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CBOR::Core - CBOR Cross Platform Profile
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Abstract

This document defines CBOR::Core, a platform-agnostic profile for CBOR (RFC 8949) intended to serve as a viable replacement for JSON in computationally advanced systems like Internet browsers, mobile phones, and Web servers. For enhanced strictness, as well as for enabling cryptographic methods like signing and hashing, to optionally be applied to "raw" (non-wrapped) CBOR data, deterministic encoding is mandated. Furthermore, the document outlines API features for manipulating CBOR data in a secure manner. This document mainly targets CBOR tool developers.

Status of This Memo

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1. Introduction

The CBOR::Core specification is based on CBOR [RFC8949]. While there are different ways you can encode certain CBOR objects, this is non-trivial to support in general purpose platform-based tools, not to mention the limited utility of such measures. To cope with this, CBOR::Core defines a specific (non-variant) encoding scheme, aka "Deterministic Encoding". The selected encoding scheme is believed to be _compatible_ with most existing systems using CBOR. See also Appendix D.

CBOR::Core is intended to be agnostic with respect to programming languages and platforms.

By combining the compact binary representation and the rich set of data types offered by CBOR, with a deterministic encoding scheme, CBOR::Core could for _new designs_, serve as a viable alternative to JSON [RFC8259]. Although the mandated encoding scheme is deployable in [CONSTRAINED] environments, the primary target is rather general-purpose computing platforms like mobile phones and Web servers.

However, for unleashing the full power of deterministic encoding, the ability to perform cryptographic operations on "raw" (non-wrapped) CBOR data, compliant CBOR::Core tools need additional functionality. See also Appendix C.

1.1. Design Goals

The primary goal with this specification, is providing a foundation for CBOR tools that enable application developers to use CBOR without requiring insights in low-level details like encoding. In most cases, it should be sufficient to consult a list of supported data types. See also Section 2.3.2.

Section 2 contains the actual specification.

1.2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.3. Common Definitions

* This document uses the conventions defined in CDDL [RFC8610] for expressing the type of CBOR [RFC8949] data items.

* Examples showing CBOR data, are expressed in "diagnostic notation" (Section 2.3.6).

* The term "CBOR object" is equivalent to "CBOR data item" used in [RFC8949].

2. Detailed Description

This section describes the three pillars that CBOR::Core relies on.

2.1. Supported CBOR Objects

The following table shows the set of CBOR objects that compliant CBOR::Core implementations MUST support:

CDDL	Comment
int	Integer
bigint	Big integer
float	16-, 32-, and 64-bit [IEEE754] floating-point numbers
tstr	Text string encoded as UTF-8 [RFC3629]
bstr	Byte string
bool	Boolean true and false
null	Object representing null
[]	Array
{}	Map
#6.nnn(type)	Tagged objects
#7.nnn	Simple values

Table 1: Supported CBOR Objects

Application-specific implementations may (of course) only have to support the CBOR::Core objects required by the targeted application(s).

2.2. Deterministic Encoding Scheme

In CBOR::Core deterministic encoding is _mandatory_. The encoding scheme adheres to Section 4.2.1 of [RFC8949] and Section 4.2.2 of [RFC8949], but adds a few constraints (denoted by RFC+), where the RFC offers choices. The following list contains a summary of the CBOR::Core deterministic encoding rules:

* RFC: Integers, represented by the int and bigint types, MUST use the int type if the value is between -2^64 and 2^64-1, otherwise the bigint type MUST be used. Shortest representation (in [RFC8949] referred to as "Preferred Serialization"), MUST be applied to both integer variants. Appendix A.1 contains a list of integer sample values and their expected encoding.

  Note that the shortest representation MUST also be applied to string lengths, array/map counts, and tag numbers.

* RFC+: Floating-point numbers MUST use the shortest [IEEE754] variant (64, 32, or 16 bits) that preserves the precision of the original value, including subnormal values. Appendix A.2 contains a list of floating-point sample values and their expected encoding.

* RFC+: Non-finite numbers (Section 2.3.4) MUST use the shortest [IEEE754] variant (64, 32, or 16 bits) that preserves the original value. Appendix B contains a sample encoder in JavaScript, while Appendix A.2 and Appendix A.3 contain a few non-finite sample values and their expected encoding.

* RFC+: Floating-point and integer objects MUST be treated as _distinct types_ regardless of their numeric value. This is compliant with "Rule 2" in Section 4.2.2 of [RFC8949].

* RFC: Map keys MUST be sorted in the bytewise lexicographic order of their deterministic encoding. Duplicate keys MUST be rejected.

* RFC+: Since CBOR encodings according to this specification maintain uniqueness, there are no additional tests needed in order to determine map key equivalence. As an (extreme) example, the floating-point numbers 0.0 and -0.0, the integer number 0, a NaN, and an empty map {}, could represent the distinct keys f90000, f98000, 00, f97e00, and a0 respectively.

* RFC: Indefinite-length objects MUST be rejected.

2.3. Implementation Considerations

In CBOR::Core there are three distinguishable levels:

Encoding level:
: "Wire format" as described in Section 2.2.

Encoder/decoder level:
: This section.

Application level:
: Constraints on data imposed by _applications_, like limiting ISO DateTime objects to UTC notation, or requiring integers representing enumerations to be in a specific range, is _out-of-scope_ for CBOR::Core.

2.3.1. API Requirements

Compliant CBOR::Core implementations MUST reject CBOR data not adhering to the deterministic encoding scheme. See also Appendix D.

An important feature that deterministic encoding brings to the table is the ability to perform cryptographic operations on "raw" CBOR data. Turn to Appendix C for an example of an application depending on such features. However, to make this a reality as well as making it easy to manipulate CBOR objects, the following functionality MUST be provided by CBOR tools compliant with this specification:

* Decoded CBOR primitives MUST remain _immutable_, regardless if they are stand-alone or being a part of a tagged object like bigfloat (see Section 3.4.4 of [RFC8949]).

* To support _variant_ CBOR data, it MUST be possible to find out the type of a CBOR object, _before_ it is referenced.

* It MUST be possible to _add_, _delete_, and _update_ the contents of CBOR map and array objects, of decoded CBOR data.

* It MUST be possible to _reserialize_ decoded CBOR data, be it updated or not.

* Irrespective of if CBOR data is decoded, updated, or created programmatically, deterministic encoding MUST be maintained.

Appendix C.2 shows an example that _updates_ and _reserializes_ decoded CBOR data.

2.3.1.1. Application vs. Encoding Level Equivalence

As a consequence of these rules, CBOR data and application / platform-level data, MUST be _separated_ for cases where _reserialization_ could present a problem.

How this separation is accomplished is out of scope for this specification. However, _encapsulation_ of CBOR data in _high-level_, and _self-rendering wrapper objects_, represents an established method, featured in similar tools for ASN.1.

The following example, using the JavaScript Date object and [CBOR.JS], highlights the difference between the application level and the encoding level:

```
// Sample CBOR tstr object: "2025-03-02T13:08:55.0201+03:00"
let cbor = CBOR.fromHex("781e323032352d30332d30325431333a30383a35352e303230312b30333a3
030");
let cborObject = CBOR.decode(cbor);

// JavaScript Date only supports milliseconds and converts time to UTC
console.log(cborObject.getDateTime().toISOString());
> 2025-03-02T10:08:55.020Z

console.log(CBOR.toHex(cborObject.encode()));  // Reserialization returns identical CB
OR data
> 781e323032352d30332d30325431333a30383a35352e303230312b30333a3030
```

As can be seen in the listing, at the _application_ level, data may not always be 100% deterministic, while at the _encoding_ level, data MUST remain intact. The only exception to this rule is if the data was received in a non-deterministic format (Appendix D).

2.3.2. Protocol Primitives

To facilitate cross-platform _protocol interoperability_, implementers of CBOR::Core compatible tools SHOULD include _decoder_ API support for the following primitive data types:

CDDL	Primitive	Comment	Notes
int	Int8	8-bit signed integer	1
uint	Uint8	8-bit unsigned integer	1
int	Int16	16-bit signed integer	1
uint	Uint16	16-bit unsigned integer	1

int	Int32	32-bit signed integer	1
uint	Uint32	32-bit unsigned integer	1
int	Int64	64-bit signed integer	1, 3
uint	Uint64	64-bit unsigned integer	1
int	Int53	53-bit signed integer	2
integer	BigInt	Integer of arbitrary size	4
float16	Float16	16-bit floating-point number	5, 6
float16 / float32	Float32	32-bit floating-point number	5, 6
float	Float64	64-bit floating-point number	6
bool	Boolean	Boolean	
null	Null	Null	7
#7.nnn	Simple	Simple values	8
tstr	String	Text string	
bstr	Bytes	Byte string	
See note	DateTime	Time object expressed as a text string	9
See note	EpochTime	Time object expressed as a number	9

Table 2: Protocol Primitives

1. Int8 - Uint64 are modeled after the "C" language including their permitted ranges. Range testing MUST be performed. That is, a hypothetical getUint8() MUST reject numbers outside of 0 to 255, whereas a hypothetical getInt8(), MUST reject numbers outside of -128 to 127.

2. Int53 is derived from the JavaScript Number type. As an integer, values outside of Number.MIN_SAFE_INTEGER (-9007199254740991) to Number.MAX_SAFE_INTEGER (9007199254740991) MUST be rejected.

Int53 should be used with caution in cross-platform scenarios.

3. Although CBOR major type 1 supports a wider range of negative values than offered by Int64, explicit use of this feature in protocols designed for cross-platform use, is NOT RECOMMENDED; it should be reserved for the unconstrained integer object, BigInt where it is a necessity.

4. Note that a hypothetical getBigInt() MUST also accept CBOR int objects since int is used for integers that fit in CBOR major type 0 and 1 objects. See also Appendix A.1.

5. Some platforms do not natively support float32 and/or float16. In this case a hypothetical getFloat16() would need to use a bigger floating-point type for the return value.

   Note that a hypothetical getFloat16() MUST reject encountered Float32 and Float64 objects.

6. Floating-point numbers also include non-finite numbers. See also Section 2.3.4.

7. Since a CBOR null typically represents the absence of a value, a decoder MUST provide a test-function, like isNull().

8. Simple values include the ranges 0-23 and 32-255. Note that bool and null actually are simple values.

9. Since CBOR lacks a "native" time object, Section 3.4 of [RFC8949] introduces two variants of time objects using the CBOR tags 0 and 1. Time objects MUST also be supported _without_ the tag construct.

   Time objects greater than "9999-12-31T23:59:59Z" (Epoch: 253402300799) MUST be rejected.

   EpochTime objects containing non-finite numbers (Section 2.3.4) or negative Epoch [TIME] values MUST be rejected.

   DateTime objects containing negative years MUST be rejected.

If a call does not match the underlying CBOR type, the call MUST be rejected. See also Appendix D.

Due to considerable variations between platforms, corresponding _encoder_ API support does not appear to be meaningful to specify in detail: Java doesn’t have built-in support for unsigned integers, whereas JavaScript requires the use of the JavaScript BigInt type for dealing with 64-bit integers.

2.3.3. CBOR Sequences

Decoders compliant with this specification MUST support CBOR sequences [RFC8742].

For decoders of "true" (binary) CBOR, there are additional requirements:

* It MUST be possible to decode one CBOR object at a time.

* Decoders MUST NOT do any assumptions about the nature of unread code (it might not even be CBOR).

2.3.4. Non-Finite Numbers

Since non-finite numbers like NaN and Infinity, are rarely used in application protocols, one could imagine a global option making decoders reject non-finite numbers, which in turn would relieve applications from having to _explicitly test_ decoded float objects for being finite ("regular") floating-point numbers. Although working, such an option would not be particularly flexible.

To cope with this as well as the fact that platform-native support for NaN with payloads like fa7f801000 is somewhat uneven, compliant CBOR::Core implementations MUST support the constructs described in the following sub-sections.

2.3.4.1. API Support Levels

Application protocols MUST be able to _selectively accept_ non-finite numbers, including distinguishing between "simple" NaN (f97e00) and NaN with payloads. This is accomplished by (internally) treating non-finite numbers as a _distinct, emulated data type_, making it possible to support the full range of floating-point numbers. The API exposes this capability as three distinct levels of floating-point number support:

BASIC:
: Supporting "regular" floating-point numbers only.

EXTENDED:
Supporting "regular" floating-point numbers, "simple" NaN, Infinity and -Infinity.

COMPLETE:
Supporting all valid floating-point numbers.

Selection of the level of floating-point number support required for a specific float object in a protocol, is accomplished through the use of different API access methods, like the following:

A hypothetical getFloat64() would reject an encountered "simple" NaN, while a hypothetical getExtendedFloat64() would treat the NaN as any other [IEEE754] floating point number.

For a concrete solution, that also addresses _encoding_ of non-finite numbers, and the payload option, see [NON-FINITE].

See also: Appendix B.

2.3.4.2. Payload Option

Traditionally, the non-finite number space is used for propagating math-related problems such as division by zero. However, in some cases there may be a desire providing more application specific data, like information related to a faulty sensor that needs attention. The following tables show a way to represent such data:

Payload
d51-d0 in _big-endian_ order

Table 3: Payload

The payload bits are subsequently conceptually put into an [IEEE754] 64-bit object having the following layout:

Sign	Exponent	Significand
0	11111111111	d0-d51 in _little-endian_ order

Table 4: Transformed Payload

The reason for _reversing_ the payload bits is to ensure that a specific bit will remain in a fix position (maintain the same value), independent of the size of the [IEEE754] variant used for encoding.

Note that the encoder will (due to the deterministic encoding rules), select the shortest serialization required to properly represent the payload. The following table shows a few examples:

Payload (hex)	CBOR Encoding	Diagnostic Notation
0	f97c00	Infinity
1	f97e00	NaN
2	f97d00	float’7d00’
3ff	f97fff	float’7fff’
400	fa7f801000	float’7f801000’
7fffff	fa7fffffff	float’7fffffff’
800000	fb7ff0000010000000	float’7ff0000010000000’
fffffffffffff	fb7fffffffffffffff	float’7fffffffffffffff’

Table 5: Sample Payload Encodings

A payload of 0 and having the sign bit set, would encode as f9fc00 (-Infinity).

Obviously, receivers (decoders), MUST use the same convention in order to recreate payloads.

See also: Appendix B.1.

2.3.5. Media Type

Protocols building on CBOR::Core, are RECOMMENDED using the media type: application/cbor.

2.3.6. Diagnostic Notation

Compliant CBOR::Core implementations SHOULD include support for _bi-directional_ diagnostic notation, to facilitate:

* Generation of developer-friendly debugging and logging data

* Easy creation of test and configuration data

Note that decoders for diagnostic notation, MUST always produce deterministically encoded CBOR data, compliant with this specification. This includes _automatic_ sorting of map keys as well.

The supported notation is compliant with a subset of Section 8 of [RFC8949] (b32' and encoding indicators were left out), but adds a few items to make diagnostic notation slightly more adapted for parsing, like single-line comments:

CDDL	Syntax	Comment	Notes
	/ _comment text_ /	Multi-line comment. Multi-line comments are treated as whitespace and may thus also be used _between_ CBOR objects.	6
	# _comment text_	Single-line comment. Single-line comments are terminated by a newline character ('\n') or EOF. Single-line comments may also terminate lines holding regular CBOR items.	6
integer	_{sign}{_0b|0o|0x_}n_	Arbitrary sized integers without fractional components or exponents. See also CBOR integer encoding. For _input_ data in diagnostic notation, binary, octal, and hexadecimal notation is also supported by prepending numbers with 0b, 0o, and 0x respectively. The latter also permit arbitrary insertions of '_' characters between	1, 2

		digits to enable grouping of data like 0b100_000000001.	
float	_{sign}n_._n{_e± _n}_	Floating-point values MUST include a decimal point and at least one fractional digit, whereas exponents are _optional_.	1, 2
float	float'_hex-data_'	Any valid 16, 32, or 64-bit float value, including NaN with payloads like float'7ff0800000000001'.	
float	NaN	Not a number (NaN) in the default CBOR encoding (f97e00).	
float	_{sign}_Infinity	Infinity.	2
bstr	h'_hex-data_'	Byte data provided in hexadecimal notation. Each byte MUST be represented by two hexadecimal digits.	3
bstr	b64'_base64-data_'	Byte data provided in base64 or base64URL notation. Padding with '=' characters is _optional_.	3, 6
bstr	'_text_'	Byte data provided as UTF-8 encoded text.	4, 5, 6
bstr	<< _object..._ >>	Construct holding zero or more comma-separated CBOR objects that are subsequently wrapped in a byte string.	6
tstr	"_text_"	UTF-8 encoded text string.	4, 5
bool	true|false	Boolean value.	

null	null	Null value.	
[]	[_object..._]	Array with zero or more comma-separated CBOR objects.	
{}	{ _key_:_value..._ }	Map with zero or more comma-separated key/value pairs. Key and value pairs are expressed as CBOR objects, separated by a ':' character.	
#6.nnn	_n_(_object_)	Tag holding a CBOR object.	1
#7.nnn	simple(_n_)	Simple value.	1
	,	Separator character for CBOR sequences.	6

Table 6: Diagnostic Notation

1. The letter _n_ in the Syntax column denotes one or more digits.

2. The optional _{sign}_ MUST be a single hyphen ('-') character.

3. _Input only_: between tokens, the whitespace characters ' ', '\t', '\r', and '\n', are _ignored_.

4. _Input only_: inside of string quotes, the control character '\n' becomes a part of the text string. For normalizing line terminators, a single '\r' or the combination '\r\n' MUST (internally) be rewritten as '\n'. To _avoid_ getting newline characters ('\n') included in multi-line text strings, a _line continuation marker_ consisting of a backslash ('\') immediately preceding the newline may be used.

5. Text strings may also include the JavaScript compatible escape sequences '\'', '\"', '\\', '\b', '\f', '\n', '\r', '\t', and '\u_hhhh_'.

6. _Input only_.

The [PLAYGROUND] offers a simple way to get acquainted with CBOR and diagnostic notation.

3. IANA Considerations

This memo includes no request to IANA.

4. Security Considerations

CBOR::Core does not introduce security issues beyond what is already applicable to [RFC8949].

Poorly written tools and applications may certainly introduce security issues, but this is out of scope for this specification.

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5.1. Normative References

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Appendix A. Sample Encodings

A.1. Integers

This _normative_ section holds a selection of CBOR integer values, with an emphasize on edge cases.

Diagnostic Notation	CBOR Encoding	Comment
0	00	Smallest positive implicit int
-1	20	Smallest negative implicit int
23	17	Largest positive implicit int
-24	37	Largest negative implicit int
24	1818	Smallest positive one-byte int
-25	3818	Smallest negative one-byte int
255	18ff	Largest positive one-byte int
-256	38ff	Largest negative one-byte int
256	190100	Smallest positive two-byte int
-257	390100	Smallest negative two-byte int
65535	19ffff	Largest positive two-byte int
-65536	39ffff	Largest

		negative two-byte int
65536	1a00010000	Smallest positive four-byte int
-65537	3a00010000	Smallest negative four-byte int
4294967295	1affffffff	Largest positive four-byte int
-4294967296	3affffffff	Largest negative four-byte int
4294967296	1b0000000100000000	Smallest positive eight-byte int
-4294967297	3b0000000100000000	Smallest negative eight-byte int
18446744073709551615	1bffffffffffffffff	Largest positive eight-byte int
-18446744073709551616	3bffffffffffffffff	Largest negative eight-byte int
18446744073709551616	c249010000000000000000	Smallest positive bigint
-18446744073709551617	c349010000000000000000	Smallest negative bigint

Table 7: Integers

A.2. Floating-Point Numbers

This _normative_ section holds a selection of [IEEE754] 16, 32, and 64-bit values, with an emphasize on edge cases.

The textual representation of the values is based on the serialization method for the Number data type, defined by [ECMASCRIPT] with one change: to comply with diagnostic notation (Section 2.3.6), all values are expressed as floating-point numbers. The rationale for using [ECMASCRIPT] serialization is because it is supposed to generate the shortest and most correct representation of [IEEE754] numbers.

Diagnostic Notation	CBOR Encoding	Comment
0.0	f90000	Zero
-0.0	f98000	Negative zero
Infinity	f97c00	Infinity
-Infinity	f9fc00	Negative infinity
NaN	f97e00	Not a number
5.960464477539063e-8	f90001	Smallest positive subnormal float16
0.00006097555160522461	f903ff	Largest positive subnormal float16
0.00006103515625	f90400	Smallest positive float16
65504.0	f97bff	Largest positive float16
1.401298464324817e-45	fa00000001	Smallest positive

		subnormal float32
1.1754942106924411e-38	fa007fffff	Largest positive subnormal float32
1.1754943508222875e-38	fa00800000	Smallest positive float32
3.4028234663852886e+38	fa7f7fffff	Largest positive float32
5.0e-324	fb0000000000000001	Smallest positive subnormal float64
2.225073858507201e-308	fb000fffffffffffff	Largest positive subnormal float64
2.2250738585072014e-308	fb0010000000000000	Smallest positive float64
1.7976931348623157e+308	fb7fefffffffffffff	Largest positive float64
-0.0000033333333333333333	fbbecbf647612f3696	Randomly selected number
10.559998512268066	fa4128f5c1	-"-
10.559998512268068	fb40251eb820000001	Next in succession
295147905179352830000.0	fa61800000	2^68 (diagnostic notation truncates precision)

2.0	f94000	Number without a fractional part
-5.960464477539063e-8	f98001	Smallest negative subnormal float16
-5.960464477539062e-8	fbbe6fffffffffff	Adjacent smallest negative subnormal float16
-5.960464477539064e-8	fbbe70000000000001	-"-
-5.960465188081798e-8	fab3800001	-"-
0.0000609755516052246	fb3f0ff7ffffffff	Adjacent largest subnormal float16
0.00006097555516052246	fb3f0ff80000000001	-"-
0.00006097555555243203416	fa387fc001	-"-
0.0000610351562499999	fb3f0fffffffffff	Adjacent smallest float16
0.0000610351562500001	fb3f10000000000001	-"-
0.0000610351635259576 1	fa38800001	-"-
65503.99999999999	fb40effbffffffff	Adjacent largest float16
65504.00000000001	fb40effc0000000001	-"-
65504.00390625	fa477fe001	-"-
1.4012984643248169e-45	fb369fffffffffff	Adjacent smallest

			subnormal float32
	1.4012984643248174e-45	fb36a0000000000001	-"-
	1.175494210692441e-38	fb380fffffbfffffff	Adjacent largest subnormal float32
	1.1754942106924412e-38	fb380fffffc0000001	-"-
	1.1754943508222874e-38	fb380ffffffffffff	Adjacent smallest float32
	1.1754943508222878e-38	fb3810000000000001	-"-
	3.4028234663852882e+38	fb47effffdffffff	Adjacent largest float32
	3.402823466385289e+38	fb47effffe0000001	-"-

Table 8: Floating-Point Numbers

A.3. Miscellaneous Items

This _normative_ section holds a selection of miscellaneous CBOR objects and their encoding.

Diagnostic Notation	CBOR Encoding	Comment
true	f5	Boolean true
null	f6	Null
simple(99)	f863	Simple value
0("2025-03-30T12:24:16Z")	c074323032352d30332d33 305431323a32343a31365a	ISO date/ time
[1, [2, 3], [4, 5]]	8301820203820405	Array combinations

{
"a": 0,
"b": 1,
"aa": 2
}
	a361610161620262616103	Map object

h'48656c6c6f2043424f5221'	4b48656c6c6f2043424f5221	Binary string
" science"	6cf09f9a8020736369656e6365	Text string with emoji
float'7f800001'	fa7f800001	NaN with payload
float'fff0001230000000'	fbfff0001230000000	NaN with payload and sign

Table 9: Miscellaneous Items

A.4. Invalid Encodings

The following table holds a selection of CBOR-encoded objects, that (by default) MUST be rejected by compliant CBOR::Core implementations.

CBOR Encoding	Diagnostic Notation	Comment	Notes

a2616201616100	{
	"b": 1,
	"a": 0
	}
		Improper map key ordering	1

98020405	[4, 5]	Array length with leading zero	1
1900ff	255	Number with leading zero	1
c34a00010000000000000000	-18446744073709551617	Number with leading zero	1
Fa41280000	10.5	Not using shortest encoding	1
fa7fc00000	NaN	Not using shortest encoding	1
fa7fffe000	float’7fff’	Not using shortest encoding	1
c243010000	65536	Incorrect value for bigint	1
5f4101420203ff	(_ h’01’, h’0203’)	Indefinite length object	2
fc		Reserved	
f818		Invalid simple value	
5b0010000000000000		Extremely large bstr length indicator: 4503599627370496	

Table 10: Invalid Encodings

1. Enabled by the measures mentioned in Appendix D.

2. Not supported by CBOR::Core.

Appendix B. Non-finite Number Encoder

The following JavaScript sample encodes non-finite numbers (Section 2.3.4) as mandated by the deterministic encoding rules:

```
// Input: 16, 32, or 64-bit non-finite number in a BigInt.
// Returns: CBOR binary in a Uint8Array.
function nonFinite2Cbor(value) {
  // Errors force execution to the statement after the while-loop.
  badValue:
    while (true) {
      if (value < 0n) break badValue;
      // Convert the value into a byte array.
      let array = [];
      let i = value;
      do {
        array.push(Number(i & 0xffn));
      } while (i >>= 8n);
      let ieee754 = new Uint8Array(array.reverse());
      // Verify that the value is a valid non-finite number.
      let exponent;
      switch (ieee754.length) {
        case 2:
          exponent = 0x7c00n;
          break;
        case 4:
          exponent = 0x7f800000n;
          break;
        case 8:
          exponent = 0x7ff0000000000000n;
          break;
        default:
          break badValue;
      }
      if ((value & exponent) != exponent) break badValue;
      // Get sign bit.
      let sign = ieee754[0] > 0x7f;
      // If not already a 16-bit value, try reducing
      // the value to the next shorter variant.
      // This done by testing if a right-shift to the
      // next shorter variant would lead to lost bits
      // in the significand.  If there would be lost bits,
      // the process terminates (break), otherwise the shift is
      // performed. Next all but the sign bit is masked away.
```

```
        // This also sets the exponent to the correct value for
        // the shorter variant.  Finally, the sign bit is
        // restored and the process is restarted.
        switch (ieee754.length) {
          case 4:
            if (value & ((1n << 13n) - 1n)) break;
            value >>= 13n;
            value &= 0x7fffn;
            if (sign) value |= 0x8000n;
            continue;
          case 8:
            if (value & ((1n << 29n) - 1n)) break;
            value >>= 29n;
            value &= 0x7fffffffn;
            if (sign) value |= 0x80000000n;
            continue;
        }
        // Reductions done, return proper CBOR encoding.
        let cbor = new Uint8Array(1 + ieee754.length);
        cbor.set(new Uint8Array([0xf9 + (ieee754.length >> 2)]));
        cbor.set(ieee754, 1);
        return cbor;
      }
    // Invalid argument.
    throw new Error("Invalid non-finite number: " + value);
  }
```

B.1. Payload Encoder

The following JavaScript sample encodes payloads (Section 2.3.4.2) as numbers as mandated by the deterministic encoding rules:

```
   // Input: up to 52 bit payload as a BigInt.
   // Input: sign (true or false)
   // Returns: CBOR binary in a Uint8Array.
   function payload2Cbor(payload, sign) {
     let left64 = sign ? 0xfff0000000000000n : 0x7ff0000000000000n;
     if (payload < 0n || payload > 0xfffffffffffffn) {
       throw new Error("Invalid payload: " + payload);
     }
     // Reverse the payload bits.
     let reversed = 0n;
     for (let i = 0; i < 52; i++) {
       reversed <<= 1n;
       reversed |= payload & 1n;
       payload >>= 1n;
     }
     // Create 64-bit IEEE-754 object.
     // Then apply deterministic encoding.
     return nonFinite2Cbor(reversed + left64);
   }
```

Appendix C. Embedded Signatures

This is a _non-normative_ appendix showing how CBOR::Core can be used for supporting embedded signatures.

The primary advantages with _embedded_ signatures compared to _enveloping_ signatures (like used by COSE [RFC9052]), include:

* Keeping the _structure_ of the original (unsigned) data intact, by simply making signatures an additional attribute.

* Enabling top-level, _object identifiers_ to become a part of the signed data as well:

  ```
  123456789({                           # CBOR tag (objectId)
    1: "This is not rocket science!",   # Object instance data
    2: [38.8882, -77.01988],            #         ""
    simple(99): signature covering the entire object
  })
  ```

  See also [COTX].

* Permitting signing CBOR data and associated security attributes (aka "headers"), _in one go_, without having to wrap data in CBOR "bstr" objects. Non-wrapped data also makes debugging and documentation easier.

Embedded signatures are for example featured in Verified Credentials [CREDENTIALS]. A drawback with designs based on JSON [RFC8259] is that they rely on _canonicalization schemes_ like JCS [RFC8785], that require specialized encoders and decoders, whereas CBOR::Core works "straight out of the box".

C.1. Sample Signature

Although this specification is not "married" to any particular signature schema, the following example uses the CBOR Signature Format [CSF]. For the sake of simplicity, the example uses an HMAC (see Appendix C.1.4) as signature algorithm.

For a more sophisticated use of CBOR::Core, combining signatures and encryption, see [WALLET].

C.1.1. Unsigned Data

Imagine you have a CBOR map object like the following that you want to sign:

```
{
  1: "data",
  2: "more data"
}
```

C.1.2. Signature Process

This section describes the steps required for adding an embedded signature to the CBOR map object in Appendix C.1.1. To avoid confusing CBOR map keys with cryptographic keys, the former are referred to as "labels".

1. Add an empty CSF container (a CBOR map) to the unsigned CBOR map using the CSF container label simple(99).

2. Add the designated signature algorithm to the CSF container using the CSF algorithm label (1).

3. _Optional_. Add other signature meta data to the CSF container. Not used in the example.

4. Generate a signature by invoking a (hypothetical) signature method with the following arguments:

   * the designated signature key.

   * the designated signature algorithm.

* the _deterministic encoding_ of the current CBOR object in its _entirety_. In the example that would be a3016464617461026 96d6f7265206461746120a10105, if expressed in hex code.

5. Add the returned signature value to the CSF container using the CSF signature label (6).

The result after the final step (using the parameters from Appendix C.1.4), should match the following CBOR object:

```
{
  1: "data",
  2: "more data",
  simple(99): {
    1: 5,
    6: h’237e674c7be1818ddd7eaacf40ca80415b9ad816880751d2136c45385207420c’
  }
}
```

Note that the signature covers the _entire_ CBOR object except for the CSF signature value and label (6).

C.1.3. Validation Process

In order to validate the embedded signature created in the Appendix C.1.2, the following steps are performed:

1. Fetch a _reference_ to the CSF container using the CSF container label simple(99). Next perform the following operations using the reference:

    1. Retrieve the signature algorithm using the CSF algorithm label (1).

    2. Retrieve the signature value using the CSF algorithm label (6).

    3. Remove the CSF algorithm label (6) and its associated value.

    Now we should have exactly the same CBOR object as we had _before_ step #4 in Appendix C.1.2. That is:

```
{
  1: "data",
  2: "more data",
  -1: {
    1: 5
  }
}
```

2. Validate the signature data by invoking a (hypothetical) signature validation method with the following arguments:

   * the designated signature key (in the example taken from Appendix C.1.4).

   * the signature algorithm retrieved in step #1.

   * the signature value retrieved in step #1.

   * the _deterministic encoding_ of the current CBOR object in its _entirety_.

Note: this is a "bare-bones" validation process, lacking the ruggedness of a real-world implementation.

C.1.4. Example Parameters

The signature and validation processes depend on the COSE [RFC9053] algorithm "HMAC 256/256" and an associated 256-bit key, here provided in hex code:

```
7fdd851a3b9d2dafc5f0d00030e22b9343900cd42ede4948568a4a2ee655291a
```

C.2. Code Example

Using a JavaScript implementation [CBOR.JS] of CBOR::Core, together with Node.js [NODE.JS], basic signature creation and validation supporting the example in Appendix C.1, could be performed by the following code:

```
// hmac.mjs
import CBOR from 'cbor-object';
const crypto = await import('node:crypto');

// Application independent CSF constants
const CSF_CONTAINER_LBL = CBOR.Simple(99);
const CSF_ALG_LBL = CBOR.Int(1);
const CSF_SIG_LBL = CBOR.Int(6);
```

```
   // COSE => Node.js algorithm translation
   const HASH_ALGORITHMS = new Map()
       .set(5, "sha256").set(6, "sha384").set(7, "sha512");

   function hmac(coseAlg, key, data) {
       let alg = HASH_ALGORITHMS.get(coseAlg);
       if (alg === undefined) throw "Unknown alg: " + coseAlg;
       return crypto.createHmac(alg, key).update(data).digest();
   }

   const SHARED_KEY = crypto.createSecretKey(
       '7fdd851a3b9d2dafc5f0d00030e22b9343900cd42ede4948568a4a2ee655291a', 'hex');

   const APP_P1_LBL  = CBOR.Int(1);                    // Application label
   const APP_P2_LBL  = CBOR.Int(2);                    //        ""

   ////////////////////////////////////
   // Create an unsigned CBOR object //
   ////////////////////////////////////
   let object = CBOR.Map()
       .set(APP_P1_LBL, CBOR.String("data"))           // Application data
       .set(APP_P2_LBL, CBOR.String("more data"));     //        ""

   ////////////////////////////////////////
   // Add a signature to the CBOR object //
   ////////////////////////////////////////
   const COSE_ALG = 5;                                 // Selected HMAC algorithm

   let csf = CBOR.Map()                                // Create CSF container and
       .set(CSF_ALG_LBL, CBOR.Int(COSE_ALG));          // add COSE algorithm to it
   object.set(CSF_CONTAINER_LBL, csf);                 // Add CSF container to object
   let sig = hmac(COSE_ALG,                            // Generate signature over
                  SHARED_KEY,                          // the current object
                  object.encode());                    // encode(): all we got so far
   csf.set(CSF_SIG_LBL, CBOR.Bytes(sig));              // Add signature to CSF container
   let cborBinary = object.encode();                   // Return CBOR as an Uint8Array

   console.log(object.toString());                     // Show in Diagnostic Notation

   ////////////////////////////////////
   // Validate the signed CBOR object //
   ////////////////////////////////////
   object = CBOR.decode(cborBinary);                   // Decode CBOR object
   csf = object.get(CSF_CONTAINER_LBL);                // Get CSF container
   let alg = csf.get(CSF_ALG_LBL).getInt32();          // Get COSE algorithm
   let sigVal = csf.remove(CSF_SIG_LBL).getBytes();    // Get and REMOVE signature value
   let actualSig = hmac(alg,                           // Calculate signature over
                        SHARED_KEY,                    // the current object
```

```
                        object.encode());             // encode(): all but the signature
   if (CBOR.compareArrays(sigVal, actualSig)) {       // HMAC validation
       throw "Signature did not validate";
   }
   // Validated object, access the "payload":
   let p1 = object.get(APP_P1_LBL).getString();       // p1 should now contain "data"
```

Note that this code depends heavily on the API features outlined in Section 2.3.1.

Appendix D. Backward Compatibility

It is assumed that _most_ systems using CBOR are able to process an _application specific_, selection of CBOR data items that are encoded in compliance with [RFC8949]. Since the deterministic encoding scheme mandated by CBOR::Core, also is compliant with [RFC8949], there should be no major interoperability issues. That is, if the previous assumption actually is correct

However, in the _other_ direction (CBOR::Core tools processing data from systems using "legacy" CBOR encoding schemes), the situation is likely to be considerably more challenging since deterministic encoding "by design" is _strict_. Due to this potential obstacle, implementers of CBOR::Core tools, are RECOMMENDED to offer _decoder_ options that permit "relaxing" the rigidness of deterministic encoding with respect to:

Numbers:
: Numbers MUST still be compliant with [RFC8949], including "Rule 2" in section 4.2.2.

Sorted maps:
: Duplicate keys MUST still be rejected.

Note that regardless of the format of _decoded_ CBOR data, compliant CBOR::Core implementations MUST internally maintain the deterministic encoding format.

That is, a bigint encoded as c249000000000000000006 would after decoding, be represented by an int encoded as 06. See also Appendix A.4.

Appendix E. Compatible Online Tools

For testing and learning about CBOR::Core, there are currently a number of compatible online tools (subject to availability...).

[PLAYGROUND]:
Browser-based CBOR "playground"

[CSF-LAB]:
Server-based CBOR and [CSF] test system

Appendix F. Compatible Implementations

For using CBOR::Core in applications, there are currently a number of compatible libraries.

[CBOR.JS]:
JavaScript-based implementation supporting browsers as well as [NODE.JS]

[OPENKEYSTORE]:
Java-based implementation that also supports [CSF]

[ANDROID-CBOR]:
Android Java-based implementation that also supports [CSF]

Document History

// RFC Editor: Please remove this section before publication

* 00. First cut.

* 01. Editorial. Changed order of columns in invalid encoding.

* 02. Editorial. "unwrapped" changed to "non-wrapped".

* 03:

  Tweaking the abstract.

  Protocol Primitives sub-section added.

  Diagnostic Notation sub-section added.

  Updated CBOR Tool Requirements

  Updated code example to actually use crypto

  Updated Acknowledgements.

  Updated Security Considerations.

* 04:

  Minor addition in CBOR tools

  Updated Acknowledgements

* 05:

  Regression bug fix

* 06:

  Media type added

* 07->00:

  Renamed from "Universal CBOR" to "CBOR Base"

  Design Goals added

  CBOR Sequences added

* 01:

  #7.nnn (simple) added

  Language nits

* 02->00:

  Renamed from "CBOR Base" to "CBOR Core"

  Language nits

  Miscellaneous Items added

* 01:

  Language nits

  <table align="left">

* 02:

  Editorial

* 03:

Added Date decoding/reserialization example

* 04:

  Editorial

  Added bstr and tstr to Protocol Primitives

* 05:

  Enveloped => Embedded (signature)

* 06:

  Updated Acknowledgements

* 07:

  Dropped CBOR/c. Now it is just CBOR::Core

  Introduced API Level Considerations

  Updated Date example, and added Rule 2 to Supporting Existing Systems

* 08:

  Elaborated on "levels"

  CBOR/Core => CBOR::Core (showing its close ties to software)

* 09:

  Embedded signature sample => simple(99)

* 10:

  Editorial

  CBOR Profile => CBOR Platform Profile

* 11:

  Editorial

  Supporting Existing Systems => Backward Compatibility

* 12:

NaN with payloads added

* 13:

  Editorial

  Non-finite number support

* 14:

  Editorial

* 15:

  Revised: Application/Encoding Level Considerations

* 16:

  Editorial

  Revised Abstract

  Non-finite number deterministic encoding

* 17:

  Editorial

  Payload option added

* 18:

  Editorial

  Int53 added

* 19:

  Editorial

  Epoch [TIME] added

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