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Modern Network Unicode

Abstract

BCP18 (RFC 2277) has been the basis for the handling of character-shaped data in IETF specifications for more than a quarter of a century now. It singles out UTF-8 (STD63, RFC 3629) as the "charset" that **MUST** be supported, and pulls in the Unicode standard with that.

Based on this, RFC 5198 both defines common conventions for the use of Unicode in network protocols and caters for the specific requirements of the legacy protocol Telnet. In applications that do not need Telnet compatibility, some of the decisions of RFC 5198 can be cumbersome.

The present specification defines "Modern Network Unicode" (MNU), which is a form of RFC 5198 Network Unicode that can be used in specifications that require the exchange of plain text over networks and where just mandating UTF-8 may not be sufficient, but there is also no desire to import all of the baggage of RFC 5198.

As characters are used in different environments, MNU is defined in a one-dimensional (1D) variant that is useful for identifiers and labels, but does not use a structure of lines. A 2D variant is defined for text that is a sequence of text lines, such as plain text documents or markdown format. Additional variances of these two base formats can be used to tailor MNU to specific areas of application.

Status

The present version of this document represents the author's reaction to initial exposure on the art@ietf.org mailing list. Some more editorial cleanup is probably desirable, but could not be achieved in time for the IETF105 Internet-Draft deadline.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

(Insert embellished copy of abstract here.)

Complex specifications that use Unicode often come with detailed information on their Unicode usage; this level of detail generally is necessary to support some legacy applications. New, simple protocol specifications generally do not have such a legacy or need such details, but can instead simply use common practice, informed by decades of using Unicode. The present specification attempts to serve as a convenient reference for such protocol specifications, reducing their need for discussing Unicode to just pointing to the present specification and making a few simple choices.

There is no intention that henceforth all new protocols "must" use the present specification. It is offered as a standards-track specification simply so it can be normatively referenced from other standards-track specifications.

1.1. Conventions

Characters in this specification are named with their Unicode name notated in the usual form U+NNNN (where NNNN is a four-to-six-digit upper case hexadecimal number giving the Unicode scalar value), or with their ASCII names (such as CR, LF, HT, RS, NUL) [[STD80](#)].

See [[RFC5137](#)] for a more detailed discussion of ways to refer in ASCII to Unicode characters (as well as to code points and code units in various transformation formats).

The following definitions apply:

Byte: 8-bit unit of information interchange, synonym for octet.

Please see [Appendix A](#) for some more detailed term definitions that may be helpful to relate this specification with the Unicode Standard; please do read its first paragraph if the definitions in this section seem inadequate.

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 BCP 14 [[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

2. 1D Modern Network Unicode

One-dimensional Modern Network Unicode (1D MNU) is the form of Modern Network Unicode that can be used for one-dimensional text, i.e., text without a structure of separate text lines. It requires conformance to [[STD63](#)], as well as to the following four mandates:

1. Control codes (U+0000 to U+001F and U+007F to U+009F) **MUST NOT** be used. (Note that this also excludes line endings, so a 1D MNU text string cannot extend beyond a single line. See [Section 3](#) below if line structure is needed.)
2. The characters U+2028 and U+2029 **MUST NOT** be used. (In case future Unicode versions add to the Unicode character categories Zl or Zp, any characters in these categories **MUST NOT** be used.)
3. Modern Network Unicode strongly RECOMMENDS that, except in unusual circumstances (see [Appendix C](#)), all text is transmitted in normalization form NFC. This mandate should not be realized by routinely normalizing all text, but by encouraging text sources to use NFC if applicable.
4. As per the Unicode specification, the code points U+FFFE and U+FFFF **MUST NOT** be used. Also, Byte Order Marks (leading U+FEFF characters) **MUST NOT** be used.

Note that several control codes have been in use historically in ASCII documents even within a single text line. For instance BS (U+0008) and CR (U+000D) have been used as a crude way to combine (by overtyping) characters; the present specification does not explicitly support this behavior anymore. HT (U+0009, "TAB") has been used for a form of compressing stretches of blank space; by keeping its actual definition open it has also been used to enable users of text to specify variable blank space ("indentation"). The present specification RECOMMENDS not using a variance for 1D MNU to enable using BS, HT, or CR; legacy usage of HT may be more appropriate in certain forms of 2D text.

3. 2D Modern Network Unicode

Two-dimensional Modern Network Unicode (2D MNU) enhances 1D MNU by structuring the text into lines. 2D MNU does this is by using the control code LF (U+000A) for a line terminator. The use of an

unterminated last line is permitted, but not encouraged. (This is not a variance.)

Historically, the Internet NVT [[RFC0854](#)] and thus, much later, Network Unicode [[RFC5198](#)] have used the combination CR+LF as a line terminator, reflecting its heritage based on teletype functionality. The use of U+000D mostly introduces additional ways to create interoperability problems. [[XML](#)] goes to great lengths to reduce the harm the presence of CR characters does to interchange of XML documents. Pages 10 and 11 of [[RFC0764](#)] discuss how CR can actually only be used in the combinations CR+NUL and CR+LF. 2D MNU simply elides the CR.

In other words, 2D MNU adds the use of line endings, represented by a single LF character (which is then the only control character allowed). Variances are available for (1) allowing or even (2) requiring the use of CR before LF.

4. 3D?

Three-dimensional forms of text have been used, e.g., by using U+000C FF ("form feed") to add a page structure to the RFC format [[RFC2223](#)], or by using U+001E RS ("record separator") to separate several (2D) JSON texts in a JSON sequence [[RFC7464](#)].

As the need for this form of structure is now mostly being addressed by building data structures around text items, the present specification does not define a 3D MNU. If needed, variances such as the use of FF or RS can be described in the documents specifying the 3D format.

5. Variances

In addition to the basic 1D and 2D versions of MNU, this specification describes a number of variances that can be used in the forms such as "2D Modern Network Unicode with VVV", or "2D Modern Network Unicode with VVV, WWW, and ZZZ" for multiple variances used. Specifications that cannot directly use the basic MNU forms may be able to use MNU with one or more of these variances added.

An example for the usage of variances: Up to RFC 8649, RFCs were formatted in "2D Modern Network Unicode with CR-tolerant lines and FF characters", or exceptionally [[RFC8265](#)], "2D Modern Network Unicode with CR-tolerant lines and FF characters and BOM".

5.1. With CR-tolerant lines

The variance "with CR-tolerant lines" allows the sequence CR LF as well as a single LF character as a line ending. This may enable

existing texts to be used as MNU without processing at the sender side (substituting that by processing at the receiver side). Note that, with this variance, a CR character cannot be used anywhere else but immediately preceding an LF character.

5.2. With CR-LF

The variance "with CR-LF lines" requires the sequence CR LF as a line ending; a single LF character is not allowed. This is appropriate for certain existing environments that have already made that determination.

5.3. With Line or Paragraph Separators

For 2D applications, and even for 1D applications that need to address text in 2D forms, it may be useful to enable the use of U+2028 and U+2029; this should be explicitly called out.

5.4. With HT Characters

In some cases, the use of HT characters ("TABs") cannot be completely excluded. The variance "with HT characters" allows their use, without attempting to define their meaning (e.g., equivalence with spaces, column definitions, etc.).

5.5. With CCC Characters

Some applications of MNU may need to add specific control characters, such as RS [[RFC7464](#)] or FF characters [[RFC2223](#)]. This variance is spelled with the ASCII name of the control character for CCC, e.g., "with RS characters".

5.6. With NFC

This variance turns the encouragement of using NFC normalization form into a requirement. Please see [Appendix C](#) for why this should be an exceptional case.

5.7. With NFKC

Some applications require a stronger form of normalization than NFC. The variance "with NFKC" swaps out NFC and uses NFKC instead. This is probably best used in conjunction with "with Unicode version NNN".

5.8. With Unicode Version NNN

Some applications need to be sure that a certain Unicode version is used. The variance "with Unicode version NNN" (where NNN is a Unicode version number) defines the Unicode version in use as NNN.

Also, it requires that only characters assigned in that Unicode version are being used.

See [Section 4](#) of [[RFC5198](#)] for more discussion of Unicode versions.

5.9. With BOM

In some environments, UTF-8 files need to be distinguished from files in other formats, and one convention that has been used in certain environments was to prepend a "Byte Order Mark" (U+FEFF) as a distinguishing mark (as UTF-8 is not influenced by different byte orders, this mark does not serve a purpose in UTF-8). Sometimes these BOMs are included for interchange to ensure local copies of the file include the distinguishing mark. This variance enables this usage.

6. Using ABNF with Unicode

Internet STD 68, [[STD68](#)], defines Augmented BNF for Syntax Specifications: ABNF. Since the late 1970s, ABNF has often been used to formally describe the pieces of text that are meant to be used in an Internet protocol. ABNF was developed at a time when character coding grew more and more complicated, and even in its current form, discusses encoding of characters only briefly ([Section 2.4](#) of [[STD68](#)]). This discussion offers no information about how this should be used today (it actually still refers to 16-bit Unicode!).

The best current practice of using ABNF for Unicode-based protocols is as follows: ABNF is used as a grammar for describing sequences of Unicode code points, valued from 0x0 to 0x10FFFF. The actual encoding (as UTF-8) is never seen on the ABNF level; see [Section 9.4](#) of [[RFC6020](#)] for a recent example of this. Approaches such as representing the rules of UTF-8 encoding in ABNF (see [Section 3.5](#) of [[RFC5255](#)] for an example) add complexity without benefit and are **NOT RECOMMENDED**.

ABNF features such as case-insensitivity in literal text strings essentially do not work for general Unicode; text string literals therefore (and by the definition in [Section 2.3](#) of [[STD68](#)]) are limited to ASCII characters. That is often not actually a problem in text-based protocol definitions. Still, characters beyond ASCII need to be allowed in many productions. ABNF does not have access to Unicode character categories and thus will be limited in its expressiveness here. The core rules defines in [Appendix B](#) of [[STD68](#)] are limited to ASCII as well; new rules will therefore need to be defined in any protocol employing modern Unicode.

The present specification recommends defining ABNF rules as in these examples:

```
; 1D modern unicode character:
uchar = %x20-7E ; exclude C0
      / %xA0-2027 ; exclude DEL, C1
      / %x202A-D7FF ; exclude U+2028/2029
      / %xE000-FFFF ; exclude U+FFFE/FFFF
      / %x10000-10FFFF ; could exclude more non-characters
```

```
; 2D modern unicode with lines -- newline:
unl = %x0A
u2dchar = unl / uchar
; alternatively, CR-tolerant newline:
ucrn1 = [%x0D] %x0A
u2dcrchar = ucrn1 / uchar
```

```
; if really needed, HT-tolerant 1D unicode character:
utchar = %x09 / uchar
```

7. IANA considerations

This specification places no requirements on IANA.

8. Security considerations

The security considerations of [[RFC5198](#)] apply.

A variance "with NUL characters" would create specific security considerations as discussed in the security considerations of [[RFC5198](#)] and should therefore only be used in circumstances that absolutely do require it.

9. References

9.1. Normative References

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Appendix A. Terminology

In order for the main body of this specification to stay readable for its target audience, we banish what could be considered excessive detail into appendices. Expert readers who know a lot more about Coded Character Sets and Unicode than the target audience is likely interested in are requested to hold back the urge to request re-introduction of excessive detail into the main body. For instance, this specification has a local definition of "Unicode character" that is useful for protocol designers, but is not actually defined by the Unicode consortium; the details are here.

Some definitions below reference definitions given in the Unicode standard and are simplified from those, which see if the full detail is needed.

Grapheme: The smallest functional unit of a writing system. For computer representation, graphemes are represented by *characters*, sometimes a single character, sometimes decomposed into multiple characters. In visible presentation, graphemes are made visible as *glyphs*; for computer use, glyphs are collected into *typefaces* (fonts). The term grapheme is used to abstract from the specific glyph used – a specific glyph from a typeface may be considered one of several *allographs* for a grapheme.

Character: Only defined as "abstract character" in [UNICODE]: A unit of information used for the organization, control, or representation of textual data (definition D7). Most characters are used to stand for graphemes or to build graphemes out of several characters. Characters are usually used in ordered sequences, which are referred to as "character strings".

Character set, Coded Character Set:

A mapping from code points to characters. Note that the shorter form term "character set" is easily misunderstood for a set of characters, which are called "character repertoire"

Character repertoire: A set of characters, in the sense of what is available as characters to choose from.

Code point: The (usually numeric) value used in a coded character set to refer to a character. Note that code points may undergo some encoding before interchange, see Unicode transformation format below. Code points can also be allocated to refer to internal constructs of a Unicode transformation format instead of referring to characters.

Unicode uses unsigned numbers between 0 and 1114111 (0x10FFFF) as code points.

Unicode transformation format (UTF): Character (and character strings) usually are interchanged as a sequence of bytes. A Unicode Transformation Format or Unicode Encoding Scheme specifies a byte serialization for a Unicode encoding form. (See definition D94 in Section 3.10, Unicode Encoding Schemes.)

Code unit: A bit combination used for encoding text for processing or interchange. The Unicode Standard uses 8-bit code units in the UTF-8 encoding form, 16-bit code units in the UTF-16 encoding form, and 32-bit code units in the UTF-32 encoding form. (See Definition D77 in Section 3.9, Unicode Encoding Forms.)

Unicode scalar value: Unicode code points except high-surrogate and low-surrogate code points (see [Appendix B](#)). In other words, the ranges of integers 0 to 0xD7FF and 0xE000 to 0x10FFFF16 inclusive. (See Definition D76 in Section 3.9, Unicode Encoding Forms.)

Unicode Character: For the purposes of the present specification, we use "Unicode Character" as a synonym for "Unicode scalar value". Note that this term includes Unicode scalar values that are not Assigned Characters; for the purposes of a specification using the present document, it is rarely useful to make this distinction, as Unicode evolves and could assign characters not assigned.

Appendix B. History, Legacy

Some of the complexity of using Unicode is, unsurprisingly, rooted in its long history of development.

Unicode originally was introduced around 1988 as a 16-bit character standard. By the early 1990s, a specification had been published, and a number of environments eagerly picked up Unicode. Unicode characters were represented as 16-bit values (UCS-2), enabling a simple character model using these uniformly 16-bit values as the characters. Programming language environments such as those of Java, JavaScript and C# are now intimately entangled with this character model.

In the mid-1990s, it became clear that 16 bits would not suffice. Unicode underwent an extension to 31 bits, and then back to ~ 21 bits (0 to 0x10FFFF). For the 16-bit environments, this was realized by switching to UTF-16, a "Unicode transformation format" (UTF-16). This reassigned some of the 16-bit code points not for characters, but for 2 sets of 1024 "surrogates" that would be used in pairs to represent characters that do not fit into 16 bits, each supplying 10 bits to together add 2^{20} code points to the 2^{16} already available (this leads to the surprising upper limit of 0x10FFFF).

In parallel, UTF-8 was created as an ASCII-compatible form of Unicode representation that would become the dominant form of text in the Web and other interchange environments.

The UCS-2 based character models of the legacy 16-bit platforms in many cases couldn't be updated for fully embracing UTF-16 right away. For instance, only much later did ECMAScript introduce the "u" (Unicode) flag for regular expressions to have them actually match "Unicode" characters. So, on these platforms, UTF-16 is handled in a UCS-2 character model, and sometimes orphaned surrogates leak out instead of Unicode characters as "code points" in interfaces that are not meant to impose these implementation limitations on the outside world.

UTF-8 is unaffected by this UTF-16 quirk and of course doesn't support encoding surrogates. (UTF-8 is careful to allow a single representation only for each Unicode character, and enabling the alternative use of surrogate pairs would violate that invariant, while isolated surrogates don't mean anything in Unicode.)

Newly designed IETF protocols typically do not have to consider these problems, but occasionally there are attempts to include isolated surrogate code points into what we call Unicode characters here.

Appendix C. Normalization

Please see [Section 3](#) of [\[RFC5198\]](#) for a brief introduction to Unicode normalization and Normalization Form C (NFC). However, since that section was written, additional experience with normalization

has led to the realization that the Unicode normalization rules do not always preserve certain details in certain writing systems.

Therefore, the implementation approach of routinely normalizing all text before interchange has fallen out of favor. Instead, implementations are encouraged to use text sources that already generally use NFC except where normalization would have been harmful. Where two text strings needs to be compared, it may be appropriate to employ normalization to both text strings for the purposes of the comparison only.

Additional complications can come from the fact that some implementations of applications may rely on operating system libraries over which they have little control. The need to maintain interoperability in such environments suggests that receivers of MNU should be prepared to receive unnormalized text and should not react to that in excessive ways; however, there also is no expectation for receivers to go out of their way doing so.

Appendix D. Relationship to RFC 5198

Of the mandates listed in [Section 2](#), the third and fourth requirement are also posed by [\[RFC5198\]](#), while the first two remove further legacy compatibility considerations.

[\[RFC5198\]](#) contains some discussion and background material that the present document does not attempt to repeat; the interested reader may therefore want to consult it as an informative reference.

Mandates of [\[RFC5198\]](#) that are specific to a version of Unicode are not picked up in this specification, e.g., there is no check for unassigned code points. Some implementations may want to add such a check; however, in general, this can hinder further evolution as it may become hard to use new characters as long as not every component on the way has been upgraded. (see also [Section 5.8.](#))

D.1. Going beyond RFC 5198

The handling of line endings (with 2D MNU prescribing LF as the line terminator, and adding or specifying CRLF line endings as variances) may be controversial. In particular, calling out CR-tolerance as an extra (and often undesirable) feature may seem novel to some readers. The handling as specified here is much closer to the way line endings are handled on the software side than the cumbersome rules of [\[RFC5198\]](#). More generally speaking, one could say that the present specification is intended to be used by state of the art protocols going forward, maybe less so by existing protocols.

Even in the "with CR-tolerant lines" variance, the CR character is only allowed as an embellishment of an immediately following LF

character. This reflects the fact that overprinting has only seen niche usage for quite a number of decades now.

Unicode Line and Paragraph separators probably seemed like a good idea at the time, but have not taken hold. Today, their occurrence is more likely to trigger a bug or even serve as an attack.

HT characters ("TABS") were needed on ASR33 terminals to speed up processing of blank spaces at 110 bit/s line speed. Unless some legacy applications require compatibility with this ancient and frequently varied convention, HT characters are no longer appropriate in Modern Network Unicode. In support of legacy compatibility cases that do require tolerating their use, the "with HT characters" variance is defined.

The version-nonspecific nature of MNU creates some fuzziness that may be undesirable but is more realistic in environments where applications choose the Unicode version with the Unicode library that happens to be available to them.

D.2. Byte order marks

For UTF-8, there is no encoding ambiguity and thus no need for a byte order mark. However, some systems have made regular of a leading U+FEFF character in UTF-8 files, anyway, often in order to mark the file as UTF-8 in case other character codings are also in use and metadata is not available. This destroys the ASCII compatibility of UTF-8; it also creates problems when systems then start to expect a BOM in UTF-8 input and none is provided. Section 6 of [\[STD63\]](#) also RECOMMENDS not using Byte Order Marks with UTF-8 when it is clear that this charset is being used, but does not phrase this as an unambiguous mandate, so we add that here (as did [\[RFC5198\]](#)), unless permitted by a variance.

Some background on the prohibition of byte order marks: The 16-bit and 32-bit encodings for Unicode are available in multiple byte orders. The byte order in use in a specific piece of text can be provided by metadata (such as a media type) or by prefixing the text with a "Byte Order Mark", U+FEFF. Since code point U+FFFE is never used in Unicode, this unambiguously identifies the byte order.

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