Technical Reports

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UNICODE IDNA COMPATIBLE PREPROCESSING (IDNA46)

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Summary

This document provides a specification for processing that provides for compatibility between older and newer versions of internationalized domain names (IDN) for lookup in client software. It allows applications such as browsers and emailers to be able to handle both the original version of internationalized domain names(IDNA2003) and the newer version (IDNA2008) compatibly, avoiding possible interoperability and security problems.

*[**Review Note**: At this point, IDNA2008 is still in development, so this draft may change as IDNA2008 changes. The following is a substantial reorganization of the earlier proposed draft of this UTS; the changes from that version are not tracked with yellow highlighting. The text is rough as yet (not yet wordsmithed or copyedited).]*

Status

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> ***A Unicode Technical Standard (UTS)** is an independent specification. Conformance to the Unicode Standard does not imply conformance to any UTS.*

Please submit corrigenda and other comments with the online reporting form [Feedback]. Related information that is useful in understanding this document is found in the References. For the latest version of the Unicode Standard see [Unicode]. For a list of current Unicode Technical Reports see [Reports]. For more information about versions of the Unicode Standard, see [Versions].

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1. Introduction

One of the great strengths of domain names is universality. With **http://Apple.com**, you can get to Apple's website no matter where you are in the world, and no matter which browser you are using. With **markdavis@google.com**, you can send an email to an author of this specification, no matter which country you are in, and no matter which emailer you are using.

Initially, domain names were restricted to only handling ASCII characters. This is was a significant burden on people using other characters. Suppose, for example, that the domain name system had been invented by Greeks, and one could only use Greek characters in URLs. Rather than **apple.com**, one would have to write something like **αππλε.κομ**. An English speaker would not only have to be acquainted with Greek characters, but would also have to pick those Greek letters that would correspond to the desired English letters. One would have to guess at the spelling of particular words, because there are not exact matches between scripts.

A large majority of the world's population faced this situation until recently, because their languages use non-ASCII characters.

1.1 IDNA2003

A system is now in place for internationalized domain names (IDN). This system is called *Internationalizing Domain Names for Applications*, or IDNA for short. It was introduced in 2003, in a series of RFCs collectively known as IDNA2003 [IDNA2003]. This system allows non-ASCII Unicode characters, which includes not only the characters needed for Latin-script languages other than English (such as Å, Ħ, or Þ), but also different scripts, such as Greek, Cyrillic, Tamil, or Korean.

The IDNA mechanism for allowing non-ASCII Unicode characters in domain names involves applying the following steps to each label in the domain name that contains Unicode characters:

1. Transforming (mapping) a Unicode string to remove case and other variant differences.
2. Checking the resulting mapped string for validity, according to certain rules.
3. Transforming the Unicode characters into a DNS-compatible ASCII string using a specialized encoding called *Punycode*.

For example, you can now type in **http://Bücher.de** into the address bar of any modern browser, and you will go to a corresponding site, even though the "ü" is not an ASCII character. This works because the IDN resolves to the Punycode string which is actually stored by the DNS for that site. Similarly, when a browser interprets a web page containing a link such as <a href="http://Bücher.de">, the appropriate site is reached. (In this document, when phrasing like "a browser interprets" is used, it refers both to domain names parsed out of URLs entered in an address bar and to those contained in links internal to HTML text.)

In this case, for the IDN **Bücher.de**, the Punycode value actually used for the domain names on the wire is **http://xn--bcher-kva.de**. The Punycode version is also typically transformed back into Unicode form for display. The resulting display string will be a string which has already been mapped according to the IDNA2003 rules. So in this example we end up with a display string that has been casefolded to lowercase:

http://Bücher.de → **http://xn--bcher-kva.de** → **http://bücher.de**

1.2 IDNA2008

There is a new version of IDNA under development. This version also consists of a collection of RFCs and is usually called IDNA2008 [IDNA2008]. The "2008" in that term does not reflect the actual date of approval, which is still pending and expected to occur in late 2009 or early 2010.

For the most common cases, the processing in IDNA2003 and IDNA2008 are identical. Both transform a Unicode domain name in a URL (like **http://öbb.at**) to the Punycode version (like **http://xn--bb-eka.at**). However, IDNA2008 does not maintain strict backwards compatibility with IDNA2003.

The main differences between the two are:

- **Additions.** Some IDNs are invalid in IDNA2003, but valid in IDNA2008.
- **Subtractions.** Some IDNs are valid in IDNA2003, but invalid in IDNA2008.
- **Deviations.** Some IDNs are valid in both, but resolve to different destinations.
- **Unpredictable Changes.** Some IDNs do not have predictable behavior in applications implementing IDNA2008, due to the option of local mappings, as explained below. They may fail, or may have any of the above characteristics.

For more detail on the differences, see Section 5.2 *IDNA2008 Characters*.

1.3 Security Considerations

The cases of deviations and unpredictable changes introduced by the differences between IDNA2008 and IDNA2003 may cause both interoperability and security problems. They affect extremely common characters: all uppercase characters, all variant-width characters (commonly used in Japan, China, and Korea), and certain other characters like the German *eszett* (U+00DF ß LATIN SMALL LETTER SHARP S) and Greek *final sigma* (U+03C2 ς GREEK SMALL LETTER FINAL SIGMA).

IDNA2003 requires a mapping phase, which maps http://ÖBB.at to http://öbb.at (for example). Mapping typically involves mapping uppercase characters to their lowercase pairs, but it also involves other types of mappings between equivalent characters, such as mapping half-width *katakana* characters to normal (full-width) *katakana* characters in Japanese. The mapping phase in IDNA2003 was included to match the insensitivity of ASCII domain names. Users are accustomed to having both http://CNN.com and http://cnn.com work identically. They would not expect the addition of an accent to make a difference: they expect that if http://Bruder.com is the same as http://bruder.com, then of course http://Brüder.com is the same as http://brüder.com. There are variants similar to case in this respect used in other scripts. The IDNA2003 mapping is based on data specified by Unicode: what later became the Unicode property [NFKC_CaseFold].

IDNA2008 does not require a mapping phase, but does *permit* one (called "Local Mapping" or "Custom Mapping") with no limitation on what the mapping can do to disallowed characters (including even ASCII uppercase characters, if they occur in an IDN). For more information on the permitted mappings, see Section 4.3 and Section 5.3 in the Protocol document of [IDNA2008]. An implementation of IDNA2008 which uses custom mapping can, in principle, allow any mappings, with unpredictable results regarding the exact interpretation of the processed IDNs. For example, the following mappings show cases where IDNs are mapped to what would be considered completely different domain names by IDNA2003 rules:

1. Map http://ÖBB.at to http://öbb.at
2. Map http://ÖBB.at to http://oebb.at
3. Map http://TÜRKIYE.com to http://türkiye.com
4. Map http://TÜRKIYE.com to http://türkıye.com (note the dotless i)—and go to a different location than #3.

IDNA2008 does define a particular mapping, but it is not normative, and does not attempt to be compatible with IDNA2003. For more information, see the Mapping document in [IDNA2008].

1.3.1 Deviations

There are a few situations where the strict application of IDNA2008 will ~~always~~ result in the resolution of IDNs to different IP addresses than in IDNA2003, unless the registry or registrant takes special action. This affects a relatively small number of characters, but some that are common in particular languages and will affect a significant number of strings in those languages. (For more information on why IDNA2008 does this, see the FAQ.) These are referred to as "Deviations"; the significant ones are listed below.

Code	Character	IDNA2008	IDNA2003	Example: IDNA2008	Example: IDNA2003
U+00DF	ß	ß	ss	http://faß.de	http://fass.de
U+03C2	ς	ς	σ	http://βόλος.com	http://βόλοσ.com
U+200D	ZWJ	ZWJ	*delete*	[TBD]	[TBD]
U+200C	ZWNJ	ZWNJ	*deleted*	[TBD]	[TBD]

These differences allow for security exploits. Consider http://www.sparkasse-gießen.de, which is for the "Gießen Savings and Loan".

1. Alice's browser supports IDNA2003. Under those rules,

http://www.sparkasse-gießen.de is mapped to http://www.sparkasse-giessen.de, which leads to a site with the IP address *oo.kk.aa.yy*.

2. She visits a friend Bob, and checks her bank statement on his browser. His browser supports IDNA2008. Under those rules, http://www.sparkasse-gießen.de is also valid, but converts to a different Punycode domain name in http://www.xn--sparkasse-gieen-2ib.de. Unless the "DE" registry bundles, this can lead to a different site with the IP address *ee.vv.ii.ll*, a spoof site.

Alice ends up at the phishing site, supplies her bank password, and is robbed. While DENIC might have a policy about bundling all of the variants of ß together (so that they all have the same owner) it is not required of registries. It is quite unlikely that all registries will have or enforce such a bundling policy in all such cases.

There are two Deviations of particular concern. IDNA2008 allows ZWJ and ZWNJ characters in labels—these were removed by the IDNA2003 mapping. In addition to mapping differently, they represent a special security concern because they are normally invisible. That is, the sequence "a<ZWJ>b" looks just like "ab". IDNA2008 does provide a special category for characters like this (called CONTEXTJ), and only permits them in certain contexts (certain sequences of Arabic or Indic characters, for example). However, lookup applications are not required to check for these contexts, so overall security is dependent on registries having correct implementations. Moreover, those context restrictions do not catch all cases where distinct domain names have visually confusable appearances.

1.4 Compatible Preprocessing

To allow client-side applications to work around the incompatibilities between IDNA2003 and IDNA2008 for lookup, this document provides a standardized preprocessing that allows conformant implementations to minimize the security and interoperability problems caused by the differences between IDNA2003 and IDNA2008. This Compatible Preprocessing, also known as IDNA46, extends IDNA2003 to Unicode 5.2 and beyond, but adds bidi validity constraints from IDNA2008. It uses Unicode [NFKC_CaseFold] (the standard Unicode property) for mapping as described in this document. Thus it will allow http://ÖBB.at (mapping it to http://öbb.at). It also allows IDNs like http://√.com (which has an associated web page), although implementations may restrict the characters that they support based on security considerations, or flag the usage of such characters in a UI.

For DNS lookup, the result of the Compatible Preprocessing is transformed by Punycoding each label that contains non-ASCII. It can then also be supplied to IDNA2008 lookup, which does not require checking of Punycode labels.

The Compatible Preprocessing produces results similar to the tactic of "try IDNA2008 then try IDNA2003". However, it has a much more cohesive approach, allowing browsers and other clients such as search engines to have a single processing step, without having to maintain two different implementations and multiple tables. It also provides a stable definition with predictable results. For a demonstration of differences between IDNA2003, IDNA2008, and the Compatible Preprocessing, see the IDNA demo.

The main goal of this document is to provide a compability mechanism for dealing with IDNA domain name lookup, not with IDNA registration. Note that neither the Compatible Preprocessing nor IDNA2008 address security problems associated with confusables (the so-called "paypal.com" problem). It is strongly recommended that UTR#36: Unicode Security Considerations [UTR36] be consulted for information on dealing with

confusables.

[**Review Note**: The technical committee decided to drop an alternative present in an earlier draft, called Hybrid, which restricted valid characters to those in IDNA2008. The consensus was that a single Compatible version was sufficient.]

1.5 Display of Internationalized Domain Names

For IDNA2003 applications, it has been customary to display the preprocessed string to the user. This is helpful for security, since it reduces the opportunity for visual confusability. Thus, for example, **http://google.com** (with a capital I in place of the L) is revealed as **http://google.com**. However, for the case of the Deviations, the distinction between the original and preprocessed form is especially important. Thus in displaying domain names, it is strongly recommended that a Display Preprocessing be applied. This is the same as the Compatible Preprocessing, except that it excludes the deviations: ß, ς, and joiners.

1.6 Notation

Sets of code pointsare defined by properties according to the syntax of *UTS#18: Unicode Regular Expressions* [UTS18] (with additional "+" signs added for clarity). Thus the set of combining marks is \p{gc=M}.

2 Conformance

The requirements for conformance on implementations of the **Unicode IDNA Compatible Preprocessing** are as follows:

C1 Given a version of Unicode and a Unicode String, a conformant implementation shall replicate the results given by applying the algorithm specified by Section 3, Preprocessing for the Compatible Proprocessing and the Display Preprocessing.

These specifications are *logical* ones, designed to be straightforward to describe. An actual implementation is free to use different methods as long the result is the same as the result generated by the logical algorithm.

Any conformant implementation may have *tighter* validity criteria than imposed by the Section 5, Validity Criteria. For example, an application could disallow or warn of domain name labels:

- with certain combinations of scripts, as Safari does
- with characters outside of the user's specified languages, as IE does.
- registered with particular registrars, as Firefox does.
- with certain confusable characters, as Firefox does.
- that are caught by the Google Safe Browsing API [SafeBrowsing]
- and so on

For more information, see UTR#36: *Unicode Security Considerations* [UTR36].

[**Review Note**: Although the main audience of this specification is applications, not registries, we may want to also mention that registries that need to support both IDNA2003 and IDNA2008 labels may also use this specification. In such cases, however, we need to specify that registries must only allow the registration of preprocessed

labels. In particular, only allowing registering a label X if:

- compatible_preprocess(X) = X, OR
- display_preprocess(X) = X AND X is bundled with compatible_preprocess(X)

3. Preprocessing

The input to the preprocessing is a prospective *domain_name* string in Unicode, which is a sequence of labels with dot separators, such as "Bücher.de". (For more about the parts of a URL, including the domain name, see Section 3.5 of [RFC1034]).

Preparation of the input *domain_name* string may have involved converting escapes in an original domain name string to Unicode code points as necessary, depending on the environment in which it is being used. For example, this can include converting:

- HTML numeric character references (NCRs) like 十 for U+5341 (十) CJK UNIFIED IDEOGRAPH-5341
- Javascript escapes like \u5341 for U+5341 (十) CJK UNIFIED IDEOGRAPH-5341
- URI/IRI %-escapes like %C3%A0 for U+00E0 (à) LATIN SMALL LETTER A WITH GRAVE.

The following series of steps, performed in order, successively alters the input *domain_name* string, and then outputs it (if there are no errors). The output of this preprocessing is also a Unicode string, which can then be converted to a string containing Punycode labels ("asciified"). The preprocessing is idempotent—applying the preprocessing again to the output will make no further changes. Where the preprocessing results in an "abort with error", the processing fails and the input string is invalid.

There are two types of preprocessing, Compatibility Preprocessing and Display Preprocessing. They differ only in the mapping table applied in the first step.

1. **Map** each character in the *domain_name* string using the appropriate mapping from IDNA Mapping Table (Section 4).
   - *domain_name = map(domain_name)*
2. **Normalize** the *domain_name* string to Unicode Normalization Form C:
   - *domain_name = toNFC(domain_name)*
3. **Split** the *domain_name* string into one or more labels, using as the following as label delimiter:
   - U+002E (.) FULL STOP
   - Note that the dot may have resulted from a mapping from other characters, such as U+2488 (⒈) DIGIT ONE FULL STOP or U+FF0E (．) FULLWIDTH FULL STOP. For more information, see Handling Label Separators.
4. **Verify** that each label in the *domain_name* meets the validity criteria in Validity Criteria (Section 5)
   - *If any label is in Punycode, and does not come from a trusted source, convert it back to Unicode and apply Steps 1-2 to it.* [Review note: this bullet could be rewritten for clarity as a step 3a: "Convert any Punycode labels back to Unicode", aborting with an error if such conversion fails.]
   - *Abort with error if the label does not comply* with the validity criteria from Section 5.

5. **Return** the ~~string resulting from the successive application of the above steps,~~ the *domain_name* resulting from Step 2 if there has been no error.

Some browsers allow also characters like "_" in domain names. Any such treatment is outside of the scope of this document.

The domain names that do not cause an error in the application of the above process are valid according to this specification. However, implementations are advised to apply additional tests to these labels such as those described in UTR#36: Unicode Security Considerations [UTR36], and take appropriate actions. For example, a label with mixed scripts or confusables may be called out in the UI.

4. IDNA Mapping Tables

There are two IDNA Mappings: one for the Compatibility Preprocessing, and one for the Display Preprocessing. The only difference between them is in the handling of the Deviations. Both are based on the Unicode Property [NFKC_CaseFold], and are defined by the following:

Compatible Mapping

1. Map each character to its NFKC_CaseFold value.
2. Also map U+3002 (。) IDEOGRAPHIC FULL STOP and any of its compatibility equivalents to U+002E (.) FULL STOP.

Display Mapping

1. Map each character that is not a Deviation character to its NFKC_CaseFold values. The Deviation characters are: U+00DF, U+03C2, U+200D, and U+200C
2. Also map U+3002 (。) IDEOGRAPHIC FULL STOP and any of its compatibility equivalents to U+002E (.) FULL STOP.

[Review note: in order for UTS46 to better agree with IDNA2003, the following mappings would need to be added to both of the above. These are already reflected in the table in Section 5.2.

- [\u200E\u200F\u202A-\u202E\u2061-\u2063\u206A-\u206F\U0001D173-\U0001D17 -> \uFFFF // causing them to be disallowed
- [\u17B4\u17B5\u115F\u1160\u3164\uFFA0] -> \uFFFF // causing them to be disallowed
- [-] -> "" // causing them to be ignored]

[Review Note: In order to improve the appearance of Greek, should we add to this that uppercase sigma is mapped to lowercase final sigma if there is at least one Greek character before it and no Greek characters after it?]

For Unicode 5.2, the characters affected by item #2 in each case consist of exactly two characters:

- U+3002 (。) IDEOGRAPHIC FULL STOP
- U+FF61 (。) HALFWIDTH IDEOGRAPHIC FULL STOP

4.1 Data Tables and Stability

While the above describes the mapping process, the normative mappings are supplied in the linked data files referenced in this section. For each version of Unicode there will be an updated version of this table: implementations will never need to actually use the above method algorithm for generating the tables—they can just use the data from these tables.

The tables will always be backwards compatible; if the description of the generation needs to be changed in order to ensure that, it will be.

[Review Note: A full list of the mappings will be maintained and linked from this document.]

5. Validity Criteria

Each of the following criteria must be satisfied for a label to be valid:

1. The label must contain at least one code point.
2. All code points in the label must be in the set defined as Allowed Characters (Section 5.1).
    - [Review Note: should add "or if Display Preprocessing, in the Deviations"]
3. The label must not contain "--" (two U+002D (-) HYPHEN-MINUS characters) in the third and fourth positions, and must neither begin nor end with a U+002D (-) HYPHEN-MINUS character.
4. The label must not begin with a combining mark, that is: \p{gc=M}.
5. If the label contains any joiner characters (\p{Join_Control}), any such characters must only occur in contexts specified in the Tables document of [IDNA2008] for CONTEXTJ characters. [Review Note: This condition should be removed, since the Join Controls will not appear in the result anyway.]
6. The label must meet the requirements for right-to-left characters specified in the Bidi document of [IDNA2008].

[Review Note: A previous review note suggested that once IDNA2008 is final, the exact specification be substituted for the last bullet. However, it would probably be best to retain the pointer. It does raise another issue, of whether the BIDI spec should be part of the validity test or not: IDNA2008 doesn't require it in clients.]

Except for list of allowed code points in condition 2, these conditions are equivalent to those required on lookup in the Protocol document of [IDNA2008].

Any particular application may have tighter validity criteria, as discussed in Section 2, *Conformance*.

5.1 Allowed Characters

The following characters are allowed in labels, after mapping is performed. The definition is based on IDNA2003; when restricted to Unicode 3.2 characters, this set closely follows the characters allowed in IDNA2003.

As with Unicode Character properties, while this list specifies the derivation of the set, the Data Files supply the normative values. The tables will always be backwards compatible; if the description of the generation needs to be changed in order to ensure that, it will be.

Formal Sets	Descriptions
[\P{Changes_When_NFKC_Casefolded}	Start with characters that are NFKC Case folded (excluding uppercase, for example).
- \p{c} - \p{z}	Remove Control Characters and Whitespace
- \p{Block=Ideographic_Description_Characters}	Remove ideographic description characters
- \p{ascii} - [\u1806 \uFFFC \uFFFD]	Remove ASCII and three special characters: U+1806 (‐) MONGOLIAN TODO SOFT HYPHEN U+FFFC ( ) OBJECT REPLACEMENT CHARACTER U+FFFD (?) REPLACEMENT CHARACTER
+ [\u002D]	Add back all the valid ASCII [Ed note: should also include [a-zA-Z1-0]]

5.2 IDNA2008 Characters

For comparison, the following defines the set of allowed characters defined by IDNA2008. This set corresponds to the union of the PVALID, CONTEXTJ, and CONTEXTO characters with rules defined by the Tables document of [IDNA2008]. This is only presented for comparison, and has no bearing on validity of this specification.

Formal Sets	Descriptions
[\P{Changes_When_NFKC_Casefolded}	Start with characters that are NFKC Case folded (as in IDNA2003)
- \p{c} - \p{z}	Remove Control Characters and Whitespace (as in IDNA2003)
- \p{s} - \p{p} - \p{nl} - \p{no} - \p{me}	Remove Symbols, Punctuation, non-decimal Numbers, and Enclosing Marks
- \p{HST=L} - \p{HST=V} - \p{HST=V}	Remove characters used for archaic Hangul (Korean)
- \p{block=Combining_Diacritical_Marks_For_Symbols} - \p{block=Musical_Symbols} - \p{block=Ancient_Greek_Musical_Notation}	Remove three blocks of technical or archaic symbols.
- [\u0640 \u07FA \u302E \u302F \u3031-\u3035 \u303B]	Remove certain exceptions: U+0640 (ـ) ARABIC TATWEEL U+07FA (?) NKO LAJANYALAN U+302E (◌) HANGUL SINGLE DOT TONE MARK U+302F (◌) HANGUL DOUBLE DOT TONE MARK U+3031 (〱) VERTICAL KANA REPEAT MARK U+3032 (〲) VERTICAL KANA REPEAT WITH VOICED SOUND MARK .. U+3035 (〵) VERTICAL KANA REPEAT MARK LOWER HALF U+303B (〻) VERTICAL IDEOGRAPHIC

	ITERATION MARK
`+ [\u00B7 \u0375 \u05F3 \u05F4 \u30FB]` `+ [\u002D \u06FD \u06FE \u0F0B \u3007]`	Add certain exceptions: U+00B7 (·) MIDDLE DOT U+0375 (͵) GREEK LOWER NUMERAL SIGN U+05F3 (׳) HEBREW PUNCTUATION GERESH U+05F4 (״) HEBREW PUNCTUATION GERSHAYIM U+30FB (・) KATAKANA MIDDLE DOT *plus* U+002D (-) HYPHEN-MINUS U+06FD (۽) ARABIC SIGN SINDHI AMPERSAND U+06FE (۾) ARABIC SIGN SINDHI POSTPOSITION MEN U+0F0B (་) TIBETAN MARK INTERSYLLABIC TSHEG U+3007 (〇) IDEOGRAPHIC NUMBER ZERO
`+ [\u00DF \u03C2]` `+ \p{JoinControl}]`	Add special exceptions (Deviations): U+00DF (ß) LATIN SMALL LETTER SHARP S U+03C2 (ς) GREEK SMALL LETTER FINAL SIGMA U+200C ( ) ZERO WIDTH NON-JOINER U+200D ( ) ZERO WIDTH JOINER

[Review Note: Once IDNA2008 is final, the exact list of characters will be aligned.]

The following table provides an illustration of the differences between the three specifications. It omits all code points unassigned in U5.2, and all ASCII, since those are the same for all three forms. The Count column shows the number of characters in each bucket. The Differences column calls out some illustrative character differences: sets with ... are abbreviated. Characters marked * for UTS46 are not modified in display.

Count	Unicode Version	IDNA2003	IDNA46	IDNA2008	Comments
432	v3.2	Disallowed	Disallowed	Disallowed	
25	v3.2	Ignored	Ignored	Disallowed	[\u034F\u180B-\u180D\u200B\u2060\uFE00
2	v3.2	Ignored	Ignored*	Valid	[\u200C\u200D]
2	v3.2	Mapped	Disallowed	Disallowed	[\u3164\uFFA0]
4,619	v3.2	Mapped	Mapped	Disallowed	... a 𝔸 𝔸 ⓐ A 𝔸 𝔸 Ⓐ ªÁÀĂẮẰẴẲÂẤẦ ẪẨǍÅǺÄǞÃ AU...
2	v3.2	Mapped	Mapped*	Valid	[ßς]
4	v3.2	Valid	Disallowed	Disallowed	[\u17B4\u17B5\u115F\u1160]
41	v3.2	Valid	Mapped	Disallowed	[illegible]
3,252	v3.2	Valid	Valid	Disallowed	...₵∃℔℗℘℞℟℣℥⊂⊄⊃⊅⊆⊈⊇☖☗☙–☯☸–♫♰–♲⊡–❐❖❘–❞❡–❵➔➘–➩➪–➾♭–♯〄〒〓〠¤¢£¥...
86,682	v3.2	Valid	Valid	Valid	
14	v4.0-5.1	Disallowed	Disallowed	Disallowed	
241	v4.0-5.1	Disallowed	Ignored	Disallowed	

473	v4.0-5.1	Disallowed	Mapped	Disallowed	
1,225	v4.0-5.1	Disallowed	Valid	Disallowed	
3,539	v4.0-5.1	Disallowed	Valid	Valid	

6 Data Files

Draft File: uts46-data-5.1.txt

The data is the standard Unicode semicolon-delimited format. The first field is the hex value of the code point, and second is the status or mapping:

- valid,
- disallowed,
- ignored (= mapped to empty string), or
- the hex values of the string the character is mapped to.

Examples:

```
0000..002C     ; disallowed                    #  NULL..COMMA
002D           ; valid                         #  HYPHEN-MINUS
...
0041           ; 0061                          #  LATIN CAPITAL LETTER A
...
00AD           ; ignored                       #  SOFT HYPHEN
...
```

[Review Note: The information above will be used to generate data files in the standard Unicode property file format for each version of Unicode starting with Unicode 5.2. Tables for a NamePrep profile [RFC3491] will also be made available.]

7 Testing

[Review Note: Conformance test files will be added for each Unicode version starting with Unicode 5.2, so that implementations can test their implementations against a set of data.]

8 Background

[Review Note: Some of this material is below duplicates some material in the introduction, and can be coalesced.]

For compatibility in the foreseeable future, special steps need to be taken with Deviations. While some steps could be taken by top-level domain registries to mitigate the above problems (the so-called "bundle" option), there are a very large number of lower level domains that are under the control of millions of other organizations. For example, the domain names under "**blogspot.com**", such as http://café.blogspot.com, are controlled by the company that has registered "blogspot". For IDNA2008 to avoid problems, no registries—at whatever level —would allow two IDNs that correspond according to the Deviations table to resolve to different IP addresses. So **blogspot.com** would need to disallow registration of both the registration of http://gefäss.blogspot.com and of http://gefäß.blogspot.com, to prevent problems (and of other cases like the normally-invisible ZWJ and ZWNJ). However, applications cannot depend on all such registries behaving correctly, because the odds are high that at least some (and likely very many) of the many thousands of registries will not check for this.

Thus the burden is primarily on applications handling IDNs to prevent the situation.

The worst of all possible cases is an implementation of IDNA2008 that uses Custom mappings. Unfortunately, there appears to be no good way to prevent security problems with these implementations, because it is impossible to anticipate what such implementations would do. Such an implementation is not limited to just the above four Deviations for exploits—it could remap even characters like "Ö" to "oe" or arbitrary other characters. Because there is no way to predict what it will do, there are no effective countermeasures for security.

Note that IDNA2008 does not make any appreciable difference in reducing problems with visually-confusable characters (so-called *homographs*). Thus programmers still need to be aware of those issues as detailed in UTR#36: Unicode Security Considerations [UTR36], including the mechanisms for detecting potentially visually-confusable characters are found in the associated UTS#39: Unicode Security Mechanisms [UTS39].

8.1 Handling Deviations

Because of the Deviations, even the strict application of IDNA2008 leads to significant new security issues. The Unicode Technical Committee and invited experts considered at length various options for dealing with Deviations. Among those options were:

1. Dual lookups, checking for differences.
    - One problem with this approach is that the IP lookup may return spurious differences, because a website may return different IP addresses for load-balancing.
2. Not mapping deviations if the registry is *trusted.* A trusted registry is one that is complies with this specification, and bundles all allowed Deviations with their mappings.
    - For example, **http://www.sparkasse-gießen.de** (if the registry for "de" bundles Deviations) would be unaltered, but that **http://www.sparkasse-gießen.com** would be mapped to **http://www.sparkasse-giessen.com** (if the "com" registry does not bundle Deviations) before any lookup. Note that this also applies to lower-level registries. The URL **http://www.sparkasse-gießen.blogspot.de** would be remapped to **http://www.sparkasse-gießen.blogspot.de** *unless* the registry for "blogspot.de" is trusted.

In the end, the consensus in the committee was that the distinction between deviations ({ss, ß, SS}, {σ, ς, Σ}, and joiners) was most important for display ~~essentially a display issue, for the preferred visual representation~~. In particular, it is strongly recommended that any registry that allows for both forms *should* always bundle them to avoid security problems. And those registries that didn't bundle would cause problems. Thus the conclusion was that the distinction between deviations did not need to be maintained in lookup, because lookup would always work with registries that are handling the deviations correctly, and would avoid security problems with the registries that didn't.

8.2 Handling Label Separators

The **Split** processing matches what is commonly done with label delimiters by browsers, whereby characters containing periods are transformed into the NFKC format *before* labels are separated. This allows the domain name to be transformed in a single pass, rather than label by label. Some of the input characters are effectively forbidden, because they would result in a sequence of two periods, and thus empty labels. The exact list of characters can be seen with the Unicode utilities using a regular expression:

- http://unicode.org/cldr/utility/list-unicodeset.jsp?a=\p{toNFKC=/\./}

The question also arises as to how to handle escaped periods (such as %2E) and characters like U+2488 (⒈) DIGIT ONE FULL STOP or U+FF0E (．) FULLWIDTH FULL STOP that decompose to sequences that include period. While %2E is outside of the scope of this document, it is useful to see how both of these are handled in current browsers:

Input	http://à%2Ecom	%2E		http://à⒈com	⒈
Internet Explorer	http://xn--0ca.com/	= "."		http://xn--1-rfa.com/	= "1."
Firefox	http://www.xn--.com-hta.com/	≠ "."		http://xn--1-rfa.com/	= "1."
Safari / Chrome	http://xn--0ca.com/	= "."		http://xn--1.com-qqa/	≠ "1."

There are three possible behaviors for characters like U+2488 (⒈) DIGIT ONE FULL STOP:

1. The dot behaves like a label separator.
2. The character is rejected
3. The dot is included in the label (the garbled punycode seen above in the ≠ cases).

[Review note: the current IDNA46 specification decomposes *before* breaking into labels. That step is included because it represents the predominant browser behavior (both FF and IE). This behavior on the part of the browsers may be due to simplicity -- it allows the entire domain name to be mapped/normalized at once.

Formally, this behavior is not compatible with IDNA2003, which uses all and only the following as label delimiters:

- U+002E (.) FULL STOP
- U+3002 (。) IDEOGRAPHIC FULL STOP
- U+FF0E (．) FULLWIDTH FULL STOP
- U+FF61 (｡) HALFWIDTH IDEOGRAPHIC FULL STOP

However, strict compatibility with IDNA2003 can be obtained even when mapping/normalizing the entire domain name at once. That is done by changing the mapping to specially map all characters whose normalizations contains a U+002E (.) FULL STOP, *aside from the IDNA2003 delimiters*. That is, the "bad" characters could be mapped to an invalid character (such as U+0001), so that the domain name would be invalidated by further steps.

Is there good reason to change this behavior -- and if so, would the browsers change to follow it?]

9 FAQ

[Review Note: Some of this material is probably best moved to the Unicode FAQ, and just referenced from here, while some is appropriate for inclusion here. What is left here, if anything, would need to be modified to remove duplication of material.]

Q. What are examples of where the different categories of IDNA implementation behave differently?

A. Here is a table that illustrates the differences, where 2003 is the current behavior in applications now.

- **Yes** indicates that the URL would be valid;
- **No** that it wouldn't be; and
- **??** that it might or might not be, depending on the exact behavior of a Custom Mapping. Such a Custom mapping might be from Ö to ö, or it might be from Ö to oe, or might not map at all. Because they are unpredictable, they are marked with ??.

URL	2003	With Compatible Preprocessing	Strict IDNA2008	IDNA2008 with Custom Mapping	Comments
http://öbb.at	Yes	Yes	Yes	Yes	Simple characters
http://ÖBB.at	Yes	Yes	No	??	Case mapping
http://√.com	Yes	Yes	No	??	Symbol
http://faß.de	Yes	Yes	Yes*	Yes*	* Deviation (different resulting IP address)
http://ԛелп.com	No	Yes	Yes	Yes	New Unicode (version 5.1) U+051B (ԛ) *cyrillic qa*

Q. How much of a problem is this actually if support for symbols like √ ~~.com~~ were just dropped immediately?

A. IDNA2008 removes many characters that were valid under IDNA2003, because it makes most symbols and punctuation illegal. So while http://√.com is valid in an IDNA2003 implementation; it would fail on a strict IDNA2008 implementation. This affects about 3,000 characters, mostly rarely used ones. A small percentage of those are security risks because of confusability. The vast majority are unproblematic: for example, having http://I♥NY.com doesn't cause security problems. IDNA2008 also has additional tests that are based on the context in which characters are found, but they apply to few characters, and don't provide any appreciable increase in security.

Q. Doesn't the removal of symbols and punctuation in IDNA2008 help security?

A. Surprisingly, not really. It doesn't do anything about the most frequent sources of spoofing; look-alike characters that are both letters, like "http://paypal.com" with a Cyrillic "a". If a symbol that can be used to spoof a letter X is removed, but there is another letter that can spoof X is retained, there is no net benefit. Weighted by frequency, according to data at Google the removal of symbols and punctuation in IDNA2008 reduces opportunities for spoofing by only about 0.000016%. In another study at Google of 1B web pages, the top 277 confusable URLs used confusable letters or numbers, not symbols or punctuation. The 278th page had a confusable URL with × (U+00D7 MULTIPLICATION SIGN - by far the most common confusable); but that page could could be even better spoofed with x (U+0445 CYRILLIC SMALL LETTER HA), which normally has precisely the same displayed shape as "x".

Q. What are the main advantages of IDNA2008?

[Review Note: Is it worth listing the advantages and disadvantages of IDNA2008?]

A. The main advantages are:

- Major improvement in updating to Unicode 5.2
- Major improvement in making process of updating to future Unicode versions (mostly) automatic
- Significant improvement in allowing needed sequences (combining marks at end of bidi label).
- Significant improvements to the BIDI rules:
  - restricting sequences that lead to "bidi label hopping". (While these new bidi rules go a long way towards reducing this problem, they do not eliminate it because they do not check for inter-label situations.)
- Improvements in some user's expectations for display of Deviations: sigma, sharp s, joiners.
- Improvement in clarifying that what people register is the unmapped form.

Q. What are the disadvantages of IDNA2008?

A. If IDNA2003 had not existed, then there would be few disadvantages to IDNA2008. Given that IDNA2003 does exist, and is widely deployed, the main disadvantages are:

- Major interoperability/security issue with Deviations and Unpredictables
- Significant interoperability issue by not continuing IDNA2003 mappings
- Significant increase in complexity, reducing the likelihood of correct implementation
  - For example, there are new contextual rules that are fairly complicated to implement, and are not in a machine-readable format. Without a comprehensive test suite and/or reference implementations to test against, it is fairly likely that there will be incompatibilities.
- Small interoperability issues caused by excluding symbols, punctuation
  - While there are many such characters, they are relatively rare.
- More fragile in that future Unicode versions require a manual step to avoid instabilities
  - That is, if Unicode version X changes properties in such a way as to add or remove characters from PVALID, it requires a manual step to retain the previous status.
- No requirements for stability: that all labels valid under Version X (>= 2008) must also be valid under all future versions.

Q. What is "bidi label hopping"?

A. It is where bidi reordering causes characters from one label to appear to be part of another label. For example, "B1.2d" in a right-to-left paragraph (where B stands for an Arabic or Hebrew letter) would display as "1.2Bd". For more information, see the Unicode bidi demo.

Q. Are the "local" mappings just a UI issue?

A. No, not if what is meant is that they are only involved in interactions with the address bar.

Examples:

- Alice sees that a URL works in her browser (say **http://faß.de** or **http://TÜRKIYE.com**).

She sends it to Bob in an email. Bob clicks on the link in his email, and doesn't find a site or goes to a wrong (and potentially malicious) site, because his browser maps to **http://fass.de** or **http://türkiye.com** while Alice's maps to **http://faß.de** or **http://türkıye.com**.

- Alice creates a web page, using <a href=" **http://faß.de**"> (or **http://TÜRKIYE.com**). Bob clicks on the link in his email, and doesn't find a site or goes to a wrong (and potentially malicious) site.
    - It is generally understood at the W3C that all attributes that take URLs should take full IRIs, not punycoded-URIs, so for example SVG, MathML, XLink, XML, etc, all take IRIs now, as does HTML5. [Editorial note: this bullet seems out of place.]
- Alice is in a IM chat with Bob. She copies in **http://faß.de** (or **http://TÜRKIYE.com**) and hits return. Bob clicks on the link he sees in his chat window. Bob clicks on the link in his email, and doesn't find a site or goes to a wrong (and potentially malicious) site.
- Alice sends a Word document to Bob with a link in it...
- Alice creates a PDF document...
- ...

Q. Do the Custom exploits require unscrupulous registries?

A. No. The exploits do not require unscrupulous registries—it only requires that registries do not police every URL that they register for possible spoofing behavior.

The custom mappings matter to security, because entering the same URL on two different browsers may go to two different IP addresses (whenever the two browsers have different custom mappings). The same thing could happen within an emailer that is parsing for URLs, and then opening a browser. And for that matter, there is nothing that prevents two different browsers from applying those custom mappings to URLs within a page, for example, to a URL in href="...".

Q. Why does IDNA2003 map final sigma (ς) to sigma (σ), map eszett (ß) to "ss", and delete ZWJ/ZWNJ?

A. This ~~is to provide full case insensitivity,~~ was following the Unicode Standard. These characters are anomalous: the uppercase of ς is Σ, the same as the uppercase of σ. Note that the text "BόλοΣ.com", which appears on **http://Bόλος.com**, illustrates this: the normal case mapping of Σ is to σ. If σ and ς were not treated as case variants in Unicode, there wouldn't be a match between BόλοΣ and Bόλος.

Similarly, the standard uppercase of ß is "SS", the same as the uppercase of "ss". Note, for example, that on http://www.uni-giessen.de, Gießen is spelled with ß, but in the top left corner spelled with GIESSEN. The situation is even more complicated:

- In Switzerland, "ss" is uniformly used instead of ß.
- The recent spelling reform in Germany and Austria changed whether ß or ss is used in many words. For example, **http://Schloß.de** was the spelling before 1996, and **http://Schloss.de** is "correct" after.
- Recently, in Unicode 5.1, an uppercase version of ß was added (ẞ), because it is attested in some cases. It is unknown, however, whether it will ever become the preferred uppercase. Unicode now treats all of these as a single equivalence class for case-insensitive matching: {ss, ß, SS, ẞ}. See also the Unicode FAQ.

For full case insensitivity (with transitivity), {ss, ß, SS} and {σ, ς, Σ} need to be treated as equivalent, with one of each set chosen as the representative in the mapping. That is what is done in the Unicode Standard, which was followed by IDNA2003.

ZWJ and ZWNJ are normally invisible, which allows them to be used for a variety of spoofs. Invisible characters (like these and soft-hyphen) are allowed on input in IDNA2003, but deleted so that they do not allow spoofs.

While these are full parts of the orthographies of the languages in question, neither IDNA2003 nor IDNA2008 ever claimed that all parts of every language's orthographies are representable in domain names. There are trivial examples even in English, like the word ***can't*** (vs ***cant***) or ***Wendy's/Arby's Group*** (NYSE WEN), which use standard English orthography but cannot be represented faithfully in a domain name .

The Unicode IDNA Compatible Preprocesssing deals with the Deviations by using a different display format that preserves these distinctions.

Q. Why allow ZWJ/ZWNJ at all?

During the development of Unicode, the ZWJ and ZWNJ were intended only for presentation —that is, they would make no difference in the semantics of a word. Thus the IDNA2003 mapping should and does delete them. That result, however, should never really be seen by users—it should be just a transient form used for comparison. Unfortunately, the way IDN works this "comparison format" (with transformations of eszett, final sigma, and deleted ZWJ/NJ) ends up being visible to the user, unless a display format is used that differs from the format used to transform for lookup.

For example, there are words such as the name of the country of Sri Lanka, which require preservation of these joiners (in this case, ZWJ) in order to appear correct to the end users when the URL comes back from the DNS server.

Q. Aren't the problems with eszett and final sigma just the same as with l, I, and 1?

A. No, The eszett and sigma are fundamentally different than I,l, and 1. With the following (using a digit 1), all browsers will go to the same location, whether they old or new:

http://goog1e.com

With the following, browsers that use IDNA2003 will go to a different location than browsers that use a strict version of IDNA2008, *unless* the registry for xx puts into place a bundle strategy.

http://gießen.xx

The same goes for Greek *sigma*, which is a more common character in Greek than the *eszett* is in German.

Q. Why doesn't IDNA2008 (or for that matter IDNA2003) restrict allowed domains on the basis of language?

A. It is extremely difficult to restrict on the basis of language, because the letters used in a particular language are not well defined. The "core" letters typically are, but many others are typically accepted in loan words, and have perfectly legitimate commercial and social use.

It is a bit easier to maintain a bright line based on script differences between characters: every Unicode character has a defined script (or is Common/Inherited). Even there it is problematic to have that as a restriction. Some languages (Japanese) require multiple scripts. And in most cases, mixtures of scripts are harmless. One can have http://SONY日本.com with no problems at all—while there are many cases of "homographs" (visually confusable characters) within the same script that a restriction based on script doesn't deal with.

The rough consensus among the IETF IDNA working group is that script/language mixing restrictions are not appropriate for the lowest-level protocol. So in this respect, IDNA2008 is no different than IDNA2003. IDNA doesn't try to attack the homograph problem, because it is too difficult to have a bright line. Effective solutions depend on information or capabilities outside of the protocol's control, such as language restrictions appropriate for a particular registry, the language of the user looking at this URL, the ability of a UI to display suspicious URLs with special highlighting, and so on.

Responsible registries can apply such restrictions. For example, a country-level registry can decide on a restricted set of characters appropriate for that country's languages. Application software can also take certain precautions—MSIE, Safari, and Chrome all display domain names in Unicode only if the user's language(s) typically use the scripts in those domain names. For more information on the kinds of techniques that implementations can use on the Unicode web site, see UTR#36: Unicode Security Considerations [UTR36].

Q. Are there differences in mapping between the IDNA46 and IDNA2003?

Yes. For a detailed table of mapping differences, see section 5.2 IDNA2008 Characters.

In particular, there are two collections of characters that changed mapping in Unicode after Unicode 3.2. All of these characters are extremely rare, and do not require any special handling.

Case Pairs. These are characters that did not have corresponding lowercase characters in Unicode 3.2, but had lowercase characters added later.

U+04C0 (Ӏ) CYRILLIC LETTER PALOCHKA
U+10A0 (Ⴀ) GEORGIAN CAPITAL LETTER AN…U+10C5 (Ⴥ) GEORGIAN CAPITAL LETTER HOE
U+2132 (Ⅎ) TURNED CAPITAL F
U+2183 (Ↄ) ROMAN NUMERAL REVERSED ONE HUNDRED

Unicode has since stabilized case folding, so that this will not happen in the future. That is, case pairs will be assigned in the same version of Unicode—so any newly assigned character will either have a case folding in that version of Unicode, or it will never have a case folding in the future.

Normalization Mappings. These are characters whose normalizations changed after Unicode 3.2 (all of them were in Unicode 4.0.0: see Corrigendum #4: Five Unihan Canonical Mapping Errors). As of Unicode 5.1, normalization is completely stabilized, so these are the only such characters.

U+2F868 (?) CJK COMPATIBILITY IDEOGRAPH-2F868 → U+2136A (?) CJK UNIFIED IDEOGRAPH-2136A
U+2F874 (?) CJK COMPATIBILITY IDEOGRAPH-2F874 → U+5F33 (?) CJK UNIFIED

IDEOGRAPH-5F33
U+2F91F (?) CJK COMPATIBILITY IDEOGRAPH-2F91F → U+43AB (?) CJK UNIFIED IDEOGRAPH-43AB
U+2F95F (?) CJK COMPATIBILITY IDEOGRAPH-2F95F → U+7AAE (?) CJK UNIFIED IDEOGRAPH-7AAE
U+2F9BF (?) CJK COMPATIBILITY IDEOGRAPH-2F9BF → U+4D57 (?) CJK UNIFIED IDEOGRAPH-4D57

[Review Note: There are additional characters that were mapped differently in IDNA2008, that should be mapped to \uFFFF so that they are invalid rather than mapped differently. These are listed in a review note in the Validity section. The above characters could also be handled that way, to prevent mapping differences.]

Q. How do implementations handle normalization for IDNA2003?

There were two corrigenda to normalization issued after 3.2. Formally speaking, an implementation applying IDNA2003 would disregard these corrigenda, but browsers do not consistently implement this behavior. In practice this makes no difference, since the characters and character sequences involved are not found except in specially-devised test cases, so it is understandable that systems may not want to maintain the extra code necessary to duplicate the broken Unicode 3.2 behavior.

Corrigendum #4: Five Unihan Canonical Mapping Errors

Corrigendum #4 deals with the 5 characters above.

Example

- 2F868 (媾) = xn--g22n
  - 3.2 normalization → xn--j74i = 2136A (□)
  - 5.2 normalization → xn--snl = 36FC (媾)

Example Behavior

- IE/Chrome/Safari - 3.2
- **FF - 5.2**

Corrigendum #5: Normalization Idempotency

Corrigendum #5 deals with with a subtle algorithmic problem.

Example

- 1100 0300 1161 0323 (ᄀ̀ ᅡ) = xn--ksa4ez54cela
  - 3.2 normalization → xn--ksa4ez795d = AC00 0300 0323 (가̀)
    → xn--ksa3e0795d = AC00 0323 0300 (가̀)
  - 5.2 normalization → xn--ksa4ez54cela = 1100 0300 1161 0323 (ᄀ̀ ᅡ)

Example Behavior

- **IE - 5.2**
- Chrome/Safari - 3.2

- FF - 3.2 -- applied twice

Unicode has since stabilized normalization, so such changes will not happen in the future.

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References

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[Feedback]	Reporting Errors and Requesting Information Online http://www.unicode.org/reporting.html
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[IDNA2008]	http://tools.ietf.org/id/idnabis
[NFKC_CaseFold]	The Unicode property specified in [UAX44], and defined by the data in DerivedNormalizationProps.txt (search for "NFKC_CaseFold").
[Reports]	Unicode Technical Reports http://www.unicode.org/reports/ *For information on the status and development process for technical reports, and for a list of technical reports.*
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[SafeBrowsing]	http://code.google.com/apis/safebrowsing/
[Unicode]	The Unicode Standard *For the latest version see:* http://www.unicode.org/versions/latest/.
[Versions]	Versions of the Unicode Standard http://www.unicode.org/versions/ *For details on the precise contents of each version of the Unicode Standard, and how to cite them.*

Modifications

The following summarizes modifications from the previous revisions of this document.

Version 2

- Draft 3
- Added notation section, draft data file (uts46-data-5.1.txt)
- Made it clear that applications can choose to have tighter validity criteria.
- Fixed the names of Sections 5.1 and 5.2
- Added a review note on how this could be extended to registries.
- Draft 2
- Small changes in wording (not typically marked with yellow).
- Additional review notes.
- Removed active links from URLs and domain names: replaced by special style.
- Fixed references.
- Added table of period behavior in 8.2
- Added comparison table of IDNA2003, UTS46, and IDNA2008 in section 5.2
- Draft 1
- Draft UTS posted for public review.
- Radical simplification as directed by the UTC.

Version 1

- Proposed Draft UTS posted for public review.
- Fixed a number of typos and problems pointed out by Marcos (mostly not noted in the text).
- Added draft security and FAQ sections.
- Replaced the introduction, and shortened the document overall; with theNFKC_CaseFolded property, the mapping is considerably simpler.
- Added specifications for the Hybrid and Compatibility implementations, including the two Modes, based on the additional material from the UTC in early 2008.
- Removed the Hybrid variant, and added a discussion of tactics for deviations.
