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CBOR Extended Diagnostic Notation (EDN)
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Abstract

This document formalizes and consolidates the definition of the Extended Diagnostic Notation (EDN) of the Concise Binary Object Representation (CBOR), addressing implementer experience.

Replacing EDN's previous informal descriptions, it updates RFC 8949, obsoleting its Section 8, and RFC 8610, obsoleting its Appendix G.

It also specifies and uses registry-based extension points, using one to support text representations of epoch-based dates/times and of IP addresses and prefixes.

```
// (This cref will be removed by the RFC editor:) The present -20
// includes the definition of raw strings. -20 is intended for use at
// IETF 125.
```

About This Document

This note is to be removed before publishing as an RFC.

The latest revision of this draft can be found at <https://cbor-wg.github.io/edn-literal/>. Status information for this document may be found at <https://datatracker.ietf.org/doc/draft-ietf-cbor-edn-literals/>.

Discussion of this document takes place on the cbor Working Group mailing list (<mailto:cbor@ietf.org>), which is archived at <https://mailarchive.ietf.org/arch/browse/cbor/>. Subscribe at <https://www.ietf.org/mailman/listinfo/cbor/>.

Source for this draft and an issue tracker can be found at <https://github.com/cbor-wg/edn-literal>.

Status of This Memo

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1. Introduction

The Concise Binary Object Representation (CBOR) (RFC8949) [STD94] is a data format whose design goals include the possibility of extremely small code size, fairly small message size, and extensibility without the need for version negotiation. In addition to the binary interchange format, the original CBOR specification described a text-based "diagnostic notation" (Section 6 of [RFC7049], now Section 8 of RFC 8949 [STD94]), in order to be able to converse about CBOR data items without having to resort to binary data. Appendix G of [RFC8610] extended this into what is also known as Extended Diagnostic Notation (EDN).

Diagnostic notation syntax is based on JSON, with extensions for representing CBOR constructs such as binary data and tags.

Standardizing EDN in addition to the actual binary interchange format CBOR does not serve to create a competing interchange format, but enables the use of a shared diagnostic notation in tools for and in documents about CBOR. Still, between tools for CBOR development and diagnosis, document generation systems, continuous integration (CI) environments, configuration files, and user interfaces for viewing and editing for all these, EDN is often "interchanged" and therefore merits a specification that facilitates interoperability within this domain as well as reliable translation to and from CBOR. EDN is not designed or intended for general-purpose use in protocol elements exchanged between systems engaged in processes outside those listed here.

This document consolidates and formalizes the definition of EDN, providing a formal grammar (see Section 5.1 and Section 5.2), and incorporating small changes based on implementation experience. It updates RFC8949, obsoleting Section 8 of RFC 8949 [STD94], and [RFC8610], obsoleting Appendix G of [RFC8610]. It is intended to serve as a single reference target that can be used in specifications that use EDN.

It also specifies two registry-based extension points for the diagnostic notation: one for additional encoding indicators, and one for adding application-oriented literal forms. It uses these registries to add encoding indicators for a more complete coverage of encoding variation, and to add application-oriented literal forms that enhance EDN with text representations of epoch-based date/times

and of IP addresses and prefixes [RFC9164] as well as an application-oriented literal that represents cryptographic hash values computed from byte strings.

In addition, this document registers a media type identifier and a content-format for CBOR diagnostic notation. This does not elevate its status as an interchange format, but recognizes that interaction between tools is often smoother if media types can be used.

Examples in RFCs often do not use media type identifiers, but special sourcecode type names that are allocated in <https://www.rfc-editor.org/materials/sourcecode-types.txt> (<https://www.rfc-editor.org/materials/sourcecode-types.txt>). At the time of writing, this resource lists four sourcecode type names that can be used in RFCs for including CBOR data items and CBOR-related languages:

- * cbor (which is actually not useful, as CBOR is a binary format and cannot be used in textual examples in an RFC),
- * cbor-diag (which is another name for EDN, as defined in the present document),
- * cbor-pretty (which is a possibly annotated and pretty-printed hexdump of an encoded CBOR data item, along the lines of the grammar of Section 5.2.1, as used for instance for some of the examples in Appendix A.3 of [RFC9290]), and
- * cddl (which is used for the Concise Data Definition Language, CDDL, see Section 1.2 below).

Note that EDN is not meant to be the only text-based representation of CBOR data items. For instance, [YAML] [RFC9512] is able to represent most CBOR data items, possibly requiring use of YAML's extension points. YAML does not provide certain features that can be useful with tools and documents needing text-based representations of CBOR data items (such as embedded CBOR or encoding indicators), but it does provide a host of other features that EDN does not provide such as anchor/alias data sharing, at a cost of higher implementation and learning complexity.

1.1. Structure of This Document

Section 2 of this document has been built from Section 8 of RFC 8949 [STD94] and Appendix G of [RFC8610]. The latter provided a number of useful extensions to the diagnostic notation originally defined in Section 6 of [RFC7049]. Section 8 of RFC 8949 [STD94] and Appendix G of [RFC8610] have collectively been called "Extended Diagnostic Notation" (EDN), giving the present document its name.

After introductory material, Section 3 illustrates the concept of application-oriented extension literals by defining the "dt", "ip", "hash", and "cri" extensions. Section 4 defines mechanisms for dealing with unknown application-oriented literals and deliberately elided information. Section 5 gives the formal syntax of EDN in ABNF, with explanations for some features of and additions to this syntax, as an overall grammar (Section 5.1) and specific grammars for the content of app-string and byte-string literals (Section 5.2). This is followed by the conventional sections for IANA Considerations (6), Security considerations (7), and References (8.1, 8.2). An informational comparison of EDN with CDDL follows in Appendix A.

1.2. Terminology

Section 8 of RFC 8949 [STD94] defines the original CBOR diagnostic notation, and Appendix G of [RFC8610] supplies a number of extensions to the diagnostic notation that result in the Extended Diagnostic Notation (EDN). The diagnostic notation extensions include popular features such as embedded CBOR (encoded CBOR data items in byte strings) and comments. A simple diagnostic notation extension that enables representing CBOR sequences was added in Section 4.2 of [RFC8742]. As diagnostic notation is not used in the kind of interchange situations where backward compatibility would pose a significant obstacle, there is little point in not using these extensions; as at least some elements of the extended form are now near-universally used, the terms "diagnostic notation" and "EDN" have become synonyms in the context of CBOR.

Therefore, when we refer to "_diagnostic notation_", we mean to include the original notation from Section 8 of RFC 8949 [STD94] as well as the extensions from Appendix G of [RFC8610], Section 4.2 of [RFC8742], and the present document. However, we stick to the abbreviation "_EDN_" as it has become quite popular and is more sharply distinguishable from other meanings than "DN" would be.

In a similar vein, the term "ABNF" in this document refers to the language defined in [STD68] as extended in [RFC7405], where the "characters" of Section 2.3 of RFC 5234 [STD68] are Unicode scalar values. Brief snippets of grammar may be given in the text as I-Regexp regular expressions [RFC9485].

The term "CDDL" (Concise Data Definition Language) refers to the data definition language defined in [RFC8610] and its registered extensions (such as those in [RFC9165]), as well as [I-D.ietf-cbor-update-8610-grammar]. Additional information about the relationship between the two languages EDN and CDDL is captured in Appendix A.

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 [BCP14] (RFC2119) (RFC8174) when, and only when, they appear in all capitals, as shown here.

1.3. (Non-)Objectives of this Document

Section 8 of RFC 8949 [STD94] states the objective of defining a common human-readable diagnostic notation with CBOR. In particular, it states:

| All actual interchange always happens in the binary format.

1.3.1. For Humans

One important application of EDN is the notation of CBOR data for humans: in specifications, on whiteboards, and for entering test data. A number of features, such as comments inside prefixed string literals, are mainly useful for people-to-people communication via EDN. Programs also often output EDN for diagnostic purposes, such as in error messages or to enable comparison (including generation of diffs via tools) with test data.

1.3.2. Determinism?

For comparison with test data, it is often useful if different implementations generate the same (or similar) output for the same CBOR data items. This is comparable to the objectives of deterministic serialization for CBOR data items themselves (Section 4.2 of RFC 8949 [STD94]). However, there are even more representation variants in EDN than in binary CBOR, and there is little point in specifically endorsing a single variant as "deterministic" when other variants may be more useful for human understanding, e.g., the << >> notation as opposed to h''; an EDN

generator may have quite a few options that control what presentation variant is most desirable for the application that it is being used for.

Because of this, a deterministic representation is not defined for EDN, and there is no expectation for "roundtripping" from EDN to CBOR and back, i.e., for an ability to convert EDN to binary CBOR and back to EDN while achieving exactly the same result as the original input EDN — the original EDN possibly was created by humans or by a different EDN generator.

1.3.3. Basic Output Format

However, there is a certain expectation that EDN generators can be configured to some basic output format, which:

- * looks like JSON where that is possible;
- * inserts encoding indicators only where the binary form differs from preferred encoding;
- * uses hexadecimal representation (h'') for byte strings, not b64'' or embedded CBOR (<<>>);
- * does not generate elaborate blank space (newlines, indentation) for pretty-printing, but does use common blank spaces such as after , and :.

EDN generators may provide configuration to consistently select either the unescaped (directly readable) or an escaped (ASCII equivalent) form of characters in string literals; the latter allows EDN to be used when the diagnostic value of fully escaped characters may be desired or in environments where non-ASCII characters may not enjoy full data transparency. Similar to JSON, EDN is designed to allow a simple tool to convert any EDN (including EDN with application extensions unknown to the tool) into fully escaped (printable ASCII and newlines only) form, as well as to inversely recover unescaped characters for all escapes where this is possible or for certain subsets of the characters (such as Unicode categories L, M, N, P, S, plus Zs or just ASCII space).

Additional features such as ensuring deterministic map ordering (Section 4.2 of RFC 8949 [STD94]) on output, or even deviating from the basic configuration in some systematic way, can further assist in comparing test data. Information obtained from a CDDL model can help in choosing application-oriented literals or specific string representations such as embedded CBOR or b64'' in the appropriate places.

2. Overview over CBOR Extended Diagnostic Notation (EDN)

CBOR is a binary interchange format. To facilitate documentation and debugging, and in particular to facilitate communication between entities cooperating in debugging, this document defines a simple human-readable diagnostic notation. All actual interchange always happens in the binary format.

Note that diagnostic notation truly was designed as a diagnostic format; it originally was not meant to be parsed. Therefore, no formal definition (as in ABNF) was given in the original documents. Recognizing that formal grammars can aid interoperation of tools and usability of documents that employ EDN, Section 5 now provides ABNF definitions.

EDN is a true superset of JSON as it is defined in [STD90] in conjunction with [RFC7493] (that is, any interoperable [RFC7493] JSON text also is an EDN text), extending it both to cover the greater expressiveness of CBOR and to increase its usability.

EDN borrows the JSON syntax for numbers (integer and floating-point, Section 2.4), certain simple values (Section 2.8), UTF-8 [STD63] text strings, arrays, and maps (maps are called objects in JSON; the diagnostic notation extends JSON here by allowing any data item in the map key position).

As EDN is used for truly diagnostic purposes, its implementations MAY support generation and possibly ingestion of EDN for CBOR data items that are well-formed but not valid. It is RECOMMENDED that an implementation enables such usage only explicitly by configuration (such as an API or CLI flag). Validity of CBOR data items is discussed in Section 5.3 of RFC 8949 [STD94], with basic validity discussed in Section 5.3.1 of RFC 8949 [STD94], and tag validity discussed in Section 5.3.2 of RFC 8949 [STD94]. Tag validity is more likely a subject for individual application-oriented extensions, while the two cases of basic validity (for text strings and for maps) are addressed in Sections 2.5.7 and 2.6.2 under the heading of `_validity_`.

The rest of this section provides an overview over specific features of EDN, starting with certain common syntactical features and then going through kinds of CBOR data items roughly in the order of CBOR major types. Any additional detailed syntax discussion needed has been deferred to Section 5.1.

2.1. Application-Oriented Extension Literals

EDN provides `_literals_` that represent CBOR data items textually. Many of the forms of literals provided are predefined by this document, but it also defines an extension point that enables defining additional `_application-oriented extension literals_`, or `_extension literals_` for short.

Extension literals start with a `_prefix_` that identifies the application-oriented extension, immediately followed by a sequence literal (Section 2.5.6) or a single-quoted or raw string literal (Section 2.5). The latter form uses its single-quoted string literal as a shorthand form for a sequence literal representing a sequence with exactly that one string data item.

This notation is generalized from Section 8 of RFC 8949 [STD94], which provides for notating byte strings in a number of [RFC4648] base encodings, where the encoded text is enclosed in single quotes, prefixed by a prefix (h for base16, b32 for base32, h32 for base32hex, b64 for base64 or base64url).

This syntax can be thought to establish a name space, with the names "h", "b32", "h32", and "b64" taken, but other names being unallocated. The present specification allows registering additional names for this namespace, which we call `_application-extension identifiers_`.

More precisely, an `_application-extension identifier_` is a name consisting of a lower-case ASCII letter ([a-z]) and zero or more additional ASCII characters that are either lower-case letters, digits, or hyphens ([a-z0-9-]). false, true, null, and undefined cannot be used as such identifiers and are reserved.

Application-extension identifiers are registered in a registry (Section 6.1).

An application-extension (such as dt) MAY also define the meaning of a variant prefix derived from its application-extension identifier by replacing each lower-case character by its upper-case counterpart (such as DT). As a convention for such definitions, using the all-uppercase variant implies making use of a tag appropriate for this application-oriented extension (such as tag number 1 for DT, where dt stands for the unwrapped number).

This specification defines a number of generally applicable application-oriented extensions (Section 3), both to motivate making these extensions generally available, and to illustrate the concept.

2.2. Comments

For presentation to humans, EDN text may benefit from comments. JSON famously does not provide for comments, and the original diagnostic notation in Section 6 of [RFC7049] inherited this property.

EDN now provides two comment syntaxes, which can be used where the syntax allows blank space (outside of constructs such as numbers, string literals, etc.):

- * inline comments, delimited by slashes ("/"):

In a position that allows blank space, any text within and including a pair of slashes is considered blank space (and thus effectively a comment).

- * end-of-line comments, delimited by "#" and an end of line (LINE FEED, U+000A):

In a position that allows blank space, any text within and including a pair of a "#" and the end of the line is considered blank space (and thus effectively a comment).

Comments can be used to annotate a CBOR structure as in:

```
/grasp-message/ [/M_DISCOVERY/ 1, /session-id/ 10584416,  
                 /objective/ [/objective-name/ "opsonize",  
                             /D, N, S/ 7, /loop-count/ 105]]
```

This reduces to [1, 10584416, ["opsonize", 7, 105]].

Another example, combining the use of inline and end-of-line comments:

```
{  
  /kty/ 1 : 4, # Symmetric  
  /alg/ 3 : 5, # HMAC 256-256  
  /k/ -1 : h'6684523ab17337f173500e5728c628547cb37df  
          e68449c65f885d1b73b49eae1'  
}
```

This reduces to {1: 4, 3: 5, -1:
h'6684523AB17337F173500E5728C628547CB37DFE68449C65F885D1B73B49EAE1'}.

2.3. Encoding Indicators

Sometimes it is useful to indicate in the diagnostic notation which of several alternative representations were actually used; for example, a data item written 1.5 by a diagnostic decoder might have been encoded as a half-, single-, or double-precision float.

The convention for encoding indicators is that anything starting with an underscore and all immediately following characters that are alphanumeric or underscore is an encoding indicator, and can be ignored by anyone not interested in this information. For example, `_` or `_3`.

Encoding indicators are always optional: EDN is usually used to describe CBOR data items at the data model level. For some diagnostic purposes, it is useful to represent the choice of a serialization variation by including encoding indicators. Implementations of EDN generally do not need to provide this functionality, but may want to be able to process EDN that contains encoding indicators, ignoring them just as a generic CBOR decoder ignores the presence of the serialization variants they express.

Encoding indicators are placed immediately to the right of the data item or of a syntactic feature that can stand for the data item the encoding of which the encoding indicator is controlling. Table 1 provides examples for encoding indicators used with various kinds of data items.

+====+=====+		
mt	examples	
+====+=====+		
0	1_1, 0x4711_3	
+-----+-----+		
1	-1_1	
+-----+-----+		
2	'A'_1	
+-----+-----+		
3	"A"_1	
+-----+-----+		
4	[_1 "bar"]	
+-----+-----+		
5	{_1 "bar": 1}	
+-----+-----+		
6	1_1(4711)	
+-----+-----+		
7	1.5_2, 0x4711p+03_3	
+-----+-----+		

Table 1: Examples of
Encoding Indicators for
Different Data Items (mt
= major type)

(In the following, an abbreviation of the form ai=nn gives nn as the numeric value of the field `_additional information_`, the low-order 5 bits of the initial byte: see Section 3 of RFC 8949 [STD94]. This field is used in encoding the "argument", i.e., the value, tag, or length; ai=0 to ai=23 mean that the value of the ai field immediately `_is_` the argument, ai=24 to ai=27 mean that the argument is carried in $2^{(ai-24)}$ (1, 2, 4, or 8) additional bytes, and ai=31 means that indefinite length encoding is used.)

An underscore followed by a decimal digit n indicates that the preceding item (or, for arrays and maps, the item starting with the preceding bracket or brace) was encoded with an additional information value of ai=24+n. For example, 1.5_1 is a half-precision floating-point number ($2^1 = 2$ additional bytes or 16 bits), while 1.5_3 is encoded as double precision ($2^3 = 8$ additional bytes or 64 bits).

The encoding indicator `_` is an abbreviation of what would in full form be `_7`, which is not used. Therefore, an underscore `_` on its own stands for indefinite length encoding (ai=31). (Note that this encoding indicator is only available behind the opening brace/bracket for map and array (Section 2.6.1): strings have a special syntax streamstring for indefinite length encoding except for the special cases `''_` and `""_` (Section 2.5.4).)

The encoding indicators `_0` to `_3` can be used to indicate ai=24 to ai=27, respectively; they therefore stand for 1, 2, 4, and 8 bytes of additional information (ai) following the initial byte in the head of the data item. (The abbreviation of `_7` into `_` was discussed above. `_4` to `_6` are not currently used in CBOR, but will be available if and when CBOR is extended to make use of ai=28 to ai=30.)

Surprisingly, Section 8.1 of RFC 8949 [STD94] does not address ai=0 to ai=23 — the assumption seems to have been that preferred serialization (Section 4.1 of RFC 8949 [STD94]) will be used when converting CBOR diagnostic notation to an encoded CBOR data item, so leaving out the encoding indicator for a data item with a preferred serialization will implicitly use ai=0 to ai=23 if that is possible. The present specification allows making this explicit:

`_i` ("immediate") stands for encoding with ai=0 to ai=23, i.e., it indicates that the argument is encoded directly in the initial byte of the CBOR item.

While no pressing use for further values for encoding indicators comes to mind, this is an extension point for EDN; Section 6.2 defines a registry for additional values.

Encoding Indicators are discussed in further detail in Section 2.5.4 for indefinite length strings and in Section 2.6.1 for arrays and maps.

2.4. Numbers

In addition to JSON's decimal number literals, EDN provides hexadecimal, octal, and binary number literals in the usual C-language notation (octal with `0o` prefix present only).

Numbers composed only of digits (of the respective base) are interpreted as CBOR integers (major type 0/1, or where the number cannot be represented in this way, major type 6 with tag 2/3). A leading "+" sign is a no-op, and a leading "-" sign inverts the sign of the number. So 0, 000, +0 all represent the same integer zero, as does -0. Similarly, 1, 001, +1 and +0001 all stand for the same integer one, and -1 and -0001 both designate the same integer minus one.

Using a decimal point (.) and/or an exponent (e for decimal, p for hexadecimal) turns the number into a floating point number (major type 7) instead, irrespective of whether it is an integral number mathematically. Note that, in floating point numbers, 0.0 is not the same number as -0.0, even if they are mathematically equal.

In Table 2, all the items on a row are the same number (also shown in CBOR, hexadecimally), but they are distinct from items in a different row.

EDN	CBOR hex
4711, 0x1267, 0o111147, 0b1001001100111	19 1267 # uint
1.5, 0.15e1, 15e-1, 0x1.8p0, 0x18p-4	F9 3E00 # float16
0, +0, -0	00 # uint
0.0, +0.0	F9 0000 # float16
-0.0	F9 8000 # float16

Table 2: Example Sets of Equivalent Notations for Some Numbers

The non-finite floating-point numbers Infinity, -Infinity, and NaN are written exactly as in this sentence (this is also a way they can be written in JavaScript, although JSON does not allow them).

See Section 5.1, Paragraph 7, Item 3 for additional details of the EDN number syntax.

(Note that literals for further number formats, e.g., for representing rational numbers as fractions, or for NaNs with non-zero payloads, can be added as application-oriented literals. Background information beyond that in [STD94] about the representation of numbers in CBOR can be found in the informational document [I-D.bormann-cbor-numbers].)

2.5. Strings

CBOR distinguishes two kinds of strings: text strings (the bytes in the string constitute UTF-8 [STD63] text, major type 3), and byte strings (CBOR does not further characterize the bytes that constitute the string, major type 2).

EDN has three direct notations for strings: double-quoted and raw strings for (UTF-8) text strings, and single-quoted strings for byte strings. The latter are useful for byte strings carrying bytes that can be meaningfully notated as UTF-8 text (Section 2.5.2).

Many strings are best notated as extension literals, which may provide detailed access to the bits within those bytes (see Section 2.5.5). Extension literals can be constructed out of single-quoted strings, raw strings, and sequence literals.

2.5.1. Double-Quoted String Literals

EDN enables notating text strings in a form compatible to that of notating text strings in JSON (i.e., as a double-quoted string literal), with a number of usability extensions. In JSON, no control characters are allowed to occur directly in text string literals; if needed, they can be specified using escapes such as `\t` or `\r`. In EDN, string literals additionally can contain newlines (LINEFEED U+000A), which are copied into the resulting string like other characters in the string literal. To deal with variability in platform presentation of newlines, any carriage return characters (U+000D) that may be present in the EDN string literal are not copied into the resulting string (see Section 5.1, Paragraph 7, Item 2). No other control characters can occur directly in a string literal, and the handling of escaped characters (`\r` etc.) is as in JSON.

JSON's escape scheme for characters that are not on Unicode's basic multilingual plane (BMP) is cumbersome (see Section 7 of RFC 8259 [STD90]). EDN keeps it, but also adds the syntax `\u{NNN}` where NNN is the Unicode scalar value as a hexadecimal number. This means the following are equivalent (the first `o` is escaped as `\u{6f}` for no particular reason):

```
"D\u{6f}mino's \u{1F073} + \u{2318}"    # \u{-escape 3 chars
"Domino's \uD83C\uDC73 + \u2318"         # escape JSON-like
"Domino's  + "                           # unescaped
```


2.5.2. Single-Quoted String Literals

Analogously to text string literals delimited by double quotes, EDN allows the use of single quotes (without a prefix) to express byte string literals with UTF-8 text; for instance, the following are equivalent:

```
'hello world'  
h'68656c6c6f20776f722664'
```

The escaping rules of JSON strings are applied equivalently for text-based byte string literals, e.g., `\\` stands for a single backslash and `\'` stands for a single quote. However, to facilitate parsing, in single-quoted strings EDN excludes certain escaping mechanisms available for double-quoted strings:

- * `\/` is an escape in JSON that is available for EDN text strings as well to ensure all JSON texts are EDN literals. Since EDN's single-quoted strings do not occur in JSON, this legacy compatibility feature is not available for them.
- * `\u`-based escapes are not available for characters in the range from U+0020 to U+007E (essentially, printable ASCII).

Single-quoted string literals can occur unprefixed and stand for the byte string that encodes its text string value (the "content"), or be prefixed by what looks like an application-extension prefix (see Section 2.1).

In a prefixed string literal, the text content of the single-quoted string literal is not used directly as a byte string, but is further processed in a way that is defined by the meaning given to the prefix. Depending on the prefix, the result of that processing can, but need not be, a byte string value.

Prefixed string literals (which are always single-quoted after the prefix) are used both for base-encoded byte string literals (see Section 2.5.5) and for application-oriented extension literals (see Section 2.1, called app-string). (Additional kinds of base-encoded string literals can be defined as application-oriented extension literals by registering their prefixes; there is no fundamental difference between the two predefined base-encoded string literal prefixes (h, b64) and any such potential future extension literal prefixes; for simplicity of expression, both cases are referred to as "extension literals".)

2.5.3. Raw String Literals

Both double-quoted and single-quoted string literals handle backslashes in a special way. For string data items that employ backslashes themselves, possibly with additional layers of processing giving these "escaping" application semantics, this can lead to an exponential duplication of backslashes that has informally been described as "quoting hell".

EDN therefore also allows text strings to be notated as raw string literals, which do not perform backslash processing. Instead, data transparency is provided by enclosing them in starting and ending delimiters built as a sequence of one or more backquote (`, U+0060 GRAVE ACCENT) characters.

For example, the I-Regexp `[^ \t\n\r"']`, a character class that excludes blank space and quoting characters, can be notated as:

```
``[^ \t\n\r"']``
```

instead of

```
"[^ \\t\\n\\r\\"']"
```

By using more backquotes for the outer delimiters than the longest sequence of backquotes that can be found in the string, internal backquotes do not prematurely end the string literal. An example for a raw string that contains a double backquote and therefore is notated starting and ending with a triple backquote:

```
```To emulate typographic quotes, sometimes duplicated backward and
forward single quotes are used, as in ``text.``
```
```

This mechanism is easy to use for the large majority of cases. However:

- * Raw strings cannot be used for empty string data items, which therefore need to be notated using double- or single-quoted strings. (Obviously, there is no need to escape the content of empty strings, so this should not be a problem.)
- * Without additional rules, raw strings could not be used for string data items that start or end with backquotes, as these would amalgamate with the start and end delimiters.

To address the latter cases, two additional rules are added:

- * After processing the backquotes used as delimiters, any single newline at the start of a raw string is removed. As a result:

```
'''a'''
```

can also be expressed as

```
'''  
a'''
```

In addition to enabling leading backquotes in raw strings, this can be very useful for documentation strings etc.

This rule also allows notating ``text`` as:

```
'''  
``text``'''
```

- * An ending delimiter with more backquotes than were used in the starting delimiter contributes the superfluous ones to the string.

This allows notating a = ``foo`` as:

```
'''a = ``foo``'''
```

(The examples given here are minimal in that they show how the additional rules work; more complex examples would be necessary to provide additional motivation why this is a good case to handle.)

See Section 5.1 for a more formal approach to defining these rules.

2.5.4. Encoding Indicators of Strings

For indefinite length encoding, strings (byte and text strings) have a special syntax streamstring. This is used (except for the special cases ``_`` and ``"_`` below) to notate their detailed composition into individual "chunks" (Section 3.2.3 of RFC 8949 [STD94]), by representing the individual chunks in sequence within parentheses, each optionally followed by a comma, with an encoding indicator `_` immediately after the opening parenthesis: e.g., `(_ h'0123', h'4567')` or `(_ "foo", "bar")`. The overall type (byte string or text string) of the string is provided by the types of the individual chunks, which all need to be of the same type (Section 3.2.3 of RFC 8949 [STD94]).

For an indefinite-length string with no chunks inside, `(_)` would be ambiguous as to whether a byte string (encoded 0x5fff) or a text string (encoded 0x7fff) is meant and is therefore not used. The

basic forms `'_` and `"_` can be used instead and are reserved for the case of no chunks only — not as short forms for the (permitted, but not really useful) encodings with only empty chunks, which need to be notated as `(_ '')`, `(_ "")`, etc., when it is desired to preserve the chunk structure.

2.5.5. Base-Encoded Byte String Literals

Besides the unprefixed byte string literals that are analogous to JSON text string literals, EDN provides extension literals that can represent byte string by base-encoding them, typically notated as prefixed string literals. The application-extension identifier selects one of the base encodings [RFC4648], without padding. Most often, the base encoding is enclosed in a single-quoted or raw string literal, prefixed by `h` for base16 or `b64` for base64 or `base64url` (the actual encodings of the latter do not overlap, so the string remains unambiguous). For example, the byte string consisting of the four bytes 12 34 56 78 (given in hexadecimal here) could be written `h'12345678'` or `b64'EjRWeA'` when using single-quoted string literals, or `h'12345678'` or `b64'EjRWeA'` when using raw string literals.

```
| (Note that Section 8 of RFC 8949 [STD94] also mentions b32
| for base32 and h32 for base32hex. This has not been
| implemented widely and therefore is not directly included in
| this specification. These and further byte string formats now
| can easily be added back as application-oriented extension
| literals.)
```

Examples often benefit from some blank space (spaces, line breaks) in byte strings literals. In certain EDN prefixed byte string literals, blank space is ignored; for instance, the following are equivalent:

```
h'48656c6c6f20776f726c64'
h'48 65 6c 6c 6f 20 77 6f 72 6c 64'
h'4 86 56c 6c6f
 20776 f726c64'
```

The internal syntax of prefixed single-quote literals such as `h''` and `b64''` can also allow comments as blank space (see Section 2.2).

```
h'68656c6c6f20776f726c64'
h'68 65 6c /doubled l!/ 6c 6f # hello
 20 /space/
 77 6f 72 6c 64' /world/
```

Slash characters are part of the base64 classic alphabet (see Table 1 in Section 4 of [RFC4648]), and they therefore need be in the b64'' set of characters that contribute to the byte string. Therefore, only end-of-line comments are available in b64 byte string literals.

```
b64'/base64 not a comment/ but one follows # comment'
h'FDB6AC 7BAE27A2D69CA2699E9EDFDBBADA2779FA25 968C2C'
```

These two byte string literals stand for the same byte string; the deliberately confusing base64 content starts with b64'/bas' which is the same as h'FDB6AC' and ends with b64' lows' which is the same as h'968C2C'.

2.5.6. CBOR Sequence Literals

In diagnostic notation, a sequence of zero or more CBOR data item literals can be enclosed in << and >>, optionally prefixed by an application-extension prefix; we speak of *_sequence literals_*. EDN mainly deals with individual data items, not with CBOR sequences [RFC8742], so the CBOR sequence represented by the sequence literal needs to be further processed to obtain the value of the literal.

Prefixed sequence literals refer to the application extension (see Section 2.1) identified by the prefix and apply the extension to its sequence content, resulting in a single data item. This data item may be a string or may not (always) be, depending on the definition of the application extension.

An unprefixed sequence literal applies CBOR encoding to the data items in its content, taken as a CBOR sequence. The value of the literal thus is a byte string with the encoded content; we also speak of *_embedded CBOR_*. For instance, each pair of columns in the following are equivalent:

```
<<1>>           h'01'
<<1, 2>>         h'0102'
<<"hello", null>> h'65 68656c6c6f f6'
<<>>             h''
```

2.5.7. Validity of Text Strings

To be valid CBOR, Section 5.3.1 of RFC 8949 [STD94] requires that text strings are byte sequences in UTF-8 [STD63] form. EDN provides several ways to construct such byte strings (see Section 5.1, Paragraph 9, Item 1 for details). These mechanisms might operate on subsequences that do not themselves constitute UTF-8, e.g., by building larger sequences out of concatenating the subsequences; for validity of a text string resulting from these mechanisms it is only

of importance that the result is UTF-8. Both double-quoted and single-quoted string literals have been defined such that they lead to byte sequences that are UTF-8: the source language of EDN is UTF-8, and all escaping mechanisms lead only to adding further UTF-8 characters. Only prefixed string literals, other application-extensions, or in certain cases concatenation (Section 5.1, Paragraph 9, Item 1) can generate non-UTF-8 byte sequences.

As discussed at the start of Section 2, EDN implementations MAY support generation and possibly ingestion of EDN for CBOR data items that are well-formed but not valid; when this is enabled, such implementations MAY relax the requirement on text strings to be valid UTF-8.

Note that neither CBOR about its text strings nor EDN about its source language make any requirements except for conformance to [STD63]. No additional Unicode processing or validation such as normalization or checking whether a scalar value is actually assigned is foreseen by EDN, particularly not any processing that is dependent on a specific Unicode version. Such processing, if offered, MUST NOT get in the way of processing the data item represented in EDN (i.e., it may be appropriate to issue warnings but not to error out or to generate output that does not match the input at the UTF-8 level).

2.6. Arrays and Maps

EDN borrows the JSON syntax for arrays and maps. (Maps are called objects in JSON.)

For maps, EDN extends the JSON syntax by allowing any data item in the map key position (before the colon).

JSON requires the use of a comma as a separator character between the elements of an array as well as between the members (key/value pairs) of a map. (These commas also were required in the original diagnostic notation defined in [STD94] and [RFC8610].) The separator commas are now optional in the places where EDN syntax allows commas. (Stylistically, leaving out the commas is more idiomatic when they occur at line breaks.)

In addition, EDN also allows, but does not require, a trailing comma before the closing bracket/brace, enabling an easier to maintain "terminator" style of their use.

In summary, the following eight examples are all equivalent:

```
[1, 2, 3]
[1, 2, 3,]
[1 2 3]
[1 2 3,]
[1 2, 3]
[1 2, 3,]
[1, 2 3]
[1, 2 3,]
```

as are

```
{1: "n", "x": "a"}
{1: "n", "x": "a",}
{1: "n" "x": "a"}
# etc.
```

| |
|--|
| CDDL's comma separators in the equivalent contexts (CDDL groups) are entirely optional (and actually are terminators, which together with their optionality allows them to be used like separators as well, or even not at all). In summary, comma use is now aligned between EDN and CDDL, in a fully backwards compatible way. |
|--|

2.6.1. Encoding Indicators of Arrays and Maps

A single underscore can be written after the opening brace of a map or the opening bracket of an array to indicate that the data item was represented in indefinite-length format. For example, `[_ 1, 2]` contains an indicator that an indefinite-length representation was used to represent the data item `[1, 2]`.

At the same position, encoding indicators for specifying the size of the array or map head for definite-length format can be used instead, specifically `_i` or `_0` to `_3`. For example `[_0 false, true]` can be used to specify the encoding of the array `[false, true]` as `98 02 f4 f5`.

2.6.2. Validity of Maps

As discussed at the start of Section 2, EDN implementations MAY support generation and possibly ingestion of EDN for CBOR data items that are well-formed but not valid (Section 5.3 of RFC 8949 [STD94]).

For maps, this is relevant for map keys that occur more than once, as in:

```
{1: "to", 1: "fro"}
```

2.7. Tags

A tag is written as a decimal unsigned integer for the tag number, followed by the tag content in parentheses; for instance, a date in the format specified by RFC 3339 (ISO 8601) could be notated as:

```
0("2013-03-21T20:04:00Z")
```

or the equivalent epoch-based time as the following:

```
1(1363896240)
```

The tag number can be followed by an encoding indicator giving the encoding of the tag head. For example:

```
1_1(1363896240)
```

(assuming preferred encoding for the tag content) is encoded as

```
d9 0001            # tag(1)
 1a 514b67b0 # unsigned(1363896240)
```

2.8. Simple values

EDN uses JSON syntax for the simple values True (true), False (false), and Null (null). Undefined is written undefined as in JavaScript.

These and all other simple values can be given as "simple()" with the appropriate integer in the parentheses. For example, simple(42) indicates major type 7, value 42, and simple(0x14) indicates false, as does simple(20) or simple(0b10100).

3. Application-Oriented Extension Literals

This document extends the syntax used in diagnostic notation to also enable application-oriented extensions. This section defines a number of application-oriented extensions.

3.1. The "dt" Extension

The application-extension identifier "dt" is used to notate a date/time literal that can be used as an Epoch-Based Date/Time as per Section 3.4.2 of RFC 8949 [STD94].

The content of the literal is a single Standard Date/Time String as per Section 3.4.1 of RFC 8949 [STD94], as a text or byte string.

The value of the literal is a number representing the result of a conversion of the given Standard Date/Time String to an Epoch-Based Date/Time. If fractional seconds are given in the text (production time-secfrac in Figure 4), the value is a floating-point number; the value is an integer number otherwise. In the all-upper-case variant of the app-prefix, the value is enclosed in a tag number 1.

Each row of Table 3 shows an example of "dt" notation and equivalent notation not using an application-extension identifier.

| dt literal | plain EDN |
|--------------------------------|--------------|
| dt'1969-07-21T02:56:16Z' | -14159024 |
| dt'1969-07-21T02:56:16.0Z' | -14159024.0 |
| dt'1969-07-21T02:56:16.5Z' | -14159023.5 |
| dt<<'1969-07-21T02:56:16.5Z'>> | -14159023.5 |
| dt<<"1969-07-21T02:56:16.5Z">> | -14159023.5 |
| DT'1969-07-21T02:56:16Z' | 1(-14159024) |

Table 3: dt and DT literals vs. plain EDN

See Section 5.2.3 for an ABNF definition for the content of dt literals.

3.2. The "ip" Extension

The application-extension identifier "ip" is used to notate an IP address literal that can be used as an IP address as per Section 3 of [RFC9164].

The content of the literal is a single IPv4address or IPv6address as per Section 3.2.2 of [RFC3986], as a text or byte string.

With the lower-case app-string prefix ip, the value of the literal is a byte string representing the binary IP address. With the upper-case app-string prefix IP, the literal is such a byte string tagged with tag number 54, if an IPv6address is used, or tag number 52, if an IPv4address is used.

As an additional case, the upper-case app-string prefix `IP''` can be used with an IP address prefix such as `2001:db8::/56` or `192.0.2.0/24`, with the equivalent tag as its value. (Note that [RFC9164] representations of address prefixes need to implement the truncation of the address byte string as described in Section 4.2 of [RFC9164]; see example below.) For completeness, the lower-case variant `ip'2001:db8::/56'` or `ip'192.0.2.0/24'` stands for an unwrapped `[56,h'20010db8']` or `[24,h'c00002']`; however, in this case the information on whether an address is IPv4 or IPv6 often needs to come from the context.

Note that this application-extension provides no direct representation of the "Interface format" defined in Section 3.1.3 of [RFC9164], an address combined with an optional prefix length and an optional zone identifier, and therefore no way to reference a zone identifier at all. (If needed, this format can be put together by building their structures explicitly, e.g., an interface format without a zone identifier can be represented as in `52([ip'192.0.2.42',24])`, or an interface format with zone identifier 42 as in `54([ip'fe80::0202:02ff:ffff:fe03:0303',64,42])`.)

Each row of Table 4 shows an example of "ip" notation and equivalent notation not using an application-extension identifier.

| ip literal | plain EDN |
|---|--|
| <code>ip'192.0.2.42'</code> | <code>h'c000022a'</code> |
| <code>ip<<'192.0.2.42'>></code> | <code>h'c000022a'</code> |
| <code>IP'192.0.2.42'</code> | <code>52(h'c000022a')</code> |
| <code>IP'192.0.2.0/24'</code> | <code>52([24,h'c00002'])</code> |
| <code>ip'2001:db8::42'</code> | <code>h'20010db80000000000000000000000000042'</code> |
| <code>IP'2001:db8::42'</code> | <code>54(h'20010db80000000000000000000000000042')</code> |
| <code>IP'2001:db8::/64'</code> | <code>54([64,h'20010db8'])</code> |

Table 4: ip and IP literals vs. plain EDN

See Section 5.2.4 for an ABNF definition for the content of ip literals.

3.3. The "hash" Extension

The application-extension identifier "hash" is used to notate the input to a cryptographic hash function as well as identify such a hash function to obtain a byte string that represents the output of that hash function.

The content of the literal is a string, optionally followed by either an integer or a text string that identifies the hash function in the COSE Algorithms registry of the CBOR Object Signing and Encryption (COSE) registry group [IANA.cose], either by the identifier (value: integer or string), or, if no algorithm is registered with this value, by its name used in the registry. If the second item is not given, the default algorithm used is -16 ("SHA-256").

No uppercase variant prefix is defined for the application-extension identifier "hash".

| hash literal | plain EDN |
|-----------------------------|---|
| hash<<'foo'>> | h'2C26B46B68FFC68FF99B453C1D304134
13422D706483BFA0F98A5E886266E7AE' |
| hash'foo' | h'2C26B46B68FFC68FF99B453C1D304134
13422D706483BFA0F98A5E886266E7AE' |
| hash<<'foo',
-16>> | h'2C26B46B68FFC68FF99B453C1D304134
13422D706483BFA0F98A5E886266E7AE' |
| hash<<'foo',
"SHA-256">> | h'2C26B46B68FFC68FF99B453C1D304134
13422D706483BFA0F98A5E886266E7AE' |
| hash<<'foo',
-44>> | h'F7FBBA6E0636F890E56FBBF3283E524C
6FA3204AE298382D624741D0DC663832
6E282C41BE5E4254D8820772C5518A2C
5A8C0C7F7EDA19594A7EB539453E1ED7' |
| hash<<'foo',
"SHA-512">> | h'F7FBBA6E0636F890E56FBBF3283E524C
6FA3204AE298382D624741D0DC663832
6E282C41BE5E4254D8820772C5518A2C
5A8C0C7F7EDA19594A7EB539453E1ED7' |

Table 5: hash literals vs. plain EDN

3.4. The "cri" Extension

The application-extension identifier "cri" is used to notate an EDN literal for a CRI reference as defined in [I-D.ietf-core-href].

The text of the literal is a URI Reference as per [RFC3986] or an IRI Reference as per [RFC3987].

The value of the literal is a CRI reference that can be converted to the text of the literal using the procedure of Section 6.1 of [I-D.ietf-core-href]. Note that there may be more than one CRI reference that can be converted to the URI/IRI reference given; implementations are expected to favor the simplest variant available and make non-surprising choices otherwise. In the all-upper-case variant of the app-prefix, the value is enclosed in a tag number CPA99.

As an example, the CBOR diagnostic notation

```
cri'https://example.com/bottarga/shaved'  
CRI'https://example.com/bottarga/shaved'
```

is equivalent to

```
[-4, ["example", "com"], ["bottarga", "shaved"]]  
CPA99([-4, ["example", "com"], ["bottarga", "shaved"]])
```

See Section 5.2.5 for an ABNF definition for the content of cri literals.

4. Stand-in Representations in Binary CBOR

In some cases, an EDN consumer cannot construct actual CBOR items that represent the CBOR data intended for eventual interchange. This document defines stand-in representation for two such cases:

- * The EDN consumer does not know (or does not implement) an application-extension identifier used in the EDN document (Section 4.1) but wants to preserve the information for a later processor.
- * The generator of some EDN intended for human consumption (such as in a specification document) may not want to include parts of the final data item, destructively replacing complete subtrees or possibly just parts of a lengthy string by `_elisions_` (Section 4.2).

Implementation note: Typically, the ultimate applications will fail if they encounter tags unknown to them, which the ones defined in this section likely are. Where chains of tools are involved in processing EDN, it may be useful to fail earlier than at the ultimate receiver in the chain unless specific processing options (e.g., command line flags) are given that indicate which of these stand-ins are expected at this stage in the chain.

4.1. Handling unknown application-extension identifiers

When ingesting CBOR diagnostic notation, any application-oriented extension literals are usually decoded and transformed into the corresponding data item during ingestion. If an application-extension is not known or not implemented by the ingesting process, this is usually an error and processing has to stop.

However, in certain cases, it can be desirable to exceptionally carry an uninterpreted application-oriented extension literal in an ingested data item, allowing to postpone its decoding to a specific later stage of ingestion.

This specification defines a CBOR Tag for this purpose: The Diagnostic Notation Unresolved Application-Extension Tag, tag number CPA999 (Section 6.5). The content of this tag is an array of a text string for the application-extension identifier, and another array:

- * For app-strings, the second array contains a single item, a text string containing the text notated by the single-quoted string in the app-string.
- * For app-sequences, the second array contains zero or more items, which represent each item in the sequence contained in the app-sequence.

For example, cri'https://example.com' can be represented as /CPA/ 999(["cri", ["https://example.com"]]), or hash<"data", -44> as /CPA/ 999(["hash", ["data", -44]]).

If a stage of ingestion is not prepared to handle the Unresolved Application-Extension Tag, this is an error and processing has to stop, as if this stage had been ingesting an unknown or unimplemented application-extension literal itself.

```
// RFC-Editor: This document uses the CPA (code point allocation)
// convention described in [I-D.bormann-cbor-draft-numbers]. For
// each usage of the term "CPA", please remove the prefix "CPA" from
// the indicated value and replace the residue with the value
```

```
// assigned by IANA; perform an analogous substitution for all other
// occurrences of the prefix "CPA" in the document.  Finally, please
// remove this note.
```

4.2. Handling information deliberately elided from an EDN document

When using EDN for exposition in a document or on a whiteboard, it is often useful to be able to leave out parts of an EDN document that are not of interest at that point of the exposition.

To facilitate this, this specification supports the use of an `_ellipsis_` (notated as three or more dots in a row, as in `...`) to indicate parts of an EDN document that have been elided (and therefore cannot be reconstructed).

Upon ingesting EDN as a representation of a CBOR data item for further processing, the occurrence of an ellipsis usually is an error and processing has to stop.

However, it is useful to be able to process EDN documents with ellipses in the automation scripts for the documents using them. This specification defines a CBOR Tag that can be used in the ingestion for this purpose: The Diagnostic Notation Ellipsis Tag, tag number CPA888 (Section 6.5). The content of this tag either is

1. null (indicating a data item entirely replaced by an ellipsis), or it is
2. an array, the elements of which are alternating between fragments of a string and the actual elisions, represented as ellipses carrying a null as content.

Elisions can stand in for entire subtrees, e.g. in:

```
[1, 2, ..., 3]
{ "a": 1,
  "b": ...,
  ...: ...
}
```

A single ellipsis (or key/value pair of ellipses) can imply eliding multiple elements in an array (members in a map); if more detailed control is required, a data definition language such as CDDL can be employed. (Note that the stand-in form defined here does not allow multiple key/value pairs with an ellipsis as a key: the CBOR data item would not be valid.)

Subtree elisions can be represented in a CBOR data item by using /CPA/888(null) as the stand-in:

```
[1, 2, 888(null), 3]
{ "a": 1,
  "b": 888(null),
  888(null): 888(null)
}
```

Elisions also can be used as part of a (text or byte) string:

```
{ "contract": "Herewith I buy" + ... + "gned: Alice & Bob",
  "bytes_in_IRI": 'https://a.example/' + ... + '&q=bergrentrger',
  "signature": h'4711...0815',
}
```

The example "contract" combines string concatenation via the + operator (Section 5.1) with an ellipsis. The example "signature" uses special syntax that allows the use of ellipses between the bytes notated `_inside_ h''` literals.

String elisions can be represented in a CBOR data item by a stand-in that wraps an array of string fragments alternating with ellipsis indicators:

```
{ "contract": /CPA/888(["Herewith I buy", 888(null),
                        "gned: Alice & Bob"]),
  "bytes_in_IRI": 888(['https://a.example/', 888(null),
                        '&q=bergrentrger']),
  "signature": 888([h'4711', 888(null), h'0815']),
}
```

Note that the use of elisions is different from "commenting out" EDN text, e.g.:

```
{ "signature": h'4711/.../0815',
  # ...: ...
}
```

The consumer of this EDN will ignore the comments and therefore will have no idea after ingestion that some information has been elided; validation steps may then simply fail instead of being informed about the elisions.

5. ABNF Definitions

This section collects grammars in ABNF form ([STD68] as extended in [RFC7405]) that serve to define the syntax of EDN and some application-oriented literals.

Implementation note: The ABNF definitions in this section are intended to be useful in a Parsing Expression Grammar (PEG) parser interpretation (see Appendix A of [RFC8610] for an introduction into PEG).

5.1. Overall ABNF Definition for Extended Diagnostic Notation

This subsection provides an overall ABNF definition for the syntax of CBOR extended diagnostic notation.

This ABNF definition treats all single-quoted string literals the same, whether they are unprefixes and constitute byte string literals, or prefixed and their content subject to further processing. The text string value of the single-quoted strings that goes into that further processing is described using separate ABNF definitions in Section 5.2; as a convention, the grammar for the content of an app-string with prefix, say, *p*, is described by an ABNF definition with the rule name *app-string-p*.

As an implementation note, some implementations may want to integrate the parsing and processing of app-string content for certain application extensions with the overall grammar. Example grammars for such integrated parsers are provided with this specification in Section 5.3.

For simplicity, the internal parsing for the built-in EDN prefixes is specified in the same way. ABNF definitions for *h''* and *b64''* are provided in Section 5.2.1 and Section 5.2.2. However, the prefixes *b32''* and *h32''* are not in wide use and an ABNF definition in this document could therefore not be based on implementation experience.

```
seq           = S [item *(MSC item) SOC]
one-item      = S item S
item          = map / array / tagged
              / number / simple
              / string / streamstring

stringl       = (tstr / bstr) spec
stringle      = stringl / ellipsis
ellipsis      = 3*"." ; "... " or more dots
string        = stringle *(S "+" S stringle)
```



```

number          = (hexfloat / hexint / octint / binint
                    / decnumber / nonfin) spec
sign            = "+" / "-"
decnumber       = [sign] (1*DIGIT ["." *DIGIT] / "." 1*DIGIT)
                    ["e" [sign] 1*DIGIT]
hexfloat        = [sign] "0x" (1*HEXDIG ["." *HEXDIG] / "." 1*HEXDIG)
                    "p" [sign] 1*DIGIT
hexint          = [sign] "0x" 1*HEXDIG
octint          = [sign] "0o" 1*ODIGIT
binint          = [sign] "0b" 1*BDIGIT
nonfin          = %s"Infinity"
                  / %s"-Infinity"
                  / %s"NaN"
simple           = %s"false"
                  / %s"true"
                  / %s"null"
                  / %s"undefined"
                  / %s"simple(" S item S ")"
uint            = "0" / DIGIT1 *DIGIT
tagged          = uint spec "(" S item S ")"

app-prefix      = lcalpha *lcl dh ; including h and b64
                  / ucalpha *ucldh ; tagged variant, if defined
app-string      = app-prefix sqstr
app-sequence    = app-prefix "<<" seq ">>"
app-rstring     = app-prefix rawstring
rawstring       = startrawdelim
                  [newline] ; swallow up to one leading newline
                  rawcontent
                  matchrawdelim
rawdelim        = 1*"``"
startrawdelim   = rawdelim
                  ; width (number of backquotes) distinguishes
                  ; between following matchrawdelim and shortrawdelim
matchrawdelim   = rawdelim ; width >= previous startrawdelim
shortrawdelim   = rawdelim ; width < previous startrawdelim
rawchars        = 1*(%x09/%x0a/%x0d / %x20-5f / %x61-7e / NONASCII)
rawcontent      = 1*(rawchars / shortrawdelim)

sqstr           = SQUOTE *single-quoted SQUOTE
bstr            = app-string / sqstr / app-rstring / rawstring
                  / app-sequence / embedded
                  ; note: rawstring is text; app-... can be any type
tstr            = DQUOTE *double-quoted DQUOTE
embedded        = "<<" seq ">>"

array           = "[" (specms S item *(MSC item) SOC / spec S) "]"
map             = "{" (specms S keyp *(MSC keyp) SOC / spec S) "}"

```

```

keyp          = item S ":" S item

; We allow %x09 HT in prose, but not in strings
blank         = %x09 / %x0A / %x0D / %x20
non-slash     = blank / %x21-2e / %x30-7F / NONASCII
non-lf        = %x09 / %x0D / %x20-7F / NONASCII
comment       = "/" *non-slash "/"
              / "#" *non-lf %x0A

; optional space
S             = *blank *(comment *blank)
; mandatory space
MS           = (blank/comment) S
; mandatory comma and/or space
MSC          = ("," S) / (MS ["," S])
; optional comma and/or space
SOC          = S ["," S]

; check semantically that strings are either all text or all bytes
; note that there must be at least one string to distinguish
streamstring = "(" MS string *(MSC string) SOC ")"
spec         = ["_" *wordchar]
specms       = ["_" *wordchar MS]

double-quoted = unescaped
              / SQUOTE
              / "\" escapable-d

single-quoted = unescaped
              / DQUOTE
              / "\" escapable-s

escapable1    = %s"b" ; BS backspace U+0008
              / %s"f" ; FF form feed U+000C
              / %s"n" ; LF line feed U+000A
              / %s"r" ; CR carriage return U+000D
              / %s"t" ; HT horizontal tab U+0009
              / "\" ; \ backslash (reverse solidus) U+005C
              / newline ; swallow escaped newline

escapable-d   = escapable1
              / DQUOTE
              / "/" ; / slash (solidus) U+002F (JSON!)
              / (%s"u" hexchar) ; uXXXX U+XXXX

escapable-s   = escapable1
              / SQUOTE
              / (%s"u" hexchar-s) ; uXXXX U+XXXX

```

```

hexchar      = "{" (1*"0" [ hexscalar ] / hexscalar) "}"
              / non-surrogate
              / two-surrogate
non-surrogate = ((DIGIT / "A"/"B"/"C" / "E"/"F") 3HEXDIG)
              / ("D" ODIGIT 2HEXDIG )
two-surrogate = high-surrogate "\" %s"u" low-surrogate
high-surrogate = "D" ("8"/"9"/"A"/"B") 2HEXDIG
low-surrogate  = "D" ("C"/"D"/"E"/"F") 2HEXDIG
hexscalar     = "10" 4HEXDIG / HEXDIG1 4HEXDIG
              / non-surrogate / 1*3HEXDIG

; single-quote hexchar-s: don't allow 0020..007e
hexchar-s    = "{" (1*"0" [ hexscalar-s ] / hexscalar-s) "}"
              / non-surrogate-s
              / two-surrogate
non-surrogate-s = "007F" ; rubout
              / "00" ("0"/"1"/"8"/"9"/HEXDIGA) HEXDIG
              / "0" HEXDIG1 2HEXDIG
              / non-surrogate-1
non-surrogate-1 = ((DIGIT1 / "A"/"B"/"C" / "E"/"F") 3HEXDIG)
              / ("D" ODIGIT 2HEXDIG )
hexscalar-s    = "10" 4HEXDIG / HEXDIG1 4HEXDIG
              / non-surrogate-1 / HEXDIG1 2HEXDIG
              / ("1"/"8"/"9"/HEXDIGA) HEXDIG
              / "7F"
              / HEXDIG1

; Note that no other C0 characters are allowed, including %x09 HT
unescaped    = %x0A ; new line
              / %x0D ; carriage return -- ignored on input
              / %x20-21
              / %x22 " ; omit 0x22 "
              / %x23-26
              / %x27 ' ; omit 0x27 '
              / %x28-5B
              / %x29 \ ; omit 0x5C \
              / %x5D-7F
              / NONASCII

newline      = [%x0D] %x0A
DQUOTE      = %x22 ; " double quote
SQUOTE      = %x27 ; ' single quote
DIGIT       = %x30-39 ; 0-9
DIGIT1      = %x31-39 ; 1-9
ODIGIT      = %x30-37 ; 0-7
BDIGIT      = %x30-31 ; 0-1
HEXDIGA     = "A" / "B" / "C" / "D" / "E" / "F"
; Note: double-quoted strings as in "A" are case-insensitive in ABNF

```

```

HEXDIG      = DIGIT / HEXDIGA
HEXDIG1     = DIGIT1 / HEXDIGA
lcalpha     = %x61-7A ; a-z
lcldh       = lcalpha / DIGIT / "-"
ucalpha     = %x41-5A ; A-Z
ucldh       = ucalpha / DIGIT / "-"
ALPHA       = lcalpha / ucalpha
wordchar    = "_" / ALPHA / DIGIT ; [_a-z0-9A-Z]
NONASCII    = %x80-D7FF / %xE000-10FFFF

```

Figure 1: Overall ABNF Definition of CBOR EDN

While an ABNF grammar defines the set of character strings that are considered to be valid EDN by this ABNF, the mapping of these character strings into the generic data model of CBOR is not always obvious.

The following additional items should help in the interpretation:

1. As mentioned in the terminology (Section 1.2), the ABNF terminal values in this document define Unicode scalar values (characters) rather than their UTF-8 encoding. For example, the Unicode PLACE OF INTEREST SIGN (U+2318) would be defined in ABNF as %x2318.
2. Unicode CARRIAGE RETURN (U+000D, often seen escaped as "\r" in many programming languages) that exist in the input (unescaped) are ignored as if they were not in the input wherever they appear. This is most important when they are found in (text or byte) string contexts (see the "unescaped" ABNF rule). On some platforms, a carriage return is always added in front of a LINE FEED (U+000A, also often seen escaped as "\n" in many programming languages), but on other platforms, carriage returns are not used at line breaks. The intent behind ignoring unescaped carriage returns is to ensure that input generated or processed on either of these kinds of platforms will generate the same bytes in the CBOR data items created from that input. (Platforms that use just a CARRIAGE RETURN by itself to signify an end of line are no longer relevant and the files they produce are out of scope for this document.) If a carriage return is needed in the CBOR data item, it can be added explicitly using the escaped form \r.

3. `decnumber` stands for an integer in the usual decimal notation, unless at least one of the optional parts starting with "." and "e" are present, in which case it stands for a floating point value in the usual decimal notation. Note that the grammar now allows `3.` for `3.0` and `.3` for `0.3` (also for hexadecimal floating point below); implementers are advised that some platform numeric parsers accept only a subset of the floating point syntax in this document and may require some preprocessing to use here.
4. `hexint`, `octint`, and `binint` stand for an integer in the usual base 16/hexadecimal ("`0x`"), base 8/octal ("`0o`"), or base 2/binary ("`0b`") notation. `hexfloat` stands for a floating point number in the usual hexadecimal notation (which uses a mantissa in hexadecimal and an exponent in decimal notation, see Section 5.12.3 of [IEEE754], Section 6.4.4.3 of [C], or Section 5.13.4 of [Cplusplus]; floating-suffix/floating-point-suffix from the latter two is not used here).
5. For `hexint`, `octint`, `binint`, and when `decnumber` stands for an integer, the corresponding CBOR data item is represented using major type 0 or 1 if possible, or using tag 2 or 3 if not. In the latter case, this specification does not define any encoding indicators that apply. If fine control over encoding is desired, this can be expressed by being explicit about the representation as a tag: E.g., `987654321098765432310`, which is equivalent to `2(h'35 8a 75 04 38 f3 80 f5 f6')` in its preferred serialization, might be written as `2_3(h'00 00 00 35 8a 75 04 38 f3 80 f5 f6'_1)` if leading zeros need to be added during serialization to obtain specific sizes for tag head, byte string head, and the overall byte string.

When `decnumber` stands for a floating point value, and for `hexfloat` and `nonfin`, a floating point data item with major type 7 is used in preferred serialization (unless modified by an encoding indicator, which then needs to be `_1`, `_2`, or `_3`). For this, the number range needs to fit into an [IEEE754] binary64 (or the size corresponding to the encoding indicator), and the precision will be adjusted to binary64 before further applying preferred serialization (or to the size corresponding to the encoding indicator). Tag 4/5 representations are not generated in these cases. Future app-prefixes could be defined to allow more control for obtaining a tag 4/5 representation directly from a hex or decimal floating point literal.

6. `spec` stands for an encoding indicator. See Section 2.3 for details.

7. The ABNF grammar for rawstrings is lenient; a parser needs to implement the comments on matchrawdelim and shortrawdelim as well. shortrawdelim only matches sequences of backquotes that are shorter than startrawdelim. matchrawdelim only matches sequences of backquotes that are as long or longer than startrawdelim. Any access number of backquotes in matchrawdelim are added to the string content.

In a PEG parser that implements predicates, these matching rules can for instance be implemented as follows:

```
startrawdelim = rawdelim&{ |(rd)|@rdlen = rd.text_value.length }
shortrawdelim = rawdelim&{ |(rd)|rd.text_value.length < @rdlen }
matchrawdelim = rawdelim&{ |(rd)|rd.text_value.length >= @rdlen }
```

1. Extended diagnostic notation allows a (text or byte) string to be built up from multiple (text or byte) string literals, separated by a + operator; these are then concatenated into a single string.

string, string1, stringl, and ellipsis realize: (1) the representation of strings in this form split up into multiple chunks, and (2) the use of ellipses to represent elisions (Section 4.2).

Note that the syntax defined here for concatenation of components uses an explicit + operator between the components to be concatenated (Appendix G.4 of [RFC8610] used simple juxtaposition, which was not widely implemented and got in the way of making the use of commas optional in other places via the rule OC).

Text strings and byte strings do not mix within such a concatenation, except that byte string literal notation can be used inside a sequence of concatenated text string notation literals, to encode characters that may be better represented in an encoded way. The following four text string values (adapted from Appendix G.4 of [RFC8610] by updating to explicit + operators) are equivalent:

```
"Hello world"
"Hello " + "world"
"Hello" + h'20' + "world"
"" + h'48656c6c6f20776f726c64' + ""
```

Similarly, the following byte string values are equivalent:

```
'Hello world'  
'Hello ' + 'world'  
'Hello ' + h'776f726c64'  
'Hello' + h'20' + 'world'  
' ' + h'48656c6c6f20776f726c64' + ' ' + b64''  
h'4 86 56c 6c6f' + h' 20776 f726c64'
```

The semantic processing of these constructs is governed by the following rules:

- * A single ... is a general ellipsis, which by itself can stand for any data item. Multiple adjacent concatenated ellipses are equivalent to a single ellipsis.
- * An ellipsis can be concatenated (on one or both sides) with string chunks (string1); the result is a CBOR tag number CPA888 that contains an array with joined together spans of such chunks plus the ellipses represented by 888(null).
- * If there is no ellipsis in the concatenated list, the result of processing the list will always be a single item.
- * The bytes in the concatenated sequence of string chunks are simply joined together, proceeding from left to right. If the left hand side of a concatenation is a text string, the joining operation results in a text string, and that result needs to be valid UTF-8 except for implementations that support and are enabled for generation/ingestion of EDN for CBOR data items that are well-formed but not valid. If the left hand side is a byte string, the right hand side also needs to be a byte string.
- * Some of the strings may be app-strings. If the result type of the app-string is an actual (text or byte) string, joining of those string chunks occurs as with chunks directly notated as string literals; otherwise the occurrence of more than one app-string or an app-string together with a directly notated string cannot be processed. (This determination must be made at the time the app-string is interpreted; see Section 4.1 for how this may not be immediately during parsing.)

5.2. ABNF Definitions for Application Extension Content

This subsection provides ABNF definitions for the content of application-oriented extension literals defined in [STD94] and in this specification, where applicable. These grammars describe the `_decoded_` content of the `sqstr` components that combine with the application-extension identifiers used as prefixes to form application-oriented extension literals. Each of these may integrate ABNF rules defined in Figure 1, which are not always repeated here.

Table 6 summarizes the app-prefix values defined in this document.

| app-prefix | content of single-quoted string | result type |
|------------|--|--|
| h | hexadecimal form of binary data | byte string |
| H | (not used) | |
| b64 | base64 forms (classic or base64url) of binary data | byte string |
| B64 | (not used) | |
| dt | RFC 3339 date/time | number (int or float) |
| DT | " | Tag 1 on the above |
| ip | IP address or prefix | byte string, array of length and byte string |
| IP | " | Tag 54 (IPv6) or 52 (IPv4) on the above |

Table 6: App-prefix Values Defined in this Document

Note that implementation platforms may already provide implementations of grammars used in application-extensions, such as of RFC 3339 for `dt''` and of IP address syntax for `ip''`. EDN-based tools may want to use these implementation libraries instead of using the grammars that are provided here as a reference.

5.2.1. h: ABNF Definition of Hexadecimal representation of a byte string

The syntax of the content of byte strings represented in hex, such as h'', h'0815', or h'/head/ 63 /contents/ 66 6f 6f' (another representation of << "foo" >>), is described by the ABNF in Figure 2. This syntax accommodates both lower case and upper case hex digits, as well as blank space (including comments) around each hex digit.

```

app-string-h      = S *(HEXDIG S HEXDIG S / ellipsis S)
                    [ "#" *non-lf]
ellipsis          = 3* "."
HEXDIG            = DIGIT / "A" / "B" / "C" / "D" / "E" / "F"
DIGIT             = %x30-39 ; 0-9
blank             = %x09 / %x0A / %x0D / %x20
non-slash         = blank / %x21-2e / %x30-10FFFF
non-lf            = %x09 / %x0D / %x20-D7FF / %xE000-10FFFF
S                 = *blank *(comment *blank )
comment           = "/" *non-slash "/"
                  / "#" *non-lf %x0A

```

Figure 2: ABNF Definition of Hexadecimal Representation of a Byte String

5.2.2. b64: ABNF Definition of Base64 representation of a byte string

The syntax of the content of byte strings represented in base64 is described by the ABNF in Figure 2.

This syntax allows both the classic (Section 4 of [RFC4648]) and the URL-safe (Section 5 of [RFC4648]) alphabet to be used. It accommodates, but does not require base64 padding. Note that inclusion of classic base64 makes it impossible to have in-line comments in b64, as "/" is valid base64-classic.

```

app-string-b64    = B *(4(b64dig B))
                    [b64dig B b64dig B ["=" B "=" / b64dig B ["="]] B]
                    [ "#" *inon-lf]
b64dig            = ALPHA / DIGIT / "-" / "_" / "+" / "/"
B                 = *iblack *(icomment *iblack)
iblack            = %x0A / %x20 ; Not HT or CR (gone)
icomment          = "#" *inon-lf %x0A
inon-lf           = %x20-D7FF / %xE000-10FFFF
ALPHA             = %x41-5a / %x61-7a
DIGIT             = %x30-39

```

Figure 3: ABNF definition of Base64 Representation of a Byte String

5.2.3. dt: ABNF Definition of RFC 3339 Representation of a Date/Time

The syntax of the content of dt literals can be described by the ABNF for date-time from [RFC3339] as summarized in Section 3 of [RFC9165]:

```

app-string-dt    = date-time

date-fullyear    = 4DIGIT
date-month       = 2DIGIT ; 01-12
date-mday        = 2DIGIT ; 01-28, 01-29, 01-30, 01-31 based on
                  ; month/year
time-hour        = 2DIGIT ; 00-23
time-minute      = 2DIGIT ; 00-59
time-second      = 2DIGIT ; 00-58, 00-59, 00-60 based on leap sec
                  ; rules
time-secfrac     = "." 1*DIGIT
time-numoffset   = ("+" / "-") time-hour ":" time-minute
time-offset      = "Z" / time-numoffset

partial-time     = time-hour ":" time-minute ":" time-second
                  [time-secfrac]
full-date        = date-fullyear "-" date-month "-" date-mday
full-time        = partial-time time-offset

date-time        = full-date "T" full-time
DIGIT            = %x30-39 ; 0-9

```

Figure 4: ABNF Definition of RFC3339 Representation of a Date/Time

5.2.4. ip: ABNF Definition of Textual Representation of an IP Address

The syntax of the content of ip literals can be described by the ABNF for IPv4address and IPv6address in Section 3.2.2 of [RFC3986], as included in slightly updated form in Figure 5.

```

app-string-ip = IPaddress [ "/" uint ]

IPaddress      = IPv4address
                / IPv6address

; ABNF from RFC 3986, re-arranged for PEG compatibility:

IPv6address    =
    /
    / [ h16
    / [ h16 *1( ":" h16 ) ] ":" 4( h16 ":" ) ls32
    / [ h16 *2( ":" h16 ) ] ":" 2( h16 ":" ) ls32
    / [ h16 *3( ":" h16 ) ] ":" h16 ":" ls32
    / [ h16 *4( ":" h16 ) ] ":" ls32
    / [ h16 *5( ":" h16 ) ] ":" h16
    / [ h16 *6( ":" h16 ) ] ":"

h16            = 1*4HEXDIG
ls32           = ( h16 ":" h16 ) / IPv4address
IPv4address    = dec-octet "." dec-octet "." dec-octet "." dec-octet
dec-octet      = "25" %x30-35 ; 250-255
                / "2" %x30-34 DIGIT ; 200-249
                / "1" 2DIGIT ; 100-199
                / %x31-39 DIGIT ; 10-99
                / DIGIT ; 0-9

HEXDIG        = DIGIT / "A" / "B" / "C" / "D" / "E" / "F"
DIGIT         = %x30-39 ; 0-9
DIGIT1        = %x31-39 ; 1-9
uint          = "0" / DIGIT1 *DIGIT

```

Figure 5: ABNF Definition of Textual Representation of an IP Address

5.2.5. cri: ABNF Definition of URI Representation of a CRI

It can be expected that implementations of the application-extension identifier "cri" will make use of platform-provided URI implementations, which will include a URI parser.

In case such a URI parser is not available or inconvenient to integrate, a grammar of the content of cri literals is provided by the ABNF for URI-reference in Section 4.1 of RFC 3986 [RFC3986] with certain re-arrangements taken from Section 5.2.4; these are reproduced in Figure 6. If the content is not ASCII only (i.e., for IRIs), first apply Section 3.1 of [RFC3987] and apply this grammar to the result.

```

app-string-cri = URI-reference
; ABNF from RFC 3986:

URI            = scheme ":" hier-part [ "?" query ] [ "#" fragment ]

hier-part      = "//" authority path-abempty
                / path-absolute
                / path-rootless
                / path-empty

URI-reference  = URI / relative-ref

absolute-URI   = scheme ":" hier-part [ "?" query ]

relative-ref   = relative-part [ "?" query ] [ "#" fragment ]

relative-part  = "//" authority path-abempty
                / path-absolute
                / path-noscheme
                / path-empty

scheme         = ALPHA *( ALPHA / DIGIT / "+" / "-" / "." )

authority      = [ userinfo "@" ] host [ ":" port ]
userinfo       = *( unreserved / pct-encoded / sub-delims / ":" )
host           = IP-literal / IPv4address / reg-name
port           = *DIGIT

IP-literal     = "[" ( IPv6address / IPvFuture ) "]"

IPvFuture      = "v" 1*HEXDIG "." 1*( unreserved / sub-delims / ":" )

; Use IPv6address, h16, ls32, IPv4address, dec-octet as re-arranged
; for PEG Compatibility in Figure 5 of [I-D.ietf-cbor-edn-literals]:

IPv6address    =
                6( h16 ":" ) ls32
                /
                "::" 5( h16 ":" ) ls32
                / [ h16
                / [ h16 *1( ":" h16 ) ] "::" 4( h16 ":" ) ls32
                / [ h16 *2( ":" h16 ) ] "::" 3( h16 ":" ) ls32
                / [ h16 *3( ":" h16 ) ] "::" 2( h16 ":" ) ls32
                / [ h16 *3( ":" h16 ) ] "::" h16 ":" ls32
                / [ h16 *4( ":" h16 ) ] "::" ls32
                / [ h16 *5( ":" h16 ) ] "::" h16
                / [ h16 *6( ":" h16 ) ] "::"

h16            = 1*4HEXDIG
ls32           = ( h16 ":" h16 ) / IPv4address
IPv4address    = dec-octet "." dec-octet "." dec-octet "." dec-octet

```

```

dec-octet      = "25" %x30-35           ; 250-255
                / "2" %x30-34 DIGIT      ; 200-249
                / "1" 2DIGIT             ; 100-199
                / %x31-39 DIGIT          ; 10-99
                / DIGIT                  ; 0-9
ALPHA          = %x41-5a / %x61-7a
DIGIT          = %x30-39
HEXDIG         = DIGIT / "A" / "B" / "C" / "D" / "E" / "F"
; case insensitive matching, i.e., including lower case

reg-name       = *( unreserved / pct-encoded / sub-delims )

path           = path-abempty           ; begins with "/" or is empty
                / path-absolute         ; begins with "/" but not "/"
                / path-noscheme         ; begins with a non-colon segment
                / path-rootless         ; begins with a segment
                / path-empty            ; zero characters

path-abempty   = *( "/" segment )
path-absolute = "/" [ segment-nz *( "/" segment ) ]
path-noscheme = segment-nz-nc *( "/" segment )
path-rootless = segment-nz *( "/" segment )
path-empty    = 0<pchar>

segment        = *pchar
segment-nz     = 1*pchar
segment-nz-nc  = 1*( unreserved / pct-encoded / sub-delims / "@" )
                ; non-zero-length segment without any colon ":"

pchar          = unreserved / pct-encoded / sub-delims / ":" / "@"

query          = *( pchar / "/" / "?" )

fragment       = *( pchar / "/" / "?" )

pct-encoded    = "%" HEXDIG HEXDIG

unreserved     = ALPHA / DIGIT / "-" / "." / "_" / "~"
reserved       = gen-delims / sub-delims
gen-delims     = ":" / "/" / "?" / "#" / "[" / "]" / "@"
sub-delims     = "!" / "$" / "&" / "'" / "(" / ")"
                / "*" / "+" / "," / ";" / "="

```

Figure 6: ABNF Definition of URI Representation of a CRI

5.3. ABNF Definitions for Integrated Extension Parsers

For some applications of EDN, it is an optimization to integrate parsers for the content of some prefixed single-quoted string literals into the main parser, handling both the string literal syntax (e.g., escapes such as `\'` and `\\`) and the syntax of the extension content in one go.

For application-extensions that only use printable ASCII characters (from U+0020 to U+007E) minus single-quote `'` and backslash `\`, the ABNF such as that given in Section 5.2 can be directly used as an integrated parser, after adding some glue ABNF. For instance, for `app-string-dt`, add an alternative to `bstr` that points to a rule for prefixed single-quoted string literals (Figure 7).

```
bstr                = sq-app-string-dt /
                      app-string / sqstr / app-sequence / embedded
sq-app-string-dt = (%s"dt'"/%s"DT'") app-string-dt '''
```

Figure 7: Glue Code for Integrated DT Parser

To facilitate writing integrated ABNF for more complex prefixed string literals, the ABNF definitions in Figure 8 may be useful and are used in the rest of this section.

```

i-HT =          %s"\t" / %s"\u" ("0009" / "{" *("0") "9}")
i-LF = %x0a / %s"\n" / %s"\u" ("000A" / "{" *("0") "A}")
i-CR = %x0d / %s"\r" / %s"\u" ("000D" / "{" *("0") "D}")

i-blank = i-LF / i-CR / " "
i-non-lf = i-HT / i-CR / %x20-26 / "\"' / %x28-5b
           / "\"\" / %x5d-7f / i-NONASCII

i-NONASCII = NONASCII / %s"\u" ESCGE7F

; hex escaping for U+007F or greater
ESCGE7F = "D" ("8"/"9"/"A"/"B") 2HEXDIG
          %s"\u" "D" ("C"/"D"/"E"/"F") 2HEXDIG
          / FOURHEX1 / "0" HEXDIG1 2HEXDIG / "00" TWOHEX1
          / "{" *("0")
          ("10" 4HEXDIG / HEXDIG1 4HEXDIG
           / FOURHEX1 / HEXDIG1 2HEXDIG / TWOHEX1)
          "}"

; xxxx - 0xxx - Dhigh\uDloow
FOURHEX1 = (DIGIT1 / "A"/"B"/"C" / "E"/"F") 3HEXDIG
           / "D" ODIGIT 2HEXDIG
; 00xx - ASCII + 007F
TWOHEX1  = ("8"/"9" / HEXDIGA) HEXDIG / "7F"

```

Figure 8: ABNF Definitions Useful for Integrated Extension Parsers

Two subsections with ABNF for integrated parsers follow, one for `h''`, and one for `b64''`. There is no requirement for a new application-extension to supply ABNF for an integrated parser (or any ABNF at all!), in particular if the parsing function is likely to be fulfilled by a platform library. If ABNF for the content of a single-quoted string is available in an application-extension specification, ABNF for an integrated parser can be written as a separate activity or also automatically derived. At the time of writing, one example for a tool performing such a derivation is available as open-source software [ABNFROB].

5.3.1. h: ABNF Definition of Integrated Parser

With glue code similar to that in Figure 7, ABNF such as that shown in Figure 9 can be used as an integrated parser for `h''` prefixed single-quote strings.

```

sq-app-string-h = %s"h'" app-string-h "'"
app-string-h = h-S *(HEXDIG h-S HEXDIG h-S / ellipsis h-S)
    ["#" *(i-non-lf)]

h-S = *(i-blank) *(h-comment *(i-blank))
h-non-slash = i-blank / %x21-26 / "\"' / %x28-2e
    / %x30-5b / "\"\" / %x5d-7f / i-NONASCII
h-comment = "/" *(h-non-slash) "/"
    / "#" *(i-non-lf) i-LF

```

Figure 9: ABNF Definition for Integrated Hex Parser

5.3.2. b64: ABNF Definition of Integrated Parser

With glue code similar to that in Figure 7, ABNF such as that shown in Figure 10 can be used as an integrated parser for h'' prefixed single-quote strings.

```

sq-app-string-b64 = %s"b64'" app-string-b64 "'"
app-string-b64 = b64-S *(4(b64dig b64-S))
    [b64dig b64-S b64dig b64-S
    ["=" b64-S "=" / b64dig b64-S ["="]] b64-S]
    ["#" *i-non-lf]
b64dig = ALPHA / DIGIT / "-" / "_" / "+" / "/"
b64-S = *i-blank *(b64-comment *i-blank)
b64-comment = "#" *i-non-lf %x0A

```

Figure 10: ABNF Definition for Integrated Base64 Parser

6. IANA Considerations

```

// RFC Editor: please replace RFC-XXXX with the RFC number of this
// RFC, [IANA.cbor-diagnostic-notation] with a reference to the new
// registry group, and remove this note.

```

6.1. CBOR Diagnostic Notation Application-extension Identifiers Registry

IANA is requested to create an "Application-Extension Identifiers" registry in a new "CBOR Diagnostic Notation" registry group [IANA.cbor-diagnostic-notation], with the policy "expert review" (Section 4.5 of RFC 8126 [BCP26]).

The experts are instructed to be frugal in the allocation of application-extension identifiers that are suggestive of generally applicable semantics, keeping them in reserve for application-extensions that are likely to enjoy wide use and can make good use of

their conciseness. The expert is also instructed to direct the registrant to provide a specification (Section 4.6 of RFC 8126 [BCP26]), but can make exceptions, for instance when a specification is not available at the time of registration but is likely forthcoming. If the expert becomes aware of application-extension identifiers that are deployed and in use, they may also initiate a registration on their own if they deem such a registration can avert potential future collisions.

Each entry in the registry must include:

Application-Extension Identifier:

a lower case ASCII [STD80] string that starts with a letter and can contain letters, digits, and hyphens after that ([a-z][a-z0-9-]*). No other entry in the registry can have the same application-extension identifier.

Description:

a brief description

Change Controller:

(see Section 2.3 of RFC 8126 [BCP26])

Reference:

a reference document that provides a description of the application-extension identifier

The initial content of the registry is shown in Table 7; all initial entries have the Change Controller "IETF".

| Application-extension Identifier | Description | Reference |
|----------------------------------|---------------------------------------|-----------------------------------|
| h | Reserved | RFC8949 |
| b32 | Reserved | RFC8949 |
| h32 | Reserved | RFC8949 |
| b64 | Reserved | RFC8949 |
| false | Reserved | RFC-XXXX |
| true | Reserved | RFC-XXXX |
| null | Reserved | RFC-XXXX |
| undefined | Reserved | RFC-XXXX |
| dt | Date/Time | RFC-XXXX |
| ip | IP Address/
Prefix | RFC-XXXX |
| hash | Cryptographic
Hash | RFC-XXXX |
| cri | Constrained
Resource
Identifier | RFC-XXXX,
[I-D.ietf-core-href] |

Table 7: Initial Content of Application-extension Identifier Registry

6.2. Encoding Indicators

IANA is requested to create an "Encoding Indicators" registry in the newly created "CBOR Diagnostic Notation" registry group [IANA.cbor-diagnostic-notation], with the policy "specification required" (Section 4.6 of RFC 8126 [BCP26]).

The experts are instructed to be frugal in the allocation of encoding indicators that are suggestive of generally applicable semantics, keeping them in reserve for encoding indicator registrations that are likely to enjoy wide use and can make good use of their conciseness. If the expert becomes aware of encoding indicators that are deployed

and in use, they may also solicit a specification and initiate a registration on their own if they deem such a registration can avert potential future collisions.

Each entry in the registry must include:

Encoding Indicator:

an ASCII [STD80] string that starts with an underscore letter and can contain zero or more underscores, letters and digits after that (`[_A-Za-z0-9]*`). No other entry in the registry can have the same Encoding Indicator.

Description:

a brief description. This description may employ an abbreviation of the form `ai=nn`, where `nn` is the numeric value of the field `_additional information_`, the low-order 5 bits of the initial byte (see Section 3 of RFC 8949 [STD94]).

Change Controller:

(see Section 2.3 of RFC 8126 [BCP26])

Reference:

a reference document that provides a description of the application-extension identifier

The initial content of the registry is shown in Table 8; all initial entries have the Change Controller "IETF".

| Encoding Indicator | Description | Reference |
|--------------------|------------------------------------|----------------------|
| _ | Indefinite Length Encoding (ai=31) | RFC8949,
RFC-XXXX |
| _i | ai=0 to ai=23 | RFC-XXXX |
| _0 | ai=24 | RFC8949,
RFC-XXXX |
| _1 | ai=25 | RFC8949,
RFC-XXXX |
| _2 | ai=26 | RFC8949,
RFC-XXXX |
| _3 | ai=27 | RFC8949,
RFC-XXXX |
| _4 | Reserved (for ai=28) | RFC-XXXX |
| _5 | Reserved (for ai=29) | RFC-XXXX |
| _6 | Reserved (for ai=30) | RFC-XXXX |
| _7 | Reserved (see _) | RFC8949,
RFC-XXXX |

Table 8: Initial Content of Encoding Indicator Registry

As the "Reference" column reflects, all the encoding indicators initially registered are already defined in Section 8.1 of RFC 8949 [STD94], with the exception of `_i`, which is defined in Section 5.1 of the present document.

6.3. Media Type

IANA is requested to add the following Media-Type to the "Media Types" registry [IANA.media-types].

| Name | Template | Reference |
|-----------------|-----------------------------|--------------------------|
| cbor-diagnostic | application/cbor-diagnostic | RFC-XXXX,
Section 6.3 |

Table 9: New Media Type application/cbor-diagnostic

Type name: application
 Subtype name: cbor-diagnostic
 Required parameters: N/A
 Optional parameters: N/A
 Encoding considerations: binary (UTF-8)
 Security considerations: Section 7 of RFC XXXX
 Interoperability considerations: none
 Published specification: Section 6.3 of RFC XXXX
 Applications that use this media type: Tools interchanging a human-readable form of CBOR
 Fragment identifier considerations: The syntax and semantics of fragment identifiers is as specified for "application/cbor". (At publication of RFC XXXX, there is no fragment identification syntax defined for "application/cbor".)
 Additional information:
 Deprecated alias names for this type: N/A

 Magic number(s): N/A

 File extension(s): .diag

 Macintosh file type code(s): N/A
 Person & email address to contact for further information: CBOR WG mailing list (cbor@ietf.org), or IETF Applications and Real-Time Area (art@ietf.org)
 Intended usage: LIMITED USE
 Restrictions on usage: CBOR diagnostic notation represents CBOR data items, which are the format intended for actual interchange. The media type application/cbor-diagnostic is intended to be used within documents about CBOR data items, in diagnostics for human consumption, and in other representations of CBOR data items that are necessarily text-based such as in configuration files or other data edited by humans, often under source-code control.
 Author/Change controller: IETF
 Provisional registration: no

6.4. Content-Format

IANA is requested to register a Content-Format number in the "CoAP Content-Formats" sub-registry, within the "Constrained RESTful Environments (CoRE) Parameters" Registry [IANA.core-parameters], as follows:

| Content-Type | Content Coding | ID | Reference |
|-----------------------------|----------------|------|-----------|
| application/cbor-diagnostic | - | TBD1 | RFC-XXXX |

Table 10: New Content-Format for application/cbor-diagnostic

TBD1 is to be assigned from the space 256..9999, according to the procedure "IETF Review or IESG Approval", preferably a number less than 1000.

6.5. Stand-in Tags

```
// RFC-Editor: This document uses the CPA (code point allocation)
// convention described in [I-D.bormann-cbor-draft-numbers]. For
// each usage of the term "CPA", please remove the prefix "CPA" from
// the indicated value and replace the residue with the value
// assigned by IANA; perform an analogous substitution for all other
// occurrences of the prefix "CPA" in the document. Finally, please
// remove this note.
```

In the "CBOR Tags" registry [IANA.cbor-tags], IANA is requested to assign the tags in Table 11 from the "specification required" space (suggested assignments: 888 and 999), with the present document as the specification reference.

| Tag | Data Item | Semantics | Reference |
|--------|---------------|---|-----------|
| CPA888 | null or array | Diagnostic Notation Ellipsis | RFC-XXXX |
| CPA999 | array | Diagnostic Notation
Unresolved Application-Extension | RFC-XXXX |

Table 11: Values for Tags

7. Security considerations

The security considerations of [STD94] and [RFC8610] apply.

The EDN specification provides two explicit extension points, application-extension identifiers (Section 6.1) and encoding indicators (Section 6.2). Extensions introduced this way can have their own security considerations (see, e.g., Section 5 of [I-D.ietf-cbor-edn-e-ref]). When implementing tools that support the use of EDN extensions, the implementer needs to be careful not to inadvertently introduce a vector for an attacker to invoke extensions not planned for by the tool operator, who might not have considered security considerations of specific extensions such as those posed by their use of dereferenceable identifiers (Section 6 of [I-D.bormann-t2trg-deref-id]). For instance, tools might require explicitly enabling the use of each extension that is not on an allowlist. This task can possibly be made less onerous by combining it with a mechanism for supplying any parameters controlling such an extension.

8. References

8.1. Normative References

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Appendix A. EDN and CDDL

This appendix is for information.

EDN was designed as a language to provide a human-readable representation of an instance, i.e., a single CBOR data item or CBOR sequence. CDDL was designed as a language to describe an (often large) set of such instances (which itself constitutes a language), in the form of a `_data definition_` or `_grammar_` (or sometimes called `_schema_`).

The two languages share some similarities, not the least because they have mutually inspired each other. But they have very different roots:

- * EDN syntax is an extension to JSON syntax [STD90]. (Any (interoperable) JSON text is also valid EDN.)
- * CDDL syntax is inspired by ABNF's syntax [STD68].

For engineers that are using both EDN and CDDL, it is easy to write "CDDLisms" or "EDNisms" into their drafts that are meant to be in the other language. (This is one more of the many motivations to always validate formal language instances with tools.)

Important differences include:

- * Comment syntax. CDDL inherits ABNF's semicolon-delimited end of line characters, while EDN finds nothing in JSON that could be inherited here. Inspired by JavaScript, EDN simplifies JavaScript's copy of the original C comment syntax to be delimited by single slashes (where line breaks are not of interest); it also adds end-of-line comments starting with #.

EDN:

```
{ / alg / 1: -7 / ECDSA 256 / }
,
{ 1:   # alg
      -7 # ECDSA 256
}
```

CDDL: ? 1 => int / tstr, ; algorithm identifier

- * Syntax for tags. CDDL's tag syntax is part of the system for referring to CBOR's fundamentals (the major type 6, in this case) and (with [I-D.ietf-cbor-update-8610-grammar]) allows specifying the actual tag number separately, while EDN's tag syntax is a simple decimal number and a pair of parentheses.

```
EDN:
  98([h'', # empty encoded protected header
    {}, # empty unprotected header
    ... # rest elided here
  ])
```

```
CDDL: COSE_Sign_Tagged = #6.98(COSE_Sign)
```

- * Embedded CBOR. EDN has a special syntax to describe the content of byte strings that are encoded CBOR data items. CDDL can specify these with a control operator, which looks very different.

```
EDN:
  98([<< {/alg/ 1: -7 /ECDSA 256/} >>, # == h'a10126'
    ... # rest elided here
  ])
```

```
CDDL: serialized_map = bytes .cbor header_map
```

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The concept of application-oriented extensions to diagnostic notation, as well as the definition for the "dt" extension, were inspired by the CoRAL work by Klaus Hartke.

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