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HTTP Framework for Time-Based Access to Resource States -- Memento

Abstract

The HTTP-based Memento framework bridges the present and past Web. It facilitates obtaining representations of prior states of a given resource by introducing datetime negotiation and TimeMaps. Datetime negotiation is a variation on content negotiation that leverages the given resource's URI and a user agent's preferred datetime. TimeMaps are lists that enumerate URIs of resources that encapsulate prior states of the given resource. The framework also facilitates recognizing a resource that encapsulates a frozen prior state of another resource.

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1. Introduction

1.1. Terminology

This specification uses the terms "resource", "request", "response", "entity-body", "content negotiation", "user agent", and "server" as described in [RFC2616], and it uses the terms "representation" and "resource state" as described in [W3C.REC-aww-20041215].

In addition, the following terms specific to the Memento framework are introduced:

- o Original Resource: An Original Resource is a resource that exists or used to exist, and for which access to one of its prior states may be required.
- o Memento: A Memento for an Original Resource is a resource that encapsulates a prior state of the Original Resource. A Memento for an Original Resource as it existed at time T is a resource that encapsulates the state the Original Resource had at time T.
- o TimeGate: A TimeGate for an Original Resource is a resource that is capable of datetime negotiation to support access to prior states of the Original Resource.
- o TimeMap: A TimeMap for an Original Resource is a resource from which a list of URIs of Mementos of the Original Resource is available.

1.2. Notational Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

When needed for extra clarity, the following conventions are used:

- o URI-R is used to denote the URI of an Original Resource.
- o URI-G is used to denote the URI of a TimeGate.
- o URI-M is used to denote the URI of a Memento.
- o URI-T is used to denote the URI of a TimeMap.

1.3. Purpose

The state of an Original Resource may change over time. Dereferencing its URI at any specific moment yields a response that reflects the resource's state at that moment: a representation of the resource's state (e.g., "200 OK" HTTP status code), an indication of its nonexistence (e.g., "404 Not Found" HTTP status code), a relation to another resource (e.g., "302 Found" HTTP status code), etc. However, responses may also exist that reflect prior states of an Original Resource: a representation of a prior state of the Original Resource, an indication that the Original Resource did not exist at some time in the past, a relation that the Original Resource had to another resource at some time in the past, etc. Mementos that provide such responses exist in Web archives, content management systems, or revision control systems, among others. For any given Original Resource several Mementos may exist, each one reflecting a frozen prior state of the Original Resource.

Examples are:

Mementos for Original Resource <http://www.ietf.org/> are as follows:

- o <http://web.archive.org/web/19970107171109/http://www.ietf.org/>
- o <http://webarchive.nationalarchives.gov.uk/20080906200044/http://www.ietf.org/>

Mementos for Original Resource http://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol are as follows:

- o http://en.wikipedia.org/w/index.php?title=Hypertext_Transfer_Protocol&oldid=366806574
- o http://en.wikipedia.org/w/index.php?title=Hypertext_Transfer_Protocol&oldid=33912
- o http://web.archive.org/web/20071011153017/http://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol

Mementos for Original Resource <http://www.w3.org/TR/webarch/> are as follows:

- o <http://www.w3.org/TR/2004/PR-webarch-20041105/>
- o <http://www.w3.org/TR/2002/WD-webarch-20020830/>
- o <http://archive.is/20120527002537/http://www.w3.org/TR/webarch/>

In the abstract, the Memento framework introduces a mechanism to access versions of Web resources that:

- o Is fully distributed in the sense that resource versions may reside on multiple servers, and that any such server is likely only aware of the versions it holds;
- o Uses the global notion of datetime as a resource version indicator and access key;
- o Leverages the following primitives of [W3C.REC-aww-20041215]: resource, resource state, representation, content negotiation, and link.

The core components of Memento's mechanism to access resource versions are:

1. The abstract notion of the state of an Original Resource (URI-R) as it existed at datetime T. Note the relationship with the ability to identify the state of a resource at datetime T by means of a URI as intended by the proposed Dated URI scheme [DATED-URI].
2. A "bridge" from the present to the past, consisting of:
 - o The existence of a TimeGate (URI-G), which is aware of (at least part of the) version history of the Original Resource (URI-R);
 - o The ability to negotiate in the datetime dimension with that TimeGate (URI-G), as a means to access the state that the Original Resource (URI-R) had at datetime T.
3. A "bridge" from the past to the present, consisting of an appropriately typed link from a Memento (URI-M), which encapsulates the state the Original Resource (URI-R) had at datetime T, to the Original Resource (URI-R).
4. The existence of a TimeMap (URI-T) from which a list of all Mementos that encapsulate a prior state of the Original Resource (URI-R) can be obtained.

This document is concerned with specifying an instantiation of these abstractions for resources that are identified by HTTP(S) URIs.

2. HTTP Headers, Link Relation Types

The Memento framework is concerned with HEAD and GET interactions with Original Resources, TimeGates, Mementos, and TimeMaps that are identified by HTTP or HTTPS URIs. Details are only provided for resources identified by HTTP URIs but apply similarly to those with HTTPS URIs.

2.1. HTTP Headers

The Memento framework operates at the level of HTTP request and response headers. It introduces two new headers ("Accept-Datetime" and "Memento-Datetime") and introduces new values for two existing headers ("Vary" and "Link"). Other HTTP headers are present or absent in Memento response/request cycles as specified by [RFC2616].

2.1.1. Accept-Datetime and Memento-Datetime

The "Accept-Datetime" request header is transmitted by a user agent to indicate it wants to access a past state of an Original Resource. To that end, the "Accept-Datetime" header is conveyed in an HTTP request issued against a TimeGate for an Original Resource, and its value indicates the datetime of the desired past state of the Original Resource.

Example of an "Accept-Datetime" request header:

```
Accept-Datetime: Thu, 31 May 2007 20:35:00 GMT
```

The "Memento-Datetime" response header is used by a server to indicate that a response reflects a prior state of an Original Resource. Its value expresses the datetime of that state. The URI of the Original Resource for which the response reflects a prior state is provided as the Target IRI of a link provided in the HTTP "Link" header that has a Relation Type of "original" (see Section 2.2).

The presence of a "Memento-Datetime" header and associated value for a given response constitutes a promise that the resource state reflected in the response will no longer change (see Section 4.5.6).

Example of a "Memento-Datetime" response header:

```
Memento-Datetime: Wed, 30 May 2007 18:47:52 GMT
```

Values for the "Accept-Datetime" and "Memento-Datetime" headers consist of a MANDATORY datetime expressed according to the [RFC1123] format, which is formalized by the rfc1123-date construction rule of

the BNF in Figure 1. This BNF is derived from the HTTP-date construction of the BNF for Full Dates provided in [RFC2616]. The datetime is case sensitive with names for days and months exactly as shown in the wkday and month construction rules of the BNF, respectively. The datetime MUST be represented in Greenwich Mean Time (GMT).

```
accept-dt-value = rfc1123-date
rfc1123-date = wkday "," SP date1 SP time SP "GMT"
date1       = 2DIGIT SP month SP 4DIGIT
              ; day month year (e.g., 20 Mar 1957)
time        = 2DIGIT ":" 2DIGIT ":" 2DIGIT
              ; 00:00:00 - 23:59:59 (e.g., 14:33:22)
wkday       = "Mon" | "Tue" | "Wed" | "Thu" | "Fri" | "Sat" |
              "Sun"
month       = "Jan" | "Feb" | "Mar" | "Apr" | "May" | "Jun" |
              "Jul" | "Aug" | "Sep" | "Oct" | "Nov" | "Dec"
```

Figure 1: BNF for the Datetime Format

2.1.2. Vary

Generally, the "Vary" header is used in HTTP responses to indicate the dimensions in which content negotiation is possible. In the Memento framework, a TimeGate uses the "Vary" header with a value that includes "accept-datetime" to convey that datetime negotiation is possible.

For example, this use of the "Vary" header indicates that datetime is the only dimension in which negotiation is possible:

```
Vary: accept-datetime
```

The use of the "Vary" header in this example shows that both datetime negotiation and media type content negotiation are possible:

```
Vary: accept-datetime, accept
```

2.1.3. Link

The Memento framework defines the "original", "timegate", "timemap", and "memento" Relation Types to convey typed links among Original Resources, TimeGates, Mementos, and TimeMaps. They are defined in Section 2.2, below. In addition, existing Relation Types may be used, for example, to support navigating among Mementos. Examples are "first", "last", "prev", "next", "predecessor-version", and "successor-version" as detailed in [RFC5988] and [RFC5829].

2.2. Link Relation Types

This section introduces the Relation Types used in the Memento framework. They are defined in a general way, and their use in HTTP "Link" headers [RFC5988] is described in detail. The use of these Relation Types in TimeMaps is described in Section 5.

2.2.1. Link Relation Type "original"

"original" -- A link with an "original" Relation Type is used to point from a TimeGate or a Memento to its associated Original Resource.

Use in HTTP "Link" headers: Responses to HTTP HEAD/GET requests issued against a TimeGate or a Memento MUST include exactly one link with an "original" Relation Type in their HTTP "Link" header.

2.2.2. Link Relation Type "timegate"

"timegate" -- A link with a "timegate" Relation Type is used to point from the Original Resource, as well as from a Memento associated with the Original Resource, to a TimeGate for the Original Resource.

Use in HTTP "Link" headers: If there is a TimeGate associated with an Original Resource or Memento that is preferred for use, then responses to HTTP HEAD/GET requests issued against these latter resources MUST include a link with a "timegate" Relation Type in their HTTP "Link" header. Since multiple TimeGates can exist for any Original Resource, multiple "timegate" links MAY occur, each with a distinct Target IRI.

2.2.3. Link Relation Type "timemap"

"timemap" -- A link with a "timemap" Relation Type is used to point from a TimeGate or a Memento associated with an Original Resource, as well as from the Original Resource itself, to a TimeMap for the Original Resource.

Attributes: A link with a "timemap" Relation Type SHOULD use the "type" attribute to convey the MIME type of the TimeMap serialization. The "from" and "until" attributes may be used to express the start and end of the temporal interval covered by Mementos listed in the TimeMap. That is, the linked TimeMap will not contain Mementos with archival datetimes outside of the expressed temporal interval. Attempts SHOULD be made to convey this interval as accurately as possible. The value for the these attributes MUST

be a datetime expressed according to the rfc1123-date construction rule of the BNF in Figure 1, and it MUST be represented in Greenwich Mean Time (GMT).

Use in HTTP "Link" headers: If there is a TimeMap associated with an Original Resource, a TimeGate, or a Memento that is preferred for use, then responses to HTTP HEAD/GET requests issued against these latter resources MUST include a link with a "timemap" Relation Type in their HTTP "Link" header. Multiple such links, each with a distinct Target IRI, MAY be expressed as a means to point to different TimeMaps or to different serializations of the same TimeMap. In all cases, use of the "from" and "until" attributes is OPTIONAL.

2.2.4. Link Relation Type "memento"

"memento" -- A link with a "memento" Relation Type is used to point from a TimeGate or a Memento for an Original Resource, as well as from the Original Resource itself, to a Memento for the Original Resource.

Attributes: A link with a "memento" Relation Type MUST include a "datetime" attribute with a value that matches the "Memento-Datetime" of the Memento that is the target of the link; that is, the value of the "Memento-Datetime" header that is returned when the URI of the linked Memento is dereferenced. The value for the "datetime" attribute MUST be a datetime expressed according to the rfc1123-date construction rule of the BNF in Figure 1, and it MUST be represented in Greenwich Mean Time (GMT). This link MAY include a "license" attribute to associate a license with the Memento; the value for the "license" attribute MUST be a URI.

Use in HTTP "Link" headers: Responses to HTTP HEAD/GET requests issued against an Original Resource, a TimeGate, and a Memento MAY include links in their HTTP "Link" headers with a "memento" Relation Type. For responses in which a Memento is selected, the provision of navigational links that lead to Mementos other than the selected one can be beneficial to the user agent. Of special importance are links that lead to the temporally first and last Memento known to the responding server, as well as links leading to Mementos that are temporally adjacent to the selected one.

3. Overview of the Memento Framework

The Memento framework defines two complementary approaches to support obtaining representations of prior states of an Original Resource:

- o **Datetime Negotiation:** Datetime negotiation is a variation on content negotiation by which a user agent expresses a datetime preference pertaining to the representation of an Original Resource, instead of, for example, a media type preference. Based on the responding server's knowledge of the past of the Original Resource, it selects a Memento of the Original Resource that best meets the user agent's datetime preference. An overview is provided in Section 3.1; details are in Section 4.
- o **TimeMaps:** A TimeMap is a resource from which a list can be obtained that provides a comprehensive overview of the past of an Original Resource. A server makes a TimeMap available that enumerates all Mementos that the server is aware of, along with their archival datetime. A user agent can obtain the TimeMap and select Mementos from it. An overview is provided in Section 3.2; details are in Section 5.

3.1. Datetime Negotiation

Figure 2 provides a schematic overview of a successful request/response chain that involves datetime negotiation. Dashed lines depict HTTP transactions between user agent and server. The interactions are for a scenario where the Original Resource resides on one server, whereas both its TimeGate and Mementos reside on another (Pattern 2.1 (Section 4.2.1) in Section 4). Scenarios also exist in which all these resources are on the same server (for example, content management systems) or all are on different servers (for example, an aggregator of TimeGates).

```

1: UA --- HTTP HEAD/GET; Accept-Datetime: T -----> URI-R
2: UA <-- HTTP 200; Link: URI-G ----- URI-R
3: UA --- HTTP HEAD/GET; Accept-Datetime: T -----> URI-G
4: UA <-- HTTP 302; Location: URI-M; Vary; Link:
    URI-R,URI-T -----> URI-G
5: UA --- HTTP GET URI-M; Accept-Datetime: T -----> URI-M
6: UA <-- HTTP 200; Memento-Datetime: T; Link:
    URI-R,URI-T,URI-G ----- URI-M

```

Figure 2: A Datetime Negotiation Request/Response Chain

- Step 1: The user agent that wants to access a prior state of the Original Resource issues an HTTP HEAD/GET against URI-R that has an "Accept-Datetime" HTTP header with a value of the datetime of the desired state.
- Step 2: The response from URI-R includes an HTTP "Link" header with a Relation Type of "timegate" pointing at a TimeGate (URI-G) for the Original Resource.
- Step 3: The user agent starts the datetime negotiation process with the TimeGate by issuing an HTTP GET request against URI-G that has an "Accept-Datetime" HTTP header with a value of the datetime of the desired prior state of the Original Resource.
- Step 4: The response from URI-G includes a "Location" header pointing at a Memento (URI-M) for the Original Resource. In addition, the response contains an HTTP "Link" header with a Relation Type of "original" pointing at the Original Resource (URI-R), and an HTTP "Link" header with a Relation Type of "timemap" pointing at a TimeMap (URI-T).
- Step 5: The user agent issues an HTTP GET request against URI-M.
- Step 6: The response from URI-M includes a "Memento-Datetime" HTTP header with a value of the archival datetime of the Memento. It also contains an HTTP "Link" header with a Relation Type of "original" pointing at the Original Resource (URI-R), with a Relation Type of "timegate" pointing at a TimeGate (URI-G) for the Original Resource, and with a Relation Type of "timemap" pointing at a TimeMap (URI-T) for the Original Resource. The state that is expressed by the response is the state the Original Resource had at the archival datetime expressed in the "Memento-Datetime" header.

In order to respond to a datetime negotiation request, the server uses an internal algorithm to select the Memento that best meets the user agent's datetime preference. The exact nature of the selection algorithm is at the server's discretion but is intended to be consistent, for example, always selecting the Memento that is nearest in time relative to the requested datetime, always selecting the Memento that is nearest in the past relative to the requested datetime, etc.

Due to the sparseness of Mementos in most systems, the value of the "Memento-Datetime" header returned by a server may differ (significantly) from the value conveyed by the user agent in "Accept-Datetime".

Although a Memento encapsulates a prior state of an Original Resource, the entity-body returned in response to an HTTP GET request issued against a Memento may very well not be byte-to-byte the same as an entity-body that was previously returned by that Original Resource. Various reasons exist why there are significant chances these would be different yet do convey substantially the same information. These include format migrations as part of a digital preservation strategy, URI-rewriting as applied by some Web archives, and the addition of banners as a means to brand Web archives.

When negotiating in the datetime dimension, the regular content negotiation dimensions (media type, character encoding, language, and compression) remain available. It is the TimeGate server's responsibility to honor (or not) such content negotiation, and in doing so it **MUST** always first select a Memento that meets the user agent's datetime preference, and then consider honoring regular content negotiation for it. As a result of this approach, the returned Memento will not necessarily meet the user agent's regular content negotiation preferences. Therefore, it is **RECOMMENDED** that the server provides "memento" links in the HTTP "Link" header pointing at Mementos that do meet the user agent's regular content negotiation requests and that have a value for the "Memento-Datetime" header in the temporal vicinity of the user agent's preferred datetime value.

A user agent that engages in datetime negotiation with a resource typically starts by issuing an HTTP HEAD, not GET, request with an "Accept-Datetime" header in order to determine how to proceed. This strategy is related to the existence of various server implementation patterns as will become clear in Section 4.

Details about the HTTP interactions involved in datetime negotiation are provided in Section 4.

3.2. TimeMaps

Figure 3 provides a schematic overview of a successful request/response chain that shows a user agent obtaining a TimeMap. The pictorial conventions are the same as the ones used in Figure 2, as is the scenario. Note that, in addition to a TimeGate, an Original Resource and a Memento can also provide a link to a TimeMap.

```

1: UA --- HTTP HEAD/GET -----> URI-R
2: UA <-- HTTP 200; Link: URI-G ----- URI-R
3: UA --- HTTP HEAD/GET -----> URI-G
4: UA <-- HTTP 302; Location: URI-M; Vary; Link:
    URI-R,URI-T -----> URI-G
5: UA --- HTTP GET URI-T -----> URI-T
6: UA <-- HTTP 200 ----- URI-T

```

Figure 3: A Request/Response Chain to Obtain a TimeMap

- Step 1: The user agent that wants to access a TimeMap for the Original Resource issues an HTTP HEAD/GET against URI-R. This can be done with or without an "Accept-Datetime" HTTP header.
- Step 2: Irrespective of the use of an "Accept-Datetime" HTTP header in Step 1, the response from URI-R includes an HTTP "Link" header with a Relation Type of "timegate" pointing at a TimeGate (URI-G) for the Original Resource.
- Step 3: The user agent issues an HTTP GET request against URI-G. This can be done with or without an "Accept-Datetime" HTTP header.
- Step 4: Irrespective of the use of an "Accept-Datetime" HTTP header in Step 1, the response contains an HTTP "Link" header with a Relation Type of "timemap" pointing at a TimeMap (URI-T).
- Step 5: The user agent issues an HTTP GET request against URI-T.
- Step 6: The response from URI-T has an entity-body that lists all Mementos for the Original Resource known to the responding server, as well as their archival datetimes.

Details about the content and serialization of TimeMaps are provided in Section 5.

4. Datetime Negotiation: HTTP Interactions

Figure 2 depicts a specific pattern to implement the Memento framework. Multiple patterns exist, and they can be grouped as follows:

- o Pattern 1 (Section 4.1) - The Original Resource acts as its own TimeGate
- o Pattern 2 (Section 4.2) - A remote resource acts as a TimeGate for the Original Resource

- o Pattern 3 (Section 4.3) - The Original Resource is a Fixed Resource
- o Pattern 4 (Section 4.4) - Mementos without a TimeGate

Details of the HTTP interactions for common cases for each of those patterns are provided in Sections 4.1 through 4.4. Appendix A summarizes the use of the "Vary", "Memento-Datetime", and "Link" headers in responses from Original Resources, TimeGates, and Mementos for the various patterns. Special cases are described in Section 4.5. Note that in the following sections, the HTTP status code of the responses with an entity-body is shown as "200 OK", but a series of "206 Partial Content" responses could be substituted.

Figure 4 shows a user agent that attempts to datetime negotiate with the Original Resource `http://a.example.org/` by including an "Accept-Datetime" header in its HTTP HEAD request. This initiating request is the same for Pattern 1 (Section 4.1) through Pattern 3 (Section 4.3).

```
HEAD / HTTP/1.1
Host: a.example.org
Accept-Datetime: Tue, 20 Mar 2001 20:35:00 GMT
Connection: close
```

Figure 4: User Agent Attempts Datetime Negotiation
with Original Resource

4.1. Pattern 1 - The Original Resource Acts as Its Own TimeGate

In this implementation pattern, the Original Resource acts as its own TimeGate, which means that URI-R and URI-G coincide. Content management systems and revision control systems can support datetime negotiation in this way as they are commonly aware of the version history of their own resources.

The response to this request when datetime negotiation for this resource is supported depends on the negotiation style it uses (200-style or 302-style) and on the existence or absence of a URI-M for Mementos that is distinct from the URI-R of the associated Original Resource. The various cases are summarized in the below table, and the server responses for each are detailed in the remainder of this section.

Pattern	Original Resource	TimeGate	Memento	Negotiation Style
Pattern 1.1 (Section 4.1.1)	URI-R	URI-R	URI-M	302
Pattern 1.2 (Section 4.1.2)	URI-R	URI-R	URI-M	200
Pattern 1.3 (Section 4.1.3)	URI-R	URI-R	URI-R	200

Table 1: Pattern 1

4.1.1. Pattern 1.1 - URI-R=URI-G; 302-Style Negotiation; Distinct URI-M

In this case, the response to the user agent's request of Figure 4 has a "302 Found" HTTP status code, and the "Location" header conveys the URI-M of the selected Memento. The use of Memento response headers and links in the response from URI-R=URI-G is as follows:

- o The "Vary" header MUST be provided, and it MUST include the "accept-datetime" value.
- o The response MUST NOT contain a "Memento-Datetime" header.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 4 is shown in Figure 5. Note the inclusion of the recommended link to the TimeGate that, in this case, has a Target IRI that is the URI-R of the Original Resource.

```
HTTP/1.1 302 Found
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Vary: accept-datetime
Location:
  http://a.example.org/?version=20010320133610
Link: <http://a.example.org/>; rel="original timegate"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 5: Response from URI-R=URI-G for Pattern 1.1

In a subsequent request, shown in Figure 6, the user agent can obtain the selected Memento by issuing an HTTP GET request against the URI-M that was provided in the "Location" header. The inclusion of the "Accept-Datetime" header in this request is not needed but will typically occur as the user agent is in datetime negotiation mode.

```
GET /?version=20010320133610 HTTP/1.1
Host: a.example.org
Accept-Datetime: Tue, 20 Mar 2001 20:35:00 GMT
Connection: close
```

Figure 6: User Agent Requests Selected Memento

The response has a "200 OK" HTTP status code, and the entity-body of the response contains the representation of the selected Memento. The use of Memento response headers and links in the response from URI-M is as follows:

- o A "Vary" header that includes an "accept-datetime" value MUST NOT be provided.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the Memento.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 6 is shown in Figure 7. Note the provision of the required "original", and the recommended "timegate" and "timemap" links. The former two point to

the Original Resource, which acts as its own TimeGate. The latter has "from" and "until" attributes to indicate the temporal interval covered by Mementos listed in the linked TimeMap.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:06:51 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Tue, 20 Mar 2001 13:36:10 GMT
Link: <http://a.example.org/>; rel="original timegate",
      <http://a.example.org/?version=all&style=timemap>
      ; rel="timemap"; type="application/link-format"
      ; from="Tue, 15 Sep 2000 11:28:26 GMT"
      ; until="Wed, 20 Jan 2010 09:34:33 GMT"
Content-Length: 23364
Content-Type: text/html; charset=utf-8
Connection: close
```

Figure 7: Response from URI-M for Pattern 1.1

4.1.2. Pattern 1.2 - URI-R=URI-G; 200-Style Negotiation; Distinct URI-M

In this case, the response to the user agent's request of Figure 4 has a "200 OK" HTTP status code, and the "Content-Location" header conveys the URI-M of the selected Memento. The use of Memento response headers and links in the response from URI-R=URI-G is as follows:

- o The "Vary" header MUST be provided, and it MUST include the "accept-datetime" value.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the selected Memento.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 4 is shown in Figure 8. Note the provision of optional "memento" links pointing at the oldest and most recent Memento for the Original Resource known to the responding server.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Vary: accept-datetime
Content-Location:
  http://a.example.org/?version=20010320133610
Memento-Datetime: Tue, 20 Mar 2001 13:36:10 GMT
Link: <http://a.example.org/>; rel="original timegate",
  <http://a.example.org/?version=20000915112826>
  ; rel="memento first"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
  <http://a.example.org/?version=20100120093433>
  ; rel="memento last"; datetime="Wed, 20 Jan 2010 09:34:33 GMT",
  <http://a.example.org/?version=all&style=timemap>
  ; rel="timemap"; type="application/link-format"
Content-Length: 23364
Content-Type: text/html; charset=utf-8
Connection: close
```

Figure 8: Response from URI-R=URI-G for Pattern 1.2

In a subsequent request, which is the same as Figure 4 but with HTTP GET instead of HEAD, the user agent can obtain the representation of the selected Memento. It will be provided as the entity-body of a response that has the same Memento headers as in Figure 8.

4.1.3. Pattern 1.3 - URI-R=URI-G; 200-Style Negotiation; No Distinct URI-M

In this case, the response to the user agent's request of Figure 4 has a "200 OK" HTTP status code, and it does not contain a "Content-Location" nor a "Location" header as there is no URI-M of the selected Memento to convey. The use of Memento response headers and links in the response from URI-R=URI-G is as follows:

- o The "Vary" header MUST be provided, and it MUST include the "accept-datetime" value.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the selected Memento.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 4 is shown in Figure 9. The recommended "timemap" and "timegate" links are included in addition to the mandatory "original" link.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Vary: accept-datetime
Memento-Datetime: Tue, 20 Mar 2001 13:36:10 GMT
Link: <http://a.example.org/>; rel="original timegate",
      <http://a.example.org/?version=all&style=timemap>
      ; rel="timemap"; type="application/link-format"
Content-Length: 23364
Content-Type: text/html;charset=utf-8
Connection: close
```

Figure 9: Response from URI-R=URI-G for Pattern 1.3

In a subsequent request, which is the same as Figure 4 but with HTTP GET instead of HEAD, the user agent can obtain the representation of the selected Memento. It will be provided as the entity-body of a response that has the same Memento headers as in Figure 9.

4.2. Pattern 2 - A Remote Resource Acts as a TimeGate for the Original Resource

In this implementation pattern, the Original Resource does not act as its own TimeGate, which means that URI-R and URI-G are different. This pattern is typically implemented by servers for which the history of their resources is recorded in remote systems such as Web archives and transactional archives [Fitch]. But servers that maintain their own history, such as content management systems and version control systems, may also implement this pattern, for example, to distribute the load involved in responding to requests for current and prior representations of resources between different servers.

This pattern is summarized in the below table and is detailed in the remainder of this section. Three cases exist that differ regarding the negotiation style that is used by the remote TimeGate and regarding the existence of a URI-M for Mementos that is distinct from the URI-G of the TimeGate.

Pattern	Original Resource	TimeGate	Memento	Negotiation Style
Pattern 2.1 (Section 4.2.1)	URI-R	URI-G	URI-M	302
Pattern 2.2 (Section 4.2.2)	URI-R	URI-G	URI-M	200
Pattern 2.3 (Section 4.2.3)	URI-R	URI-G	URI-G	200

Table 2: Pattern 2

The response by the Original Resource to the request shown in Figure 4 is the same for all three cases. The use of headers and links in the response from URI-R is as follows:

- o A "Vary" header that includes an "accept-datetime" value MUST NOT be provided.
- o The response MUST NOT contain a "Memento-Datetime" header.
- o The "Link" header SHOULD be provided. It MUST NOT include a link with an "original" Relation Type. If a preferred TimeGate is associated with the Original Resource, then it MUST include a link with a "timegate" Relation Type that has the URI-G of the TimeGate as Target IRI. If a preferred TimeMap is associated with the Original Resource, then it SHOULD include a link with a "timemap" Relation Type that has the URI-T of the TimeGate as Target IRI. Multiple "timegate" and "timemap" links can be provided to accommodate situations in which the server is aware of multiple TimeGates or TimeMaps for the Original Resource.

Figure 10 shows such a response. Note the absence of an "original" link as the responding resource is neither a TimeGate nor a Memento.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:02:12 GMT
Server: Apache
Link: <http://arxiv.example.net/timegate/http://a.example.org/>
    ; rel="timegate"
Content-Length: 255
Connection: close
Content-Type: text/html; charset=iso-8859-1
```

Figure 10: Response from URI-R<>URI-G for Pattern 2

Once a user agent has obtained the URI-G of a remote TimeGate for the Original Resource, it can engage in datetime negotiation with that TimeGate. Figure 11 shows the request issued against the TimeGate, whereas Sections 4.2.1 through 4.2.3 detail the responses for various TimeGate implementation patterns.

```
HEAD /timegate/http://a.example.org/ HTTP/1.1
Host: arxiv.example.net
Accept-Datetime: Tue, 20 Mar 2001 20:35:00 GMT
Connection: close
```

Figure 11: User Agent Engages in Datetime Negotiation
with Remote TimeGate

4.2.1. Pattern 2.1 - URI-R<>URI-G; 302-Style Negotiation; Distinct URI-M

In case the TimeGate uses a 302 negotiation style, the response to the user agent's request of Figure 11 has a "302 Found" HTTP status code, and the "Location" header conveys the URI-M of the selected Memento. The use of Memento response headers and links in the response from URI-G is as follows:

- o The "Vary" header MUST be provided, and it MUST include the "accept-datetime" value.
- o The response MUST NOT contain a "Memento-Datetime" header.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 11 is shown in Figure 12. It contains the mandatory "original" link that points back to the Original Resource associated with this TimeGate, and it shows the recommended "timemap" link that includes "from" and "until" attributes.

```
HTTP/1.1 302 Found
Date: Thu, 21 Jan 2010 00:02:14 GMT
Server: Apache
Vary: accept-datetime
Location:
  http://arxiv.example.net/web/20010321203610/http://a.example.org/
Link: <http://a.example.org/>; rel="original",
  <http://arxiv.example.net/timemap/http://a.example.org/>
    ; rel="timemap"; type="application/link-format"
    ; from="Tue, 15 Sep 2000 11:28:26 GMT"
    ; until="Wed, 20 Jan 2010 09:34:33 GMT"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 12: Response from URI-G<>URI-R for Pattern 2.1

In a subsequent HTTP GET request, shown in Figure 13, the user agent can obtain the selected Memento by issuing an HTTP GET request against the URI-M that was provided in the "Location" header. The inclusion of the "Accept-Datetime" header in this request is not needed but will typically occur as the user agent is in datetime negotiation mode.

```
GET /web/20010321203610/http://a.example.org/ HTTP/1.1
Host: arxiv.example.net/
Accept-Datetime: Tue, 20 Mar 2001 20:35:00 GMT
Connection: close
```

Figure 13: User Agent Requests Selected Memento

The response has a "200 OK" HTTP status code. The use of Memento response headers and links in the response from URI-M is as follows:

- o A "Vary" header that includes an "accept-datetime" value MUST NOT be provided.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the Memento.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 13 is shown in Figure 14. Note the provision of the recommended "timegate" and "timemap" links.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:02:15 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Wed, 21 Mar 2001 20:36:10 GMT
Link: <http://a.example.org/>; rel="original",
      <http://arxiv.example.net/timemap/http://a.example.org/>
      ; rel="timemap"; type="application/link-format",
      <http://arxiv.example.net/timegate/http://a.example.org/>
      ; rel="timegate"
Content-Length: 25532
Content-Type: text/html; charset=utf-8
Connection: close
```

Figure 14: Response from URI-M for Pattern 2.1

4.2.2. Pattern 2.2 - URI-R<>URI-G; 200-Style Negotiation; Distinct URI-M

In case the TimeGate uses a 200 negotiation style, and each Memento has a distinct URI-M, the response to the user agent's request of Figure 11 has a "200 OK" HTTP status code, and the "Content-Location" header conveys the URI-M of the selected Memento. The use of Memento response headers and links in the response from URI-G is as follows:

- o The "Vary" header MUST be provided, and it MUST include the "accept-datetime" value.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the Memento.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 11 is shown in Figure 15.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Vary: accept-datetime
Content-Location:
  http://arxiv.example.net/web/20010321203610/http://a.example.org/
Memento-Datetime: Wed, 21 Mar 2001 20:36:10 GMT
Link: <http://a.example.org/>; rel="original",
      <http://arxiv.example.net/timemap/http://a.example.org/>
      ; rel="timemap"; type="application/link-format",
      <http://arxiv.example.net/timegate/http://a.example.org/>
      ; rel="timegate"
Content-Length: 25532
Content-Type: text/html;charset=utf-8
Connection: close
```

Figure 15: Response from URI-G<>URI-R for Pattern 2.2

In a subsequent request, which is the same as Figure 11 but with HTTP GET instead of HEAD, the user agent can obtain the representation of the selected Memento. It will be provided as the entity-body of a response that has the same Memento headers as Figure 15.

4.2.3. Pattern 2.3 - URI-R<>URI-G; 200-Style Negotiation; No Distinct URI-M

In case the TimeGate uses a 200 negotiation style, but Mementos have no distinct URIs, the response to the user agent's request of Figure 11 has a "200 OK" HTTP status code, and it does not contain a "Content-Location" nor "Location" header as there is no URI-M of the selected Memento to convey. The use of Memento response headers and links in the response from URI-G is as follows:

- o The "Vary" header MUST be provided, and it MUST include the "accept-datetime" value.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the Memento.
- o The "Link" header MUST be provided, and it MUST contain at least a link with the "original" Relation Type that has the URI-R of the Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

The server's response to the request of Figure 11 is shown in Figure 16.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Vary: accept-datetime
Memento-Datetime: Wed, 21 Mar 2001 20:36:10 GMT
Link: <http://a.example.org/>; rel="original",
      <http://arxiv.example.net/timemap/http://a.example.org/>
      ; rel="timemap"; type="application/link-format",
      <http://arxiv.example.net/timegate/http://a.example.org/>
      ; rel="timegate"
Content-Length: 25532
Content-Type: text/html; charset=utf-8
Connection: close
```

Figure 16: Response from URI-G<>URI-R for Pattern 2.3

In a subsequent request, which is the same as Figure 11 but with HTTP GET instead of HEAD, the user agent can obtain the representation of the selected Memento. It will be provided as the entity-body of a response that has the same Memento headers as Figure 16.

4.3. Pattern 3 - The Original Resource is a Fixed Resource

This pattern does not involve datetime negotiation with a TimeGate, but it can be implemented for Original Resources that never change state or do not change anymore past a certain point in their existence, meaning that URI-R and URI-M coincide either from the outset or starting at some point in time. This pattern is summarized in the below table. Examples are tweets or stable media resources on news sites.

Pattern	Original Resource	TimeGate	Memento	Negotiation Style
Pattern 3	URI-R	-	URI-R	-

Table 3: Pattern 3

Servers that host such resources can support the Memento framework by treating the stable resource (FixedResource as per [W3C.gen-ont-20090420]) as a Memento. The use of Memento response headers and links in responses from such a stable resource is as follows:

- o A "Vary" header that includes an "accept-datetime" value MUST NOT be provided.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the datetime at which the resource became stable. Providing this value includes a promise that the resource has not changed since this datetime and will not change anymore beyond it.
- o The "Link" header MUST be provided and MUST have a link with the "original" Relation Type that has the URI-R of the stable resource itself as Target IRI.

Figure 17 shows a response to an HTTP HEAD request for the resource with URI-R `http://a.example.org/` that has been stable since March 20, 2009.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Fri, 20 Mar 2009 11:00:00 GMT
Link: <http://a.example.org/>; rel="original"
Content-Length: 875
Content-Type: text/html; charset=utf-8
Connection: close
```

Figure 17: Response from URI-R=URI-M for Pattern 3

4.4. Pattern 4 - Mementos without a TimeGate

Cases may occur in which a server hosts Mementos but does not expose a TimeGate for them. This can, for example, be the case if the server's Mementos result from taking a snapshot of the state of a set of Original Resources from another server as it is being retired. As a result, only a single Memento per Original Resource is hosted, making the introduction of a TimeGate unnecessary. But it may also be the case for servers that host multiple Mementos for an Original Resource but consider exposing TimeGates too expensive. In this case, URI-R and URI-M are distinct, but a TimeGate is absent. This case is summarized in the below table.

Pattern	Original Resource	TimeGate	Memento	Negotiation Style
Pattern 4	URI-R	-	URI-M	-

Table 4: Pattern 4

Servers that host such Mementos without TimeGates can still support the Memento framework by providing the appropriate Memento headers and links. Their use is as follows for a response from URI-M:

- o A "Vary" header that includes an "accept-datetime" value MUST NOT be provided.
- o The response MUST include a "Memento-Datetime" header. Its value expresses the archival datetime of the Memento.
- o The "Link" header MUST be provided, and it MUST have a link with the "original" Relation Type that has the URI-R of the associated Original Resource as Target IRI. The provision of other links is encouraged and is subject to the considerations described in Section 2.2.

Figure 18 shows a response to an HTTP HEAD request for the Memento with URI-M

`http://arxiv.example.net/web/20010321203610/http://a.example.org/`. Note the use of links: three links have the URI-M of the Memento as Target IRI and have respective Relation Types "memento", "first", and "last". This combination indicates that this is the only Memento for the Original Resource with Target IRI provided by the "original" link (`http://a.example.org/`) of which the server is aware. Note also that such a response does not imply that there is no server whatsoever that exposes a TimeGate; it merely means that the responding server neither provides nor is aware of the location of a TimeGate.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Wed, 21 Mar 2001 20:36:10 GMT
Link: <http://a.example.org/>; rel="original",
      <http://arxiv.example.net/web/20010321203610/http://a.example.org/>
      ; rel="first last memento"
      ; datetime="Wed, 21 Mar 2001 20:36:10 GMT"
Content-Length: 25532
Content-Type: text/html;charset=utf-8
Connection: close
```

Figure 18: Response from URI-M<>URI-R for Pattern 4

4.5. Special Cases

4.5.1. Original Resource Provides No "timegate" Link

Cases exist in which the response from the Original Resource does not contain a "timegate" link, including:

- o The Original Resource's server does not support the Memento framework;
- o The Original Resource no longer exists, and the responding server is not aware of its prior existence;
- o The server that hosted the Original Resource no longer exists.

In all these cases, the user agent should attempt to determine an appropriate TimeGate for the Original Resource, either automatically or interactively supported by the user.

4.5.2. Server Exists but Original Resource No Longer Does

Cases exist in which the server knows that an Original Resource used to exist, but no longer provides a current representation. If there is a preferred TimeGate for such a discontinued Original Resource, then the server MUST include a "timegate" link in responses to requests for it. This may allow access to Mementos for the Original Resource even if it no longer exists. A server's response to a request for the discontinued resource `http://a.example.org/pic` is illustrated in Figure 19.

```
HTTP/1.1 404 Not Found
Date: Thu, 21 Jan 2010 00:02:12 GMT
Server: Apache
Link:
  <http://arxiv.example.net/timegate/http://a.example.org/pic>
  ; rel="timegate"
Content-Length: 255
Content-Type: text/html; charset=iso-8909-1
Connection: close
```

Figure 19: Response from an Original Resource That No Longer Exists

4.5.3. Issues with Accept-Datetime

The following special cases may occur regarding the "Accept-Datetime" header when a user agent issues a request against a TimeGate:

- o If the value of the "Accept-Datetime" is either earlier than the datetime of the first Memento or later than the datetime of the most recent Memento known to the TimeGate, the first or most recent Memento MUST be selected, respectively.
- o If the value of the "Accept-Datetime" does not conform to the rfc1123-date construction rule of the BNF in Figure 1, the response MUST have a "400 Bad Request" HTTP status code.
- o If a user agent issues a request against a TimeGate and fails to include an "Accept-Datetime" request header, the most recent Memento SHOULD be selected.

In all cases, the use of headers and links in responses is as described for TimeGates in the respective scenarios.

4.5.4. Memento of a 3XX Response

Cases exist in which HTTP responses with 3XX status codes are archived. For example, crawl-based Web archives commonly archive responses with HTTP status codes "301 Moved Permanently" and "302 Found", whereas Linked Data archives hold on to "303 See Other" responses.

If the Memento requested by the user agent is an archived version of an HTTP response with a 3XX status code, the server's response MUST have the same 3XX HTTP status code. The use of other Memento headers is as described for Mementos in the respective scenarios.

The user agent's handling of an HTTP response with a 3XX status code is not affected by the presence of a "Memento-Datetime" header. The user agent MUST behave in the same manner as it does with HTTP responses with a 3XX status code that do not have a "Memento-Datetime" header.

However, the user agent MUST be aware that the URI that was selected from the "Location" header of an HTTP response with a 3XX status code might not be that of a Memento but rather of an Original Resource. In the latter case, it SHOULD proceed by looking for a Memento of the selected Original Resource.

For example, Figure 20 shows the response to an HTTP GET request for `http://a.example.org` issued on April 11, 2008. This response is archived as a Memento of `http://a.example.org` that has as URI-M `http://arxiv.example.net/web/20080411000650/http://a.example.org`. The response to an HTTP GET on this URI-M is shown in Figure 21. It is a replay of the original response with "Memento-Datetime" and "Link" headers added, to allow a user agent to understand the response is a Memento. In Figure 21, the value of the "Location" header is the same as in the original response; it identifies an Original Resource. The user agent proceeds with finding a Memento for this Original Resource. Web archives sometimes overwrite the value that was originally provided in the "Location" header in order to point at a Memento they hold of the resource to which the redirect originally led. This is shown in Figure 22. In this case, the user agent may decide it found an appropriate Memento.

```
HTTP/1.1 301 Moved Permanently
Date: Fri, 11 Apr 2008 00:06:50 GMT
Server: Apache
Location: http://b.example.org
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 20: Response Is a Redirect

```
HTTP/1.1 301 Moved Permanently
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Fri, 11 Apr 2008 00:06:50 GMT
Location: http://b.example.org
Link: <http://a.example.org>; rel="original",
      <http://arxiv.example.net/timemap/http://a.example.org>
      ; rel="timemap"; type="application/link-format",
      <http://arxiv.example.net/timegate/http://a.example.org>
      ; rel="timegate"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 21: Response is a Memento of a Redirect; Leads to an Original Resource

```
HTTP/1.1 301 Moved Permanently
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Fri, 11 Apr 2008 00:06:50 GMT
Location:
  http://arxiv.example.net/web/20080411000655/http://b.example.org
Link: <http://a.example.org>; rel="original",
      <http://arxiv.example.net/timemap/http://a.example.org>
      ; rel="timemap"; type="application/link-format",
      <http://arxiv.example.net/timegate/http://a.example.org>
      ; rel="timegate"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 22: Response is a Memento of a Redirect; Leads to a Memento

4.5.5. Memento of Responses with 4XX or 5XX HTTP Status Codes

Cases exist in which responses with 4XX and 5XX HTTP status codes are archived. If the Memento requested by the user agent is an archived version of such an HTTP response, the server's response MUST have the same 4XX or 5XX HTTP status code. The use of headers and links in responses is as described for Mementos in the respective scenarios.

For example, Figure 23 shows the 404 response to an HTTP GET request for `http://a.example.org` issued on April 11, 2008. This response is archived as a Memento of `http://a.example.org` that has as URI-M `http://arxiv.example.net/web/20080411000650/http://a.example.org`. The response to an HTTP HEAD on this URI-M is shown in Figure 24. It

is a replay of the original response with "Memento-Datetime" and "Link" headers added, to allow a user agent to understand the response is a Memento.

```
HTTP/1.1 404 Not Found
Date: Fri, 11 Apr 2008 00:06:50 GMT
Server: Apache
Content-Length: 255
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 23: Response Is a 404

```
HTTP/1.1 404 Not Found
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Fri, 11 Apr 2008 00:06:50 GMT
Link: <http://a.example.org>; rel="original",
      <http://arxiv.example.net/timemap/http://a.example.org>
      ; rel="timemap"; type="application/link-format",
      <http://arxiv.example.net/timegate/http://a.example.org>
      ; rel="timegate"
Content-Length: 255
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 24: Response Is a Memento of a 404

4.5.6. Sticky "Memento-Datetime" and "original" Link for Mementos

A response to an HTTP HEAD/GET request issued against a Memento:

- o Includes a "Memento-Datetime" header that entails a promise that the response is archived, frozen in time. The value of the header expresses the archival datetime of the Memento.
- o Includes a link in the HTTP "Link" header with an "original" Relation Type that unambiguously points to the Original Resource associated with the Memento. The Target IRI of the link is the URI-R of that Original Resource.

Both the "Memento-Datetime" header and the "original" link MUST be "sticky" in the following ways:

- o The server that originally assigns them MUST retain them in all responses to HTTP requests (with or without an "Accept-Datetime" request header) that occur against the Memento after the time of

their original assignment, and the server MUST NOT change the value of the "Memento-Datetime" header nor the Target IRI of the "original" link.

- o Applications that mirror Mementos at a different URI MUST retain them and MUST NOT change them unless mirroring involves a meaningful state change. This allows, among others, duplicating a Web archive at a new location while preserving the value of the "Memento-Datetime" header and the link with the "original" Relation Type for the archived resources. For example, when mirroring, the "Last-Modified" header will be updated to reflect the time of mirroring at the new URI, whereas the value for "Memento-Datetime" will be maintained.

4.5.7. Intermediate Resources

An intermediate resource is a resource that issues a redirect to a TimeGate, to a Memento, or to another intermediate resource, and thus plays an active role in the Memento infrastructure. Intermediate resources commonly exist in Web archives on the path from a TimeGate to an appropriate Memento.

A response of an intermediate resource has an HTTP status code indicative of HTTP redirection (e.g., 302) and uses Memento headers and links that allow user agents to recognize that the resource plays a role in the Memento framework:

- o A "Vary" header that includes an "accept-datetime" value MUST NOT be provided.
- o The response MUST NOT include a "Memento-Datetime" header.
- o The "Link" header MUST be provided, and it MUST have a link with the "original" Relation Type that has the URI-R of the associated Original Resource as Target IRI. Links with "timegate", "timemap", and "memento" Relation Types are OPTIONAL and, if provided, MUST pertain to the Original Resource for which the user agent is trying to obtain a Memento.

A user agent MUST follow a redirection provided by an intermediate resource; multiple such redirections can be chained.

Consider the case where a user agent follows the "timegate" link provided in Figure 10 and engages in datetime negotiation with the assumed TimeGate in the manner shown in Figure 11. But instead of receiving a response as shown in Figure 12, it receives the one shown below in Figure 25. Such a response is unambiguously recognizable as coming from an intermediate resource.

```
HTTP/1.1 302 Found
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Location:
  http://arxiv.example.net/new-timegate/http://a.example.org/
Link: <http://a.example.org>; rel="original"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 25: Redirecting Resource Redirects to a TimeGate

4.5.8. Resources Excluded from Datetime Negotiation

When delivering a Memento to a user agent, a Web archive commonly enhances that Memento's archived content, for example, by including a banner that provides branding and highlights the archival status of the Memento. The resources that are involved in providing such system-specific functionality, many times JavaScript or images, must be used in their current state.

A server that generally supports datetime negotiation should make resources that need to be excluded from datetime negotiation recognizable. Doing so allows a user agent to refrain from attempting to access a Memento for them. In order to achieve this, the server SHOULD include a special-purpose link in the HTTP "Link" header when responding to an HTTP HEAD/GET request to a resource excluded from datetime negotiation. This link has "http://mementoweb.org/terms/donotnegotiate" as Target IRI and "type", defined in [RFC6903], as the value of the "rel" attribute. Other Memento headers as defined in Section 2.1 SHOULD NOT be provided.

Figure 26 shows the response to an HTTP HEAD request from a resource excluded from datetime negotiation.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Link: <http://mementoweb.org/terms/donotnegotiate>; rel="type"
Content-Length: 238
Content-Type: application/javascript; charset=UTF-8
Connection: close
```

Figure 26: Response to an HTTP HEAD Request from a Resource Excluded from Datetime Negotiation

5. TimeMaps: Content and Serialization

A TimeMap is introduced to support retrieving a comprehensive list of all Mementos for a specific Original Resource known to a server. The entity-body of a response to an HTTP GET request issued against a TimeMap's URI-T:

- o MUST list the URI-R of the Original Resource that the TimeMap is about;
- o MUST list the URI-M and archival datetime of each Memento for the Original Resource known to the server, preferably in a single document, or, alternatively in multiple documents that can be gathered by following contained links with a "timemap" Relation Type;
- o SHOULD list the URI-G of one or more TimeGates for the Original Resource known to the responding server;
- o SHOULD, for self-containment, list the URI-T of the TimeMap itself;
- o MUST unambiguously type listed resources as being Original Resource, TimeGate, Memento, or TimeMap.

The entity-body of a response from a TimeMap MAY be serialized in various ways, but the link-value format serialization described here MUST be supported. In this serialization, the entity-body MUST be formatted in the same way as the value of an HTTP "Link" header, and hence MUST comply to the "link-value" construction rule of Section 5. The Link header field of [RFC5988], and the media type of the entity-body MUST be "application/link-format" as introduced in [RFC6690]. Links contained in the entity-body MUST be interpreted as follows:

- o The Context IRI is set to the anchor parameter, when specified;
- o The Context IRI of links with the "self" Relation Types is the URI-T of the TimeMap, i.e., the URI of the resource from which the TimeMap was requested;
- o The Context IRI of all other links is the URI-R of the Original Resource, which is provided as the Target IRI of the link with an "original" Relation Type.

In order to retrieve the link-value serialization of a TimeMap, a user agent uses an "Accept" request header with a value set to "application/link-format". This is shown in Figure 27.

```
GET /timemap/http://a.example.org/ HTTP/1.1
Host: arxiv.example.net
Accept: application/link-format;q=1.0
Connection: close
```

Figure 27: Request for a TimeMap

If the TimeMap requested by the user agent exists, the server's response has a "200 OK" HTTP status code and the list of Mementos is provided in the entity-body of the response. Such a response is shown in Figure 28.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Content-Length: 4883
Content-Type: application/link-format
Connection: close

<http://a.example.org>;rel="original",
<http://arxiv.example.net/timemap/http://a.example.org>
  ; rel="self";type="application/link-format"
  ; from="Tue, 20 Jun 2000 18:02:59 GMT"
  ; until="Wed, 09 Apr 2008 20:30:51 GMT",
<http://arxiv.example.net/timegate/http://a.example.org>
  ; rel="timegate",
<http://arxiv.example.net/web/20000620180259/http://a.example.org>
  ; rel="first memento";datetime="Tue, 20 Jun 2000 18:02:59 GMT"
  ; license="http://creativecommons.org/publicdomain/zero/1.0/",
<http://arxiv.example.net/web/20091027204954/http://a.example.org>
  ; rel="last memento";datetime="Tue, 27 Oct 2009 20:49:54 GMT"
  ; license="http://creativecommons.org/publicdomain/zero/1.0/",
<http://arxiv.example.net/web/20000621011731/http://a.example.org>
  ; rel="memento";datetime="Wed, 21 Jun 2000 01:17:31 GMT"
  ; license="http://creativecommons.org/publicdomain/zero/1.0/",
<http://arxiv.example.net/web/20000621044156/http://a.example.org>
  ; rel="memento";datetime="Wed, 21 Jun 2000 04:41:56 GMT"
  ; license="http://creativecommons.org/publicdomain/zero/1.0/",
...
```

Figure 28: Response from a TimeMap

5.1. Special Cases

5.1.1. Index and Paging TimeMaps

Cases exist in which a TimeMap points at one or more other TimeMaps:

- o Index TimeMap - A TimeMap can merely point at other TimeMaps and not list any Mementos itself. This can happen when Mementos are spread across several archives that share a front-end. An example is shown in Figure 29.
- o Paging TimeMap - The number of available Mementos can require introducing multiple TimeMaps that can be paged. An example is shown in Figure 30. Note that a Paging TimeMap contains links to other TimeMaps but actually also lists Mementos.

In both cases, including the "from" and "until" attributes for "timemap" links is RECOMMENDED as a means to express the temporal span of Mementos listed in each TimeMap. Note that TimeMaps obtained by following a "timemap" link can contain links to further TimeMaps.

```
<http://a.example.org>;rel="original",  
<http://arxiv.example.net/timegate/http://a.example.org>  
; rel="timegate",  
<http://arxiv.example.net/timemap/http://a.example.org>  
; rel="self";type="application/link-format",  
<http://arxiv1.example.net/timemap/http://a.example.org>  
; rel="timemap";type="application/link-format"  
; from="Wed, 21 Jun 2000 04:41:56 GMT"  
; until="Wed, 09 Apr 2008 20:30:51 GMT",  
<http://arxiv2.example.net/timemap/http://a.example.org>  
; rel="timemap";type="application/link-format"  
; from="Thu, 10 Apr 2008 20:30:51 GMT"  
; until="Tue, 27 Oct 2009 20:49:54 GMT",  
<http://arxiv3.example.net/timemap/http://a.example.org>  
; rel="timemap";type="application/link-format"  
; from="Thu, 29 Oct 2009 20:30:51 GMT"
```

Figure 29: Index TimeMap

```

<http://a.example.org>;rel="original",
<http://arxiv.example.net/timegate/http://a.example.org>
  ; rel="timegate",
<http://arxiv.example.net/timemap/1/http://a.example.org>
  ; rel="self";type="application/link-format"
  ; from="Tue, 20 Jun 2000 18:02:59 GMT"
  ; until="Wed, 09 Apr 2008 20:30:51 GMT",
<http://arxiv.example.net/timemap/2/http://a.example.org>
  ; rel="timemap";type="application/link-format"
  ; from="Thu, 10 Apr 2008 20:30:51 GMT"
  ; until="Tue, 27 Oct 2009 20:49:54 GMT",
<http://arxiv.example.net/timemap/3/http://a.example.org>
  ; rel="timemap";type="application/link-format"
  ; from="Thu, 29 Oct 2009 20:30:51 GMT"
  ; until="Fri, 31 Aug 2012 12:22:34 GMT"
<http://arxiv.example.net/web/20000620180259/http://a.example.org>
  ; rel="memento";datetime="Tue, 20 Jun 2000 18:02:59 GMT",
<http://arxiv.example.net/web/20000621011731/http://a.example.org>
  ; rel="memento";datetime="Wed, 21 Jun 2000 01:17:31 GMT",
<http://arxiv.example.net/web/20000621044156/http://a.example.org>
  ; rel="memento";datetime="Wed, 21 Jun 2000 04:41:56 GMT",
...

```

Figure 30: Paging TimeMap

5.1.2. Mementos for TimeMaps

A TimeMap itself can act as an Original Resource for which a TimeGate and Mementos may exist. Hence, the response from a TimeMap could include a "timegate" link to a TimeGate via which prior TimeMap versions are available. And, in cases where URI-T=URI-R=URI-G (a TimeMap is an Original Resource that acts as its own TimeGate), an "original" link pointing at the TimeMap URI-T would be included.

Therefore, caution is required in cases where a TimeMap for an Original Resource wants to explicitly express in a "Link" header for which Original Resource it is a TimeMap. It can do so by including a "timemap" link that has the URI-R of the Original Resource as Context IRI and the URI-T of the TimeMap as Target IRI.

Figure 31 shows the response to an HTTP HEAD request against a TimeMap that has `http://arxiv.example.net/timemap/http://a.example.org` as URI-T. This TimeMap provides information about Mementos for the Original Resource that has `http://a.example.org` as URI-R. The response includes an "original" link pointing to the Original Resource that this TimeMap is about. Note the use of the "anchor" attribute in this link to convey the URI-R of that Original Resource.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Link: <http://arxiv.example.net/timemap/http://a.example.org>
      ; anchor="http://a.example.org"; rel="timemap"
      ; type="application/link-format"
Content-Length: 0
Content-Type: application/link-format; charset=UTF-8
Connection: close
```

Figure 31: TimeMap Links to the Original Resource It Is about

6. IANA Considerations

6.1. HTTP Headers

IANA has registered the "Accept-Datetime" and "Memento-Datetime" HTTP headers (defined in Section 2.1.1) in the "Permanent Message Header Field Names" registry:

- o Header field name: Accept-Datetime
- o Applicable protocol: "http" (RFC 2616)
- o Status: informational
- o Author/Change controller: Herbert Van de Sompel, Los Alamos National Laboratory, hvdsomp@gmail.com
- o Specification document(s): this document
- o Header field name: Memento-Datetime
- o Applicable protocol: "http" (RFC 2616)
- o Status: informational
- o Author/Change controller: Herbert Van de Sompel, Los Alamos National Laboratory, hvdsomp@gmail.com
- o Specification document(s): this document

6.2. Link Relation Types

IANA has registered the Relation Types "original", "timegate", "timemap", and "memento" (defined in Section 2.2) in the "Link Relation Types" registry:

- o Relation Name: original
- o Description: The Target IRI points to an Original Resource.
- o Reference: this document
- o Notes: An Original Resource is a resource that exists or used to exist, and for which access to one of its prior states may be required.

- o Relation Name: timegate
- o Description: The Target IRI points to a TimeGate for an Original Resource.
- o Reference: this document
- o Notes: A TimeGate for an Original Resource is a resource that is capable of datetime negotiation to support access to prior states of the Original Resource.

- o Relation Name: timemap
- o Description: The Target IRI points to a TimeMap for an Original Resource.
- o Reference: this document
- o Notes: A TimeMap for an Original Resource is a resource from which a list of URIs of Mementos of the Original Resource is available.

- o Relation Name: memento
- o Description: The Target IRI points to a Memento, a fixed resource that will not change state anymore.
- o Reference: this document
- o Notes: A Memento for an Original Resource is a resource that encapsulates a prior state of the Original Resource.

7. Security Considerations

Provision of a "timegate" HTTP "Link" header in responses to requests for an Original Resource that is protected (e.g., 401 or 403 HTTP response codes) is OPTIONAL. The inclusion of this Link when requesting authentication is at the server's discretion; cases may exist in which a server protects the current state of a resource, but supports open access to prior states and thus chooses to supply this HTTP "Link" header. Conversely, the server may choose to not advertise the TimeGate URIs (e.g., they exist in an intranet archive) for unauthenticated requests.

The veracity of archives and the relationships between Original Resources and Mementos is beyond the scope of this document. Even in the absence of malice, it is possible for separate archives to have different Mementos for the same Original Resource at the same datetime if the state of the Original Resource was dependent on the requesting archive's user agent IP address, specific HTTP request headers, and possibly other factors.

Further authentication, encryption, and other security-related issues are otherwise orthogonal to Memento.

8. Acknowledgements

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9. References

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Appendix A. Use of Headers and Relation Types per Pattern

Response Header	Pattern	Original Resource	TimeGate	Memento
Vary: accept-datetime	Pattern 1.1 (Section 4.1.1) & Pattern 1.2 (Section 4.1.2)	1	1	0
	Pattern 1.3 (Section 4.1.3)	1	1	1
	Pattern 2.1 (Section 4.2.1) & Pattern 2.2 (Section 4.2.2)	0	1	0
	Pattern 2.3 (Section 4.2.3)	0	1	1
	Pattern 3 (Section 4.3)	1	NA	1
	Pattern 4 (Section 4.4)	0	NA	1

(cont.)

Response Header	Pattern	Original Resource	TimeGate	Memento
Vary: Memento- Datetime	Pattern 1.1 (Section 4.1.1) & Pattern 1.2 (Section 4.1.2)	0	0	1
	Pattern 1.3 (Section 4.1.3)	1	1	1
	Pattern 2.1 (Section 4.2.1) & Pattern 2.2 (Section 4.2.2)	0	0	1
	Pattern 2.3 (Section 4.2.3)	0	1	1
	Pattern 3 (Section 4.3)	1	NA	1
	Pattern 4 (Section 4.4)	0	NA	1

(cont.)

Response Header	Pattern	Original Resource	TimeGate	Memento
Link: rel="original"	Pattern 1.1 (Section 4.1.1) & Pattern 1.2 (Section 4.1.2)	0	1	1
	Pattern 1.3 (Section 4.1.3)	1	1	1
	Pattern 2.1 (Section 4.2.1) & Pattern 2.2 (Section 4.2.2)	0	1	1
	Pattern 2.3 (Section 4.2.3)	0	1	1
	Pattern 3 (Section 4.3)	1	NA	1
	Pattern 4 (Section 4.4)	0	NA	1

(cont.)

Response Header	Pattern	Original Resource	TimeGate	Memento
Link: rel="timegate"	Pattern 1.1 (Section 4.1.1)	>=0	>=0	>=0
	& Pattern 1.2 (Section 4.1.2)			
	Pattern 1.3 (Section 4.1.3)	>=0	>=0	>=0
	Pattern 2.1 (Section 4.2.1)	>=0	0	>=0
	& Pattern 2.2 (Section 4.2.2)			
	Pattern 2.3 (Section 4.2.3)	>=0	>=0	>=0
	Pattern 3 (Section 4.3)	NA	NA	NA
	Pattern 4 (Section 4.4)	NA	NA	NA

(cont.)

Response Header	Pattern	Original Resource	TimeGate	Memento
Link: rel="timemap"	Pattern 1.1 (Section 4.1.1)	>=0	>=0	>=0
	& Pattern 1.2 (Section 4.1.2)			
	Pattern 1.3 (Section 4.1.3)	>=0	>=0	>=0
	Pattern 2.1 (Section 4.2.1)	>=0	>=0	>=0
	& Pattern 2.2 (Section 4.2.2)			
	Pattern 2.3 (Section 4.2.3)	>=0	>=0	>=0
	Pattern 3 (Section 4.3)	>=0	NA	>=0
	Pattern 4 (Section 4.4)	>=0	NA	>=0

(cont.)

Response Header	Pattern	Original Resource	TimeGate	Memento
Link: rel="memento"	Pattern 1.1 (Section 4.1.1) & Pattern 1.2 (Section 4.1.2)	>=0	>=0	>=0
	Pattern 1.3 (Section 4.1.3)	>=0	>=0	>=0
	Pattern 2.1 (Section 4.2.1) & Pattern 2.2 (Section 4.2.2)	>=0	>=0	>=0
	Pattern 2.3 (Section 4.2.3)	>=0	>=0	>=0
	Pattern 3 (Section 4.3)	>=0	NA	>=0
	Pattern 4 (Section 4.4)	>=0	NA	>=0

Table 5: Memento Headers

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