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

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

                        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     | TimeGate | Memento |   Negotiation   |
|          |   Resource     |          |         |     Style       |
+----------+----------------+----------+---------+-----------------+
| Pattern  |     URI-R      |    -     |  URI-R  |        -        |
|    3     |                |          |         |                 |
+----------+----------------+----------+---------+-----------------+
```

                          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    | TimeGate | Memento |   Negotiation   |
|          |    Resource    |          |         |      Style      |
+----------+----------------+----------+---------+-----------------+
|  Pattern |     URI-R      |    -     |  URI-M  |       -         |
|    4     |                |          |         |                 |
+----------+----------------+----------+---------+-----------------+
```

                         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) & 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)	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) & 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

(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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