U+13AC U+13D2 from the Cherokee block look similar to the ASCII characters "STPETER" as they might appear when presented using a "creative" font family.

In some examples of confusable characters, it is unlikely that the average human could tell the difference between the real string and the fake string. (Indeed, there is no programmatic way to distinguish with full certainty which is the fake string and which is the real string; in some contexts, the string formed of Cherokee characters might be the real string and the string formed of ASCII characters might be the fake string.) Because PRECIS-compliant strings can contain almost any properly-encoded Unicode code point, it can be relatively easy to fake or mimic some strings in systems that use the PRECIS framework. The fact that some strings are easily confused introduces security vulnerabilities of the kind that have also plagued the World Wide Web, specifically the phenomenon known as phishing.

Despite the fact that some specific suggestions about identification and handling of confusable characters appear in the Unicode Security Considerations [UTR36] and the Unicode Security Mechanisms [UTS39], it is also true (as noted in [RFC5890]) that "there are no comprehensive technical solutions to the problems of confusable characters". Because it is impossible to map visually similar characters without a great deal of context (such as knowing the font families used), the PRECIS framework does nothing to map similar-
looking characters together, nor does it prohibit some characters because they look like others.

Nevertheless, specifications for application protocols that use this framework MUST describe how confusable characters can be abused to compromise the security of systems that use the protocol in question, along with any protocol-specific suggestions for overcoming those threats. In particular, software implementations and service deployments that use PRECIS-based technologies are strongly encouraged to define and implement consistent policies regarding the registration, storage, and presentation of visually similar characters. The following recommendations are appropriate:

1. An application service SHOULD define a policy that specifies the scripts or blocks of characters that the service will allow to be registered (e.g., in an account name) or stored (e.g., in a file name). Such a policy SHOULD be informed by the languages and scripts that are used to write registered account names; in particular, to reduce confusion, the service SHOULD forbid registration or storage of strings that contain characters from more than one script and SHOULD restrict registrations to characters drawn from a very small number of scripts (e.g., scripts that are well-understood by the administrators of the service, to improve manageability).

2. User-oriented application software SHOULD define a policy that specifies how internationalized strings will be presented to a human user. Because every human user of such software has a preferred language or a small set of preferred languages, the software SHOULD gather that information either explicitly from the user or implicitly via the operating system of the user’s device. Furthermore, because most languages are typically represented by a single script or a small set of scripts, and because most scripts are typically contained in one or more blocks of characters, the software SHOULD warn the user when presenting a string that mixes characters from more than one script or block, or that uses characters outside the normal range of the user’s preferred language(s). (Such a recommendation is not intended to discourage communication across different communities of language users; instead, it recognizes the existence of such communities and encourages due caution when presenting unfamiliar scripts or characters to human users.)

The challenges inherent in supporting the full range of Unicode code points have in the past led some to hope for a way to programatically negotiate more restrictive ranges based on locale, script, or other relevant factors, to tag the locale associated with
10.6. Security of Passwords

Two goals of passwords are to maximize the amount of entropy and to minimize the potential for false positives. These goals can be achieved in part by allowing a wide range of code points and by ensuring that passwords are handled in such a way that code points are not compared aggressively. Therefore, it is NOT RECOMMENDED for application protocols to profile the FreeformClass for use in passwords in a way that removes entire categories (e.g., by disallowing symbols or punctuation). Furthermore, it is NOT RECOMMENDED for application protocols to map uppercase and titlecase code points to their lowercase equivalents in such strings; instead, it is RECOMMENDED to preserve the case of all code points contained in such strings and to compare them in a case-sensitive manner.

That said, software implementers need to be aware that there exist tradeoffs between entropy and usability. For example, allowing a user to establish a password containing "uncommon" code points might make it difficult for the user to access a service when using an unfamiliar or constrained input device.

Some application protocols use passwords directly, whereas others reuse technologies that themselves process passwords (one example of such a technology is the Simple Authentication and Security Layer [RFC4422]). Moreover, passwords are often carried by a sequence of protocols with backend authentication systems or data storage systems such as RADIUS [RFC2865] and LDAP [RFC4510]. Developers of application protocols are encouraged to look into reusing these profiles instead of defining new ones, so that end-user expectations about passwords are consistent no matter which application protocol is used.

Further discussion of password handling can be found in [I-D.ietf-precis-saslprepbis].

11. Interoperability Considerations

Although strings that are consumed in PRECIS-based application protocols are often encoded using UTF-8 [RFC3629], the exact encoding is a matter for the application protocol that uses PRECIS, not for the PRECIS framework.

It is known that some existing systems are unable to support the full Unicode character set, or even any characters outside the ASCII range. If two (or more) applications need to interoperate when
exchanging data (e.g., for the purpose of authenticating a username or password), they will naturally need to have in common at least one coded character set (as defined by [RFC6365]). Establishing such a baseline is a matter for the application protocol that uses PRECIS, not for the PRECIS framework.

The PRECIS framework, which is defined in terms of the latest version of Unicode as of the time of this writing (6.3), treats the character U+19DA NEW TAI LUE THAM as DISALLOWED. Implementers need to be aware that this treatment is different from IDNA2008 (originally defined in terms of Unicode 5.2), which treats U+19DA as PVALID.

12. References

12.1. Normative References


12.2. Informative References


12.3. URIs


Appendix A. Codepoint Table

If one applies the property calculation rules from Section 8 to the code points 0x0000 to 0x10FFFF in Unicode 6.3, the result is as shown in the following table, in Unicode Character Database (UCD) format. The columns of the table are as follows:

1. The code point or codepoint range.

2. The assignment for the code point or range, where the value is one of PVALID, DISALLOWED, UNASSIGNED, CONTEXTO, CONTEXTJ, or FREE_PVAL (where the latter includes ID_DIS).

3. The name or names for the code point or range.

This table is non-normative, is included only for illustrative purposes, and applies only to Unicode 6.3, not to past or future versions of Unicode. Please note that the strings displayed in the third column are not necessarily the formal name of the code point (as defined in [UNICODE]) because the fixed width of the RFC format necessitated truncation of many names.

<table>
<thead>
<tr>
<th>Codepoint Range</th>
<th>Assignment</th>
<th>Name(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000..001F</td>
<td>DISALLOWED</td>
<td># &lt;control&gt;</td>
</tr>
<tr>
<td>0020</td>
<td>FREE_PVAL</td>
<td># SPACE</td>
</tr>
<tr>
<td>0021..007E</td>
<td>PVALID</td>
<td># EXCLAM MARK..TILDE</td>
</tr>
<tr>
<td>007F..009F</td>
<td>DISALLOWED</td>
<td># &lt;control&gt;</td>
</tr>
<tr>
<td>00A0..00AC</td>
<td>FREE_PVAL</td>
<td># NO-BREAK SPACE..NOT SIGN</td>
</tr>
<tr>
<td>00AD</td>
<td>DISALLOWED</td>
<td># SOFT HYPH</td>
</tr>
<tr>
<td>00AE..00B6</td>
<td>FREE_PVAL</td>
<td># REGISTERED SIGN..PILCROW SIGN</td>
</tr>
<tr>
<td>00B7</td>
<td>CONTEXTO</td>
<td># MIDDLE DOT</td>
</tr>
<tr>
<td>00B8..00BF</td>
<td>FREE_PVAL</td>
<td># CEDILLA..INV QUEST IND</td>
</tr>
<tr>
<td>00C0..00D6</td>
<td>PVALID</td>
<td># LAT CAP LET A W GRAV..LAT CAP O</td>
</tr>
<tr>
<td>00D7</td>
<td>FREE_PVAL</td>
<td># MULTIPLICATION SIGN</td>
</tr>
<tr>
<td>00D8..00F6</td>
<td>PVALID</td>
<td># LAT CAP LET O W STROKE..LAT SM</td>
</tr>
<tr>
<td>00F7</td>
<td>FREE_PVAL</td>
<td># DIVISION SIGN</td>
</tr>
<tr>
<td>00F8..0131</td>
<td>PVALID</td>
<td># LAT SM LET O W STROKE..LAT SM LET</td>
</tr>
<tr>
<td>0132..0133</td>
<td>FREE_PVAL</td>
<td># LAT CAP LIG IJ..LAT SM LIB IJ</td>
</tr>
<tr>
<td>0134..013E</td>
<td>PVALID</td>
<td># LAT CAP LET J W CIRCUM..LAT SM LET</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>013F..0140</td>
<td># LAT CAP LET L W MID DOT..LAT SM LET</td>
<td></td>
</tr>
<tr>
<td>0141..0148</td>
<td># LAT CAP LET L W STROKE..LAT SM LET</td>
<td></td>
</tr>
<tr>
<td>0149</td>
<td># LAT SM LET N PRECEDED BY APOS</td>
<td></td>
</tr>
<tr>
<td>014A..017E</td>
<td># LAT CAP LET ENG..LAT SM LET Z W CA</td>
<td></td>
</tr>
<tr>
<td>017F</td>
<td># LAT SM LET LONG S</td>
<td></td>
</tr>
<tr>
<td>0180..01C3</td>
<td># LAT SM LET B W STROKE..LAT SM RETR</td>
<td></td>
</tr>
<tr>
<td>01C4..01CC</td>
<td># LAT CAP LET DZ W CARON..LAT SM</td>
<td></td>
</tr>
<tr>
<td>01CD..01F0</td>
<td># LAT CAP LET A W CARON..LAT SM LET J</td>
<td></td>
</tr>
<tr>
<td>01F1..01F3</td>
<td># LAT CAP LET DZ..LAT SM LET DZ</td>
<td></td>
</tr>
<tr>
<td>01F4..02AF</td>
<td># LAT CAP LET G W ACUTE..LAT SM</td>
<td></td>
</tr>
<tr>
<td>02B0..02B8</td>
<td># MOD LET SM H..MOD LET SM Y</td>
<td></td>
</tr>
<tr>
<td>02B9..02C1</td>
<td># MOD LET PRIME..MOD LET REV GLOT ST</td>
<td></td>
</tr>
<tr>
<td>02C2..02C5</td>
<td># MOD LET L ARROW..MOD LET D ARROW</td>
<td></td>
</tr>
<tr>
<td>02C6..02D1</td>
<td># MOD LET CIRCUM ACC..MOD LET HALF TR</td>
<td></td>
</tr>
<tr>
<td>02D2..02EB</td>
<td># MOD LET CENT R HALF RING..MOD LET Y</td>
<td></td>
</tr>
<tr>
<td>02EC</td>
<td># MOD LET VOICING</td>
<td></td>
</tr>
<tr>
<td>02ED</td>
<td># MOD LET UNASPIRATED</td>
<td></td>
</tr>
<tr>
<td>02EE</td>
<td># MOD LET DOUBLE APOS</td>
<td></td>
</tr>
<tr>
<td>02EF..02FF</td>
<td># MOD LET LOW D ARR..MOD LET LOW L AR</td>
<td></td>
</tr>
<tr>
<td>0300..034E</td>
<td># COMB GRAVE ACCENT..COMB UP ARROW BE</td>
<td></td>
</tr>
<tr>
<td>034F</td>
<td># DISALLOWED</td>
<td></td>
</tr>
<tr>
<td>0350..0374</td>
<td># COMB RIGHT ARROWHEAD..GREEK NUM SIG</td>
<td></td>
</tr>
<tr>
<td>0375</td>
<td># GREEK LOW NUM SIGN</td>
<td></td>
</tr>
<tr>
<td>0376..0377</td>
<td># GR CAP LET PAMPHYLIAN DIGAMMA..GR S</td>
<td></td>
</tr>
<tr>
<td>0378..0379</td>
<td># GREEK COMB GRAVE ACCENT..COMB UP ARROW BE</td>
<td></td>
</tr>
<tr>
<td>037A</td>
<td># GR YPOGEGRAMMENI..GR SM REV DOT LUN</td>
<td></td>
</tr>
<tr>
<td>037B..037D</td>
<td># GR SM REV LUN SIG..GR SM REV DOT LU</td>
<td></td>
</tr>
<tr>
<td>037E</td>
<td># GREEK QUEST MARK</td>
<td></td>
</tr>
<tr>
<td>037F..0383</td>
<td># GREEK SM REV DOT LUN SIG..GR SM REV DOT LU</td>
<td></td>
</tr>
<tr>
<td>0384..0385</td>
<td># GREEK TONOS..GREEK DIALYTIKA TONOS</td>
<td></td>
</tr>
<tr>
<td>0386</td>
<td># GR CAP LET ALPHA W TONOS</td>
<td></td>
</tr>
<tr>
<td>0387</td>
<td># GREEK SYM ANO TELEIA</td>
<td></td>
</tr>
<tr>
<td>0388..038A</td>
<td># GREEK CAP LET EPSILON W TONOS..GR CAP</td>
<td></td>
</tr>
<tr>
<td>038B</td>
<td># GREEK CAP LET EPSILON W TONOS..GR CAP</td>
<td></td>
</tr>
<tr>
<td>038C</td>
<td># GREEK CAP LETOMICRON W TONOS</td>
<td></td>
</tr>
<tr>
<td>038D</td>
<td># GREEK CAP LETOMICRON W TONOS</td>
<td></td>
</tr>
<tr>
<td>038E..03A1</td>
<td># GREEK CAP LET EPSILON W TONOS..GR CAP</td>
<td></td>
</tr>
<tr>
<td>03A2</td>
<td># GREEK CAP LET EPSILON W TONOS..GR CAP</td>
<td></td>
</tr>
<tr>
<td>03A3..03CF</td>
<td># GREEK CAP LET SIGMA..GR CAP</td>
<td></td>
</tr>
<tr>
<td>03D0..03D2</td>
<td># GR BETA SYM..GR UPSILON W HOOK</td>
<td></td>
</tr>
<tr>
<td>03D3..03D4</td>
<td># GR UPSILON W ACUTE AND HOOK..GR UP</td>
<td></td>
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0E50..0E59  ; PVALID  # THAI DIG ZERO..THAI DIG NINE
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0F0B ; PVALID # TIB MARK INTERSYLLABIC TSHEG
0F0C..0F17 ; FREE_PVAL # TIB MARK DELIMITER TSHEG BSTAR..TIB
0F18..0F19 ; PVALID # TIB ASTROLOGICAL SIGN -KHYUD PA..TIB
0F1A..0F1F ; FREE_PVAL # TIB SIGN RDEL DKAR GCIG..TIB SIGN RD
0F20..0F29 ; PVALID # TIB DIG ZERO..TIB DIG NINE
0F2A..0F34 ; FREE_PVAL # TIB DIG HALF ONE..TIB MARK BSDUS R
0F35 ; PVALID # TIB MARK NGAS BZUNG NYI ZLA
0F36 ; FREE_PVAL # TIB MARK CARET DZUD RTAGS BZHI MIG C
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0F85 ; FREE_PVAL # TIB MARK PALUTA
0F86..0F8F ; PVALID # TIB SIGN LCI RTAGS..TIB SUBJOIN S
0F90..0F97 ; PVALID # TIB SUBJOIN LET KA..TIB SUBJOIN
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0FC7..0FCC ; FREE_PVAL # TIB SYM RDO RJE RGYA GRAM..TIB SY
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166D..166E ; FREE_PVAL # CANAD SYL CHI SIGN..CANAD SYLLAB
166F..167F ; PVALID # CANAD SYL QAI..CANAD SYL B
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1681..169A ; PVALID # OGHAM LET BEITH..OGHAM LET PEITH
169B..169C ; FREE_PVAL # OGHAM FEATHER MARK..OGHAM REV FEAT
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17B6..17D3 ; PVALID # KHMER VOW SIGN AA..KHMER SIGN BATHA
17D4..17D6 ; FREE_PVAL # KHMER SIGN KHAN..KHMER SIGN CAMNUC
17D7 ; PVALID # KHMER SIGN LEK TOO
17D8..17DB ; FREE_PVAL # KHMER SIGN BEYYAL..KHMER CURR SYM R
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180B..180E ; DISALLOWED # MONG FREE VAR SEL ONE..MONG VOW SEP
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1D78  ; FREE_PVAL  # MOD LET CYR EN
1D79..1D9A  ; PVALID  # LAT SM LET INSULAR G..LAT SM LE
1D9B..1DFF  ; FREE_PVAL  # MOD LET SM TURNED ALPHA..MOD LET SM TURNED ALPHA
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<td>EURO-CURRENCY SIGN..TURKISH LIRA SI</td>
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<td>20D0..20DC</td>
<td>PVALID</td>
<td>COMB LEFT HARPOON ABOVE..COMB FOUR</td>
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<tr>
<td>20DD..20E0</td>
<td>FREE_PVAL</td>
<td>COMB ENC CIRC..COMB ENC CIRC BACKS</td>
</tr>
<tr>
<td>20E1</td>
<td>PVALID</td>
<td>COMB L R ARROW ABOVE</td>
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<td>20E2..20E4</td>
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<td>COMB ENC SCREEN..COMB ENC UPWARD PO</td>
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<td>ACCOUNT OF..TURNED GREEK SM LET IOT</td>
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<td>212A..212B</td>
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<td>KELVIN SIGN..ANGSTROM SIGN</td>
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<td>212C..2131</td>
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<td>SCRIPT CAP C..SCRIPT CAP F</td>
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<td>TURNED CAP F</td>
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<td>FREE_PVAL</td>
<td>SCRIPT CAP M..AKTIESELSKAB</td>
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<td>214F..2182</td>
<td>FREE_PVAL</td>
<td>SYM FOR SAMAR SOURCE..ROM NUM TEN T</td>
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<td>2183..2184</td>
<td>PVALID</td>
<td>ROM NUM REV ONE HUNDRED..LAT SM LET</td>
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<td>FREE_PVAL</td>
<td>ROM NUM SIX LATE FORM..VULGAR FRACT</td>
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<td>LEFTWARDS ARROW..HOURGLASS W FLO</td>
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<td>SYM FOR NULL..SYM FOR SUB FORM</td>
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<td>2440..244A</td>
<td>FREE_PVAL</td>
<td>OCR HOOK..OCR DOUBLE BACKSLASH</td>
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<td>WHITE MEDIUM STAR..HEAVY CIRCLED SA</td>
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<td>FREE_PVAL</td>
<td>LAT SUB SM LET J..MOD LET CAP V</td>
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<td>PVALID</td>
<td>LAT CAP LET S W SWASH TAIL..COPT SY</td>
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<td>FREE_PVAL</td>
<td>COPT SYM MI RO..COPT SYM SHIMA SIMA</td>
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<td>2CEB..2CF3</td>
<td>PVALID</td>
<td>COPT CAP LET CRYPTOGRAMMIC SHEI..CO</td>
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<td>FREE_PVAL</td>
<td>COPT OLD NUB FULL STOP..COPT MORPHO</td>
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<td>PVALID</td>
<td>TIFINAGH LET YA..TIFINAGH LETTER YO</td>
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A6E6..A6EF  ; FREE_PVAL    # BAMUM LET MO..BAMUM LET KOGHOM
A6F0..A6F1  ; PVALID      # BAMUM COMB MARK KOQNDON..BAMUM COMB
A6F2..A6F7  ; FREE_PVAL    # BAMUM NJAEMLI..BAMUM QUEST MARK
A6F8..A6FF  ; UNASSIGNED  # <reserved>..<reserved>
A700..A716  ; FREE_PVAL    # MOD LET CHIN TONE YIN PING..MOD
A717..A71F  ; PVALID      # MOD LET DOT VERT BAR..MOD L
A720..A721  ; FREE_PVAL    # MOD LET STRESS AND HIGH TONE..MOD
A722..A726  ; PVALID      # LAT CAP LET EGYPT ALEF..LAT SM LET
A770        ; UNASSIGNED  # <reserved>
A771..A788  ; PVALID      # MOD LET DOT VERT BAR..MOD L
A789..A78E  ; FREE_PVAL    # MOD LET COLON..MOD LET SH EQUALS SI
A78F        ; UNASSIGNED  # <reserved>
A790..A793  ; PVALID      # LAT CAP LET N W DESC..LAT SM LET C
A794..A79F  ; UNASSIGNED  # <reserved>..<reserved>
A7A0..A7A8  ; PVALID      # LAT CAP LET G W OBLIQUE STROKE..LAT
A7AB..A7AF  ; UNASSIGNED  # <reserved>..<reserved>
A7F8..A7F9  ; FREE_PVAL    # MOD LET CAP H W STROKE..MOD LET SM
A7FA..A827  ; PVALID      # LAT SM LET SALTILLO..LAT SM LET L W
A828..A837  ; FREE_PVAL    # MOD LET CAP H W STROKE..MOD LET SM
A83A..A83F  ; UNASSIGNED  # <reserved>..<reserved>
A840..A84F  ; FREE_PVAL    # PHAGS-PA LET KA..PHAGS-PA LET CAN
A850..A85F  ; UNASSIGNED  # <reserved>..<reserved>
A860..A86F  ; FREE_PVAL    # PHAGS-PA LET KA..PHAGS-PA LET CAN
A870..A87F  ; PVALID      # SAUR SIGN ANUSVARA..SAUR SIGN VIRAM
A880..A88F  ; PVALID      # SAUR SIGN VIRAM..SAUR SIGN VIRAM
A890..A89F  ; PVALID      # SAUR DIG ZERO..SAUR DIG NINE
A89A..A89F  ; UNASSIGNED  # <reserved>..<reserved>
A89D..A89F  ; FREE_PVAL    # SAUR DIG VERSACC..SAUR DIG CAN
A8AF..A8B6  ; PVALID      # DEVAN DIG VERSACC..DEVAN DIG CAN
A8B7..A8BF  ; PVALID      # DEVAN DIG VERSACC..DEVAN DIG CAN
A8C0..A8C7  ; UNASSIGNED  # <reserved>..<reserved>
A8D0..A8D9  ; FREE_PVAL    # DEVAN SIGN PUSHPIKA..DEVAN CARET
A8DA..A8DF  ; UNASSIGNED  # <reserved>..<reserved>
A8E0..A8EF  ; PVALID      # COMB DEVAN DIG ZERO..DEVAN SIGN CAN
A8F8..A8FA  ; FREE_PVAL    # DEVAN SIGN PUSHPIKA..DEVAN CARET
A8FB..A8FF  ; PVALID      # DEVAN HEADSTROKE
A900..A90F  ; UNASSIGNED  # <reserved>..<reserved>
A910..A91F  ; FREE_PVAL    # KAYAH LI DIG ZERO..KAYAH LI TONE CA
A920..A92F  ; FREE_PVAL    # KAYAH LI DIG ZERO..KAYAH LI TONE CA
A930..A93F  ; PVALID      # REJANG LET KA..REJANG VIRAMA
A940..A94F  ; UNASSIGNED  # <reserved>..<reserved>
A950..A95F  ; FREE_PVAL    # REJANG SECTION MARK
A960..A977  ; DISALLOWED  # HANGUL CHO TIKEUT-MIUEM..HANGUL CHO
A978..A97F  ; UNASSIGNED  # <reserved>..<reserved>
A980..A98F  ; PVALID      # JAV SIGN PANYANGGA..JAV PANGKON
A990..A99F  ; FREE_PVAL    # JAV LEFT RERENGGAN..JAV TURNED PADA
A9A0..A9A9  ; UNASSIGNED  # <reserved>..<reserved>
A9B0..A9B9  ; PVALID      # JAV PANYANGGA..JAV PANGKON
A9C0..A9C9  ; FREE_PVAL    # JAV LEFT RERENGGAN..JAV TURNED PADA
A9D0..A9F9  ; FREE_PVAL    # JAV PADA TIRIA TUMETES..JAV PADA I
A9E0..A9FF  ; UNASSIGNED  # <reserved>..<reserved>
A9F0..A9FF  ; PVALID  # CHAM LET A..CHAM CONS SIGN WA
AA37..AA3F  ; UNASSIGNED  # <reserved>..<reserved>
AA40..AA4D  ; PVALID  # CHAM LET FIN K..CHAM CONS SIGN FIN
AA4E..AA4F  ; UNASSIGNED  # <reserved>..<reserved>
AA50..AA59  ; PVALID  # CHAM DIG ZERO..CHAM DIG NINE
AA5A..AA5B  ; UNASSIGNED  # <reserved>..<reserved>
AA5C..AA5F  ; FREE_PVAL  # CHAM PUNCT SPIRAL..CHAM PUNCT TR
AA60..AA76  ; PVALID  # MYAN LET KHAMTI GA..MYAN LOGOGRAM K
AA77..AA79  ; FREE_PVAL  # MYAN SYM AITON EXCLAM..MYAN SYM AIT
AA7A..AA7B  ; PVALID  # MYAN LET AITON RA..MYAN SIGN PAO KA
AA7C..AA7F  ; UNASSIGNED  # <reserved>..<reserved>
AA80..AA82  ; PVALID  # TAI VIET LET LOW KO..TAI VIET TONE
AAC3..AAC9  ; UNASSIGNED  # <reserved>..<reserved>
AA9D..AAAD  ; PVALID  # TAI VIET SYM KON..TAI VIET SYM SAM
AAB2..AABB  ; UNASSIGNED  # <reserved>..<reserved>
AAE0..AAE5  ; PVALID  # MEETEI MAYEK LET E..MEETEI MAYEK VO
AAF0..AAF1  ; FREE_PVAL  # MEETEI MAYEK CHEIKHAN..MEETEI MAYEK
AAMB..AACF  ; PVALID  # MEETEI MAYEK ANJI..MEETEI MAYEK VIR
AB00..AB01  ; PVALID  # TAI VIET SYM KON..TAI VIET SYM SAM
AB07..AB08  ; UNASSIGNED  # <reserved>..<reserved>
AB09..AB0E  ; PVALID  # ETHI SYL TTHU..ETHI SYL TTHO
AB11..AB1F  ; UNASSIGNED  # <reserved>..<reserved>
AB20..AB26  ; PVALID  # ETHI SYL CCHHA..ETHI SYL CCHHO
AB27..AB28  ; UNASSIGNED  # <reserved>..<reserved>
AB28..AB2E  ; PVALID  # ETHI SYL BBAA..ETHI SYL BBO
AB2F..AB2F  ; UNASSIGNED  # <reserved>..<reserved>
ABCC..ABC1  ; PVALID  # MEETEI MAYEK LET KOK..MEETEI MAYEK
ABEB..ABEE  ; FREE_PVAL  # MEETEI MAYEK CHEIKHEI
ABEE..ABEF  ; UNASSIGNED  # <reserved>..<reserved>
ABF0..ABF9  ; PVALID  # MEETEI MAYEK DIG ZERO..MEETEI MAYEK
ABFA..ABFF  ; UNASSIGNED  # <reserved>..<reserved>
AC00..DA7A  ; PVALID  # <Hangul Syllable>
D7A4..D7AF  ; UNASSIGNED  # <reserved>..<reserved>
D7B0..D7C6  ; DISALLOWED  # HANGUL JUNG O-YEO..HANGUL JUNG ARAE
D7C7..D7CA  ; UNASSIGNED  # <reserved>..<reserved>
D7CB..D7F8  ; DISALLOWED  # HANGUL JONG NIEUN-RIEUL..HANGUL JON
D7F9..D7FF  ; UNASSIGNED  # <reserved>..<reserved>
D800..F8FF  ; DISALLOWED  # <Non Private Use High Surrogate>
F900..FA6D  ; PVALID  # CJK COMP IDEOGRAPHIC IDEOGRAPH
FA6E..FA6F  ; UNASSIGNED  # <reserved>..<reserved>
FA70..FA79  ; PVALID  # CJK COMP IDEOGRAPHIC IDEOGRAPH
FADA..FAFF  ; UNASSIGNED  # <reserved>..<reserved>
FB00..FB06  ; FREE_PVAL  # LAT SM LIG FF..LAT SM LIG ST
FFA1..FFBE  ; FREE_PVAL   # HALFW HANGUL LET KIYEOK..HALFW HANGUL
FFBF..FFC1  ; UNASSIGNED  # <reserved>..<reserved>
FFC2..FFC7  ; FREE_PVAL   # HALFW HANGUL LET A..HALFW HANGUL
FFC8..FFC9  ; UNASSIGNED  # <reserved>..<reserved>
FFCA..FFCF  ; FREE_PVAL   # HALFW HANGUL LET YEO..HALFW HANGUL
FFD0..FFD1  ; UNASSIGNED  # <reserved>..<reserved>
FFD2..FFD7  ; FREE_PVAL   # HALFW HANGUL LET YO..HALFW HANGUL
FFD8..FFD9  ; UNASSIGNED  # <reserved>..<reserved>
FFDA..FFDF  ; UNASSIGNED  # <reserved>..<reserved>
FFE0..FFE6  ; FREE_PVAL   # FULLW CENT SIGN..FULLW WON SIGN
FFE7        ; UNASSIGNED  # <reserved>
FFE8..FFEE  ; FREE_PVAL   # HALFW FORMS LIGHT VERT..HALFW WH
FFEF..FFF8  ; UNASSIGNED  # <reserved>..<reserved>
FFFF..FFFF  ; DISALLOWED  # <noncharacter>..<noncharacter>
10000..1000B; PVALID   # LIN B SYL B008 A..LIN B SYL
1000C       ; UNASSIGNED  # <reserved>
1000D..10026; PVALID   # LIN B SYL B036 JO..LIN B SYL
10027       ; UNASSIGNED  # <reserved>
10028..1003A; PVALID   # LIN B SYL B060 RA..LIN B SYL
1003B       ; UNASSIGNED  # <reserved>
1003C..1003D; PVALID   # LIN B SYL B017 ZA..LIN B SYL
1003E       ; UNASSIGNED  # <reserved>
1003F..1004D; PVALID   # LIN B SYL B020 ZO..LIN B SYL
1004E..1004F; UNASSIGNED  # <reserved>..<reserved>
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1005E..1007F; UNASSIGNED  # <reserved>..<reserved>
10080..100FA; PVALID   # LIN B IDEOGRAPH B100 MAN..LIN B IDEOGRAPH B180
100FB..100FF; UNASSIGNED  # <reserved>..<reserved>
10100..10102; FREE_PVAL # AEG WORD SEP LINE..AEG CHECK MARK
10103..10106; UNASSIGNED  # <reserved>..<reserved>
10107..10133; FREE_PVAL # AEG NUM ONE..AEG NUM NINETY THOUSAND
10134..10136; UNASSIGNED  # <reserved>..<reserved>
10137..1018A; FREE_PVAL # AEG WEIGHT BASE UNIT..GREEK ZERO SI
1018B..101BF; UNASSIGNED  # <reserved>..<reserved>
10190..1019B; FREE_PVAL # ROM SEXTANS SIGN..ROM CENTURAL SIG
1019C..101CF; UNASSIGNED  # <reserved>..<reserved>
101D0..101FC; FREE_PVAL # PHAISTOS DISC SIGN PED..PHAISTOS DISC SIGN COMB OBLIQUE STR
101FD       ; PVALID   # PHAISTOS DISC SIGN COMB OBLIQUE STR
101FE..1027F; UNASSIGNED  # <reserved>..<reserved>
10280..1029C; PVALID   # Lycian LET A..LYCIAN LET X
1029D..1029F; UNASSIGNED  # <reserved>..<reserved>
102A0..102D0; PVALID   # CARIAN LET A..CARIAN LET UUU3
102D1..102FF; UNASSIGNED  # <reserved>..<reserved>
10300..1031E; PVALID   # OLD ITAL LET A..OLD ITAL LET UU
1031F       ; UNASSIGNED  # <reserved>
10320..10323; FREE_PVAL  # OLD ITAL NUM ONE..OLD ITAL NUM F
10324..1032F; UNASSIGNED  # <reserved>..<reserved>
10330..10340; PVALID  # GOTH LET AHSA..GOTH LET PAIRTHRA
10341; FREE_PVAL  # GOTH LET NINETY
10342..10349; PVALID  # GOTH LET RAIDA..GOTH LET OTHAL
1034A; FREE_PVAL  # GOTH LET NINE HUNDRED
1034B..1037F; UNASSIGNED  # <reserved>..<reserved>
10380..1038D; FREE_PVAL  # OLD PERS SIGN A..OLD PERS SIGN HA
10392..10399; PVALID  # OLD PERS SIGN AURAMAZDAA..OLD PERS
1039D..103A0; FREE_PVAL  # OLD PERS WORD DIVIDER..OLD PERS NUM
103A1..103A4; FREE_PVAL  # OLD PERS NUM ONE..OLD PERS NUM NINETY
103A5..103CE; UNASSIGNED  # <reserved>..<reserved>
103D0..103D5; FREE_PVAL  # OLD PERS WORD DIVIDER..OLD PERS NUM
103D6..103FF; UNASSIGNED  # <reserved>..<reserved>
10400..1040D; PVALID  # DESERET CAP LET LONG I..OSMANYA LET
10481..10484; FREE_PVAL  # OLD ITAL NUM ONE..OLD ITAL NUM F
10485..10489; FREE_PVAL  # <reserved>..<reserved>
1048A..1048F; FREE_PVAL  # IMP ARAM SECT SIGN..IMP ARAM
10490..10499; FREE_PVAL  # IMP ARAM SECT SIGN..IMP ARAM NUM
1049A..1049F; FREE_PVAL  # IMP ARAM SECT SIGN..IMP ARAM
104A0..104A9; PVALID  # OSMANYA DIG ZERO..OSMANYA DIG NINE
104AA..104AF; PVALID  # OSMANYA DIG ZERO..OSMANYA DIG NINE
10500..10509; PVALID  # CYPRIOT SYL A..CYPRIOT SYL JA
10516..1051F; UNASSIGNED  # <reserved>..<reserved>
10520..1052F; UNASSIGNED  # <reserved>..<reserved>
10530..1053F; PVALID  # CYPRIOT SYL KA..CYPRIOT SYL KA
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10560..1056F; UNASSIGNED  # <reserved>..<reserved>
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10580..1058F; UNASSIGNED  # <reserved>..<reserved>
10590..1059F; FREE_PVAL  # IMP ARAM SECT SIGN..IMP ARAM
105AE..105BE; PVALID  # MERO CURS LOG RMT..MERO CURS L
105C0..105D5; PVALID  # KHARO VOW SIGN A..KHARO VOW SIGN A
105D6..105DF; UNASSIGNED  # <reserved>..<reserved>
105E0..105FF; UNASSIGNED  # <reserved>..<reserved>
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10640..1064F; UNASSIGNED  # <reserved>..<reserved>
10650..1065F; PVALID  # KHARO VOW SIGN E..KHARO VOW SI
10660..1066F; PVALID  # IMP ARAM SECT SIGN..IMP ARAM
10A07..10A0B; UNASSIGNED # <reserved>..<reserved>
10A0C..10A13; PVALID # Kharo Vow Len Mark..Kharo Let
10A14 ; UNASSIGNED # <reserved>
10A15..10A17; PVALID # Kharo Let CA..Kharo Let JA
10A18 ; UNASSIGNED # <reserved>
10A19..10A33; PVALID # Kharo Let NYA..Kharo Let TTT
10A34..10A37; UNASSIGNED # <reserved>..<reserved>
10A38..10A3A; PVALID # Kharo Sign Bar Above..Kharo Sign D
10A3B..10A3E; UNASSIGNED # <reserved>..<reserved>
10A3F ; PVALID # Kharo Virama
10A40..10A47; FREE_PVAL # Kharo Dig One..Kharo Num One
10A48..10A4F; UNASSIGNED # <reserved>..<reserved>
10A50..10A58; PVALID # Kharo Punct Dot..Kharo Punct
10A59..10A5C; UNASSIGNED # <reserved>..<reserved>
10A60..10A7C; PVALID # Old S Arab Let HE..Old South Arab
10A7D..10A7F; FREE_PVAL # Old S Arab Num One..Old South Arab
10A80..10A9F; UNASSIGNED # <reserved>..<reserved>
10B00..10B35; PVALID # Avestan Let A..Avestan Let HE
10B36..10B3B; UNASSIGNED # <reserved>..<reserved>
10B3C..10B3F; FREE_PVAL # Avestan ABBR Mark..Large One Ring O
10B40..10B55; PVALID # Inscript Parthian Let Aleph..Inscript
10B56..10B5C; UNASSIGNED # <reserved>..<reserved>
10B5D..10B5F; FREE_PVAL # Inscript Parthian Num One..Inscript
10B60..10B72; PVALID # Inscript Pahlavi Let Aleph..Inscript
10B73..10B77; UNASSIGNED # <reserved>..<reserved>
10B78..10B7F; FREE_PVAL # Inscript Pahlavi Num One..Inscript
10B80..10BFF; UNASSIGNED # <reserved>..<reserved>
10C00..10C48; PVALID # Old Turk Let Orkhon A..Old Turk Let
10C49..10E5F; UNASSIGNED # <reserved>..<reserved>
10E60..10E7E; FREE_PVAL # Rumi Dig One..Rumi Fraction Two THI
10E7F..10FFF; UNASSIGNED # <reserved>..<reserved>
11000..11046; PVALID # Brahmi Sign Candrabindu..Brahmi Vir
11047..1104D; FREE_PVAL # Brahmi Danda..Brahmi Punct Lotus
1104E..11051; UNASSIGNED # <reserved>..<reserved>
11052..11065; FREE_PVAL # Brahmi Num One..Brahmi Num One Thou
11066..1106F; PVALID # Brahmi Dig Zero..Brahmi Dig Nine
11070..1107F; UNASSIGNED # <reserved>..<reserved>
11080..110BA; PVALID # Kaithi Sign Candrabindu..Kaithi Sig
110BB..110BC; FREE_PVAL # Kaithi ABBR Sign..Kaithi Enum Sign
110BD ; DISALLOWED # Kaithi Num Sign
110BE..110C1; FREE_PVAL # Kaithi Sect Mark..Kaithi Double Dan
110C2..110C5; UNASSIGNED # <reserved>..<reserved>
110D0..110F8; PVALID # Sora Sompeng Letter Sah..Sora Sompeng
110F9..110EF; UNASSIGNED # <reserved>..<reserved>
11100..11134; PVALID # Chakma Sign Candrabindu..Chakma Maayy
11135 ; UNASSIGNED # <reserved>
1136..1113F; PVALID # CHAKMA DIG ZERO..CHAKMA DIG NINE
1140..11143; FREE_PVAL # CHAKMA SECT MARK..CHAKMA QUEST MARK
1144..1117F; UNASSIGNED # <reserved>..<reserved>
1180..111C4; PVALID # SHARADA SIGN CANDRABINDU..SHARADA OM
11C5..111C8; FREE_PVAL # SHARADA DANDA..SHARADA SEPARATOR
11CF..111CF; UNASSIGNED # <reserved>..<reserved>
11D0..111D9; PVALID # SHARADA DIG ZERO..SHARADA DIG NINE
11DA..111EA; PVALID # SHARADA SIGN NUKTA
116B..1116BF; UNASSIGNED # <reserved>..<reserved>
116C..1116C9; PVALID # TAKRI LET A..TAKRI SIGN NUKTA
116CA..1116FF; UNASSIGNED # <reserved>..<reserved>
12000..1236E; PVALID # CUNEI SIGN A..CUNEI SIGN ZUM
1236F..123FF; UNASSIGNED # <reserved>..<reserved>
12400..1246F; FREE_PVAL # CUNEI NUM SIGN TWO ASH..CUNEI NUM
1246G..1246F; UNASSIGNED # <reserved>..<reserved>
12470..1247F; FREE_PVAL # CUNEI PUNCT SIGN OLD ASSYRIAN WORD
1247H..124FF; UNASSIGNED # <reserved>..<reserved>
13000..1342F; PVALID # EGYPT HIERO A001..EGYPT HIERO AA032
1342G..1342F; UNASSIGNED # <reserved>..<reserved>
16800..168FF; PVALID # BAMUM LET PHASE-A NGKUE MFON..BAMUN LE
16A39..16A3F; FREE_PVAL # CUNEI NUM SIGN TWO ASH..CUNEI NUM
16A3G..16A3F; UNASSIGNED # <reserved>..<reserved>
16F60..16F7E; FREE_PVAL # MIAO LET NA..MIAO LET HA
16F7F..16F8E; UNASSIGNED # <reserved>..<reserved>
16F8F..16F9F; FREE_PVAL # MIAO TONE RIGHT..MIAO LET REF TON
16FA0..16FAF; UNASSIGNED # <reserved>..<reserved>
1'B000..1'B001; PVALID # KATA LET ARCH E..KATA LET ARCH YE
1'B002..1'BFFF; UNASSIGNED # <reserved>..<reserved>
1D000..1D0FF; FREE_PVAL # BYZ MUS SYM PSILI..BYZ MUS
1D0F6..1D10F; UNASSIGNED # <reserved>..<reserved>
1D100..1D12F; FREE_PVAL # MUS SYM SINGLE BARLINE..MUS SYMBOL
1D12G..1D12H; UNASSIGNED # <reserved>..<reserved>
1D129..1D164; FREE_PVAL # MUS SYM MULT MEASURE REST..MUS SYM ONE
1D165..1D16F; PVALID # MUS SYM COMB STEM..MUS SYM COMB TREMOL
1D166..1D16C; FREE_PVAL # MUS SYM FING TREM-1..MUS SYM FING TREM
1D16D..1D172; PVALID # MUS SYM COMB AUG DOT..MUS SYM COMB FL
1D173..1D17A; DISALLOWED # MUS SYM BEGIN BEAM..MUS SYM END PHRASE
1D17B..1D182; PVALID # MUS SYM COMB ACCENT..MUS SYM COMB LOUR
1D183..1D184; PVALID # MUS SYM ARP UP..MUS SYM ARP DOWN
1D185..1D18F; FREE_PVAL # MUS SYM COMB DOIT..MUS SYM COMB TRIPLE
1D18C..1D1AF; FREE_PVAL # MUS SYM RINFORZANDO..MUS SYM DEG SLASH
1D1A0..1D1AD; PVALID # MUS SYM COMB DOWN BOW..MUS SYM COMB SN
1D1AE..1D1DD; FREE_PVAL # MUS SYM PEDAL MARK..MUS SYM PES SUBPUN
1D1DE..1D1FF; UNASSIGNED # <reserved>..<reserved>
1D200..1D24F; FREE_PVAL # GREEK VOCAL NOTATION SYM-1..GREEK INS
1D24G..1D24F; FREE_PVAL # COMB GREEK MUS TRISEME..COMB GREEK MU
1EE00..1EE03; FREE_PVAL # ARAB MATH ALEF..ARAB MATH DAL
1EE04 ; UNASSIGNED # <reserved>
1EE05..1EE1F; FREE_PVAL # ARAB MATH WAW..ARAB MATH DOTLESS QAF
1EE20 ; UNASSIGNED # <reserved>
1EE21..1EE22; FREE_PVAL # ARAB MATH INIT BEH..ARAB MATH INIT JEE
1EE23 ; UNASSIGNED # <reserved>
1EE24 ; FREE_PVAL # ARAB MATH INIT HEH
1EE25..1EE26; UNASSIGNED # <reserved>..<reserved>
1EE27 ; FREE_PVAL # ARAB MATH INIT HAH
1EE28 ; UNASSIGNED # <reserved>
1EE29..1EE32; FREE_PVAL # ARAB MATH INIT YEH..ARAB MATH INIT QAF
1EE33 ; UNASSIGNED # <reserved>
1EE34..1EE37; FREE_PVAL # ARAB MATH INIT SHEEN..ARAB MATH INITIA
1EE38 ; UNASSIGNED # <reserved>
1EE39 ; FREE_PVAL # ARAB MATH INIT SHEEN
1EE3A ; UNASSIGNED # <reserved>
1EE3B ; FREE_PVAL # ARAB MATH INIT GHAIN
1EE3C..1EE41; UNASSIGNED # <reserved>..<reserved>
1EE42 ; FREE_PVAL # ARAB MATH TAILED JEEM
1EE43..1EE46; UNASSIGNED # <reserved>..<reserved>
1EE47 ; FREE_PVAL # ARAB MATH TAILED HAH
1EE48 ; UNASSIGNED # <reserved>
1EE49 ; FREE_PVAL # ARAB MATH TAILED YEH
1EE4A ; UNASSIGNED # <reserved>
1EE4B ; FREE_PVAL # ARAB MATH TAILED LAM
1EE4C ; UNASSIGNED # <reserved>
1EE4D..1EE4F; FREE_PVAL # ARAB MATH TAILED NOON..ARAB MATH TAILE
1EE50 ; UNASSIGNED # <reserved>
1EE51..1EE52; FREE_PVAL # ARAB MATH TAILED QAF..ARAB MATH TAILED
1EE53 ; UNASSIGNED # <reserved>
1EE54 ; FREE_PVAL # ARAB MATH TAILED SHEEN
1EE55..1EE56; UNASSIGNED # <reserved>..<reserved>
1EE57 ; FREE_PVAL # ARAB MATH TAILED KHAH
1EE58 ; UNASSIGNED # <reserved>
1EE59 ; FREE_PVAL # ARAB MATH TAILED DAD
1EE5A ; UNASSIGNED # <reserved>
1EE5B ; FREE_PVAL # ARAB MATH TAILED GHAIN
1EE5C ; UNASSIGNED # <reserved>
1EE5D ; FREE_PVAL # ARAB MATH TAILED DOTLESS NOON
1EE5E ; UNASSIGNED # <reserved>
1EE5F ; FREE_PVAL # ARAB MATH TAILED DOTLESS GHAIN
1EE60 ; UNASSIGNED # <reserved>
1EE61..1EE62; FREE_PVAL # ARAB MATH STRETCHED BEH..ARAB MATH STR
1EE63 ; UNASSIGNED # <reserved>
1EE64 ; FREE_PVAL # ARAB MATH STRETCHED HEH
1EE65..1EE66; UNASSIGNED # <reserved>..<reserved>
1EE67..1EE6A; FREE_PVAL # ARAB MATH STRETCHED HAH..ARAB MATH STR
1EE6B ; UNASSIGNED # <reserved>
1EE6C..1EE72; FREE_PVAL   # ARAB MATH STRETCHED MEEM..ARAB MATH STET
1EE73    ; UNASSIGNED   # <reserved>
1EE74..1EE77; FREE_PVAL   # ARAB MATH STRETCHED SHEEN..ARAB MATH S
1EE78    ; UNASSIGNED   # <reserved>
1EE79..1EE7C; FREE_PVAL   # ARAB MATH STRETCHED DAD..ARAB MATH STR
1EE7D    ; UNASSIGNED   # <reserved>
1EE7E    ; FREE_PVAL     # ARAB MATH STRETCHED DOTLESS FEH
1EE7F    ; UNASSIGNED   # <reserved>
1EE80..1EE89; FREE_PVAL   # ARAB MATH LOOPED ALEF..ARAB MATH LOOPE
1EE8A    ; UNASSIGNED   # <reserved>
1EE8B..1EE9B; FREE_PVAL   # ARAB MATH LOOPED LAM..ARAB MATH LOOPED
1EE9C..1EEA0; UNASSIGNED # <reserved>..<reserved>
1EEA1..1EEA3; FREE_PVAL   # ARAB MATH DOUBLE-STRUCK BEH..ARAB MATH
1EEA4    ; UNASSIGNED   # <reserved>
1EEA5..1EEA9; FREE_PVAL   # ARAB MATH DOUBLE-STRUCK WAW..ARAB MATH
1EEAA    ; UNASSIGNED   # <reserved>
1EEAB..1EEBB; FREE_PVAL   # ARAB MATH DOUBLE-STRUCK LAM..ARAB MATH
1EEBC..1EEEF; UNASSIGNED # <reserved>..<reserved>
1EEF0..1EEF1; FREE_PVAL   # ARAB MATH OP MEEM W HAH W TATWHEEL..AR
1EEF2..1EEFF; UNASSIGNED # <reserved>..<reserved>
1F000..1F02B; FREE_PVAL   # MAHJONG TILE EAST WIND..MAHJONG TILE B
1F02C..1F02F; UNASSIGNED # <reserved>..<reserved>
1F030..1F093; FREE_PVAL   # DOMINO TILE HORIZ BACK..DOMINO TILE VE
1F094..1F09F; UNASSIGNED # <reserved>..<reserved>
1F0A0..1F0AE; FREE_PVAL   # PLAY CARD BACK..PLAY CARD KING OF SPADE
1F0AF..1F0B0; UNASSIGNED # <reserved>..<reserved>
1F0B1..1F0BE; FREE_PVAL   # PLAY CARD ACE OF HEARTS..PLAY CARD KING
1F0BF..1F0C0; UNASSIGNED # <reserved>..<reserved>
1F0C1..1F0CF; FREE_PVAL   # PLAY CARD ACE OF DIAMONDS..PLAY CARD KING
1F0D0    ; UNASSIGNED   # <reserved>
1F0D1..1F0DF; FREE_PVAL   # PLAY CARD ACE OF CLUBS..PLAY CARD KING
1F0E0..1F0FF; UNASSIGNED # <reserved>..<reserved>
1F100..1F10A; FREE_PVAL   # DIG ZERO FULL STOP..DIG NINE COMMA
1F10B..1F10F; UNASSIGNED # <reserved>..<reserved>
1F110..1F12E; FREE_PVAL   # PARENTHESES LAT CAP LET A..CIRCLE
1F12F    ; UNASSIGNED   # <reserved>
1F130..1F16B; FREE_PVAL   # SQUARE LAT CAP LET A..RAISED MUMPS
1F16C..1F16F; UNASSIGNED # <reserved>..<reserved>
1F170..1F19A; FREE_PVAL   # NEG SQ LAT CAP LET A..NEG SQUARE VS
1F19B..1F1E5; UNASSIGNED # <reserved>..<reserved>
1F1E6..1F202; FREE_PVAL   # REG IND SYMB LET A..REG IND SYMB
1F203..1F20F; UNASSIGNED # <reserved>..<reserved>
1F210..1F23A; FREE_PVAL   # SQ CJK UNIF IDEOGRAPHIC-624B..SQ CJK UNIF IDEOGRAPHIC-672C
1F23B..1F23F; UNASSIGNED # <reserved>..<reserved>
1F240..1F248; FREE_PVAL   # TORT SH BRACK CJK UNIF IDEOGRAPHIC-672C..TORT SH BRACK
1F249..1F24F; UNASSIGNED # <reserved>..<reserved>
1F250..1F251; FREE_PVAL   # CIRC IDEOGRAPH ADVANTAGE..CIRC IDEOGRAPH ACCEPT
1F252..1F2FF; UNASSIGNED # <reserved>..<reserved>
Appendix B. Acknowledgements

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