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Preparation of Internationalized Host Names

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Abstract

This document describes how to prepare internationalized host names for use in the DNS. The steps include:

- mapping characters to other characters, such as to change their case
- normalizing the characters
- excluding characters that are prohibited from appearing in internationalized host names

This document does not specify a wire protocol. This preparation should be done before the DNS request.

1. Introduction

When expanding today's DNS to include internationalized host names, those new names will be handled in many parts of the DNS. The Internationalized Domain Name (IDN) Working Group's requirements document [IDNReq] describes a framework for domain name handling as well as requirements for the new names.

A user can enter a domain name into an application program in a myriad of fashions. Depending on the input method, the characters entered in the domain name may or may not be those that are allowed in internationalized host names. Thus, there must be a way to normalized the user's input before the name is resolved in the DNS.

It is a design goal of this document to allow users to enter host names in applications and have the highest chance of getting the name correct. Another, often conflicting, design goal is to allow as wide of a range of characters as possible to be allowed in host names. The user should not be limited to only entering exactly the characters that might have been used, but to instead be able to enter characters that unambiguously normalize to characters in the desired host name. Although it would be easy to use the process in this step to "correct" perceived mis-features or bugs in the current character standards, this document expressly does not do so.

This document describes the steps needed to convert a name part from one that is entered by the user to one that can be used in the DNS.

Within a fully-qualified domain name, some labels may be internationalized, while others are not. This specification should be applied to all internationalized labels. An application must be able to recognize which part is internationalized; the method for such recognition is outside of the scope of this document. Note that this specification is harmless to the non-internationalized labels: when the steps described here are applied to non-internationalized labels, the label will not change.

1.1 Terminology

The key words "MUST", "SHALL", "REQUIRED", "SHOULD", "RECOMMENDED", and "MAY" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Examples in this document use the notation for code points and names from the Unicode Standard [Unicode3] and ISO/IEC 10646 [ISO10646]. For example, the letter "a" may be represented as either "U+0061" or "LATIN SMALL LETTER A". In the lists of prohibited characters, the "U+" is left off to make the lists easier to read. The names of character ranges are shown in square brackets (such as "[SYMBOLS]") and do not come from the standards.

Note: A glossary of terms used in Unicode and ISO/IEC 10646 can be found in [Glossary]. Information on the 10646/Unicode character model can be found in [CharModel].

2. Preparation Overview

The steps for preparing names are:

1) Input from the application service interface -- This can be done in many ways and is not specified in this document

2) Map -- For each character in the input, check if it has a mapping and, if so, replace it with its mapping. The mappings are a combination

of folding uppercase characters to lowercase and hyphen mapping. This is described in Section 4.

3) Normalize -- Normalize the characters. This is described in Section 5.

4) Look for prohibited output -- Check for any characters that are not allowed in the output. If any are found, return an error to the application service interface. This is described in Section 6.

5) Resolution of the prepared name -- This must be specified in a different IDN document.

The above steps MUST be performed in the order given in order to comply with this specification.

The steps in this document have associated tables in the document. The tables are derived from outside sources, and the derivation is briefly described in the document. Although a great deal of effort has gone into preparing the tables, there is a chance that the tables do not correctly reflect the outside sources. Regardless of whether or not the tables differ from the sources, implementations MUST use the tables in this document for their processing. That is, if there is an error in the tables, the tables must still be used. Future versions of this document may include corrections and additions to the tables.

3. Mapping

Each character in the input stream is checked against the mapping table. The mapping table can be found in Appendix E of this document. That table includes all the steps described in the subsections below.

The mappings can be one-to-none, one-to-one, or one-to-many. That is, some characters may be eliminated or replaced by more than one character, and the output of this step might be shorter or longer than the input. Because of this, an application MUST be prepared to receive a longer or shorter string than the one input in the nameprep algorithm.

Rationale: Characters that are not wanted in internationalized name parts can either be mapped to nothing in the mapping step, or cause an error in the prohibition step. The general guideline used to pick between the two outcomes was that removing alphabetic, non-protocol characters be done in the mapping step, but all other removals be done in the prohibition step. This allows for simple linguistic errors on the part of an input mechanism to be caught in the mapping step, but to not hide serious errors such as entering protocol characters or invisible characters from the user.

3.1 Case mapping

The input string is case folded according to [UTR21]. For most characters, this is the same thing as changing the input character to a lowercase character. For some characters, however, more complex transformations occur. The mapping table in Appendix E is derived by applying the rules for equivalence classes from [UTR21].

Rationale: This step could have been "change all lowercase characters into uppercase characters". However, the upper-to-lower folding was chosen because most users of the Internet today enter host names in lowercase.

3.2 Additional folding mappings

There are some characters that do not have mappings in [UTR21] but still need processing. These characters include a few Greek characters and many symbols that contain Latin characters. The list of characters to add to the mapping table were determined by the following algorithm:

```
b = NormalizeWithKC(Fold(a));
c = NormalizeWithKC(Fold(b));
if c is not the same as b, add a mapping for "a to c".
```

Because NormalizeWithKC(Fold(c)) always equals c, the table is stable from that point on.

3.3 Mapped out

The following characters are simply deleted from the input (that is, they are mapped to nothing) because their presence or absence should not make two domain names different.

Some characters are only useful in line-based text, and are otherwise invisible and ignored.

```
00AD; SOFT HYPHEN
1806; MONGOLIAN TODO SOFT HYPHEN
200B; ZERO WIDTH SPACE
FEFF; ZERO WIDTH NO-BREAK SPACE
```

Variation selectors and cursive connectors select different glyphs, but do not bear semantics.

```
180B; MONGOLIAN FREE VARIATION SELECTOR ONE
180C; MONGOLIAN FREE VARIATION SELECTOR TWO
180D; MONGOLIAN FREE VARIATION SELECTOR THREE
200C; ZERO WIDTH NON-JOINER
200D; ZERO WIDTH JOINER
```

4. Normalization

The output of the mapping step is normalized using form KC, as described in [UTR15]. Using form KC instead of form C causes many characters that are identical or near-identical to be converted into a single character. Note that this specification refers to a specific version of [UTR15]. If a later version of [UTR15] changes the algorithm used for normalizing, that later version MUST NOT be used with this specification. Note that it is likely that this specification will be revised if UTR15 is changed, but until that happens, only the specified version of [UTR15] must be used.

5. Prohibited Output

Before the text can be emitted, it must be checked for prohibited code points. There is a variety of prohibited code points, as described in this section.

One of the goals of IDN is to allow the widest possible set of host names as long as those host names do not cause other problems, such as conflict with other standards. Specifically, experience with current DNS names have shown that there is a desire for host names that include personal names, company names, and spoken phrases. A goal of this section is to prohibit as few characters that might be used in these contexts as possible.

The collected list of prohibited code points can be found in Appendix F of this document. The list in Appendix F MUST be used by implementations of this specification. If there are any discrepancies between the list in Appendix F and subsections below, the list Appendix F always takes precedence.

Some code points listed in one section would also appear in other sections. Each code point is only listed once in the table in Appendix F.

5.1 Currently-prohibited ASCII characters

Some of the ASCII characters that are currently prohibited in host names by [STD13] are also used in protocol elements such as URIs [URI]. The other characters in the range U+0000 to U+007F that are not currently allowed are also prohibited in host name parts to reserve them for future use in protocol elements.

```
0000-002C; [ASCII]
002E-002F; [ASCII]
003A-0040; [ASCII]
005B-0060; [ASCII]
007B-007F; [ASCII]
```

5.2 Space characters

Space characters would make visual transcription of URLs nearly impossible and could lead to user entry errors in many ways.

0020; SPACE
00A0; NO-BREAK SPACE
2000; EN QUAD
2001; EM QUAD
2002; EN SPACE
2003; EM SPACE
2004; THREE-PER-EM SPACE
2005; FOUR-PER-EM SPACE
2006; SIX-PER-EM SPACE
2007; FIGURE SPACE
2008; PUNCTUATION SPACE
2009; THIN SPACE
200A; HAIR SPACE
202F; NARROW NO-BREAK SPACE
3000; IDEOGRAPHIC SPACE
1680; OGHAM SPACE MARK
200B; ZERO WIDTH SPACE

5.3 Control characters

Control characters cannot be seen and can cause unpredictable results when displayed.

0000-001F; [CONTROL CHARACTERS]
007F; DELETE
0080-009F; [CONTROL CHARACTERS]
2028; LINE SEPARATOR
2029; PARAGRAPH SEPARATOR

5.4 Private use and replacement characters

Because private-use characters do not have defined meanings, they are prohibited. The private-use characters are:

E000-F8FF; [PRIVATE USE, PLANE 0]
F0000-FFFFD; [PRIVATE USE, PLANE 15]
100000-10FFFD; [PRIVATE USE, PLANE 16]

The replacement character (U+FFFD) has no known semantic definition in a name, and is often displayed by renderers to indicate "there would be some character here, but it cannot be rendered". For example, on a computer with no Asian fonts, a name with three katakana characters might be rendered with three replacement characters.

FFFD; REPLACEMENT CHARACTER

5.5 Non-character code points

Non-character code points are code points that have been assigned in ISO/IEC 10646 but are not characters. Because they are already assigned, they are guaranteed not to later change into characters.

```
FFFE-FFFF; [NONCHARACTER CODE POINTS]
1FFFE-1FFFF; [NONCHARACTER CODE POINTS]
2FFFE-2FFFF; [NONCHARACTER CODE POINTS]
3FFFE-3FFFF; [NONCHARACTER CODE POINTS]
4FFFE-4FFFF; [NONCHARACTER CODE POINTS]
5FFFE-5FFFF; [NONCHARACTER CODE POINTS]
6FFFE-6FFFF; [NONCHARACTER CODE POINTS]
7FFFE-7FFFF; [NONCHARACTER CODE POINTS]
8FFFE-8FFFF; [NONCHARACTER CODE POINTS]
9FFFE-9FFFF; [NONCHARACTER CODE POINTS]
AFFFE-AFFFF; [NONCHARACTER CODE POINTS]
BFFFE-BFFFF; [NONCHARACTER CODE POINTS]
CFFFE-CFFFF; [NONCHARACTER CODE POINTS]
DFFFE-DFFFF; [NONCHARACTER CODE POINTS]
EFFFE-EFFFF; [NONCHARACTER CODE POINTS]
FFFFE-FFFFF; [NONCHARACTER CODE POINTS]
10FFFE-10FFFF; [NONCHARACTER CODE POINTS]
```

5.6 Surrogate codes

The following code points are permanently reserved for use as surrogate code values in the UTF-16 encoding, will never be assigned to characters, and are therefore prohibited:

```
D800-DFFF; [SURROGATE CODES]
```

5.7 Inappropriate for plain text

The following characters should not appear in regular text.

```
FFF9; INTERLINEAR ANNOTATION ANCHOR
FFFA; INTERLINEAR ANNOTATION SEPARATOR
FFFB; INTERLINEAR ANNOTATION TERMINATOR
FFFC; OBJECT REPLACEMENT CHARACTER
```

5.8 Inappropriate for domain names

The ideographic description characters allow different sequences of characters to be rendered the same way, which makes them inappropriate for host names that must have a single canonical order.

```
2FF0-2FFF; [IDEOGRAPHIC DESCRIPTION CHARACTERS]
```

5.9 Change display properties

The following characters, some of which are deprecated in ISO/IEC 10646, can cause changes in display or the order in which characters appear

when rendered.

200E; LEFT-TO-RIGHT MARK
200F; RIGHT-TO-LEFT MARK
202A; LEFT-TO-RIGHT EMBEDDING
202B; RIGHT-TO-LEFT EMBEDDING
202C; POP DIRECTIONAL FORMATTING
202D; LEFT-TO-RIGHT OVERRIDE
202E; RIGHT-TO-LEFT OVERRIDE
206A; INHIBIT SYMMETRIC SWAPPING
206B; ACTIVATE SYMMETRIC SWAPPING
206C; INHIBIT ARABIC FORM SHAPING
206D; ACTIVATE ARABIC FORM SHAPING
206E; NATIONAL DIGIT SHAPES
206F; NOMINAL DIGIT SHAPES

5.10 Inappropriate characters from common input mechanisms

U+3002 is used as if it were U+002E in many input mechanisms, particularly in Asia. This prohibition allows input mechanisms to safely map U+3002 to U+002E before doing nameprep without worrying about preventing users from accessing legitimate host name parts.

3002; IDEOGRAPHIC FULL STOP

6. Unassigned Code Points

All code points not assigned in ISO/IEC 10646 are called "unassigned code points". Authoritative name servers MUST NOT have internationalized name parts that contain any unassigned code points. DNS requests MAY contain name parts that contain unassigned code points. Note that this is the only part of this document where the requirements for queries differs from the requirements for names in DNS zones.

Using two different policies for where unassigned code points can appear in the DNS prevents the need for versioning the IDN protocol [IDNrev]. This is very useful since it makes the overall processing simpler and do not impose a "protocol" to handle versioning. It is expected that ISO/IEC 10646 will be updated fairly frequently; recently, it has happened approximately once a year. Each time a new version of ISO/IEC 10646 appears, a new version of this document can be created. Some end users will want to use the new code points as soon as they are defined.

The list of unassigned code points can be found in Appendix G of this document. The list in Appendix G MUST be used by implementations of this specification. If there are any discrepancies between the list in Appendix G and the ISO/IEC 10646 specification, the list Appendix G always takes precedence.

Due to the way that versioning is handled in this section, host names that are embedded in structures that cannot be changed (such as the signed parts of digital certificates) MUST NOT have internationalized name parts that contain any unassigned code points.

6.1 Categories of code points

Each code point in ISO/IEC 10646 can be categorized by how it acts in the process described in earlier sections of this document:

AO Code points that may be in the output

MN Code points that cannot be in the output because they are mapped to nothing or never appear as output from normalization

D Code points that cannot be in the output because they are disallowed in the prohibition step

U Unassigned code points

A subsequent version of this document that references a newer version of ISO/IEC 10646 with new code points will inherently have some code points move from category U to either D, MN, or AO. For backwards compatibility, no future version of this document will move code points from any other category. That is, no current AO, MN, or D code points will ever change to a different category.

Authoritative name servers MUST NOT contain any name that has code points outside of AO for the latest version of this document. That is, they are forbidden to contain any IDN names containing code points from the MN, D, or U categories.

Applications creating name queries MUST treat U code points as if they were AO when preparing the name parts according to this document. Those applications MAY optionally have a preprocess that provide stricter checks: treating unassigned code points in the input as errors, or warning the user about the fact that the code point is unassigned in the version of this document that the software is based on; such a choice is a local matter for the software.

Non-authoritative DNS servers MAY reject names that contain code points that are in categories MN or D for the version of this document that they implement, but MUST NOT reject names because they contain name parts with code points from category U.

6.2 Reasons for difference between authoritative servers and requests

Different software using different versions of this document need to interoperate with maximal compatibility. The scheme described in this section (authoritative name servers MUST NOT use unassigned code points,

requests MAY include unassigned code points) allows that compatibility without introducing any known security or interoperability issues.

The list below shows what happens if a request contains a code point from category U that is allowed in a newer version of this document. The request either resolves to the domain name that was intended, or resolves to no domain at all. In this list, the request comes from an application using version "oldVersion" of this document, the authoritative name server is using version "newVersion" of this document, and the code point X was in category U on oldVersion, and has changed category to AO, MN, or D. There are 3 possible scenarios:

1. X becomes AO -- In newVersion, X is in category AO. Because the application passed X through, it gets back correct data from the authoritative name server. There is one exceptional case, where X is a combining mark.

The order of combining marks is normalized, so if another combining mark Y has a lower combining class than X then XY will be put in the canonical order YX. (Unassigned code points are never reordered, so this doesn't happen in oldVersion). If the request contains YX, the request will get correct data from the authoritative name server. However, no domain name can be registered with XY, so a request with XY will get a "no such host" error.

2. X becomes MN -- In newVersion, X is normalized to code point "nX" and therefore X is now put in category MN. This cannot exist in any domain name, so any request containing X will get back a "no such host" error. Note, however, if the request had contained the letter nX, it would have gotten back correct data.

3. X becomes D -- In newVersion, X is in category MN. This cannot exist in any domain name, so any request containing X will get back a "no such host" error.

In none of the cases does the request get data for a host name other than the one it actually wanted.

The processing in this document is always stable. If a string S is the result of processing on newVersion, then it will remain the same when processed on oldVersion.

There is always a way for the application to get the correct data from the authoritative name server. For example, suppose that <ALPHA> was unassigned in oldVersion, and that it is assigned in newVersion, but case-folded to <alpha>. As long as the application supplies strings containing <alpha> instead of <ALPHA>, the correct data will be returned. Because the processing is stable, a different application running newVersion can pass a processed host name to the application running oldVersion. It will only contain <alpha>, and will return the correct results from the authoritative name server.

6.3 Versions of applications and authoritative name servers

Another way to see that this versioning system works is to compare what happens when an application uses a newer or older version of this document.

Newer application -- Suppose that a application or intermediary DNS server is using version newVersion and the authoritative name server is using version oldVersion. This case is simple: there will be no names on the server that cannot be accessed by the application because the resolver uses a superset of the code points accepted by the server.

Newer server -- Suppose that an application or intermediary DNS server is using oldVersion and the authoritative name server is using newVersion. Because the application passed through any unassigned code points, the user can access names on the server that use code points in newVersion. No names on the site can have code points that are unassigned in newVersion, since that is illegal. In this case, the application has to enter the unassigned code points in the correct order, and has to use unassigned code points that would make it through both the mapping and the normalization steps.

7. Security Considerations

Much of the security of the Internet relies on the DNS. Thus, any change to the characteristics of the DNS can change the security of much of the Internet.

Host names are used by users to connect to Internet servers. The security of the Internet would be compromised if a user entering a single internationalized name could be connected to different servers based on different interpretations of the internationalized host name.

Current applications may assume that the characters allowed in host names will always be the same as they are in [STD13]. This document vastly increases the number of characters available in host names. Every program that uses "special" characters in conjunction with host names may be vulnerable to attack based on the new characters allowed by this specification.

8. References

[CharModel] Unicode Technical Report;17, Character Model. <http://www.unicode.org/unicode/reports/tr17/>.

[Glossary] Unicode Glossary, <http://www.unicode.org/glossary/>.

[IDNReq] Zita Wenzel and James Seng, "Requirements of Internationalized

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[IDNRev] Marc Blanchet, "Handling versions of internationalized domain names protocols", draft-ietf-idn-version

[ISO10646] ISO/IEC 10646-1:2000. International Standard -- Information technology -- Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane.

[Normalize] Character Normalization in IETF Protocols, draft-duerst-i18n-norm-03

[RFC2119] Scott Bradner, "Key words for use in RFCs to Indicate Requirement Levels", March 1997, RFC 2119.

[RFC2396] Tim Berners-Lee, et. al., "Uniform Resource Identifiers (URI): Generic Syntax", August 1998, RFC 2396.

[RFC2732] Robert Hinden, et. al., Format for Literal IPv6 Addresses in URL's, December 1999, RFC 2732.

[STD13] Paul Mockapetris, "Domain names - concepts and facilities" (RFC 1034) and "Domain names - implementation and specification" (RFC 1035, STD 13, November 1987.

[Unicode3] The Unicode Consortium, "The Unicode Standard -- Version 3.0", ISBN 0-201-61633-5. Described at <http://www.unicode.org/unicode/standard/versions/Unicode3.0.html>.

[URIs] For example: Roy Fielding et. al., "Uniform Resource Identifiers: Generic Syntax", August 1998, RFC 2396; Robert Hinden et. al, "IPv6 Literal Addresses in URL's", December 1999, RFC 2732.

[UTR15] Mark Davis and Martin Duerst. Unicode Normalization Forms. Unicode Technical Report;15. <http://www.unicode.org/unicode/reports/tr15/>.

[UTR21] Mark Davis. Case Mappings. Unicode Technical Report;21. <http://www.unicode.org/unicode/reports/tr21/>.

A. Acknowledgements

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Additional significant improvements were proposed by:

Jonathan Rosenne
Kent Karlsson
Scott Hollenbeck

B. Differences Between -02 and -03 Drafts

Throughout: Changed "ISO 10646" to "ISO/IEC 10646". Changed "codepoint" to "code point".

Abstract: Added last sentence.

1: Removed the sentence about [IDNComp] in the first paragraph. Clarified the design goals in the third paragraph. Added new last paragraph about processing name parts.

3: Added sentence at the end of the second paragraph about accepting shorter or longer responses. Changed "Design note" to "Rationale".

3.1: Revised the first paragraph to make it clearer that the mapping is not simple lowercasing. Changed "Design note" to "Rationale".

3.2: Made it clearer that the normalization is with form KC.

5: Removed the previous third paragraph, which discussed the DNS service interface.

5.1: Added references for URIs.

5.4: Changed the sentence about the replacement character to read "...and is often displayed by renderers to indicate...".

5.10: Added this section, which prohibits U+3002.

6: Removed "yet" from the first sentence.

8: Fixed the reference for [IDNReq] and [STD13]. Removed the reference to [IDNComp]. Added the reference for [URIs].

C: Changed wording of the section.

E, F, G: Added tags to the beginning and end of the tables.

F: Added 3002 (from section 5.10). Added FDD0-FDEF, which were omitted in error.

C. IANA Considerations

None.

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E. Mapping Table

The following is the mapping table from Section 3. The table has three columns:
- the character that is mapped from
- the zero or more characters that it is mapped to
- the reason for the mapping
The columns are separated by semicolons. Note that the second column may be empty, or it may have one character, or it may have more than one character, with each character separated by a space.

```
----- Start Mapping Table -----
0041; 0061; Case map
0042; 0062; Case map
0043; 0063; Case map
0044; 0064; Case map
0045; 0065; Case map
0046; 0066; Case map
0047; 0067; Case map
0048; 0068; Case map
0049; 0069; Case map
004A; 006A; Case map
004B; 006B; Case map
```

```
004C; 006C; Case map
004D; 006D; Case map
004E; 006E; Case map
004F; 006F; Case map
0050; 0070; Case map
0051; 0071; Case map
0052; 0072; Case map
0053; 0073; Case map
0054; 0074; Case map
0055; 0075; Case map
0056; 0076; Case map
0057; 0077; Case map
0058; 0078; Case map
0059; 0079; Case map
005A; 007A; Case map
00AD; ; Map out
00B5; 03BC; Case map
00C0; 00E0; Case map
00C1; 00E1; Case map
00C2; 00E2; Case map
00C3; 00E3; Case map
00C4; 00E4; Case map
00C5; 00E5; Case map
00C6; 00E6; Case map
00C7; 00E7; Case map
00C8; 00E8; Case map
00C9; 00E9; Case map
00CA; 00EA; Case map
00CB; 00EB; Case map
00CC; 00EC; Case map
00CD; 00ED; Case map
00CE; 00EE; Case map
00CF; 00EF; Case map
00D0; 00F0; Case map
00D1; 00F1; Case map
00D2; 00F2; Case map
00D3; 00F3; Case map
00D4; 00F4; Case map
00D5; 00F5; Case map
00D6; 00F6; Case map
00D8; 00F8; Case map
00D9; 00F9; Case map
00DA; 00FA; Case map
00DB; 00FB; Case map
00DC; 00FC; Case map
00DD; 00FD; Case map
00DE; 00FE; Case map
00DF; 0073 0073; Case map
0100; 0101; Case map
0102; 0103; Case map
0104; 0105; Case map
```

0106; 0107; Case map
0108; 0109; Case map
010A; 010B; Case map
010C; 010D; Case map
010E; 010F; Case map
0110; 0111; Case map
0112; 0113; Case map
0114; 0115; Case map
0116; 0117; Case map
0118; 0119; Case map
011A; 011B; Case map
011C; 011D; Case map
011E; 011F; Case map
0120; 0121; Case map
0122; 0123; Case map
0124; 0125; Case map
0126; 0127; Case map
0128; 0129; Case map
012A; 012B; Case map
012C; 012D; Case map
012E; 012F; Case map
0130; 0069; Case map
0131; 0069; Case map
0132; 0133; Case map
0134; 0135; Case map
0136; 0137; Case map
0139; 013A; Case map
013B; 013C; Case map
013D; 013E; Case map
013F; 0140; Case map
0141; 0142; Case map
0143; 0144; Case map
0145; 0146; Case map
0147; 0148; Case map
0149; 02BC 006E; Case map
014A; 014B; Case map
014C; 014D; Case map
014E; 014F; Case map
0150; 0151; Case map
0152; 0153; Case map
0154; 0155; Case map
0156; 0157; Case map
0158; 0159; Case map
015A; 015B; Case map
015C; 015D; Case map
015E; 015F; Case map
0160; 0161; Case map
0162; 0163; Case map
0164; 0165; Case map
0166; 0167; Case map
0168; 0169; Case map

016A; 016B; Case map
016C; 016D; Case map
016E; 016F; Case map
0170; 0171; Case map
0172; 0173; Case map
0174; 0175; Case map
0176; 0177; Case map
0178; 00FF; Case map
0179; 017A; Case map
017B; 017C; Case map
017D; 017E; Case map
017F; 0073; Case map
0181; 0253; Case map
0182; 0183; Case map
0184; 0185; Case map
0186; 0254; Case map
0187; 0188; Case map
0189; 0256; Case map
018A; 0257; Case map
018B; 018C; Case map
018E; 01DD; Case map
018F; 0259; Case map
0190; 025B; Case map
0191; 0192; Case map
0193; 0260; Case map
0194; 0263; Case map
0196; 0269; Case map
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33BF; 006D 0077; Additional folding
33C0; 006B 03C9; Additional folding
33C1; 006D 03C9; Additional folding
33C3; 0062 0071; Additional folding
33C6; 0063 2215 006B 0067; Additional folding

```
33C7; 0063 006F 002E; Additional folding
33C8; 0064 0062; Additional folding
33C9; 0067 0079; Additional folding
33CB; 0068 0070; Additional folding
33CD; 006B 006B; Additional folding
33CE; 006B 006D; Additional folding
33D7; 0070 0068; Additional folding
33D9; 0070 0070 006D; Additional folding
33DA; 0070 0072; Additional folding
33DC; 0073 0076; Additional folding
33DD; 0077 0062; Additional folding
FB00; 0066 0066; Case map
FB01; 0066 0069; Case map
FB02; 0066 006C; Case map
FB03; 0066 0066 0069; Case map
FB04; 0066 0066 006C; Case map
FB05; 0073 0074; Case map
FB06; 0073 0074; Case map
FB13; 0574 0576; Case map
FB14; 0574 0565; Case map
FB15; 0574 056B; Case map
FB16; 057E 0576; Case map
FB17; 0574 056D; Case map
FEFF; ; Map out
FF21; FF41; Case map
FF22; FF42; Case map
FF23; FF43; Case map
FF24; FF44; Case map
FF25; FF45; Case map
FF26; FF46; Case map
FF27; FF47; Case map
FF28; FF48; Case map
FF29; FF49; Case map
FF2A; FF4A; Case map
FF2B; FF4B; Case map
FF2C; FF4C; Case map
FF2D; FF4D; Case map
FF2E; FF4E; Case map
FF2F; FF4F; Case map
FF30; FF50; Case map
FF31; FF51; Case map
FF32; FF52; Case map
FF33; FF53; Case map
FF34; FF54; Case map
FF35; FF55; Case map
FF36; FF56; Case map
FF37; FF57; Case map
FF38; FF58; Case map
FF39; FF59; Case map
FF3A; FF5A; Case map
----- End Mapping Table -----
```

F. Prohibited Code Point List

```
----- Start Prohibited Table -----
0000-002C
002E-002F
003A-0040
005B-0060
007B-007F
0080-009F
00A0
1680
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
200A
200B
200E
200F
2028
2029
202A
202B
202C
202D
202E
202F
206A
206B
206C
206D
206E
206F
2FF0-2FFF
3000
3002
D800-DFFF
E000-F8FF
FFF9
FFFA
FFFB
FFFC
FFFD
```

```
FFFE-FFFF
1FFFE-1FFFF
2FFFE-2FFFF
3FFFE-3FFFF
4FFFE-4FFFF
5FFFE-5FFFF
6FFFE-6FFFF
7FFFE-7FFFF
8FFFE-8FFFF
9FFFE-9FFFF
AFFFE-AFFFF
BFFFE-BFFFF
CFFFE-CFFFF
DFFFE-DFFFF
EFFFE-EFFFF
F0000-FFFFD
FFFFE-FFFFF
100000-10FFFD
10FFFE-10FFFF
----- End Prohibited Table -----
```

NOTE WELL: Software that follows this specification that will be used to check names before they are put in authoritative name servers MUST add all unassigned code pints to the list of characters that are prohibited. See Section 6 for more details.

G. Unassigned Code Point List

```
----- Start Unassigned Table -----
0220-0221
0234-024F
02AE-02AF
02EF-02FF
034F-035F
0363-0373
0376-0379
037B-037D
037F-0383
038B
038D
03A2
03CF
03D8-03D9
03F4-03FF
0487
048A-048B
04C5-04C6
04C9-04CA
04CD-04CF
04F6-04F7
```

04FA–0530
0557–0558
0560
0588
058B–0590
05A2
05BA
05C5–05CF
05EB–05EF
05F5–060B
060D–061A
061C–061E
0620
063B–063F
0656–065F
066E–066F
06EE–06EF
06FF
070E
072D–072F
074B–077F
07B1–0900
0904
093A–093B
094E–094F
0955–0957
0971–0980
0984
098D–098E
0991–0992
09A9
09B1
09B3–09B5
09BA–09BB
09BD
09C5–09C6
09C9–09CA
09CE–09D6
09D8–09DB
09DE
09E4–09E5
09FB–0A01
0A03–0A04
0A0B–0A0E
0A11–0A12
0A29
0A31
0A34
0A37
0A3A–0A3B
0A3D

0A43–0A46
0A49–0A4A
0A4E–0A58
0A5D
0A5F–0A65
0A75–0A80
0A84
0A8C
0A8E
0A92
0AA9
0AB1
0AB4
0ABA–0ABB
0AC6
0ACA
0ACE–0ACF
0AD1–0ADF
0AE1–0AE5
0AF0–0B00
0B04
0B0D–0B0E
0B11–0B12
0B29
0B31
0B34–0B35
0B3A–0B3B
0B44–0B46
0B49–0B4A
0B4E–0B55
0B58–0B5B
0B5E
0B62–0B65
0B71–0B81
0B84
0B8B–0B8D
0B91
0B96–0B98
0B9B
0B9D
0BA0–0BA2
0BA5–0BA7
0BAB–0BAD
0BB6
0BBA–0BBD
0BC3–0BC5
0BC9
0BCE–0BD6
0BD8–0BE6
0BF3–0C00
0C04

0C0D
0C11
0C29
0C34
0C3A-0C3D
0C45
0C49
0C4E-0C54
0C57-0C5F
0C62-0C65
0C70-0C81
0C84
0C8D
0C91
0CA9
0CB4
0CBA-0CBD
0CC5
0CC9
0CCE-0CD4
0CD7-0CDD
0CDF
0CE2-0CE5
0CF0-0D01
0D04
0D0D
0D11
0D29
0D3A-0D3D
0D44-0D45
0D49
0D4E-0D56
0D58-0D5F
0D62-0D65
0D70-0D81
0D84
0D97-0D99
0DB2
0DBC
0DBE-0DBF
0DC7-0DC9
0DCB-0DCE
0DD5
0DD7
0DE0-0DF1
0DF5-0E00
0E3B-0E3E
0E5C-0E80
0E83
0E85-0E86
0E89

0E8B-0E8C
0E8E-0E93
0E98
0EA0
0EA4
0EA6
0EA8-0EA9
0EAC
0EBA
0EBE-0EBF
0EC5
0EC7
0ECE-0ECF
0EDA-0EDB
0EDE-0EFF
0F48
0F6B-0F70
0F8C-0F8F
0F98
0FBD
0FCD-0FCE
0FD0-0FFF
1022
1028
102B
1033-1035
103A-103F
105A-109F
10C6-10CF
10F7-10FA
10FC-10FF
115A-115E
11A3-11A7
11FA-11FF
1207
1247
1249
124E-124F
1257
1259
125E-125F
1287
1289
128E-128F
12AF
12B1
12B6-12B7
12BF
12C1
12C6-12C7
12CF

12D7
12EF
130F
1311
1316–1317
131F
1347
135B–1360
137D–139F
13F5–1400
1677–167F
169D–169F
16F1–177F
17DD–17DF
17EA–17FF
180F
181A–181F
1878–187F
18AA–1DFF
1E9C–1E9F
1EFA–1EFF
1F16–1F17
1F1E–1F1F
1F46–1F47
1F4E–1F4F
1F58
1F5A
1F5C
1F5E
1F7E–1F7F
1FB5
1FC5
1FD4–1FD5
1FDC
1FF0–1FF1
1FF5
1FFF
2047
204E–2069
2071–2073
208F–209F
20B0–20CF
20E4–20FF
213B–2152
2184–218F
21F4–21FF
22F2–22FF
237C
239B–23FF
2427–243F
244B–245F

24EB–24FF
2596–259F
25F8–25FF
2614–2618
2672–2700
2705
270A–270B
2728
274C
274E
2753–2755
2757
275F–2760
2768–2775
2795–2797
27B0
27BF–27FF
2900–2E7F
2E9A
2EF4–2EFF
2FD6–2FEF
2FFC–2FFF
303B–303D
3040
3095–3098
309F–30A0
30FF–3104
312D–3130
318F
31B8–31FF
321D–321F
3244–325F
327C–327E
32B1–32BF
32CC–32CF
32FF
3377–337A
33DE–33DF
33FF
4DB6–4DFF
9FA6–9FFF
A48D–A48F
A4A2–A4A3
A4B4
A4C1
A4C5
A4C7–ABFF
D7A4–D7FF
FA2E–FAFF
FB07–FB12
FB18–FB1C

FB37
FB3D
FB3F
FB42
FB45
FBB2-FBD2
FD40-FD4F
FD90-FD91
FDC8-FDEF
FDFC-FE1F
FE24-FE2F
FE45-FE48
FE53
FE67
FE6C-FE6F
FE73
FE75
FEFD-FEFE
FF00
FF5F-FF60
FFBF-FFC1
FFC8-FFC9
FFD0-FFD1
FFD8-FFD9
FFDD-FFDF
FFE7
FFEF-FFF8
10000-1FFFD
20000-2FFFD
30000-3FFFD
40000-4FFFD
50000-5FFFD
60000-6FFFD
70000-7FFFD
80000-8FFFD
90000-9FFFD
A0000-AFFFD
B0000-BFFFD
C0000-CFFFD
D0000-DFFFD
E0000-EFFFD
----- End Unassigned Table -----