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Compression Dictionary Transport
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Abstract

This document specifies a mechanism for dictionary-based compression in the Hypertext Transfer Protocol (HTTP). By utilizing this technique, clients and servers can reduce the size of transmitted data, leading to improved performance and reduced bandwidth consumption. This document extends existing HTTP compression methods and provides guidelines for the delivery and use of compression dictionaries within the HTTP protocol.

About This Document

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

Status information for this document may be found at https://datatracker.ietf.org/doc/draft-ietf-httpbis-compression-dictionary/.

Discussion of this document takes place on the HTTP Working Group mailing list (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 for this draft and an issue tracker can be found at https://github.com/httpwg/http-extensions/labels/compression-dictionary.

Status of This Memo

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

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1. Introduction

This specification defines a mechanism for using designated [HTTP] responses as an external dictionary for future HTTP responses for compression schemes that support using external dictionaries (e.g., Brotli [RFC7932] and Zstandard [RFC8878]).

This document describes the HTTP headers used for negotiating dictionary usage and registers content encoding values for compressing with Brotli and Zstandard using a negotiated dictionary.

The negotiation of dictionary usage leverages HTTP's content negotiation (see Section 12 of [HTTP]) and is usable with all versions of HTTP.

1.1. Use Cases

Any HTTP response can be specified to be used as a compression dictionary for future HTTP requests which provides a lot of flexibility. There are two common use cases that are seen frequently:

1.1.1. Version Upgrade

Using a previous version of a resource as a dictionary for a newer version enables delivery of a delta-compressed version of the changes, usually resulting in significantly smaller responses than can be achieved by compression alone.

For example:

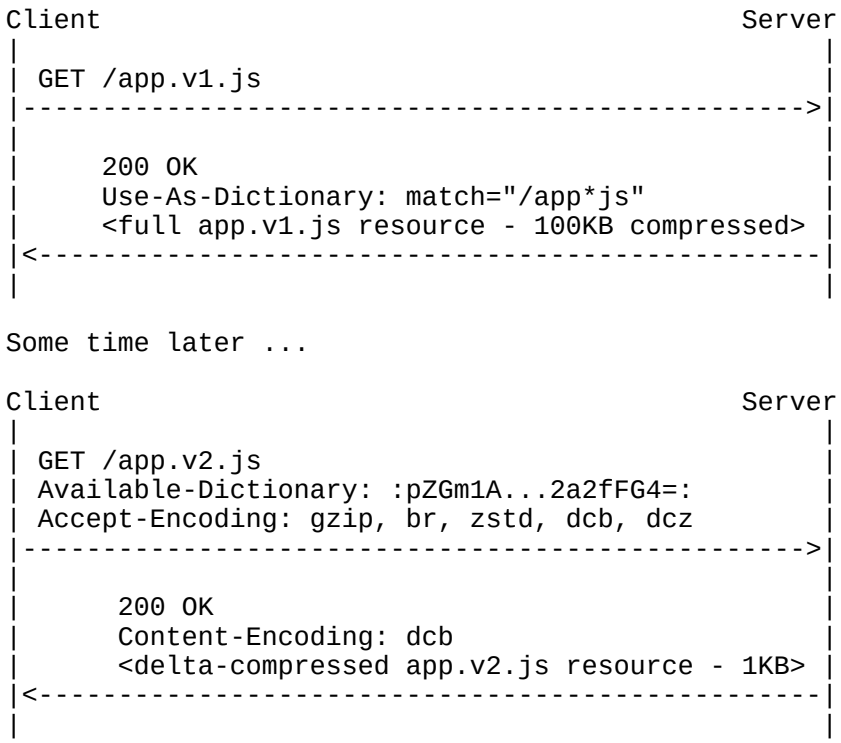
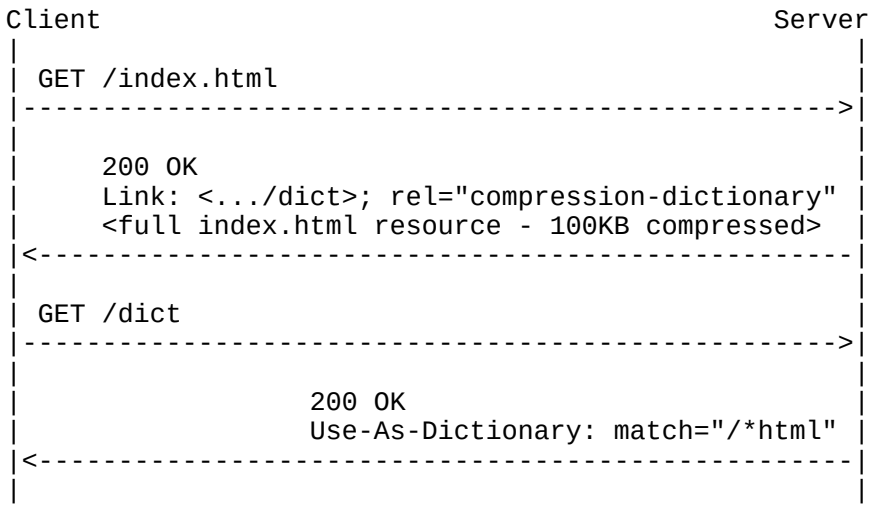


Figure 1: Version Upgrade Example

1.1.2. Common Content

If several resources share common patterns in their responses then it can be useful to reference an external dictionary that contains those common patterns, effectively compressing them out of the responses. Some examples of this are common template HTML for similar pages across a site and common keys and values in API calls.

For example:



Some time later ...

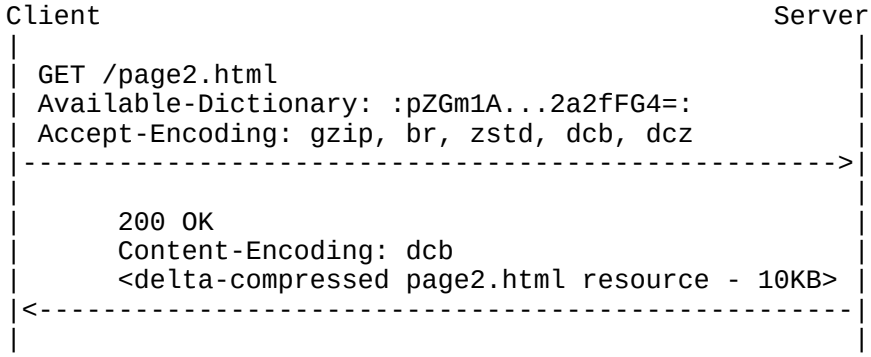


Figure 2: Common Content Example

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 following terminology from Section 3 of [STRUCTURED-FIELDS] to specify syntax and parsing: Dictionary, String, Inner List, Token, and Byte Sequence.

This document uses the line folding strategies described in [FOLDING].

This document also uses terminology from [HTTP] and [HTTP-CACHING].

2. Dictionary Negotiation

2.1. Use-As-Dictionary

When responding to a HTTP Request, a server can advertise that the response can be used as a dictionary for future requests for URLs that match the rules specified in the Use-As-Dictionary response header.

The Use-As-Dictionary response header is a Structured Field [STRUCTURED-FIELDS] Dictionary with values for "match", "match-dest", "id", and "type".

2.1.1. match

The "match" value of the Use-As-Dictionary header is a String value that provides the URL Pattern to use for request matching (see [URLPATTERN]).

The URL Pattern used for matching does not support using regular expressions.

The following algorithm is used to validate that a given String value is a valid URL Pattern that does not use regular expressions and is for the same Origin (Section 4.3.1 of [HTTP]) as the dictionary. It will return TRUE for a valid match pattern and FALSE for an invalid pattern that MUST NOT be used:

1. Let MATCH be the value of "match" for the given dictionary.

2. Let URL be the URL of the dictionary request.

3. Let PATTERN be a URL pattern created by running the steps to create a URL pattern by setting input=MATCH, and baseURL=URL (see Part create of [URLPATTERN]).

4. If the result of running the "has regexp groups" steps for PATTERN returns TRUE then return FALSE (see Part has regexp groups of [URLPATTERN]).

5. Return TRUE.

The "match" value is required and MUST be included in the Use-As-Dictionary response header for the dictionary to be considered valid.

Operating at the HTTP-level, the specified match patterns will operate on the percent-encoded version of the URL path (see Section 2 of [URL]).

For example the URL "http://www.example.com/d端sseldorf" would be encoded as "http://www.example.com/d%C3%BCsseldorf" and a relevant match pattern would be:

Use-As-Dictionary: match="/d%C3%BCsseldorf"

2.1.2. match-dest

The "match-dest" value of the Use-As-Dictionary header is an Inner List of String values that provides a list of Fetch request destinations for the dictionary to match (see Part RequestDestination of [FETCH]).

An empty list for "match-dest" MUST match all destinations.

For clients that do not support request destinations, the client MUST treat it as an empty list and match all destinations.

The "match-dest" value is optional and defaults to an empty list.

2.1.3. id

The "id" value of the Use-As-Dictionary header is a String value that specifies a server identifier for the dictionary. If an "id" value is present and has a string length longer than zero then it MUST be sent to the server in a "Dictionary-ID" request header when the client sends an "Available-Dictionary" request header for the same dictionary (see Section 2.2).

The server identifier MUST be treated as an opaque string by the client.

The server identifier MUST NOT be relied upon by the server to guarantee the contents of the dictionary. The dictionary hash MUST be validated before use.

The "id" value string length (after any decoding) supports up to 1024 characters.

The "id" value is optional and defaults to the empty string.

2.1.4. type

The "type" value of the Use-As-Dictionary header is a Token value that describes the file format of the supplied dictionary.

"raw" is defined as a dictionary format which represents an unformatted blob of bytes suitable for any compression scheme to use.

If a client receives a dictionary with a type that it does not understand, it MUST NOT use the dictionary.

The "type" value is optional and defaults to "raw".

2.1.5. Examples

2.1.5.1. Path Prefix

A response that contained a response header:

NOTE: '\' line wrapping per RFC 8792

```
Use-As-Dictionary: \
  match="/product/*", match-dest=("document")
```

Would specify matching any document request for a URL with a path prefix of /product/ on the same Origin (Section 4.3.1 of [HTTP]) as the original request.

2.1.5.2. Versioned Directories

A response that contained a response header:

```
Use-As-Dictionary: match="/app/*/main.js"
```

Would match any path that starts with "/app/" and ends with "/main.js".

2.2. Available-Dictionary

When a HTTP client makes a request for a resource for which it has an appropriate dictionary, it can add a "Available-Dictionary" request header to the request to indicate to the server that it has a dictionary available to use for compression.

The "Available-Dictionary" request header is a Structured Field [STRUCTURED-FIELDS] Byte Sequence containing the [SHA-256] hash of the contents of a single available dictionary.

The client MUST only send a single "Available-Dictionary" request header with a single hash value for the best available match that it has available.

For example:

Available-Dictionary: :pZGm1Av0IEBKARczz7exkNYsZb8LzaMrV7J32a2fFG4=:

2.2.1. Dictionary freshness requirement

To be considered as a match, the dictionary resource MUST be either fresh [HTTP-CACHING] or allowed to be served stale (see eg [RFC5861]).

2.2.2. Dictionary URL matching

When a dictionary is stored as a result of a "Use-As-Dictionary" directive, it includes a "match" string and optional "match-dest" string that are used to match an outgoing request from a client to the available dictionaries.

To see if an outbound request matches a given dictionary, the following algorithm will return TRUE for a successful match and FALSE for no-match:

1. If the current client supports request destinations and a "match-dest" string was provided with the dictionary:
    * Let DEST be the value of "match-dest" for the given dictionary.
    * Let REQUEST_DEST be the value of the destination for the current request.
    * If DEST is not an empty list and if REQUEST_DEST is not in the DEST list of destinations, return FALSE
2. Let BASEURL be the URL of the dictionary request.
3. Let URL represent the URL of the outbound request being checked.
4. If the Origin of BASEURL and the Origin of URL are not the same, return FALSE (see Section 4.3.1 of [HTTP]).
5. Let MATCH be the value of "match" for the given dictionary.

6. Let PATTERN be a URL pattern created by running the steps to create a URL pattern by setting input=MATCH, and baseURL=URL (see Part create of [URLPATTERN]).

7. Return the result of running the "match" steps on PATTERN with input=URL which will check for a match between the request URL and the supplied "match" string (see Part match of [URLPATTERN]).

2.2.3. Multiple matching dictionaries

When there are multiple dictionaries that match a given request URL, the client MUST pick a single dictionary using the following rules:

1. For clients that support request destinations, a dictionary that specifies and matches a "match-dest" takes precedence over a match that does not use a destination.

2. Given equivalent destination precedence, the dictionary with the longest "match" takes precedence.

3. Given equivalent destination and match length precedence, the most recently fetched dictionary takes precedence.

2.3. Dictionary-ID

When a HTTP client makes a request for a resource for which it has an appropriate dictionary and the dictionary was stored with a server-provided "id" in the Use-As-Dictionary response then the client MUST echo the stored "id" in a "Dictionary-ID" request header.

The "Dictionary-ID" request header is a Structured Field [STRUCTURED-FIELDS] String of up to 1024 characters (after any decoding) and MUST be identical to the server-provided "id".

For example, given a HTTP response that set a dictionary ID:

Use-As-Dictionary: match="/app/*/main.js", id="dictionary-12345"

A future request that matches the given dictionary will include both the hash and the ID:

Available-Dictionary: :pZGm1Av0IEBKARczz7exkNYsZb8LzaMrV7J32a2fFG4=:
Dictionary-ID: "dictionary-12345"

3. The ’compression-dictionary’ Link Relation Type

This specification defines the ’compression-dictionary’ link relation type [WEB-LINKING] that provides a mechanism for a HTTP response to provide a URL for a compression dictionary that is related to, but not directly used by the current HTTP response.

The ’compression-dictionary’ link relation type indicates that fetching and caching the specified resource is likely to be beneficial for future requests. The response to some of those future requests are likely to be able to use the indicated resource as a compression dictionary.

Clients can fetch the provided resource at a time that they determine would be appropriate.

The response to the fetch for the compression dictionary needs to include a "Use-As-Dictionary" and caching response headers for it to be usable as a compression dictionary. The link relation only provides the mechanism for triggering the fetch of the dictionary.

The following example shows a link to a resource at https://example.org/dict.dat that is expected to produce a compression dictionary:

```
Link: <https://example.org/dict.dat>; rel="compression-dictionary"
```

4. Dictionary-Compressed Brotli

The "dcb" content encoding identifies a resource that is a "Dictionary-Compressed Brotli" stream.

A "Dictionary-Compressed Brotli" stream has a fixed header that is followed by a Shared Brotli [SHARED-BROTLI] stream. The header consists of a fixed 4-byte sequence and a 32-byte hash of the external dictionary that was used. The Shared Brotli stream is created using the referenced external dictionary and a compression window that is at most 16 MB in size.

The dictionary used for the "dcb" content encoding is a "raw" dictionary type as defined in Section 2.1.4 and is treated as a prefix dictionary as defined in section 9.2 of the Shared Brotli Compressed Data Format draft. [SHARED-BROTLI]

The 36-byte fixed header is as follows:

Magic_Number: 4 fixed bytes: 0xff, 0x44, 0x43, 0x42.

SHA_256_Hash: 32 bytes. SHA-256 hash digest of the dictionary [SHA-256].

Clients that announce support for dcb content encoding MUST be able to decompress resources that were compressed with a window size of up to 16 MB.

With Brotli compression, the full dictionary is available during compression and decompression independent of the compression window, allowing for delta-compression of resources larger than the compression window.

5. Dictionary-Compressed Zstandard

The "dcz" content encoding identifies a resource that is a "Dictionary-Compressed Zstandard" stream.

A "Dictionary-Compressed Zstandard" stream is a binary stream that starts with a 40-byte fixed header and is followed by a Zstandard [RFC8878] stream of the response that has been compressed with an external dictionary.

The dictionary used for the "dcz" content encoding is a "raw" dictionary type as defined in Section 2.1.4 and is treated as a raw dictionary as per section 5 of RFC 8878.

The 40-byte header consists of a fixed 8-byte sequence followed by the 32-byte SHA-256 hash of the external dictionary that was used to compress the resource:

Magic_Number: 8 fixed bytes: 0x5e, 0x2a, 0x4d, 0x18, 0x20, 0x00, 0x00, 0x00.

SHA_256_Hash: 32 bytes. SHA-256 hash digest of the dictionary [SHA-256].

The 40-byte header is a Zstandard skippable frame (little-endian 0x184D2A5E) with a 32-byte length (little-endian 0x00000020) that is compatible with existing Zstandard decoders.

Clients that announce support for dcz content encoding MUST be able to decompress resources that were compressed with a window size of at least 8 MB or 1.25 times the size of the dictionary, which ever is greater, up to a maximum of 128 MB.

The window size used will be encoded in the content (currently, this can be expressed in powers of two only) and it MUST be lower than this limit. An implementation MAY treat a window size that exceeds the limit as a decoding error.

With Zstandard compression, the full dictionary is available during compression and decompression until the size of the input exceeds the compression window. Beyond that point the dictionary becomes unavailable. Using a compression window that is 1.25 times the size of the dictionary allows for full delta compression of resources that have grown by 25% between releases while still giving the client control over the memory it will need to allocate for a given response.

6. Negotiating the content encoding

When a compression dictionary is available for use compressing the response to a given request, the encoding to be used is negotiated through the regular mechanism for negotiating content encoding in HTTP through the "Accept-Encoding" request header and "Content-Encoding" response header.

The dictionary to use is negotiated separately and advertised in the "Available-Dictionary" request header.

6.1. Accept-Encoding

When a dictionary is available for use on a given request, and the client chooses to make dictionary-based content-encoding available, the client adds the dictionary-aware content encodings that it supports to the "Accept-Encoding" request header. e.g.:

Accept-Encoding: gzip, deflate, br, zstd, dcb, dcz

When a client does not have a stored dictionary that matches the request, or chooses not to use one for the request, the client MUST NOT send its dictionary-aware content-encodings in the "Accept-Encoding" request header.

6.2. Content-Encoding

If a server supports one of the dictionary encodings advertised by the client and chooses to compress the content of the response using the dictionary that the client has advertised then it sets the "Content-Encoding" response header to the appropriate value for the algorithm selected. e.g.:

Content-Encoding: dcb

If the response is cacheable, it MUST include a "Vary" header to prevent caches serving dictionary-compressed resources to clients that don’t support them or serving the response compressed with the wrong dictionary:

Vary: accept-encoding, available-dictionary

7. IANA Considerations

7.1. Content Encoding

IANA is asked to enter the following into the "HTTP Content Coding Registry" registry maintained at <https://www.iana.org/assignments/http-parameters/http-parameters.xhtml>:

* Name: dcb
* Description: "Dictionary-Compressed Brotli" data format.
* Reference: This document
* Notes: Section 4

IANA is asked to enter the following into the "HTTP Content Coding Registry" registry maintained at <https://www.iana.org/assignments/http-parameters/http-parameters.xhtml>:

* Name: dcz
* Description: "Dictionary-Compressed Zstandard" data format.
* Reference: This document
* Notes: Section 5

7.2. Header Field Registration

IANA is asked to update the "Hypertext Transfer Protocol (HTTP) Field Name Registry" registry maintained at <https://www.iana.org/assignments/http-fields/http-fields.xhtml> according to the table below:

Field Name	Status	Reference
Use-As-Dictionary	permanent	Section 2.1 of this document
Available-Dictionary	permanent	Section 2.2 of this document
Dictionary-ID	permanent	Section 2.3 of this document

Table 1

7.3. Link Relation Registration

IANA is asked to update the "Link Relation Types" registry maintained at <https://www.iana.org/assignments/link-relations/link-relations.xhtml>:

* Relation Name: compression-dictionary

* Description: Refers to a compression dictionary used for content encoding.

* Reference: This document, Section 3

8. Compatibility Considerations

It is not unusual for there to be devices on the network path that intercept, inspect and process HTTP requests (web proxies, firewalls, intrusion detection systems, etc). To minimize the risk of these devices incorrectly processing dictionary-compressed responses, compression dictionary transport MUST only be used in secure contexts (HTTPS).

9. Security Considerations

The security considerations for Brotli [RFC7932], Shared Brotli [SHARED-BROTLI] and Zstandard [RFC8878] apply to the dictionary-based versions of the respective algorithms.

9.1. Changing content

The dictionary must be treated with the same security precautions as the content, because a change to the dictionary can result in a change to the decompressed content.

The dictionary is validated using a SHA-256 hash of the content to make sure that the client and server are both using the same dictionary. The strength of the SHA-256 hash algorithm isn't explicitly needed to counter attacks since the dictionary is being served from the same origin as the content. That said, if a weakness is discovered in SHA-256 and it is determined that the dictionary negotiation should use a different hash algorithm, the "Use-As-Dictionary" response header can be extended to specify a different algorithm and the server would just ignore any "Available-Dictionary" requests that do not use the updated hash.

9.2. Reading content

The compression attacks in Section 2.6 of [RFC7457] show that it's a bad idea to compress data from mixed (e.g. public and private) sources -- the data sources include not only the compressed data but also the dictionaries. For example, if you compress secret cookies using a public-data-only dictionary, you still leak information about the cookies.

Not only can the dictionary reveal information about the compressed data, but vice versa, data compressed with the dictionary can reveal the contents of the dictionary when an adversary can control parts of data to compress and see the compressed size. On the other hand, if the adversary can control the dictionary, the adversary can learn information about the compressed data.

9.3. Security Mitigations

If any of the mitigations do not pass, the client MUST drop the response and return an error.

9.3.1. Cross-origin protection

To make sure that a dictionary can only impact content from the same origin where the dictionary was served, the URL Pattern used for matching a dictionary to requests (Section 2.1.1) is guaranteed to be for the same origin that the dictionary is served from.

9.3.2. Response readability

For clients, like web browsers, that provide additional protection against the readability of the payload of a response and against user tracking, additional protections MUST be taken to make sure that the use of dictionary-based compression does not reveal information that would not otherwise be available.

In these cases, dictionary compression MUST only be used when both the dictionary and the compressed response are fully readable by the client.

In browser terms, that means that both are either same-origin to the context they are being fetched from or that the response is cross-origin and passes the CORS check (see Part CORS check of [FETCH]).

9.3.3. Server Responsibility

As with any usage of compressed content in a secure context, a potential timing attack exists if the attacker can control any part of the dictionary, or if it can read the dictionary and control any part of the content being compressed, while performing multiple requests that vary the dictionary or injected content. Under such an attack, the changing size or processing time of the response reveals information about the content, which might be sufficient to read the supposedly secure response.

In general, a server can mitigate such attacks by preventing variations per request, as in preventing active use of multiple dictionaries for the same content, disabling compression when any portion of the content comes from uncontrolled sources, and securing access and control over the dictionary content in the same way as the response content. In addition, the following requirements on a server are intended to disable dictionary-aware compression when the client provides CORS request header fields that indicate a cross-origin request context.

The following algorithm will return FALSE for cross-origin requests where precautions such as not using dictionary-based compression should be considered:

1. If there is no "Sec-Fetch-Site" request header then return TRUE.

2. if the value of the "Sec-Fetch-Site" request header is "same-origin" then return TRUE.

3. If there is no "Sec-Fetch-Mode" request header then return TRUE.

4. If the value of the "Sec-Fetch-Mode" request header is "navigate" or "same-origin" then return TRUE.

5. If the value of the "Sec-Fetch-Mode" request header is "cors":

    * If the response does not include an "Access-Control-Allow-Origin" response header then return FALSE.

* If the request does not include an "Origin" request header then return FALSE.

* If the value of the "Access-Control-Allow-Origin" response header is "*" then return TRUE.

* If the value of the "Access-Control-Allow-Origin" response header matches the value of the "Origin" request header then return TRUE.

6. return FALSE.

10. Privacy Considerations

Since dictionaries are advertised in future requests using the hash of the content of the dictionary, it is possible to abuse the dictionary to turn it into a tracking cookie.

To mitigate any additional tracking concerns, clients MUST treat dictionaries in the same way that they treat cookies [RFC6265]. This includes partitioning the storage as cookies are partitioned as well as clearing the dictionaries whenever cookies are cleared.

11. References

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