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Structured Headers for HTTP
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Abstract

This document describes a set of data types and algorithms associated with them that are intended to make it easier and safer to define and handle HTTP header fields. It is intended for use by new specifications of HTTP header fields as well as revisions of existing header field specifications when doing so does not cause interoperability issues.

Note to Readers

RFC EDITOR: please remove this section before publication

Discussion of this draft takes place on the HTTP working group mailing list (ietf-http-wg@w3.org), which is archived at <https://lists.w3.org/Archives/Public/ietf-http-wg/> [1].

Working Group information can be found at <https://httpwg.github.io/> [2]; source code and issues list for this draft can be found at <https://github.com/httpwg/http-extensions/labels/header-structure> [3].

Tests for implementations are collected at <https://github.com/httpwg/structured-header-tests> [4].

Implementations are tracked at <https://github.com/httpwg/wiki/wiki/Structured-Headers> [5].

Status of This Memo

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Internet-Draft

Structured Headers for HTTP

December 2018

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[1.](#) Introduction

Specifying the syntax of new HTTP header fields is an onerous task; even with the guidance in [\[RFC7231\]](#), [Section 8.3.1](#), there are many decisions - and pitfalls - for a prospective HTTP header field author.

Once a header field is defined, bespoke parsers and serialisers often need to be written, because each header has slightly different handling of what looks like common syntax.

This document introduces a set of common data structures for use in HTTP header field values to address these problems. In particular, it defines a generic, abstract model for header field values, along with a concrete serialisation for expressing that model in HTTP/1 [\[RFC7230\]](#) header fields.

HTTP headers that are defined as "Structured Headers" use the types defined in this specification to define their syntax and basic handling rules, thereby simplifying both their definition by specification writers and handling by implementations.

Additionally, future versions of HTTP can define alternative serialisations of the abstract model of these structures, allowing headers that use it to be transmitted more efficiently without being redefined.

Note that it is not a goal of this document to redefine the syntax of existing HTTP headers; the mechanisms described herein are only intended to be used with headers that explicitly opt into them.

To specify a header field that is a Structured Header, see [Section 2](#).

[Section 3](#) defines a number of abstract data types that can be used in Structured Headers.

Those abstract types can be serialised into and parsed from textual headers - such as those used in HTTP/1 - using the algorithms described in [Section 4](#).

[1.1](#). Intentionally Strict Processing

This specification intentionally defines strict parsing and serialisation behaviours using step-by-step algorithms; the only error handling defined is to fail the operation altogether.

This is designed to encourage faithful implementation and therefore good interoperability. Therefore, implementations that try to be "helpful" by being more tolerant of input are doing a disservice to the overall community, since it will encourage other implementations to implement similar (but likely subtly different) workarounds.

In other words, strict processing is an intentional feature of this specification; it allows non-conformant input to be discovered and corrected early, and avoids both interoperability and security issues that might otherwise result.

Note that as a result of this strictness, if a header field is appended to by multiple parties (e.g., intermediaries, or different components in the sender), it could be that an error in one party's value causes the entire header field to fail parsing.

[1.2.](#) Notational Conventions

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.

This document uses the Augmented Backus-Naur Form (ABNF) notation of [[RFC5234](#)], including the VCHAR, SP, DIGIT, ALPHA and DQUOTE rules from that document. It also includes the OWS rule from [[RFC7230](#)].

This document uses algorithms to specify parsing and serialisation behaviours, and ABNF to illustrate expected syntax in HTTP/1-style header fields.

For parsing from HTTP/1 header fields, implementations MUST follow the algorithms, but MAY vary in implementation so as the behaviours are indistinguishable from specified behaviour. If there is disagreement between the parsing algorithms and ABNF, the specified algorithms take precedence. In some places, the algorithms are "greedy" with whitespace, but this should not affect conformance.

For serialisation to HTTP/1 header fields, the ABNF illustrates the range of acceptable wire representations with as much fidelity as possible, and the algorithms define the recommended way to produce them. Implementations MAY vary from the specified behaviour so long as the output still matches the ABNF.

[2.](#) Defining New Structured Headers

To define a HTTP header as a structured header, its specification needs to:

- o Reference this specification. Recipients and generators of the header need to know that the requirements of this document are in effect.
- o Specify the header field's allowed syntax for values, in terms of the types described in [Section 3](#), along with their associated semantics. Syntax definitions are encouraged to use the ABNF rules beginning with "sh-" defined in this specification.
- o Specify any additional constraints upon the syntax of the structured used, as well as the consequences when those constraints are violated. When Structured Headers parsing fails, the header is discarded (see [Section 4.2](#)); in most situations, header-specific constraints should do likewise.

Note that a header field definition cannot relax the requirements of a structure or its processing because doing so would preclude handling by generic software; they can only add additional constraints. Likewise, header field definitions should use Structured Headers for the entire header field value, not a portion thereof.

For example:

Foo-Example Header

The Foo-Example HTTP header field conveys information about how much Foo the message has.

Foo-Example is a Structured Header [RFCxxxx]. Its value MUST be a dictionary ([RFCxxxx], Section Y.Y). Its ABNF is:

```
Foo-Example = sh-dictionary
```

The dictionary MUST contain:

- * Exactly one member whose key is "foo", and whose value is an integer ([RFCxxxx], Section Y.Y), indicating the number of foos in the message.

* Exactly one member whose key is "barUrls", and whose value is a string ([RFCxxxx], Section Y.Y), conveying the Bar URLs for the message. See below for processing requirements.

If the parsed header field does not contain both, it MUST be ignored.

"foo" MUST be between 0 and 10, inclusive; other values MUST cause the header to be ignored.

"barUrls" contains a space-separated list of URI-references ([\[RFC3986\], Section 4.1](#)):

```
barURLs = URI-reference *( 1*SP URI-reference )
```

If a member of barURLs is not a valid URI-reference, it MUST cause that value to be ignored.

If a member of barURLs is a relative reference ([\[RFC3986\], Section 4.2](#)), it MUST be resolved ([\[RFC3986\], Section 5](#)) before being used.

This specification defines minimums for the length or number of various structures supported by Structured Headers implementations. It does not specify maximum sizes in most cases, but header authors should be aware that HTTP implementations do impose various limits on the size of individual header fields, the total number of fields, and/or the size of the entire header block.

[3.](#) Structured Header Data Types

This section defines the abstract value types that can be composed into Structured Headers. The ABNF provided represents the on-wire format in HTTP/1.

[3.1.](#) Dictionaries

Dictionaries are ordered maps of key-value pairs, where the keys are short, textual strings and the values are items ([Section 3.5](#)). There can be one or more members, and keys are required to be unique.

Implementations MUST provide access to dictionaries both by index and by key. Specifications MAY use either means of accessing the members.

The ABNF for dictionaries in HTTP/1 headers is:

```
sh-dictionary = dict-member *( OWS "," OWS dict-member )
dict-member  = member-name "=" member-value
member-name  = key
member-value = sh-item
key          = lcalpha *( lcalpha / DIGIT / "_" / "-" )
lcalpha      = %x61-7A ; a-z
```

In HTTP/1, keys and values are separated by "=" (without whitespace), and key/value pairs are separated by a comma with optional whitespace. For example:

```
Example-DictHeader: en="Applepie", da=*w4ZibGV0w6ZydGU=*
```

Typically, a header field specification will define the semantics of individual keys, as well as whether their presence is required or optional. Recipients MUST ignore keys that are undefined or unknown, unless the header field's specification specifically disallows them.

Parsers MUST support dictionaries containing at least 1024 key/value pairs, and dictionary keys with at least 64 characters.

[3.2.](#) Lists

Lists are arrays of items ([Section 3.5](#)) with one or more members.

The ABNF for lists in HTTP/1 headers is:

```
sh-list      = list-member *( OWS "," OWS list-member )
list-member  = sh-item
```

In HTTP/1, each member is separated by a comma and optional

whitespace. For example, a header field whose value is defined as a list of strings could look like:

```
Example-StrListHeader: "foo", "bar", "It was the best of times."
```

Header specifications can constrain the types of individual values if necessary.

Parsers MUST support lists containing at least 1024 members.

[3.3.](#) Lists of Lists

Lists of Lists are arrays of arrays containing items ([Section 3.5](#)).

The ABNF for lists of lists in HTTP/1 headers is:

```
sh-listlist = inner-list *( OWS "," OWS inner-list )
inner-list  = list-member *( OWS ";" OWS list-member )
```

In HTTP/1, each inner-list is separated by a comma and optional whitespace, and members of the inner-list are separated by semicolons and optional whitespace. For example, a header field whose value is defined as a list of lists of strings could look like:

```
Example-StrListListHeader: "foo";"bar", "baz", "bat"; "one"
```

Header specifications can constrain the types of individual inner-list values if necessary.

Parsers MUST support lists of lists containing at least 1024 members, and inner-lists containing at least 256 members.

[3.4.](#) Parameterised Lists

Parameterised Lists are arrays of parameterised identifier with one or more members.

A parameterised identifier is a token ([Section 3.9](#)) with an optional set of parameters, each parameter having a textual name and an optional value that is an item ([Section 3.5](#)). Ordering between parameters is not significant, and duplicate parameters MUST cause parsing to fail.

The ABNF for parameterised lists in HTTP/1 headers is:

```
sh-param-list = param-item *( OWS "," OWS param-item )
param-item    = primary-id *parameter
primary-id    = sh-token
parameter     = OWS ";" OWS param-name [ "=" param-value ]
param-name    = key
param-value   = sh-item
```

In HTTP/1, each param-id is separated by a comma and optional whitespace (as in Lists), and the parameters are separated by semicolons. For example:

```
Example-ParamListHeader: abc_123;a=1;b=2; cdef_456, ghi;q="9";r="w"
```

Parsers MUST support parameterised lists containing at least 1024 members, support members with at least 256 parameters, and support parameter keys with at least 64 characters.

[3.5.](#) Items

An item is can be a integer ([Section 3.6](#)), float ([Section 3.7](#)), string ([Section 3.8](#)), token ([Section 3.9](#)}, byte sequence ([Section 3.10](#)), or Boolean ([Section 3.11](#)).

The ABNF for items in HTTP/1 headers is:

```
sh-item = sh-integer / sh-float / sh-string / sh-token / sh-binary
         / sh-boolean
```

[3.6.](#) Integers

Integers have a range of -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807 inclusive (i.e., a 64-bit signed integer).

The ABNF for integers in HTTP/1 headers is:

```
sh-integer = ["-"] 1*19DIGIT
```

For example:

```
Example-IntegerHeader: 42
```

[3.7.](#) Floats

Floats are integers with a fractional part, that can be stored as IEEE 754 double precision numbers (binary64) ([\[IEEE754\]](#)).

The ABNF for floats in HTTP/1 headers is:

```
sh-float = ["-"] (  
    DIGIT "." 1*14DIGIT /  
    2DIGIT "." 1*13DIGIT /  
    3DIGIT "." 1*12DIGIT /  
    4DIGIT "." 1*11DIGIT /  
    5DIGIT "." 1*10DIGIT /  
    6DIGIT "." 1*9DIGIT /  
    7DIGIT "." 1*8DIGIT /  
    8DIGIT "." 1*7DIGIT /  
    9DIGIT "." 1*6DIGIT /  
    10DIGIT "." 1*5DIGIT /  
    11DIGIT "." 1*4DIGIT /  
    12DIGIT "." 1*3DIGIT /  
    13DIGIT "." 1*2DIGIT /  
    14DIGIT "." 1DIGIT )
```

For example, a header whose value is defined as a float could look like:

```
Example-FloatHeader: 4.5
```

[3.8.](#) Strings

Strings are zero or more printable ASCII [[RFC0020](#)] characters (i.e., the range 0x20 to 0x7E). Note that this excludes tabs, newlines, carriage returns, etc.

The ABNF for strings in HTTP/1 headers is:

```
sh-string = DQUOTE *(chr) DQUOTE  
chr       = unescaped / escaped  
unescaped = %x20-21 / %x23-5B / %x5D-7E  
escaped   = "\" ( DQUOTE / "\" )
```

In HTTP/1 headers, strings are delimited with double quotes, using a backslash ("\") to escape double quotes and backslashes. For example:

```
Example-StringHeader: "hello world"
```

Note that strings only use DQUOTE as a delimiter; single quotes do not delimit strings. Furthermore, only DQUOTE and "\" can be escaped; other sequences MUST cause parsing to fail.

Unicode is not directly supported in this document, because it causes a number of interoperability issues, and - with few exceptions - header values do not require it.

When it is necessary for a field value to convey non-ASCII string content, a byte sequence ([Section 3.10](#)) SHOULD be specified, along with a character encoding (preferably UTF-8).

Parsers MUST support strings with at least 1024 characters.

[3.9.](#) Tokens

Tokens are short textual words; their abstract model is identical to their expression in the textual HTTP serialisation.

The ABNF for tokens in HTTP/1 headers is:

```
sh-token = ALPHA *( ALPHA / DIGIT / "_" / "-" / "." / ":" / "%" / "*" / "/" )
```

Parsers MUST support tokens with at least 512 characters.

[3.10.](#) Byte Sequences

Byte sequences can be conveyed in Structured Headers.

The ABNF for a byte sequence in HTTP/1 headers is:

```
sh-binary = "*" *(base64) "*"
base64    = ALPHA / DIGIT / "+" / "/" / "="
```

In HTTP/1 headers, a byte sequence is delimited with asterisks and encoded using base64 ([\[RFC4648\]](#), [Section 4](#)). For example:

```
Example-BinaryHdr: *cHJldGVuZCB0aGlzIGlzIGJpbmFyeSBjb250ZW50Lg==*
```

Parsers MUST support byte sequences with at least 16384 octets after

decoding.

[3.11.](#) Booleans

Boolean values can be conveyed in Structured Headers.

The ABNF for a Boolean in HTTP/1 headers is:

```
sh-boolean = "?" boolean
boolean    = %54 / %46 ; capital "T" or "F"
```

In HTTP/1 headers, a byte sequence is indicated with a leading "?" character. For example:

Example-BoolHdr: ?T

[4.](#) Structured Headers in HTTP/1

This section defines how to serialise and parse Structured Headers in HTTP/1 textual header fields, and protocols compatible with them (e.g., in HTTP/2 [[RFC7540](#)] before HPACK [[RFC7541](#)] is applied).

[4.1.](#) Serialising Structured Headers into HTTP/1

Given a structure defined in this specification:

1. If the structure is a dictionary, return the result of Serialising a Dictionary ([Section 4.1.1](#)).
2. If the structure is a parameterised list, return the result of Serialising a Parameterised List ([Section 4.1.4](#)).
3. If the structure is a list of lists, return the result of Serialising a List of Lists ({ser-listlist}).
4. If the structure is a list, return the result of Serialising a List [Section 4.1.2](#).
5. If the structure is an item, return the result of Serialising an Item ([Section 4.1.5](#)).

6. Otherwise, fail serialisation.

[4.1.1.](#) Serialising a Dictionary

Given a dictionary as `input_dictionary`:

1. Let `output` be an empty string.
2. For each member `mem` of `input_dictionary`:
 1. Let `name` be the result of applying Serialising an Key ([Section 4.1.1.1](#)) to `mem`'s member-name.
 2. Append `name` to `output`.
 3. Append `"="` to `output`.
 4. Let `value` be the result of applying Serialising an Item ([Section 4.1.5](#)) to `mem`'s member-value.
 5. Append `value` to `output`.
6. If more members remain in `input_dictionary`:

1. Append a COMMA to `output`.
2. Append a single WS to `output`.
3. Return `output`.

[4.1.1.1.](#) Serialising a Key

Given a key as `input_key`:

1. If `input_key` is not a sequence of characters, or contains characters not allowed in the ABNF for key, fail serialisation.
2. Let `output` be an empty string.
3. Append `input_key` to `output`, using ASCII encoding [[RFC0020](#)].
4. Return `output`.

[4.1.2.](#) Serialising a List

Given a list as `input_list`:

1. Let output be an empty string.
2. For each member `mem` of `input_list`:
 1. Let `value` be the result of applying Serialising an Item ([Section 4.1.5](#)) to `mem`.
 2. Append `value` to output.
3. If more members remain in `input_list`:
 1. Append a COMMA to output.
 2. Append a single WS to output.
3. Return output.

[4.1.3.](#) Serialising a List of Lists

Given a list of lists of items as `input_list`:

1. Let output be an empty string.
2. For each member `inner_list` of `input_list`:

1. If `inner_list` is not a list, fail serialisation.
2. If `inner_list` is empty, fail serialisation.
3. For each `inner_mem` of `inner_list`:
 1. Let `value` be the result of applying Serialising an Item ([Section 4.1.5](#)) to `inner_mem`.
 2. Append `value` to output.

3. If more members remain in inner_list:
 1. Append a ";" to output.
 2. Append a single WS to output.
4. If more members remain in input_list:
 1. Append a COMMA to output.
 2. Append a single WS to output.
3. Return output.

[4.1.4.](#) Serialising a Parameterised List

Given a parameterised list as input_plist:

1. Let output be an empty string.
2. For each member mem of input_plist:
 1. Let id be the result of applying Serialising a Token ([Section 4.1.9](#)) to mem's token.
 2. Append id to output.
 3. For each parameter in mem's parameters:
 1. Append ";" to output.
 2. Let name be the result of applying Serialising a Key ([Section 4.1.1.1](#)) to parameter's param-name.
 3. Append name to output.
 4. If parameter has a param-value:

1. Let value be the result of applying Serialising an Item ([Section 4.1.5](#)) to parameter's param-value.
2. Append "=" to output.

3. Append value to output.
4. If more members remain in input_plist:
 1. Append a COMMA to output.
 2. Append a single WS to output.
3. Return output.

[4.1.5.](#) Serialising an Item

Given an item as input_item:

1. If input_item is an integer, return the result of applying Serialising an Integer ([Section 4.1.6](#)) to input_item.
2. If input_item is a float, return the result of applying Serialising a Float ([Section 4.1.7](#)) to input_item.
3. If input_item is a string, return the result of applying Serialising a String ([Section 4.1.8](#)) to input_item.
4. If input_item is a token, return the result of Serialising a Token ([Section 4.1.9](#)) to input_item.
5. If input_item is a Boolean, return the result of applying Serialising a Boolean ([Section 4.1.11](#)) to input_item.
6. If input_item is a byte sequence, return the result of applying Serialising a Byte Sequence ([Section 4.1.10](#)) to input_item.
7. Otherwise, fail serialisation.

[4.1.6.](#) Serialising an Integer

Given an integer as input_integer:

1. If input_integer is not an integer in the range of -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807 inclusive, fail serialisation.
2. Let output be an empty string.

3. If `input_integer` is less than (but not equal to) 0, append "-" to output.
4. Append `input_integer`'s numeric value represented in base 10 using only decimal digits to output.
5. Return output.

[4.1.7.](#) Serialising a Float

Given a float as `input_float`:

1. If `input_float` is not a IEEE 754 double precision number, fail serialisation.
2. Let output be an empty string.
3. If `input_float` is less than (but not equal to) 0, append "-" to output.
4. Append `input_float`'s integer component represented in base 10 using only decimal digits to output; if it is zero, append "0".
5. Append "." to output.
6. Append `input_float`'s decimal component represented in base 10 using only decimal digits to output; if it is zero, append "0".
7. Return output.

[4.1.8.](#) Serialising a String

Given a string as `input_string`:

1. If `input_string` is not a sequence of characters, or contains characters outside the range allowed by VCHAR or SP, fail serialisation.
2. Let output be an empty string.
3. Append DQUOTE to output.
4. For each character `char` in `input_string`:
 1. If `char` is "\" or DQUOTE:
 1. Append "\" to output.

2. Append char to output, using ASCII encoding [[RFC0020](#)].
5. Append DQUOTE to output.
6. Return output.

[4.1.9](#). Serialising a Token

Given a token as `input_token`:

1. If `input_token` is not a sequence of characters, or contains characters not allowed in [Section 3.9](#), fail serialisation.
2. Let output be an empty string.
3. Append `input_token` to output, using ASCII encoding [[RFC0020](#)].
4. Return output.

[4.1.10](#). Serialising a Byte Sequence

Given a byte sequence as `input_bytes`:

1. If `input_bytes` is not a sequence of bytes, fail serialisation.
2. Let output be an empty string.
3. Append "*" to output.
4. Append the result of base64-encoding `input_bytes` as per [\[RFC4648\]](#), [Section 4](#), taking account of the requirements below.
5. Append "*" to output.
6. Return output.

The encoded data is required to be padded with "=", as per [\[RFC4648\]](#), [Section 3.2](#).

Likewise, encoded data SHOULD have pad bits set to zero, as per

[\[RFC4648\]](#), [Section 3.5](#), unless it is not possible to do so due to implementation constraints.

[4.1.11](#). Serialising a Boolean

Given a Boolean as `input_boolean`:

1. If `input_boolean` is not a boolean, fail serialisation.

2. Let `output` be an empty string.
3. Append "?" to `output`.
4. If `input_boolean` is true, append "T" to `output`.
5. If `input_boolean` is false, append "F" to `output`.
6. Return `output`.

[4.2](#). Parsing HTTP/1 Header Fields into Structured Headers

When a receiving implementation parses textual HTTP header fields (e.g., in HTTP/1 or HTTP/2) that are known to be Structured Headers, it is important that care be taken, as there are a number of edge cases that can cause interoperability or even security problems. This section specifies the algorithm for doing so.

Given an ASCII string `input_string` that represents the chosen header's field-value, and `header_type`, one of "dictionary", "list", "list-list", "param-list", or "item", return the parsed header value.

1. Discard any leading OWS from `input_string`.
2. If `header_type` is "dictionary", let `output` be the result of Parsing a Dictionary from Text ([Section 4.2.1](#)).
3. If `header_type` is "list", let `output` be the result of Parsing a List from Text ([Section 4.2.3](#)).
4. If `header_type` is "list-list", let `output` be the result of Parsing a List of Lists from Text ([Section 4.2.4](#)).

5. If `header_type` is "param-list", let output be the result of Parsing a Parameterised List from Text ([Section 4.2.5](#)).
6. If `header_type` is "item", let output be the result of Parsing an Item from Text ([Section 4.2.7](#)).
7. Discard any leading OWS from `input_string`.
8. If `input_string` is not empty, fail parsing.
9. Otherwise, return output.

When generating `input_string`, parsers MUST combine all instances of the target header field into one comma-separated field-value, as per

[\[RFC7230\]](#), [Section 3.2.2](#); this assures that the header is processed correctly.

For Lists, Lists of Lists, Parameterised Lists and Dictionaries, this has the effect of correctly concatenating all instances of the header field, as long as individual individual members of the top-level data structure are not split across multiple header instances.

Strings split across multiple header instances will have unpredictable results, because comma(s) and whitespace inserted upon combination will become part of the string output by the parser. Since concatenation might be done by an upstream intermediary, the results are not under the control of the serialiser or the parser.

Integers, Floats and Byte Sequences cannot be split across multiple headers because the inserted commas will cause parsing to fail.

If parsing fails - including when calling another algorithm - the entire header field's value MUST be discarded. This is intentionally strict, to improve interoperability and safety, and specifications referencing this document cannot loosen this requirement.

Note that this has the effect of discarding any header field with non-ASCII characters in `input_string`.

[4.2.1](#). Parsing a Dictionary from Text

Given an ASCII string `input_string`, return an ordered map of (key, item). `input_string` is modified to remove the parsed value.

1. Let `dictionary` be an empty, ordered map.
2. While `input_string` is not empty:
 1. Let `this_key` be the result of running Parse a Key from Text ([Section 4.2.2](#)) with `input_string`.
 2. If `dictionary` already contains `this_key`, fail parsing.
 3. Consume the first character of `input_string`; if it is not "=", fail parsing.
 4. Let `this_value` be the result of running Parse Item from Text ([Section 4.2.7](#)) with `input_string`.
 5. Add key `this_key` with value `this_value` to `dictionary`.
 6. Discard any leading OWS from `input_string`.

7. If `input_string` is empty, return `dictionary`.
 8. Consume the first character of `input_string`; if it is not COMMA, fail parsing.
 9. Discard any leading OWS from `input_string`.
 10. If `input_string` is empty, fail parsing.
3. No structured data has been found; fail parsing.

[4.2.2](#). Parsing a Key from Text

Given an ASCII string `input_string`, return a key. `input_string` is modified to remove the parsed value.

1. If the first character of `input_string` is not `lcalpha`, fail parsing.

2. Let `output_string` be an empty string.
3. While `input_string` is not empty:
 1. Let `char` be the result of removing the first character of `input_string`.
 2. If `char` is not one of `lcalpha`, `DIGIT`, `"_"`, or `"-"`:
 1. Prepend `char` to `input_string`.
 2. Return `output_string`.
 3. Append `char` to `output_string`.
4. Return `output_string`.

[4.2.3](#). Parsing a List from Text

Given an ASCII string `input_string`, return a list of items. `input_string` is modified to remove the parsed value.

1. Let `items` be an empty array.
2. While `input_string` is not empty:
 1. Let `item` be the result of running Parse Item from Text ([Section 4.2.7](#)) with `input_string`.

2. Append `item` to `items`.
3. Discard any leading OWS from `input_string`.
4. If `input_string` is empty, return `items`.
5. Consume the first character of `input_string`; if it is not `COMMA`, fail parsing.
6. Discard any leading OWS from `input_string`.
7. If `input_string` is empty, fail parsing.

3. No structured data has been found; fail parsing.

[4.2.4.](#) Parsing a List of Lists from Text

Given an ASCII string `input_string`, return a list of lists of items. `input_string` is modified to remove the parsed value.

1. let `top_list` be an empty array.
2. Let `inner_list` be an empty array.
3. While `input_string` is not empty:
 1. Let `item` be the result of running Parse Item from Text ([Section 4.2.7](#)) with `input_string`.
 2. Append `item` to `inner_list`.
 3. Discard any leading OWS from `input_string`.
 4. If `input_string` is empty, append `inner_list` to `top_list` and return `top_list`.
 5. Let `char` be the result of consuming the first character of `input_string`.
 6. If `char` is COMMA:
 1. Append `inner_list` to `top_list`.
 2. Let `inner_list` be an empty array.
 7. Else if `char` is not ";", fail parsing.
 8. Discard any leading OWS from `input_string`.

9. If `input_string` is empty, fail parsing.
4. No structured data has been found; fail parsing.

[4.2.5.](#) Parsing a Parameterised List from Text

Given an ASCII string `input_string`, return a list of parameterised identifiers. `input_string` is modified to remove the parsed value.

1. Let `items` be an empty array.
2. While `input_string` is not empty:
 1. Let `item` be the result of running Parse Parameterised Identifier from Text ([Section 4.2.6](#)) with `input_string`.
 2. Append `item` to `items`.
 3. Discard any leading OWS from `input_string`.
 4. If `input_string` is empty, return `items`.
 5. Consume the first character of `input_string`; if it is not COMMA, fail parsing.
 6. Discard any leading OWS from `input_string`.
 7. If `input_string` is empty, fail parsing.
3. No structured data has been found; fail parsing.

[4.2.6](#). Parsing a Parameterised Identifier from Text

Given an ASCII string `input_string`, return an token with an unordered map of parameters. `input_string` is modified to remove the parsed value.

1. Let `primary_identifier` be the result of Parsing a Token from Text ([Section 4.2.10](#)) from `input_string`.
2. Let `parameters` be an empty, unordered map.
3. In a loop:
 1. Discard any leading OWS from `input_string`.
 2. If the first character of `input_string` is not ";", exit the loop.

3. Consume a ";" character from the beginning of `input_string`.
4. Discard any leading OWS from `input_string`.
5. let `param_name` be the result of Parsing a key from Text ([Section 4.2.2](#)) from `input_string`.
6. If `param_name` is already present in `parameters`, fail parsing.
7. Let `param_value` be a null value.
8. If the first character of `input_string` is "=":
 1. Consume the "=" character at the beginning of `input_string`.
 2. Let `param_value` be the result of Parsing an Item from Text ([Section 4.2.7](#)) from `input_string`.
9. Add key `param_name` with value `param_value` to `parameters`.
4. Return the tuple (`primary_identifier`, `parameters`).

[4.2.7](#). Parsing an Item from Text

Given an ASCII string `input_string`, return an item. `input_string` is modified to remove the parsed value.

1. If the first character of `input_string` is a "-" or a DIGIT, process `input_string` as a number ([Section 4.2.8](#)) and return the result.
2. If the first character of `input_string` is a DQUOTE, process `input_string` as a string ([Section 4.2.9](#)) and return the result.
3. If the first character of `input_string` is "*", process `input_string` as a byte sequence ([Section 4.2.11](#)) and return the result.
4. If the first character of `input_string` is "?", process `input_string` as a Boolean ([Section 4.2.12](#)) and return the result.
5. If the first character of `input_string` is an ALPHA, process `input_string` as a token ([Section 4.2.10](#)) and return the result.
6. Otherwise, fail parsing.

[4.2.8](#). Parsing a Number from Text

Given an ASCII string `input_string`, return a number. `input_string` is modified to remove the parsed value.

NOTE: This algorithm parses both Integers [Section 3.6](#) and Floats [Section 3.7](#), and returns the corresponding structure.

1. Let `type` be "integer".
2. Let `sign` be 1.
3. Let `input_number` be an empty string.
4. If the first character of `input_string` is "-", remove it from `input_string` and set `sign` to -1.
5. If `input_string` is empty, fail parsing.
6. If the first character of `input_string` is not a DIGIT, fail parsing.
7. While `input_string` is not empty:
 1. Let `char` be the result of removing the first character of `input_string`.
 2. If `char` is a DIGIT, append it to `input_number`.
 3. Else, if `type` is "integer" and `char` is ".", append `char` to `input_number` and set `type` to "float".
 4. Otherwise, prepend `char` to `input_string`, and exit the loop.
 5. If `type` is "integer" and `input_number` contains more than 19 characters, fail parsing.
 6. If `type` is "float" and `input_number` contains more than 16 characters, fail parsing.
8. If `type` is "integer":

1. Parse `input_number` as an integer and let `output_number` be the product of the result and sign.
2. If `output_number` is outside the range defined in [Section 3.6](#), fail parsing.

9. Otherwise:
 1. If the final character of `input_number` is ".", fail parsing.
 2. Parse `input_number` as a float and let `output_number` be the product of the result and sign.
10. Return `output_number`.

[4.2.9](#). Parsing a String from Text

Given an ASCII string `input_string`, return an unquoted string. `input_string` is modified to remove the parsed value.

1. Let `output_string` be an empty string.
2. If the first character of `input_string` is not `DQUOTE`, fail parsing.
3. Discard the first character of `input_string`.
4. While `input_string` is not empty:
 1. Let `char` be the result of removing the first character of `input_string`.
 2. If `char` is a backslash ("`\`"):
 1. If `input_string` is now empty, fail parsing.
 2. Else:
 1. Let `next_char` be the result of removing the first character of `input_string`.

2. If `next_char` is not `DQUOTE` or `"\"`, fail parsing.
3. Append `next_char` to `output_string`.
3. Else, if `char` is `DQUOTE`, return `output_string`.
4. Else, if `char` is in the range `%x00-1f` or `%x7f` (i.e., is not in `VCHAR` or `SP`), fail parsing.
5. Else, append `char` to `output_string`.
5. Reached the end of `input_string` without finding a closing `DQUOTE`; fail parsing.

[4.2.10.](#) Parsing a Token from Text

Given an ASCII string `input_string`, return a token. `input_string` is modified to remove the parsed value.

1. If the first character of `input_string` is not ALPHA, fail parsing.
2. Let `output_string` be an empty string.
3. While `input_string` is not empty:
 1. Let `char` be the result of removing the first character of `input_string`.
 2. If `char` is not one of ALPHA, DIGIT, `"_"`, `"-"`, `"."`, `":"`, `"%"`, `"*"` or `"/"`:
 1. Prepend `char` to `input_string`.
 2. Return `output_string`.
 3. Append `char` to `output_string`.
4. Return `output_string`.

[4.2.11.](#) Parsing a Byte Sequence from Text

Given an ASCII string `input_string`, return a byte sequence.
`input_string` is modified to remove the parsed value.

1. If the first character of `input_string` is not "*", fail parsing.
2. Discard the first character of `input_string`.
3. If there is not a "*" character before the end of `input_string`, fail parsing.
4. Let `b64_content` be the result of removing content of `input_string` up to but not including the first instance of the character "*".
5. Consume the "*" character at the beginning of `input_string`.
6. If `b64_content` contains a character not included in ALPHA, DIGIT, "+", "/" and "=", fail parsing.

7. Let `binary_content` be the result of Base 64 Decoding [[RFC4648](#)] `b64_content`, synthesising padding if necessary (note the requirements about recipient behaviour below).
8. Return `binary_content`.

Because some implementations of base64 do not allow reject of encoded data that is not properly "=" padded (see [[RFC4648](#)], [Section 3.2](#)), parsers SHOULD NOT fail when it is not present, unless they cannot be configured to do so.

Because some implementations of base64 do not allow rejection of encoded data that has non-zero pad bits (see [[RFC4648](#)], [Section 3.5](#)), parsers SHOULD NOT fail when it is present, unless they cannot be configured to do so.

This specification does not relax the requirements in [[RFC4648](#)], [Section 3.1](#) and 3.3; therefore, parsers MUST fail on characters outside the base64 alphabet, and on line feeds in encoded data.

[4.2.12](#). Parsing a Boolean from Text

Given an ASCII string `input_string`, return a Boolean. `input_string` is modified to remove the parsed value.

1. If the first character of `input_string` is not "?", fail parsing.
2. Discard the first character of `input_string`.
3. If the first character of `input_string` case-sensitively matches "T", discard the first character, and return true.
4. If the first character of `input_string` case-sensitively matches "F", discard the first character, and return false.
5. No value has matched; fail parsing.

5. IANA Considerations

This draft has no actions for IANA.

6. Security Considerations

The size of most types defined by Structured Headers is not limited; as a result, extremely large header fields could be an attack vector (e.g., for resource consumption). Most HTTP implementations limit the sizes of size of individual header fields as well as the overall header block size to mitigate such attacks.

It is possible for parties with the ability to inject new HTTP header fields to change the meaning of a Structured Header. In some circumstances, this will cause parsing to fail, but it is not possible to reliably fail in all such circumstances.

7. References

7.1. Normative References

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[7.2](#). Informative References

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[7.3.](#) URIs

- [1] <https://lists.w3.org/Archives/Public/ietf-http-wg/>
- [2] <https://httpwg.github.io/>
- [3] <https://github.com/httpwg/http-extensions/labels/header-structure>
- [4] <https://github.com/httpwg/structured-header-tests>
- [5] <https://github.com/httpwg/wiki/wiki/Structured-Headers>
- [6] <https://github.com/httpwg/structured-header-tests>

[Appendix A.](#) Acknowledgements

Many thanks to Matthew Kerwin for his detailed feedback and careful consideration during the development of this specification.

[Appendix B.](#) Frequently Asked Questions

[B.1.](#) Why not JSON?

Earlier proposals for structured headers were based upon JSON [[RFC8259](#)]. However, constraining its use to make it suitable for HTTP header fields required senders and recipients to implement specific additional handling.

For example, JSON has specification issues around large numbers and objects with duplicate members. Although advice for avoiding these issues is available (e.g., [[RFC7493](#)]), it cannot be relied upon.

Likewise, JSON strings are by default Unicode strings, which have a number of potential interoperability issues (e.g., in comparison). Although implementers can be advised to avoid non-ASCII content where unnecessary, this is difficult to enforce.

Another example is JSON's ability to nest content to arbitrary depths. Since the resulting memory commitment might be unsuitable (e.g., in embedded and other limited server deployments), it's necessary to limit it in some fashion; however, existing JSON implementations have no such limits, and even if a limit is specified, it's likely that some header field definition will find a need to violate it.

Because of JSON's broad adoption and implementation, it is difficult to impose such additional constraints across all implementations; some deployments would fail to enforce them, thereby harming interoperability.

Since a major goal for Structured Headers is to improve interoperability and simplify implementation, these concerns led to a format that requires a dedicated parser and serialiser.

Additionally, there were widely shared feelings that JSON doesn't "look right" in HTTP headers.

[B.2.](#) Structured Headers don't "fit" my data.

Structured headers intentionally limits the complexity of data structures, to assure that it can be processed in a performant manner with little overhead. This means that work is necessary to fit some data types into them.

Sometimes, this can be achieved by creating limited substructures in values, and/or using more than one header. For example, consider:

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```
Example-Thing: name="Widget", cost=89.2, descriptions="foo bar"  
Example-Description: foo; url="https://example.net"; context=123,  
                    bar; url="https://example.org"; context=456
```

Since the description contains a list of key/value pairs, we use a Parameterised List to represent them, with the token for each item in the list used to identify it in the "descriptions" member of the Example-Thing header.

When specifying more than one header, it's important to remember to describe what a processor's behaviour should be when one of the headers is missing.

If you need to fit arbitrarily complex data into a header, Structured Headers is probably a poor fit for your use case.

[B.3.](#) What should generic Structured Headers implementations expose?

A generic implementation should expose the top-level parse ([Section 4.2](#)) and serialise ([Section 4.1](#)) functions. They need not be functions; for example, it could be implemented as an object, with methods for each of the different top-level types.

For interoperability, it's important that generic implementations be complete and follow the algorithms closely; see [Section 1.1](#). To aid this, a common test suite is being maintained by the community; see <https://github.com/httpwg/structured-header-tests> [7].

[Appendix C.](#) Changes

RFC Editor: Please remove this section before publication.

[C.1.](#) Since [draft-ietf-httpbis-header-structure-08](#)

- o Disallow whitespace before items properly (#703).
- o Created "key" for use in dictionaries and parameters, rather than relying on identifier (#702). Identifiers have a separate minimum supported size.
- o Expanded the range of special characters allowed in identifier to include all of ALPHA, ".", ":", and "%" (#702).

- o Use "?" instead of "!" to indicate a Boolean (#719).
- o Added "Intentionally Strict Processing" (#684).

- o Gave better names for referring specs to use in Parameterised Lists (#720).
- o Added Lists of Lists (#721).
- o Rename Identifier to Token (#725).
- o Add implementation guidance (#727).

C.2. Since [draft-ietf-httpbis-header-structure-07](#)

- o Make Dictionaries ordered mappings (#659).
- o Changed "binary content" to "byte sequence" to align with Infra specification (#671).
- o Changed "mapping" to "map" for #671.
- o Don't fail if byte sequences aren't "=" padded (#658).
- o Add Booleans (#683).
- o Allow identifiers in items again (#629).
- o Disallowed whitespace before items (#703).
- o Explain the consequences of splitting a string across multiple headers (#686).

C.3. Since [draft-ietf-httpbis-header-structure-06](#)

- o Add a FAQ.
- o Allow non-zero pad bits.
- o Explicitly check for integers that violate constraints.

[C.4.](#) Since [draft-ietf-httpbis-header-structure-05](#)

- o Reorganise specification to separate parsing out.
- o Allow referencing specs to use ABNF.
- o Define serialisation algorithms.
- o Refine relationship between ABNF, parsing and serialisation algorithms.

[C.5.](#) Since [draft-ietf-httpbis-header-structure-04](#)

- o Remove identifiers from item.
- o Remove most limits on sizes.
- o Refine number parsing.

[C.6.](#) Since [draft-ietf-httpbis-header-structure-03](#)

- o Strengthen language around failure handling.

[C.7.](#) Since [draft-ietf-httpbis-header-structure-02](#)

- o Split Numbers into Integers and Floats.
- o Define number parsing.
- o Tighten up binary parsing and give it an explicit end delimiter.
- o Clarify that mappings are unordered.
- o Allow zero-length strings.
- o Improve string parsing algorithm.
- o Improve limits in algorithms.
- o Require parsers to combine header fields before processing.

- o Throw an error on trailing garbage.

C.8. Since [draft-ietf-httpbis-header-structure-01](#)

- o Replaced with [draft-nottingham-structured-headers](#).

C.9. Since [draft-ietf-httpbis-header-structure-00](#)

- o Added signed 64bit integer type.
- o Drop UTF8, and settle on [BCP137](#) ::EmbeddedUnicodeChar for h1-unicode-string.
- o Change h1_blob delimiter to ":" since "'" is valid t_char

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