

HTTP Working Group  
Internet-Draft  
Obsoletes: [7234](#) (if approved)  
Intended status: Standards Track  
Expires: July 17, 2021

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January 13, 2021

HTTP Caching  
draft-ietf-httpbis-cache-14

## Abstract

The Hypertext Transfer Protocol (HTTP) is a stateless application-level protocol for distributed, collaborative, hypertext information systems. This document defines HTTP caches and the associated header fields that control cache behavior or indicate cacheable response messages.

This document obsoletes [RFC 7234](#).

## Editorial Note

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

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

Working Group information can be found at <https://httpwg.org/>; source code and issues list for this draft can be found at <https://github.com/httpwg/http-core>.

The changes in this draft are summarized in [Appendix C.15](#).

## Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

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Internet-Draft

HTTP Caching

January 2021

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## Table of Contents

<a href="#">1.</a>	Introduction . . . . .	<a href="#">4</a>
<a href="#">1.1.</a>	Requirements Notation . . . . .	<a href="#">5</a>
<a href="#">1.2.</a>	Syntax Notation . . . . .	<a href="#">5</a>
<a href="#">1.3.</a>	Delta Seconds . . . . .	<a href="#">5</a>
<a href="#">2.</a>	Overview of Cache Operation . . . . .	<a href="#">6</a>
<a href="#">3.</a>	Storing Responses in Caches . . . . .	<a href="#">7</a>
<a href="#">3.1.</a>	Storing Header and Trailer Fields . . . . .	<a href="#">8</a>
<a href="#">3.2.</a>	Updating Stored Header Fields . . . . .	<a href="#">9</a>

3.3.	Storing Incomplete Responses . . . . .	10
3.4.	Combining Partial Content . . . . .	10
3.5.	Storing Responses to Authenticated Requests . . . . .	10
4.	Constructing Responses from Caches . . . . .	11
4.1.	Calculating Cache Keys with Vary . . . . .	12

4.2.	Freshness . . . . .	13
4.2.1.	Calculating Freshness Lifetime . . . . .	15
4.2.2.	Calculating Heuristic Freshness . . . . .	15
4.2.3.	Calculating Age . . . . .	16
4.2.4.	Serving Stale Responses . . . . .	17
4.3.	Validation . . . . .	18
4.3.1.	Sending a Validation Request . . . . .	18
4.3.2.	Handling a Received Validation Request . . . . .	19
4.3.3.	Handling a Validation Response . . . . .	20
4.3.4.	Freshening Stored Responses upon Validation . . . . .	21
4.3.5.	Freshening Responses with HEAD . . . . .	21
4.4.	Invalidating Stored Responses . . . . .	22
5.	Field Definitions . . . . .	23
5.1.	Age . . . . .	23
5.2.	Cache-Control . . . . .	23
5.2.1.	Request Cache-Control Directives . . . . .	24
5.2.2.	Response Cache-Control Directives . . . . .	26
5.2.3.	Cache Control Extensions . . . . .	30
5.2.4.	Cache Directive Registry . . . . .	31
5.3.	Expires . . . . .	31
5.4.	Pragma . . . . .	32
5.5.	Warning . . . . .	33
6.	Relationship to Applications and Other Caches . . . . .	33
7.	Security Considerations . . . . .	34
7.1.	Cache Poisoning . . . . .	34
7.2.	Timing Attacks . . . . .	34
7.3.	Caching of Sensitive Information . . . . .	35
8.	IANA Considerations . . . . .	35
8.1.	Field Name Registration . . . . .	35
8.2.	Cache Directive Registration . . . . .	35
8.3.	Warn Code Registry . . . . .	36
9.	References . . . . .	36
9.1.	Normative References . . . . .	36
9.2.	Informative References . . . . .	37
Appendix A.	Collected ABNF . . . . .	38
Appendix B.	Changes from <a href="#">RFC 7234</a> . . . . .	38

<a href="#">Appendix C.</a>	Change Log . . . . .	<a href="#">39</a>
<a href="#">C.1.</a>	Between <a href="#">RFC7234</a> and draft 00 . . . . .	<a href="#">39</a>
<a href="#">C.2.</a>	Since <a href="#">draft-ietf-httpbis-cache-00</a> . . . . .	<a href="#">39</a>
<a href="#">C.3.</a>	Since <a href="#">draft-ietf-httpbis-cache-01</a> . . . . .	<a href="#">40</a>
<a href="#">C.4.</a>	Since <a href="#">draft-ietf-httpbis-cache-02</a> . . . . .	<a href="#">40</a>
<a href="#">C.5.</a>	Since <a href="#">draft-ietf-httpbis-cache-03</a> . . . . .	<a href="#">40</a>
<a href="#">C.6.</a>	Since <a href="#">draft-ietf-httpbis-cache-04</a> . . . . .	<a href="#">41</a>
<a href="#">C.7.</a>	Since <a href="#">draft-ietf-httpbis-cache-05</a> . . . . .	<a href="#">41</a>
<a href="#">C.8.</a>	Since <a href="#">draft-ietf-httpbis-cache-06</a> . . . . .	<a href="#">41</a>
<a href="#">C.9.</a>	Since <a href="#">draft-ietf-httpbis-cache-07</a> . . . . .	<a href="#">42</a>
<a href="#">C.10.</a>	Since <a href="#">draft-ietf-httpbis-cache-08</a> . . . . .	<a href="#">42</a>
<a href="#">C.11.</a>	Since <a href="#">draft-ietf-httpbis-cache-09</a> . . . . .	<a href="#">42</a>

<a href="#">C.12.</a>	Since <a href="#">draft-ietf-httpbis-cache-10</a> . . . . .	<a href="#">42</a>
<a href="#">C.13.</a>	Since <a href="#">draft-ietf-httpbis-cache-11</a> . . . . .	<a href="#">42</a>
<a href="#">C.14.</a>	Since <a href="#">draft-ietf-httpbis-cache-12</a> . . . . .	<a href="#">42</a>
<a href="#">C.15.</a>	Since <a href="#">draft-ietf-httpbis-cache-13</a> . . . . .	<a href="#">44</a>
Acknowledgments . . . . .		<a href="#">44</a>
Authors' Addresses . . . . .		<a href="#">44</a>

## [1.](#) Introduction

The Hypertext Transfer Protocol (HTTP) is a stateless application-level request/response protocol that uses extensible semantics and self-descriptive messages for flexible interaction with network-based hypertext information systems. It is typically used for distributed information systems, where the use of response caches can improve performance. This document defines aspects of HTTP related to caching and reusing response messages.

An HTTP `_cache_` is a local store of response messages and the subsystem that controls storage, retrieval, and deletion of messages in it. A cache stores cacheable responses to reduce the response time and network bandwidth consumption on future equivalent requests. Any client or server MAY use a cache, though not when acting as a tunnel.

A `_shared cache_` is a cache that stores responses for reuse by more than one user; shared caches are usually (but not always) deployed as a part of an intermediary. A `_private cache_`, in contrast, is dedicated to a single user; often, they are deployed as a component of a user agent.

HTTP caching's goal is significantly improving performance by reusing a prior response message to satisfy a current request. A cache considers a stored response "fresh", as defined in [Section 4.2](#), if it can be reused without "validation" (checking with the origin server to see if the cached response remains valid for this request). A fresh response can therefore reduce both latency and network overhead each time the cache reuses it. When a cached response is not fresh, it might still be reusable if validation can freshen it ([Section 4.3](#)) or if the origin is unavailable ([Section 4.2.4](#)).

This document obsoletes [RFC 7234](#), with the changes being summarized in [Appendix B](#).

### [1.1](#). Requirements Notation

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.

Section 2 of [[Semantics](#)] defines conformance criteria and contains considerations regarding error handling.

### [1.2](#). Syntax Notation

This specification uses the Augmented Backus-Naur Form (ABNF) notation of [[RFC5234](#)], extended with the notation for case-sensitivity in strings defined in [[RFC7405](#)].

It also uses a list extension, defined in Section 5.6.1 of [[Semantics](#)], that allows for compact definition of comma-separated lists using a '#' operator (similar to how the '\*' operator indicates repetition). [Appendix A](#) shows the collected grammar with all list operators expanded to standard ABNF notation.

The following core rule is included by reference, as defined in [\[RFC5234\], Appendix B.1](#): DIGIT (decimal 0-9).

[Semantics] defines the following rules:

HTTP-date = <HTTP-date, see [\[Semantics\]](#), Section 5.6.7>  
OWS = <OWS, see [\[Semantics\]](#), Section 5.6.3>  
field-name = <field-name, see [\[Semantics\]](#), Section 5.1>  
quoted-string = <quoted-string, see [\[Semantics\]](#), Section 5.6.4>  
token = <token, see [\[Semantics\]](#), Section 5.6.2>

### [1.3](#). Delta Seconds

The delta-seconds rule specifies a non-negative integer, representing time in seconds.

delta-seconds = 1\*DIGIT

A recipient parsing a delta-seconds value and converting it to binary form ought to use an arithmetic type of at least 31 bits of non-negative integer range. If a cache receives a delta-seconds value greater than the greatest integer it can represent, or if any of its subsequent calculations overflows, the cache MUST consider the value to be 2147483648 ( $2^{(31)}$ ) or the greatest positive integer it can conveniently represent.

| \*Note:\* The value 2147483648 is here for historical reasons,  
| represents infinity (over 68 years), and does not need to be  
| stored in binary form; an implementation could produce it as a  
| canned string if any overflow occurs, even if the calculations  
| are performed with an arithmetic type incapable of directly  
| representing that number. What matters here is that an  
| overflow be detected and not treated as a negative value in  
| later calculations.

## [2](#). Overview of Cache Operation

Proper cache operation preserves the semantics of HTTP transfers ([\[Semantics\]](#)) while reducing the transmission of information already held in the cache. Although caching is an entirely OPTIONAL feature of HTTP, it can be assumed that reusing a cached response is

desirable and that such reuse is the default behavior when no requirement or local configuration prevents it. Therefore, HTTP cache requirements are focused on preventing a cache from either storing a non-reusable response or reusing a stored response inappropriately, rather than mandating that caches always store and reuse particular responses.

The `_cache key_` is comprised of, at a minimum, the request method and target URI used to retrieve the stored response; the method determines under which circumstances that response can be used to satisfy a subsequent request. However, many HTTP caches in common use today only cache GET responses, and therefore only use the URI as the cache key, forwarding other methods.

If a request target is subject to content negotiation, the cache might store multiple responses for it. Caches differentiate these responses by incorporating values of the original request's selecting header fields into the cache key as well, using information in the Vary response header field, as per [Section 4.1](#).

Caches might incorporate additional material into the cache key. For example, user agent caches might include the referring site's identity, thereby "double keying" the cache to avoid some privacy risks (see [Section 7.2](#)).

Most commonly, caches store the successful result of a retrieval request: i.e., a 200 (OK) response to a GET request, which contains a representation of the target resource (Section 9.3.1 of [[Semantics](#)]). However, it is also possible to store redirects, negative results (e.g., 404 (Not Found)), incomplete results (e.g., 206 (Partial Content)), and responses to methods other than GET if the method's definition allows such caching and defines something suitable for use as a cache key.

A cache is `_disconnected_` when it cannot contact the origin server or otherwise find a forward path for a request. A disconnected cache can serve stale responses in some circumstances ([Section 4.2.4](#)).

### [3.](#) Storing Responses in Caches

A cache **MUST NOT** store a response to a request unless:

- o the request method is understood by the cache;
- o the response status code is final (see Section 15 of [[Semantics](#)]);
- o if the response status code is 206 or 304, or the "must-understand" cache directive (see [Section 5.2.2.2](#)) is present: the cache understands the response status code;
- o the "no-store" cache directive is not present in the response (see [Section 5.2.2.4](#));
- o if the cache is shared: the "private" response directive is either not present or allows a shared cache to store a modified response; see [Section 5.2.2.7](#));
- o if the cache is shared: the Authorization header field is not present in the request (see Section 11.6.2 of [[Semantics](#)]) or a response directive is present that explicitly allows shared caching (see [Section 3.5](#)); and,
- o the response contains at least one of:
  - \* a public response directive (see [Section 5.2.2.6](#));
  - \* a private response directive, if the cache is not shared (see [Section 5.2.2.7](#));
  - \* an Expires header field (see [Section 5.3](#));
  - \* a max-age response directive (see [Section 5.2.2.9](#));
  - \* if the cache is shared: an s-maxage response directive (see [Section 5.2.2.10](#));
  - \* a Cache Control Extension that allows it to be cached (see [Section 5.2.3](#)); or,
  - \* a status code that is defined as heuristically cacheable (see [Section 4.2.2](#)).

Note that a cache-control extension can override any of the

requirements listed; see [Section 5.2.3](#).

In this context, a cache has "understood" a request method or a response status code if it recognizes it and implements all specified caching-related behavior.

Note that, in normal operation, some caches will not store a response that has neither a cache validator nor an explicit expiration time, as such responses are not usually useful to store. However, caches are not prohibited from storing such responses.

### [3.1](#). Storing Header and Trailer Fields

Caches MUST include all received response header fields - including unrecognised ones - when storing a response; this assures that new HTTP header fields can be successfully deployed. However, the following exceptions are made:

- o The Connection header field and fields whose names are listed in it are required by Section 7.6.1 of [\[Semantics\]](#) to be removed before forwarding the message. This MAY be implemented by doing so before storage.
- o Likewise, some fields' semantics require them to be removed before forwarding the message, and this MAY be implemented by doing so before storage; see Section 7.6.1 of [\[Semantics\]](#) for some examples.
- o The no-cache ([Section 5.2.2.3](#)) and private ([Section 5.2.2.7](#)) cache directives can have arguments that prevent storage of header fields by all caches and shared caches, respectively.
- o Header fields that are specific to a client's proxy configuration MUST NOT be stored, unless the cache incorporates the identity of the proxy into the cache key. Effectively, this is limited to Proxy-Authenticate (Section 11.7.1 of [\[Semantics\]](#)), Proxy-Authentication-Info (Section 11.7.3 of [\[Semantics\]](#)), and Proxy-Authorization (Section 11.7.2 of [\[Semantics\]](#)).

Caches MAY either store trailer fields separate from header fields, or discard them. Caches MUST NOT combine trailer fields with header fields.

### [3.2.](#) Updating Stored Header Fields

Caches are required to update a stored response's header fields from another (typically newer) response in several situations; for example, see [Section 3.4](#), [Section 4.3.4](#) and [Section 4.3.5](#).

When doing so, the cache MUST add each header field in the provided response to the stored response, replacing field values that are already present, with the following exceptions:

- o Header fields excepted from storage in [Section 3.1](#),
- o Header fields that the cache's stored response depends upon, as described below,
- o Header fields that are automatically processed and removed by the recipient, as described below, and
- o The Content-Length header field.

In some cases, caches (especially in user agents) store the results of processing the received response, rather than the response itself, and updating header fields that affect that processing can result in inconsistent behavior and security issues. Caches in this situation MAY omit these header fields from updating stored responses on an exceptional basis, but SHOULD limit such omission to those fields necessary to assure integrity of the stored response.

For example, a browser might decode the content coding of a response while it is being received, creating a disconnect between the data it has stored and the response's original metadata. Updating that stored metadata with a different Content-Encoding header field would be problematic. Likewise, a browser might store a post-parse HTML tree, rather than the content received in the response; updating the Content-Type header field would not be workable in this case, because any assumptions about the format made in parsing would now be invalid.

Furthermore, some fields are automatically processed and removed by the HTTP implementation; for example, the Content-Range header field. Implementations MAY automatically omit such header fields from updates, even when the processing does not actually occur.

Note that the Content-\* prefix is not a signal that a header field is omitted from update; it is a convention for MIME header fields, not HTTP.

### [3.3.](#) Storing Incomplete Responses

If the request method is GET, the response status code is 200 (OK), and the entire response header section has been received, a cache MAY store a response body that is not complete (Section 3.4 of [\[Semantics\]](#)) if the stored response is recorded as being incomplete. Likewise, a 206 (Partial Content) response MAY be stored as if it were an incomplete 200 (OK) response. However, a cache MUST NOT store incomplete or partial-content responses if it does not support the Range and Content-Range header fields or if it does not understand the range units used in those fields.

A cache MAY complete a stored incomplete response by making a subsequent range request (Section 14.2 of [\[Semantics\]](#)) and combining the successful response with the stored response, as defined in [Section 3.4](#). A cache MUST NOT use an incomplete response to answer requests unless the response has been made complete, or the request is partial and specifies a range wholly within the incomplete response. A cache MUST NOT send a partial response to a client without explicitly marking it using the 206 (Partial Content) status code.

### [3.4.](#) Combining Partial Content

A response might transfer only a partial representation if the connection closed prematurely or if the request used one or more Range specifiers (Section 14.2 of [\[Semantics\]](#)). After several such transfers, a cache might have received several ranges of the same representation. A cache MAY combine these ranges into a single stored response, and reuse that response to satisfy later requests, if they all share the same strong validator and the cache complies with the client requirements in Section 15.3.7.3 of [\[Semantics\]](#).

When combining the new response with one or more stored responses, a cache MUST update the stored response header fields using the header fields provided in the new response, as per [Section 3.2](#).

### [3.5.](#) Storing Responses to Authenticated Requests

A shared cache MUST NOT use a cached response to a request with an Authorization header field (Section 11.6.2 of [[Semantics](#)]) to satisfy any subsequent request unless the response contains a Cache-Control field with a response directive ([Section 5.2.2](#)) that allows it to be stored by a shared cache and the cache conforms to the requirements of that directive for that response.

In this specification, the following response directives have such an effect: must-revalidate ([Section 5.2.2.1](#)), public ([Section 5.2.2.6](#)), and s-maxage ([Section 5.2.2.10](#)).

#### 4. Constructing Responses from Caches

When presented with a request, a cache MUST NOT reuse a stored response, unless:

- o The presented target URI (Section 7.1 of [[Semantics](#)]) and that of the stored response match, and
- o the request method associated with the stored response allows it to be used for the presented request, and
- o selecting header fields nominated by the stored response (if any) match those presented (see [Section 4.1](#)), and
- o the stored response does not contain the no-cache cache directive ([Section 5.2.2.3](#)), unless it is successfully validated ([Section 4.3](#)), and
- o the stored response is either:
  - \* fresh (see [Section 4.2](#)), or
  - \* allowed to be served stale (see [Section 4.2.4](#)), or
  - \* successfully validated (see [Section 4.3](#)).

Note that a cache-control extension can override any of the requirements listed; see [Section 5.2.3](#).

When a stored response is used to satisfy a request without validation, a cache MUST generate an Age header field ([Section 5.1](#)), replacing any present in the response with a value equal to the stored response's `current_age`; see [Section 4.2.3](#).

A cache MUST write through requests with methods that are unsafe (Section 9.2.1 of [[Semantics](#)]) to the origin server; i.e., a cache is not allowed to generate a reply to such a request before having forwarded the request and having received a corresponding response.

Also, note that unsafe requests might invalidate already-stored responses; see [Section 4.4](#).

A response that is stored or storable can be used to satisfy multiple requests, provided that it is allowed to reuse that response for the requests in question. This enables caches to `_collapse requests_` - or combine multiple incoming requests into a single forward one upon a cache miss - thereby reducing load on the origin server and network. However, note that if the response returned is not able to be used for some or all of the collapsed requests, additional latency might be introduced, because they will need to be forwarded to be satisfied.

When more than one suitable response is stored, a cache MUST use the most recent one (as determined by the Date header field). It can also forward the request with "Cache-Control: max-age=0" or "Cache-Control: no-cache" to disambiguate which response to use.

A cache that does not have a clock available MUST NOT use stored responses without revalidating them upon every use.

#### [4.1](#). Calculating Cache Keys with Vary

When a cache receives a request that can be satisfied by a stored response that has a Vary header field (Section 12.5.5 of [[Semantics](#)]), it MUST NOT use that response unless all the selecting header fields nominated by the Vary header field match in both the original request (i.e., that associated with the stored response),

and the presented request.

The selecting header fields from two requests are defined to match if and only if those in the first request can be transformed to those in the second request by applying any of:

- o adding or removing whitespace, where allowed in the header field's syntax
- o combining multiple header field lines with the same field name (see Section 5.2 of [[Semantics](#)])
- o normalizing both header field values in a way that is known to have identical semantics, according to the header field's specification (e.g., reordering field values when order is not significant; case-normalization, where values are defined to be case-insensitive)

If (after any normalization that might take place) a header field is absent from a request, it can only match another request if it is also absent there.

A Vary header field value containing a member "\*" always fails to match.

The stored response with matching selecting header fields is known as the `_selected response_`.

If multiple selected responses are available (potentially including responses without a Vary header field), the cache will need to choose one to use. When a selecting header field has a known mechanism for doing so (e.g., qvalues on Accept and similar request header fields), that mechanism MAY be used to select a preferred response. If such a mechanism is not available, or leads to equally preferred responses, the most recent response (as determined by the Date header field) is used, as per [Section 4](#).

Some resources mistakenly omit the Vary header field from their default response (i.e., the one sent when no more preferable response is available), with the effect of selecting it for requests to that

resource even when more preferable responses are available. When a cache has multiple responses for a target URI and one or more omits the Vary header field, it SHOULD use the most recent (see [Section 4.2.3](#)) valid Vary field value available to select an appropriate response for the request.

If no selected response is available, the cache cannot satisfy the presented request. Typically, it is forwarded to the origin server in a (possibly conditional; see [Section 4.3](#)) request.

## [4.2.](#) Freshness

A `_fresh_` response is one whose age has not yet exceeded its freshness lifetime. Conversely, a `_stale_` response is one where it has.

A response's `_freshness lifetime_` is the length of time between its generation by the origin server and its expiration time. An `_explicit expiration time_` is the time at which the origin server intends that a stored response can no longer be used by a cache without further validation, whereas a `_heuristic expiration time_` is assigned by a cache when no explicit expiration time is available.

A response's `_age_` is the time that has passed since it was generated by, or successfully validated with, the origin server.

When a response is fresh, it can be used to satisfy subsequent requests without contacting the origin server, thereby improving efficiency.

The primary mechanism for determining freshness is for an origin server to provide an explicit expiration time in the future, using either the Expires header field ([Section 5.3](#)) or the max-age response directive ([Section 5.2.2.9](#)). Generally, origin servers will assign future explicit expiration times to responses in the belief that the representation is not likely to change in a semantically significant way before the expiration time is reached.

If an origin server wishes to force a cache to validate every request, it can assign an explicit expiration time in the past to indicate that the response is already stale. Compliant caches will

normally validate a stale cached response before reusing it for subsequent requests (see [Section 4.2.4](#)).

Since origin servers do not always provide explicit expiration times, caches are also allowed to use a heuristic to determine an expiration time under certain circumstances (see [Section 4.2.2](#)).

The calculation to determine if a response is fresh is:

$$\text{response\_is\_fresh} = (\text{freshness\_lifetime} > \text{current\_age})$$

`freshness_lifetime` is defined in [Section 4.2.1](#); `current_age` is defined in [Section 4.2.3](#).

Clients can send the `max-age` or `min-fresh` request directives ([Section 5.2.1](#)) to constrain or relax freshness calculations for the corresponding response. However, caches are not required to honor them.

When calculating freshness, to avoid common problems in date parsing:

- o Although all date formats are specified to be case-sensitive, a cache recipient SHOULD match the field value case-insensitively.
- o If a cache recipient's internal implementation of time has less resolution than the value of an HTTP-date, the recipient MUST internally represent a parsed Expires date as the nearest time equal to or earlier than the received value.
- o A cache recipient MUST NOT allow local time zones to influence the calculation or comparison of an age or expiration time.
- o A cache recipient SHOULD consider a date with a zone abbreviation other than "GMT" to be invalid for calculating expiration.

Note that freshness applies only to cache operation; it cannot be used to force a user agent to refresh its display or reload a resource. See [Section 6](#) for an explanation of the difference between caches and history mechanisms.

#### [4.2.1.](#) Calculating Freshness Lifetime

A cache can calculate the freshness lifetime (denoted as `freshness_lifetime`) of a response by using the first match of:

- o If the cache is shared and the `s-maxage` response directive ([Section 5.2.2.10](#)) is present, use its value, or
- o If the `max-age` response directive ([Section 5.2.2.9](#)) is present, use its value, or
- o If the `Expires` response header field ([Section 5.3](#)) is present, use its value minus the value of the `Date` response header field (using the time the message was received if it is not present, as per [Section 10.2.2](#) of [[Semantics](#)]), or
- o Otherwise, no explicit expiration time is present in the response. A heuristic freshness lifetime might be applicable; see [Section 4.2.2](#).

Note that this calculation is not vulnerable to clock skew, since all of the information comes from the origin server.

When there is more than one value present for a given directive (e.g., two `Expires` header field lines or multiple `Cache-Control: max-age` directives), either the first occurrence should be used, or the response should be considered stale. If directives conflict (e.g., both `max-age` and `no-cache` are present), the most restrictive directive should be honored. Caches are encouraged to consider responses that have invalid freshness information (e.g., a `max-age` directive with non-integer content) to be stale.

#### [4.2.2.](#) Calculating Heuristic Freshness

Since origin servers do not always provide explicit expiration times, a cache MAY assign a heuristic expiration time when an explicit time is not specified, employing algorithms that use other field values (such as the `Last-Modified` time) to estimate a plausible expiration time. This specification does not provide specific algorithms, but does impose worst-case constraints on their results.

A cache MUST NOT use heuristics to determine freshness when an explicit expiration time is present in the stored response. Because of the requirements in [Section 3](#), this means that heuristics can only be used on responses without explicit freshness whose status codes are defined as `_heuristically cacheable_` (e.g., see Section 15.1 of [\[Semantics\]](#)), and those responses without explicit freshness that have been marked as explicitly cacheable (e.g., with a "public" response directive).

Note that in previous specifications heuristically cacheable response status codes were called "cacheable by default."

If the response has a Last-Modified header field (Section 8.8.2 of [\[Semantics\]](#)), caches are encouraged to use a heuristic expiration value that is no more than some fraction of the interval since that time. A typical setting of this fraction might be 10%.

| \*Note:\* [Section 13.9 of \[RFC2616\]](#) prohibited caches from  
| calculating heuristic freshness for URIs with query components  
| (i.e., those containing '?'). In practice, this has not been  
| widely implemented. Therefore, origin servers are encouraged  
| to send explicit directives (e.g., Cache-Control: no-cache) if  
| they wish to prevent caching.

#### [4.2.3](#). Calculating Age

The Age header field is used to convey an estimated age of the response message when obtained from a cache. The Age field value is the cache's estimate of the number of seconds since the origin server generated or validated the response. The Age value is therefore the sum of the time that the response has been resident in each of the caches along the path from the origin server, plus the time it has been in transit along network paths.

Age calculation uses the following data:

`_age_value_` The term "age\_value" denotes the value of the Age header field ([Section 5.1](#)), in a form appropriate for arithmetic operation; or 0, if not available.

`_date_value_` The term "date\_value" denotes the value of the Date header field, in a form appropriate for arithmetic operations. See Section 10.2.2 of [\[Semantics\]](#) for the definition of the Date header field, and for requirements regarding responses without it.

`_now_` The term "now" means "the current value of the clock at the

Internet-Draft

HTTP Caching

January 2021

host performing the calculation". A host ought to use NTP ([\[RFC5905\]](#)) or some similar protocol to synchronize its clocks to Coordinated Universal Time.

`_request_time_` The current value of the clock at the host at the time the request resulting in the stored response was made.

`_response_time_` The current value of the clock at the host at the time the response was received.

A response's age can be calculated in two entirely independent ways:

1. the "apparent\_age": `response_time` minus `date_value`, if the local clock is reasonably well synchronized to the origin server's clock. If the result is negative, the result is replaced by zero.
2. the "corrected\_age\_value", if all of the caches along the response path implement HTTP/1.1 or greater. A cache **MUST** interpret this value relative to the time the request was initiated, not the time that the response was received.

```
apparent_age = max(0, response_time - date_value);
```

```
response_delay = response_time - request_time;  
corrected_age_value = age_value + response_delay;
```

The `corrected_age_value` **MAY** be used as the `corrected_initial_age`. In circumstances where very old cache implementations that might not correctly insert Age are present, `corrected_initial_age` can be calculated more conservatively as

```
corrected_initial_age = max(apparent_age, corrected_age_value);
```

The `current_age` of a stored response can then be calculated by adding the time (in seconds) since the stored response was last validated by the origin server to the `corrected_initial_age`.

```
resident_time = now - response_time;  
current_age = corrected_initial_age + resident_time;
```

#### [4.2.4.](#) Serving Stale Responses

A "stale" response is one that either has explicit expiry information or is allowed to have heuristic expiry calculated, but is not fresh according to the calculations in [Section 4.2](#).

A cache MUST NOT generate a stale response if it is prohibited by an explicit in-protocol directive (e.g., by a "no-cache" cache directive, a "must-revalidate" cache-response-directive, or an applicable "s-maxage" or "proxy-revalidate" cache-response-directive; see [Section 5.2.2](#)).

A cache MUST NOT generate a stale response unless it is disconnected or doing so is explicitly permitted by the client or origin server (e.g., by the max-stale request directive in [Section 5.2.1](#), by extension directives such as those defined in [\[RFC5861\]](#), or by configuration in accordance with an out-of-band contract).

#### [4.3.](#) Validation

When a cache has one or more stored responses for a requested URI, but cannot serve any of them (e.g., because they are not fresh, or one cannot be selected; see [Section 4.1](#)), it can use the conditional request mechanism (Section 13.1 of [\[Semantics\]](#)) in the forwarded request to give the next inbound server an opportunity to select a valid stored response to use, updating the stored metadata in the process, or to replace the stored response(s) with a new response. This process is known as `_validating_` or `_revalidating_` the stored response.

##### [4.3.1.](#) Sending a Validation Request

When generating a conditional request for validation, a cache starts with either a request it is attempting to satisfy, or - if it is initiating the request independently - it synthesises a request using a stored response by copying the method, target URI, and request header fields identified by the Vary header field ([Section 4.1](#)).

It then updates that request with one or more precondition header

fields. These contain validator metadata sourced from stored response(s) that have the same cache key.

The precondition header fields are then compared by recipients to determine whether any stored response is equivalent to a current representation of the resource.

One such validator is the timestamp given in a Last-Modified header field (Section 8.8.2 of [[Semantics](#)]), which can be used in an If-Modified-Since header field for response validation, or in an If-Unmodified-Since or If-Range header field for representation selection (i.e., the client is referring specifically to a previously obtained representation with that timestamp).

Another validator is the entity-tag given in an ETag field (Section 8.8.3 of [[Semantics](#)]). One or more entity-tags, indicating one or more stored responses, can be used in an If-None-Match header field for response validation, or in an If-Match or If-Range header field for representation selection (i.e., the client is referring specifically to one or more previously obtained representations with the listed entity-tags).

#### [4.3.2.](#) Handling a Received Validation Request

Each client in the request chain may have its own cache, so it is common for a cache at an intermediary to receive conditional requests from other (outbound) caches. Likewise, some user agents make use of conditional requests to limit data transfers to recently modified representations or to complete the transfer of a partially retrieved representation.

If a cache receives a request that can be satisfied by reusing one of its stored 200 (OK) or 206 (Partial Content) responses, the cache SHOULD evaluate any applicable conditional header field preconditions received in that request with respect to the corresponding validators contained within the selected response. A cache MUST NOT evaluate conditional header fields that only apply to an origin server, occur in a request with semantics that cannot be satisfied with a cached response, or occur in a request with a target resource for which it has no stored responses; such preconditions are likely intended for

some other (inbound) server.

The proper evaluation of conditional requests by a cache depends on the received precondition header fields and their precedence. In summary, the If-Match and If-Unmodified-Since conditional header fields are not applicable to a cache, and If-None-Match takes precedence over If-Modified-Since. See Section 13.2.2 of [[Semantics](#)] for a complete specification of precondition precedence.

A request containing an If-None-Match header field (Section 13.1.2 of [[Semantics](#)]) indicates that the client wants to validate one or more of its own stored responses in comparison to whichever stored response is selected by the cache.

When a cache decides to revalidate its own stored responses for a request that contains an If-None-Match list of entity-tags, the cache MAY combine the received list with a list of entity-tags from its own stored set of responses (fresh or stale) and send the union of the two lists as a replacement If-None-Match header field value in the forwarded request. If a stored response contains only partial content, the cache MUST NOT include its entity-tag in the union unless the request is for a range that would be fully satisfied by

that partial stored response. If the response to the forwarded request is 304 (Not Modified) and has an ETag field value with an entity-tag that is not in the client's list, the cache MUST generate a 200 (OK) response for the client by reusing its corresponding stored response, as updated by the 304 response metadata ([Section 4.3.4](#)).

If an If-None-Match header field is not present, a request containing an If-Modified-Since header field (Section 13.1.3 of [[Semantics](#)]) indicates that the client wants to validate one or more of its own stored responses by modification date.

If a request contains an If-Modified-Since header field and the Last-Modified header field is not present in a selected stored response, a cache SHOULD use the stored response's Date field value (or, if no Date field is present, the time that the stored response was received) to evaluate the conditional.

A cache that implements partial responses to range requests, as

defined in Section 14.2 of [[Semantics](#)], also needs to evaluate a received If-Range header field (Section 13.1.5 of [[Semantics](#)]) regarding its selected stored response.

#### [4.3.3.](#) Handling a Validation Response

Cache handling of a response to a conditional request depends upon its status code:

- o A 304 (Not Modified) response status code indicates that the stored response can be updated and reused; see [Section 4.3.4](#).
- o A full response (i.e., one containing content) indicates that none of the stored responses nominated in the conditional request is suitable. Instead, the cache MUST use the full response to satisfy the request. The cache MAY store such a full response, subject to its constraints (see [Section 3](#)).
- o However, if a cache receives a 5xx (Server Error) response while attempting to validate a response, it can either forward this response to the requesting client, or act as if the server failed to respond. In the latter case, the cache can send a previously stored response, subject to its constraints on doing so (see [Section 4.2.4](#)), or retry the validation request.

#### [4.3.4.](#) Freshening Stored Responses upon Validation

When a cache receives a 304 (Not Modified) response and already has one or more stored 200 (OK) responses for the applicable cache key, the cache needs to identify which (if any) are to be updated by the new information provided, and then do so.

The stored response(s) to update are identified by using the first match (if any) of:

- o If the new response contains one or more `_strong validators_` (see Section 8.8.1 of [[Semantics](#)]), then each of those strong

validators identify the selected representation for update. All the stored responses with one of those same strong validators are identified for update. If none of the stored responses contain at least one of the same strong validators, then the cache MUST NOT use the new response to update any stored responses.

- o If the new response contains no strong validators but does contain one or more `_weak validators_`, and those validators correspond to one of the cache's stored responses, then the most recent of those matching stored responses is identified for update.
- o If the new response does not include any form of validator (such as where a client generates an If-Modified-Since request from a source other than the Last-Modified response header field), and there is only one stored response, and that stored response also lacks a validator, then that stored response is identified for update.

For each stored response identified, the cache MUST update its header fields with the header fields provided in the 304 (Not Modified) response, as per [Section 3.2](#).

#### [4.3.5](#). Freshening Responses with HEAD

A response to the HEAD method is identical to what an equivalent request made with a GET would have been, without sending the content. This property of HEAD responses can be used to invalidate or update a cached GET response if the more efficient conditional GET request mechanism is not available (due to no validators being present in the stored response) or if transmission of the content is not desired even if it has changed.

When a cache makes an inbound HEAD request for a target URI and receives a 200 (OK) response, the cache SHOULD update or invalidate each of its stored GET responses that could have been selected for that request (see [Section 4.1](#)).

For each of the stored responses that could have been selected, if the stored response and HEAD response have matching values for any received validator fields (ETag and Last-Modified) and, if the HEAD response has a Content-Length header field, the value of Content-Length matches that of the stored response, the cache SHOULD update

the stored response as described below; otherwise, the cache SHOULD consider the stored response to be stale.

If a cache updates a stored response with the metadata provided in a HEAD response, the cache MUST use the header fields provided in the HEAD response to update the stored response (see [Section 3.2](#)).

#### [4.4](#). Invalidating Stored Responses

Because unsafe request methods (Section 9.2.1 of [\[Semantics\]](#)) such as PUT, POST or DELETE have the potential for changing state on the origin server, intervening caches are required to invalidate stored responses to keep their contents up to date.

A cache MUST invalidate the target URI (Section 7.1 of [\[Semantics\]](#)) when a non-error status code is received in response to an unsafe request method (including methods whose safety is unknown).

A cache MAY invalidate other URIs when a non-error status code is received in response to an unsafe request method (including methods whose safety is unknown). In particular, the URI(s) in the Location and Content-Location response header fields (if present) are candidates for invalidation; other URIs might be discovered through mechanisms not specified in this document. However, a cache MUST NOT trigger an invalidation under these conditions if the origin (Section 4.3.1 of [\[Semantics\]](#)) of the URI to be invalidated differs from that of the target URI (Section 7.1 of [\[Semantics\]](#)). This helps prevent denial-of-service attacks.

`_Invalidate_` means that the cache will either remove all stored responses whose target URI matches the given URI, or will mark them as "invalid" and in need of a mandatory validation before they can be sent in response to a subsequent request.

A "non-error response" is one with a 2xx (Successful) or 3xx (Redirection) status code.

Note that this does not guarantee that all appropriate responses are invalidated globally; a state-changing request would only invalidate responses in the caches it travels through.

## [5.](#) Field Definitions

This section defines the syntax and semantics of HTTP fields related to caching.

### [5.1.](#) Age

The "Age" response header field conveys the sender's estimate of the time since the response was generated or successfully validated at the origin server. Age values are calculated as specified in [Section 4.2.3](#).

Age = delta-seconds

The Age field value is a non-negative integer, representing time in seconds (see [Section 1.3](#)).

Although it is defined as a singleton header field, a cache encountering a message with multiple Age field lines SHOULD use the first field line, discarding subsequent ones.

If the field value (after discarding additional lines, as per above) is invalid (e.g., it contains a list or something other than a non-negative integer), a cache SHOULD consider the response to be stale.

The presence of an Age header field implies that the response was not generated or validated by the origin server for this request. However, lack of an Age header field does not imply the origin was contacted.

### [5.2.](#) Cache-Control

The "Cache-Control" header field is used to list directives for caches along the request/response chain. Such cache directives are unidirectional in that the presence of a directive in a request does not imply that the same directive is present in the response, or to be repeated in it.

See [Section 5.2.3](#) for information about how Cache-Control directives defined elsewhere are handled.

A proxy, whether or not it implements a cache, MUST pass cache directives through in forwarded messages, regardless of their significance to that application, since the directives might apply to all recipients along the request/response chain. It is not possible to target a directive to a specific cache.

Cache directives are identified by a token, to be compared case-insensitively, and have an optional argument that can use both token and quoted-string syntax. For the directives defined below that define arguments, recipients ought to accept both forms, even if a specific form is required for generation.

```
Cache-Control = #cache-directive
```

```
cache-directive = token [ "=" ( token / quoted-string ) ]
```

For the cache directives defined below, no argument is defined (nor allowed) unless stated otherwise.

#### [5.2.1.](#) Request Cache-Control Directives

This section defines cache request directives. They are advisory; caches MAY implement them, but are not required to.

##### [5.2.1.1.](#) max-age

Argument syntax:

```
delta-seconds (see Section 1.3)
```

The "max-age" request directive indicates that the client prefers a response whose age is less than or equal to the specified number of seconds. Unless the max-stale request directive is also present, the client does not wish to receive a stale response.

This directive uses the token form of the argument syntax: e.g., 'max-age=5' not 'max-age="5"'. A sender MUST NOT generate the quoted-string form.

##### [5.2.1.2.](#) max-stale

Argument syntax:

```
delta-seconds (see Section 1.3)
```

The "max-stale" request directive indicates that the client will accept a response that has exceeded its freshness lifetime. If a value is present, then the client is willing to accept a response

that has exceeded its freshness lifetime by no more than the specified number of seconds. If no value is assigned to max-stale, then the client will accept a stale response of any age.

This directive uses the token form of the argument syntax: e.g., 'max-stale=10' not 'max-stale="10"'. A sender MUST NOT generate the quoted-string form.

#### [5.2.1.3.](#) min-fresh

Argument syntax:

delta-seconds (see [Section 1.3](#))

The "min-fresh" request directive indicates that the client prefers a response whose freshness lifetime is no less than its current age plus the specified time in seconds. That is, the client wants a response that will still be fresh for at least the specified number of seconds.

This directive uses the token form of the argument syntax: e.g., 'min-fresh=20' not 'min-fresh="20"'. A sender MUST NOT generate the quoted-string form.

#### [5.2.1.4.](#) no-cache

The "no-cache" request directive indicates that the client prefers stored response not be used to satisfy the request without successful validation on the origin server.

#### [5.2.1.5.](#) no-store

The "no-store" request directive indicates that a cache MUST NOT store any part of either this request or any response to it. This directive applies to both private and shared caches. "MUST NOT store" in this context means that the cache MUST NOT intentionally store the information in non-volatile storage, and MUST make a best-effort attempt to remove the information from volatile storage as promptly as possible after forwarding it.

This directive is *not* a reliable or sufficient mechanism for ensuring privacy. In particular, malicious or compromised caches might not recognize or obey this directive, and communications networks might be vulnerable to eavesdropping.

Note that if a request containing this directive is satisfied from a cache, the no-store request directive does not apply to the already stored response.

#### [5.2.1.6.](#) no-transform

The "no-transform" request directive indicates that the client is asking for intermediaries to avoid transforming the content, as defined in Section 7.7 of [[Semantics](#)].

#### [5.2.1.7.](#) only-if-cached

The "only-if-cached" request directive indicates that the client only wishes to obtain a stored response. Caches that honor this request directive SHOULD, upon receiving it, either respond using a stored response consistent with the other constraints of the request, or respond with a 504 (Gateway Timeout) status code.

### [5.2.2.](#) Response Cache-Control Directives

This section defines cache response directives. A cache MUST obey the Cache-Control directives defined in this section.

#### [5.2.2.1.](#) must-revalidate

The "must-revalidate" response directive indicates that once the response has become stale, a cache MUST NOT reuse that response to satisfy another request until it has been successfully validated by the origin, as defined by [Section 4.3](#).

The must-revalidate directive is necessary to support reliable operation for certain protocol features. In all circumstances a

cache MUST NOT ignore the must-revalidate directive; in particular, if a cache is disconnected, the cache MUST generate an error response rather than reuse the stale response. The generated status code SHOULD be 504 (Gateway Timeout) unless another error status code is more applicable.

The must-revalidate directive ought to be used by servers if and only if failure to validate a request could cause incorrect operation, such as a silently unexecuted financial transaction.

The must-revalidate directive also permits a shared cache to reuse a response to a request containing an Authorization header field (Section 11.6.2 of [[Semantics](#)]), subject to the above requirement on revalidation ([Section 3.5](#)).

#### [5.2.2.2](#). must-understand

The "must-understand" response directive limits caching of the response to a cache that understands and conforms to the requirements for that response's status code.

Responses containing "must-understand" SHOULD also contain the "no-store" directive; caches that implement "must-understand" SHOULD ignore the "no-store" directive in responses that contain both directives and a status code that the cache understands and conforms to any related caching requirements.

#### [5.2.2.3](#). no-cache

Argument syntax:

#field-name

The "no-cache" response directive, in its unqualified form (without an argument), indicates that the response MUST NOT be used to satisfy any other request without forwarding it for validation and receiving a successful response; see [Section 4.3](#).

This allows an origin server to prevent a cache from using the response to satisfy a request without contacting it, even by caches that have been configured to send stale responses.

The qualified form of no-cache response directive, with an argument that lists one or more field names, indicates that a cache MAY use the response to satisfy a subsequent request, subject to any other restrictions on caching, if the listed header fields are excluded from the subsequent response or the subsequent response has been successfully revalidated with the origin server (updating or removing those fields). This allows an origin server to prevent the re-use of certain header fields in a response, while still allowing caching of the rest of the response.

The field names given are not limited to the set of header fields defined by this specification. Field names are case-insensitive.

This directive uses the quoted-string form of the argument syntax. A sender SHOULD NOT generate the token form (even if quoting appears not to be needed for single-entry lists).

| \*Note:\* The qualified form of the directive is often handled by  
| caches as if an unqualified no-cache directive was received;  
| i.e., the special handling for the qualified form is not widely  
| implemented.

#### [5.2.2.4.](#) no-store

The "no-store" response directive indicates that a cache MUST NOT store any part of either the immediate request or response, and MUST NOT use the response to satisfy any other request.

This directive applies to both private and shared caches. "MUST NOT store" in this context means that the cache MUST NOT intentionally store the information in non-volatile storage, and MUST make a best-effort attempt to remove the information from volatile storage as promptly as possible after forwarding it.

This directive is not a reliable or sufficient mechanism for ensuring privacy. In particular, malicious or compromised caches might not recognize or obey this directive, and communications networks might be vulnerable to eavesdropping.

Note that the "must-understand" cache directive overrides "no-store" in certain circumstances; see [Section 5.2.2.2](#).

#### [5.2.2.5.](#) no-transform

The "no-transform" response directive indicates that an intermediary (regardless of whether it implements a cache) MUST NOT transform the content, as defined in Section 7.7 of [[Semantics](#)].

#### [5.2.2.6.](#) public

The "public" response directive indicates that a cache MAY store the response even if it would otherwise be prohibited, subject to the constraints defined in [Section 3](#). In other words, public explicitly marks the response as cacheable. For example, public permits a shared cache to reuse a response to a request containing an Authorization header field ([Section 3.5](#)).

Note that it is unnecessary to add the public directive to a response that is already cacheable according to [Section 3](#).

If a response with the public directive has no explicit freshness information, it is heuristically cacheable ([Section 4.2.2](#)).

#### [5.2.2.7.](#) private

Argument syntax:

#field-name

The unqualified "private" response directive indicates that a shared cache MUST NOT store the response (i.e., the response is intended for a single user). It also indicates that a private cache MAY store the response, subject the constraints defined in [Section 3](#), even if the response would not otherwise be heuristically cacheable by a private cache.

If a qualified private response directive is present, with an argument that lists one or more field names, then only the listed header fields are limited to a single user: a shared cache MUST NOT store the listed header fields if they are present in the original response, but MAY store the remainder of the response message without those header fields, subject the constraints defined in [Section 3](#).

The field names given are not limited to the set of header fields defined by this specification. Field names are case-insensitive.

This directive uses the quoted-string form of the argument syntax. A sender SHOULD NOT generate the token form (even if quoting appears not to be needed for single-entry lists).

| \*Note:\* This usage of the word "private" only controls where  
| the response can be stored; it cannot ensure the privacy of the  
| message content. Also, the qualified form of the directive is  
| often handled by caches as if an unqualified private directive  
| was received; i.e., the special handling for the qualified form  
| is not widely implemented.

#### [5.2.2.8.](#) proxy-revalidate

The "proxy-revalidate" response directive indicates that once the response has become stale, a shared cache MUST NOT reuse that response to satisfy another request until it has been successfully validated by the origin, as defined by [Section 4.3](#). This is analogous to must-revalidate ([Section 5.2.2.1](#)), except that proxy-revalidate does not apply to private caches.

Note that "proxy-revalidate" on its own does not imply that a response is cacheable. For example, it might be combined with the public directive ([Section 5.2.2.6](#)), allowing the response to be cached while requiring only a shared cache to revalidate when stale.

#### [5.2.2.9.](#) max-age

Argument syntax:

delta-seconds (see [Section 1.3](#))

The "max-age" response directive indicates that the response is to be considered stale after its age is greater than the specified number of seconds.

This directive uses the token form of the argument syntax: e.g., 'max-age=5' not 'max-age="5"'. A sender MUST NOT generate the quoted-string form.

#### [5.2.2.10.](#) s-maxage

Argument syntax:

delta-seconds (see [Section 1.3](#))

The "s-maxage" response directive indicates that, for a shared cache, the maximum age specified by this directive overrides the maximum age specified by either the max-age directive or the Expires header field.

The s-maxage directive incorporates the proxy-revalidate ([Section 5.2.2.8](#)) response directive's semantics for a shared cache. A shared cache **MUST NOT** reuse a stale response with s-maxage to satisfy another request until it has been successfully validated by the origin, as defined by [Section 4.3](#). This directive also permits a shared cache to reuse a response to a request containing an Authorization header field, subject to the above requirements on maximum age and revalidation ([Section 3.5](#)).

This directive uses the token form of the argument syntax: e.g., 's-maxage=10' not 's-maxage="10"'. A sender **MUST NOT** generate the quoted-string form.

#### [5.2.3.](#) Cache Control Extensions

The Cache-Control header field can be extended through the use of one or more cache-extension tokens, each with an optional value. A cache **MUST** ignore unrecognized cache directives.

Informational extensions (those that do not require a change in cache behavior) can be added without changing the semantics of other directives.

Behavioral extensions are designed to work by acting as modifiers to the existing base of cache directives. Both the new directive and the old directive are supplied, such that applications that do not understand the new directive will default to the behavior specified by the old directive, and those that understand the new directive will recognize it as modifying the requirements associated with the old directive. In this way, extensions to the existing cache-control directives can be made without breaking deployed caches.

Internet-Draft

HTTP Caching

January 2021

For example, consider a hypothetical new response directive called "community" that acts as a modifier to the private directive: in addition to private caches, any cache that is shared only by members of the named community is allowed to cache the response. An origin server wishing to allow the UCI community to use an otherwise private response in their shared cache(s) could do so by including

```
Cache-Control: private, community="UCI"
```

A cache that recognizes such a community cache-extension could broaden its behavior in accordance with that extension. A cache that does not recognize the community cache-extension would ignore it and adhere to the private directive.

New extension directives ought to consider defining:

- o What it means for a directive to be specified multiple times,
- o When the directive does not take an argument, what it means when an argument is present,
- o When the directive requires an argument, what it means when it is missing,
- o Whether the directive is specific to requests, responses, or able to be used in either.

#### 5.2.4. Cache Directive Registry

The "Hypertext Transfer Protocol (HTTP) Cache Directive Registry" defines the namespace for the cache directives. It has been created and is now maintained at <<https://www.iana.org/assignments/http-cache-directives>>.

A registration MUST include the following fields:

- o Cache Directive Name
- o Pointer to specification text

Values to be added to this namespace require IETF Review (see [\[RFC8126\], Section 4.8](#)).

### 5.3. Expires

The "Expires" response header field gives the date/time after which the response is considered stale. See [Section 4.2](#) for further discussion of the freshness model.

The presence of an Expires header field does not imply that the original resource will change or cease to exist at, before, or after that time.

The Expires field value is an HTTP-date timestamp, as defined in Section 5.6.7 of [[Semantics](#)].

Expires = HTTP-date

For example

Expires: Thu, 01 Dec 1994 16:00:00 GMT

A cache recipient MUST interpret invalid date formats, especially the value "0", as representing a time in the past (i.e., "already expired").

If a response includes a Cache-Control header field with the max-age directive ([Section 5.2.2.9](#)), a recipient MUST ignore the Expires header field. Likewise, if a response includes the s-maxage directive ([Section 5.2.2.10](#)), a shared cache recipient MUST ignore the Expires header field. In both these cases, the value in Expires is only intended for recipients that have not yet implemented the Cache-Control header field.

An origin server without a clock MUST NOT generate an Expires header field unless its value represents a fixed time in the past (always expired) or its value has been associated with the resource by a system or user with a reliable clock.

Historically, HTTP required the Expires field value to be no more than a year in the future. While longer freshness lifetimes are no longer prohibited, extremely large values have been demonstrated to cause problems (e.g., clock overflows due to use of 32-bit integers for time values), and many caches will evict a response far sooner than that.

#### [5.4.](#) Pragma

The "Pragma" request header field was defined for HTTP/1.0 caches, so that clients could specify a "no-cache" request (as Cache-Control was not defined until HTTP/1.1).

However, support for Cache-Control is now widespread. As a result, this specification deprecates Pragma.

| \*Note:\* Because the meaning of "Pragma: no-cache" in responses  
| was never specified, it does not provide a reliable replacement  
| for "Cache-Control: no-cache" in them.

#### [5.5.](#) Warning

The "Warning" header field was used to carry additional information about the status or transformation of a message that might not be reflected in the status code. This specification obsoletes it, as it is not widely generated or surfaced to users. The information it carried can be gleaned from examining other header fields, such as Age.

### [6.](#) Relationship to Applications and Other Caches

Applications using HTTP often specify additional forms of caching. For example, Web browsers often have history mechanisms such as "Back" buttons that can be used to redisplay a representation retrieved earlier in a session.

Likewise, some Web browsers implement caching of images and other assets within a page view; they may or may not honor HTTP caching semantics.

The requirements in this specification do not necessarily apply to how applications use data after it is retrieved from a HTTP cache. For example, a history mechanism can display a previous representation even if it has expired, and an application can use cached data in other ways beyond its freshness lifetime.

This specification does not prohibit the application from taking HTTP caching into account; for example, a history mechanism might tell the user that a view is stale, or it might honor cache directives (e.g., Cache-Control: no-store).

However, when an application caches data and does not make this apparent to or easily controllable by the user, it is strongly encouraged to define its operation with respect to HTTP cache directives, so as not to surprise authors who expect caching semantics to be honoured. For example, while it might be reasonable to define an application cache "above" HTTP that allows a response containing Cache-Control: no-store to be reused for requests that are directly related to the request that fetched it (such as those created during the same page load), it would likely be surprising and confusing to users and authors if it were allowed to be reused for requests unrelated in any way to the one from which it was obtained.

## [7.](#) Security Considerations

This section is meant to inform developers, information providers, and users of known security concerns specific to HTTP caching. More general security considerations are addressed in "HTTP/1.1" (Section 11 of [[Messaging](#)]) and "HTTP Semantics" ([Section 17](#) of [[Semantics](#)]).

Caches expose additional potential vulnerabilities, since the contents of the cache represent an attractive target for malicious exploitation. Because cache contents persist after an HTTP request is complete, an attack on the cache can reveal information long after a user believes that the information has been removed from the network. Therefore, cache contents need to be protected as sensitive information.

### [7.1.](#) Cache Poisoning

Various attacks might be amplified by being stored in a shared cache. Such "cache poisoning" attacks use the cache to distribute malicious content to many clients, and are especially effective when an attacker can use implementation flaws, elevated privileges, or other

techniques to insert such a response into a cache.

One common attack vector for cache poisoning is to exploit differences in message parsing on proxies and in user agents; see Section 6.3 of [[Messaging](#)] for the relevant requirements regarding HTTP/1.1.

## [7.2.](#) Timing Attacks

Because one of the primary uses of a cache is to optimise performance, its use can "leak" information about what resources have been previously requested.

For example, if a user visits a site and their browser caches some of its responses, and then navigates to a second site, that site can attempt to load responses it knows exists on the first site. If they load quickly, it can be assumed that the user has visited that site, or even a specific page on it.

Such "timing attacks" can be mitigated by adding more information to the cache key, such as the identity of the referring site (to prevent the attack described above). This is sometimes called "double keying."

## [7.3.](#) Caching of Sensitive Information

Implementation and deployment flaws (as well as misunderstanding of cache operation) might lead to caching of sensitive information (e.g., authentication credentials) that is thought to be private, exposing it to unauthorized parties.

Note that the Set-Cookie response header field [[RFC6265](#)] does not inhibit caching; a cacheable response with a Set-Cookie header field can be (and often is) used to satisfy subsequent requests to caches. Servers who wish to control caching of these responses are encouraged to emit appropriate Cache-Control response header fields.

## [8.](#) IANA Considerations

The change controller for the following registrations is: "IETF (iesg@ietf.org) - Internet Engineering Task Force".

### 8.1. Field Name Registration

First, introduce the new "Hypertext Transfer Protocol (HTTP) Field Name Registry" at <<https://www.iana.org/assignments/http-fields>> as described in Section 18.4 of [[Semantics](#)].

Then, please update the registry with the field names listed in the table below:

Field Name	Status	Ref.	Comments
Age	standard	5.1	
Cache-Control	standard	5.2	
Expires	standard	5.3	
Pragma	standard	5.4	
Warning	obsoleted	5.5	

Table 1

### 8.2. Cache Directive Registration

Please update the "Hypertext Transfer Protocol (HTTP) Cache Directive Registry" at <<https://www.iana.org/assignments/http-cache-directives>> with the registration procedure of [Section 5.2.4](#) and the cache directive names summarized in the table below.

Cache Directive	Reference
max-age	<a href="#">Section 5.2.1.1</a> , <a href="#">Section 5.2.2.9</a>
max-stale	<a href="#">Section 5.2.1.2</a>
min-fresh	<a href="#">Section 5.2.1.3</a>
must-revalidate	<a href="#">Section 5.2.2.1</a>
must-understand	<a href="#">Section 5.2.2.2</a>

no-cache	<a href="#">Section 5.2.1.4</a> , <a href="#">Section 5.2.2.3</a>
no-store	<a href="#">Section 5.2.1.5</a> , <a href="#">Section 5.2.2.4</a>
no-transform	<a href="#">Section 5.2.1.6</a> , <a href="#">Section 5.2.2.5</a>
only-if-cached	<a href="#">Section 5.2.1.7</a>
private	<a href="#">Section 5.2.2.7</a>
proxy-revalidate	<a href="#">Section 5.2.2.8</a>
public	<a href="#">Section 5.2.2.6</a>
s-maxage	<a href="#">Section 5.2.2.10</a>

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Table 2

### [8.3.](#) Warn Code Registry

Please add a note to the "Hypertext Transfer Protocol (HTTP) Warn Codes" registry at <https://www.iana.org/assignments/http-warn-codes> to the effect that Warning is obsoleted.

## [9.](#) References

### [9.1.](#) Normative References

[Messaging]

Fielding, R., Ed., Nottingham, M., Ed., and J. Reschke, Ed., "HTTP/1.1", Work in Progress, Internet-Draft, [draft-ietf-httpbis-messaging-14](#), January 13, 2021, <https://tools.ietf.org/html/draft-ietf-httpbis-messaging-14>.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC5234] Crocker, D., Ed. and P. Overell, "Augmented BNF for Syntax Specifications: ABNF", STD 68, [RFC 5234](#), DOI 10.17487/RFC5234, January 2008, <https://www.rfc-editor.org/info/rfc5234>.

[RFC 7405](#), DOI 10.17487/RFC7405, December 2014,  
<<https://www.rfc-editor.org/info/rfc7405>>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in [RFC 2119](#) Key Words", [BCP 14](#), [RFC 8174](#), DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

[Semantics]

Fielding, R., Ed., Nottingham, M., Ed., and J. Reschke, Ed., "HTTP Semantics", Work in Progress, Internet-Draft, [draft-ietf-httpbis-semantics-14](#), January 13, 2021, <<https://tools.ietf.org/html/draft-ietf-httpbis-semantics-14>>.

## 9.2. Informative References

[RFC2616] Fielding, R., Gettys, J., Mogul, J., Frystyk, H., Masinter, L., Leach, P., and T. Berners-Lee, "Hypertext Transfer Protocol -- HTTP/1.1", [RFC 2616](#), DOI 10.17487/RFC2616, June 1999, <<https://www.rfc-editor.org/info/rfc2616>>.

[RFC5861] Nottingham, M., "HTTP Cache-Control Extensions for Stale Content", [RFC 5861](#), DOI 10.17487/RFC5861, April 2010, <<https://www.rfc-editor.org/info/rfc5861>>.

[RFC5905] Mills, D., Martin, J., Ed., Burbank, J., and W. Kasch, "Network Time Protocol Version 4: Protocol and Algorithms Specification", [RFC 5905](#), DOI 10.17487/RFC5905, June 2010, <<https://www.rfc-editor.org/info/rfc5905>>.

[RFC6265] Barth, A., "HTTP State Management Mechanism", [RFC 6265](#), DOI 10.17487/RFC6265, April 2011, <<https://www.rfc-editor.org/info/rfc6265>>.

[RFC7234] Fielding, R., Ed., Nottingham, M., Ed., and J. F. Reschke, Ed., "Hypertext Transfer Protocol (HTTP): Caching", [RFC 7234](#), DOI 10.17487/RFC7234, June 2014, <<https://www.rfc-editor.org/info/rfc7234>>.

[RFC8126] Cotton, M., Leiba, B., and T. Narten, "Guidelines for Writing an IANA Considerations Section in RFCs", [BCP 26](#), [RFC 8126](#), DOI 10.17487/RFC8126, June 2017, <<https://www.rfc-editor.org/info/rfc8126>>.

## [Appendix A](#). Collected ABNF

In the collected ABNF below, list rules are expanded as per Section 5.6.1.1 of [[Semantics](#)].

Age = delta-seconds

Cache-Control = [ cache-directive \*( OWS "," OWS cache-directive ) ]

Expires = HTTP-date

HTTP-date = <HTTP-date, see [[Semantics](#)], Section 5.6.7>

OWS = <OWS, see [[Semantics](#)], Section 5.6.3>

cache-directive = token [ "=" ( token / quoted-string ) ]

delta-seconds = 1\*DIGIT

field-name = <field-name, see [[Semantics](#)], Section 5.1>

quoted-string = <quoted-string, see [[Semantics](#)], Section 5.6.4>

token = <token, see [[Semantics](#)], Section 5.6.2>

## [Appendix B](#). Changes from [RFC 7234](#)

Handling of duplicate and conflicting cache directives has been clarified. ([Section 4.2.1](#))

Cache invalidation of the URIs in the Location and Content-Location header fields is no longer required, but still allowed. ([Section 4.4](#))

Cache invalidation of the URIs in the Location and Content-Location header fields is disallowed when the origin is different; previously, it was the host. ([Section 4.4](#))

Handling invalid and multiple Age header field values has been clarified. ([Section 5.1](#))

Some cache directives defined by this specification now have stronger prohibitions against generating the quoted form of their values, since this has been found to create interoperability problems. Consumers of extension cache directives are no longer required to accept both token and quoted-string forms, but they still need to

parse them properly for unknown extensions. ([Section 5.2](#))

The "public" and "private" cache directives were clarified, so that they do not make responses reusable under any condition. ([Section 5.2.2](#))

The "must-understand" cache directive was introduced; caches are no longer required to understand the semantics of new response status codes unless it is present. ([Section 5.2.2.2](#))

The Warning response header was obsoleted. Much of the information supported by Warning could be gleaned by examining the response, and the remaining warn-codes - although potentially useful - were entirely advisory. In practice, Warning was not added by caches or intermediaries. ([Section 5.5](#))

#### [Appendix C](#). Change Log

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

##### [C.1](#). Between [RFC7234](#) and draft 00

The changes were purely editorial:

- o Change boilerplate and abstract to indicate the "draft" status, and update references to ancestor specifications.
- o Remove version "1.1" from document title, indicating that this specification applies to all HTTP versions.
- o Adjust historical notes.
- o Update links to sibling specifications.
- o Replace sections listing changes from [RFC 2616](#) by new empty sections referring to RFC 723x.
- o Remove acknowledgements specific to RFC 723x.
- o Move "Acknowledgements" to the very end and make them unnumbered.

## C.2. Since [draft-ietf-httpbis-cache-00](#)

The changes are purely editorial:

- o Moved all extensibility tips, registration procedures, and registry tables from the IANA considerations to normative sections, reducing the IANA considerations to just instructions that will be removed prior to publication as an RFC.

Fielding, et al.

Expires July 17, 2021

[Page 39]

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Internet-Draft

HTTP Caching

January 2021

## C.3. Since [draft-ietf-httpbis-cache-01](#)

- o Cite [RFC 8126](#) instead of [RFC 5226](#) (<<https://github.com/httpwg/http-core/issues/75>>)
- o In [Section 5.4](#), misleading statement about the relation between Pragma and Cache-Control (<<https://github.com/httpwg/http-core/issues/92>>, <<https://www.rfc-editor.org/errata/eid4674>>)

## C.4. Since [draft-ietf-httpbis-cache-02](#)

- o In [Section 3](#), explain that only final responses are cacheable (<<https://github.com/httpwg/http-core/issues/29>>)
- o In [Section 5.2.2](#), clarify what responses various directives apply to (<<https://github.com/httpwg/http-core/issues/52>>)
- o In [Section 4.3.1](#), clarify the source of validators in conditional requests (<<https://github.com/httpwg/http-core/issues/110>>)
- o Revise [Section 6](#) to apply to more than just History Lists (<<https://github.com/httpwg/http-core/issues/126>>)
- o In [Section 5.5](#), deprecated "Warning" header field (<<https://github.com/httpwg/http-core/issues/139>>)
- o In [Section 3.5](#), remove a spurious note (<<https://github.com/httpwg/http-core/issues/141>>)

## C.5. Since [draft-ietf-httpbis-cache-03](#)

- o In [Section 2](#), define what a disconnected cache is

(<https://github.com/httpwg/http-core/issues/5>)

- o In [Section 4](#), clarify language around how to select a response when more than one matches (<https://github.com/httpwg/http-core/issues/23>)
- o in [Section 4.2.4](#), mention stale-while-revalidate and stale-if-error (<https://github.com/httpwg/http-core/issues/122>)
- o Remove requirements around cache request directives (<https://github.com/httpwg/http-core/issues/129>)
- o Deprecate Pragma (<https://github.com/httpwg/http-core/issues/140>)

- o In [Section 3.5](#) and [Section 5.2.2](#), note effect of some directives on authenticated requests (<https://github.com/httpwg/http-core/issues/161>)

#### [C.6.](#) Since [draft-ietf-httpbis-cache-04](#)

- o In [Section 5.2](#), remove the registrations for stale-if-error and stale-while-revalidate which happened in [RFC 7234](#) (<https://github.com/httpwg/http-core/issues/207>)

#### [C.7.](#) Since [draft-ietf-httpbis-cache-05](#)

- o In [Section 3.3](#), clarify how weakly framed content is considered for purposes of completeness (<https://github.com/httpwg/http-core/issues/25>)
- o Throughout, describe Vary and cache key operations more clearly (<https://github.com/httpwg/http-core/issues/28>)
- o In [Section 3](#), remove concept of "cacheable methods" in favor of prose (<https://github.com/httpwg/http-core/issues/54>), <https://www.rfc-editor.org/errata/eid5300>)
- o Refactored [Section 7](#), and added a section on timing attacks (<https://github.com/httpwg/http-core/issues/233>)

- o Changed "cacheable by default" to "heuristically cacheable" throughout (<<https://github.com/httpwg/http-core/issues/242>>)

#### C.8. Since [draft-ietf-httpbis-cache-06](#)

- o In [Section 3](#) and [Section 5.2.2.2](#), change response cacheability to only require understanding the response status code if the must-understand cache directive is present (<<https://github.com/httpwg/http-core/issues/120>>)
- o Change requirements for handling different forms of cache directives in [Section 5.2](#) (<<https://github.com/httpwg/http-core/issues/128>>)
- o Fix typo in [Section 5.2.2.10](#) (<<https://github.com/httpwg/http-core/issues/264>>)
- o In [Section 5.2.2.6](#) and [Section 5.2.2.7](#), clarify "private" and "public" so that they do not override all other cache directives (<<https://github.com/httpwg/http-core/issues/268>>)

- o In [Section 3](#), distinguish between private with and without qualifying headers (<<https://github.com/httpwg/http-core/issues/270>>)
- o In [Section 4.1](#), clarify that any "\*" as a member of Vary will disable caching (<<https://github.com/httpwg/http-core/issues/286>>)
- o In [Section 1.1](#), reference [RFC 8174](#) as well (<<https://github.com/httpwg/http-core/issues/303>>)

#### C.9. Since [draft-ietf-httpbis-cache-07](#)

- o Throughout, replace "effective request URI", "request-target" and similar with "target URI" (<<https://github.com/httpwg/http-core/issues/259>>)
- o In [Section 5.2.2.6](#) and [Section 5.2.2.7](#), make it clear that these directives do not ignore other requirements for caching

(<https://github.com/httpwg/http-core/issues/320>>)

- o In [Section 3.3](#), move definition of "complete" into semantics (<https://github.com/httpwg/http-core/issues/334>>)

[C.10.](#) Since [draft-ietf-httpbis-cache-08](#)

- o [Appendix A](#) now uses the sender variant of the "#" list expansion (<https://github.com/httpwg/http-core/issues/192>>)

[C.11.](#) Since [draft-ietf-httpbis-cache-09](#)

- o In [Section 5.1](#), discuss handling of invalid and multiple Age header field values (<https://github.com/httpwg/http-core/issues/193>>)
- o Switch to xml2rfc v3 mode for draft generation (<https://github.com/httpwg/http-core/issues/394>>)

[C.12.](#) Since [draft-ietf-httpbis-cache-10](#)

- o In [Section 5.2](#) (Cache-Control), adjust ABNF to allow empty lists (<https://github.com/httpwg/http-core/issues/210>>)

[C.13.](#) Since [draft-ietf-httpbis-cache-11](#)

- o None.

[C.14.](#) Since [draft-ietf-httpbis-cache-12](#)

- o In [Section 4.2.4](#), remove 'no-store', as it won't be in cache in the first place (<https://github.com/httpwg/http-core/issues/447>>)
- o In [Section 3.1](#), make it clear that only response headers need be stored (<https://github.com/httpwg/http-core/issues/457>>)
- o Rewrote "Updating Stored Header Fields" [Section 3.2](#) (<https://github.com/httpwg/http-core/issues/458>>)
- o In [Section 4.2.1](#) clarify how to handle invalid and conflicting directives (<https://github.com/httpwg/http-core/issues/460>>)

- o In [Section 4.3.3](#), mention retry of failed validation requests (<<https://github.com/httpwg/http-core/issues/462>>)
- o In [Section 4.3.3](#), clarify requirement on storing a full response to a conditional request (<<https://github.com/httpwg/http-core/issues/463>>)
- o In [Section 5.1](#), clarify error handling (<<https://github.com/httpwg/http-core/issues/471>>)
- o In [Section 4.2](#), remove spurious "UTC" (<<https://github.com/httpwg/http-core/issues/472>>)
- o In [Section 4.2](#), correct the date-related rule names to consider case-insensitive (<<https://github.com/httpwg/http-core/issues/473>>)
- o In [Section 6](#), strengthen recommendation for application caches to pay attention to cache directives (<<https://github.com/httpwg/http-core/issues/474>>)
- o In [Section 4](#), mention collapsed requests (<<https://github.com/httpwg/http-core/issues/475>>)
- o In [Section 4.4](#), relax requirements on Content-Location and Location invalidation (<<https://github.com/httpwg/http-core/issues/478>>)
- o In [Section 4.3.4](#), refine the exceptions to update on a 304 (<<https://github.com/httpwg/http-core/issues/488>>)
- o Moved table of Cache-Control directives into [Section 8.2](#) (<<https://github.com/httpwg/http-core/issues/506>>)
- o In [Section 1.2](#), remove unused core ABNF rules (<<https://github.com/httpwg/http-core/issues/529>>)

- o Changed to using "payload data" when defining requirements about the data being conveyed within a message, instead of the terms "payload body" or "response body" or "representation body", since they often get confused with the HTTP/1.1 message body (which

includes transfer coding) (<<https://github.com/httpwg/http-core/issues/553>>)

#### C.15. Since [draft-ietf-httpbis-cache-13](#)

- o In [Section 5.2.2.1](#), clarify requirements around generating an error response (<<https://github.com/httpwg/http-core/issues/608>>)
- o Changed to using "content" instead of "payload" or "payload data" to avoid confusion with the payload of version-specific messaging frames (<<https://github.com/httpwg/http-core/issues/654>>)
- o In [Section 4.3.4](#), clarify how multiple validators are handled (<<https://github.com/httpwg/http-core/issues/659>>)
- o In [Section 4.2.3](#), [Section 5.2](#), and [Section 5.2.2.3](#), remove notes about very old HTTP/1.0 behaviours (<<https://github.com/httpwg/http-core/issues/660>>)
- o In [Section 5.2.2.2](#), modify operation to be more backwards-compatible with existing implementations (<<https://github.com/httpwg/http-core/issues/661>>)

#### Acknowledgments

See Appendix "Acknowledgments" of [[Semantics](#)].

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