HTTP framework for time-based access to resource states -- Memento
draft-vandesompel-memento-05

Abstract

   The HTTP-based Memento framework bridges the present and past Web by
   interlinking current resources with resources that encapsulate their
   past. It facilitates accessing prior states of a resource,
   encapsulated in archival resources in Web archives or version
   resources in content management systems, by leveraging the resource's
   URI and a preferred datetime. To this end, the framework introduces
   datetime negotiation (a variation on content negotiation) and new
   Relation Types. It also introduces discovery mechanisms to support
   these capabilities.

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1. Introduction

1.1. Terminology

This specification uses the terms "resource", "request", "response",
"entity-body", "content negotiation", "client", "user agent",
"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 Tj is a resource
   that encapsulates the state the Original Resource had at time Tj.

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.

o Redirecting Resource: A Redirecting Resource is a resource that
   issues a redirect to a TimeGate, to a Memento, or to another
   Redirecting Resource, and thus plays an active role in the Memento
   infrastructure.

1.2. Purpose

The state of an Original Resource may change over time.
Dereferencing its URI at any specific moment in time 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 non-existence (e.g. "404 Not Found" HTTP
status code), a relation to another resource (e.g. "302 Found" HTTP
status code), etc. However, resources may also exist that
encapsulate prior states of an Original Resource. Each such
resource, named a Memento, has its own URI that, when dereferenced,
yields a response that reflects a prior state of the 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 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. In terms of the Ontology for Relating Generic and Specific Information Resources [W3C.gen-ont-20090420]), a Memento is a FixedResource.

Examples are:

Mementos for Original Resource http://www.ietf.org/ :

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 :

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/ :

o http://www.w3.org/TR/2004/PR-webarch-20041105/

o http://www.w3.org/TR/2002/WD-webarch-20020830/

o http://webarchive.nationalarchives.gov.uk/20100304163140/http://
   www.w3.org/TR/webarch/

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

o Is fully distributed in the sense that resource versions may reside on multiple hosts, and that any such host 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 a resource identified by
URI-R as it existed at some time Tj. Note the relationship with the
ability to identify a the state of a resource at some datetime Tj by
means of a URI as intended by the proposed Dated URI scheme
[I-D.masinter-dated-uri].

2. A bridge from the present to the past, consisting of:

o   An appropriately typed link from the resource identified by URI-R
    to an associated TimeGate identified by URI-G, which is aware of
    (at least part of the) version history of the resource identified
    by URI-R;

o   The ability to negotiate in the datetime dimension with the
    TimeGate identified by URI-G, as a means to access the state that
    the resource identified by URI-R had at some datetime Tj.

3. A bridge from the past to the present, consisting of an
appropriately typed link from a resource identified by URI-M, which
encapsulates the state a resource identified by URI-R had at some
datetime Tj, to the resource identified by URI-R.

Section 2 and Section 3 of this document are concerned with
specifying an instantiation of these abstractions for resources that
are identified by HTTP(S) URIs, whereas Section 4 details an approach
to support batch discovery of TimeGates and TimeMaps that is based on
well-known URI [RFC5785] and host-meta [RFC6415].

1.3. 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.

   o When scenarios are described that involve multiple Mementos,
      URI-M0 denotes the URI of the first Memento known to the
      responding server, URI-Mn denotes the URI of the most recent known
      Memento, URI-Mj denotes the URI of the selected Memento, URI-Mi
      denotes the URI of the Memento that is temporally previous to the
      selected Memento, and URI-Mk denotes the URI of the Memento that
      is temporally after the selected Memento. The respective
      datetimes for these Mementos are T0, Tn, Tj, Ti, and Tk; it holds
      that T0 <= Ti <= Tj <= Tk <= Tn.

2. **The Memento Framework, Datetime Negotiation component: HTTP headers,
      HTTP Link Relation Types**

   The Memento framework is concerned 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",
   "Memento-Datetime"), introduces new values for two existing headers
   ("Vary", "Link"), and uses an existing header ("Location") without
   modification. All these headers are described below. Other HTTP
   headers are present or absent in Memento response/request cycles as
   specified by [RFC2616].

2.1.1. **Accept-Datetime, Memento-Datetime**

   The "Accept-Datetime" request header is used by a user agent to
   indicate it wants to access a Memento that encapsulates 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.

   The "Memento-Datetime" response header is used by a server to
   indicate that the response is a Memento, and its value expresses the

datetime of the state of an Original Resource that is encapsulated in
that Memento. The URI of that Original Resource is provided in the
response, as the Target IRI (see [RFC5988]) 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 resource constitutes a promise that the resource is stable
and that its state will no longer change. This means that, in terms
of the Ontology for Relating Generic and Specific Information
Resources (see [W3C.gen-ont-20090420]), a Memento is a FixedResource.

As a consequence, "Memento-Datetime" headers associated with a
Memento MUST be "sticky" in the following ways:

o The server that originally assigns the "Memento-Datetime" header
   and value MUST retain that header in all responses to HTTP
   requests (with or without "Accept-Datetime" header) that occur
   against the Memento after the time of the original assignment of
   the header, and it MUST NOT change its associated value.

o Applications that mirror Mementos at a different URI MUST retain
   the "Memento-Datetime" header and MUST NOT change its value unless
   mirroring involves a meaningful state change. This allows, for
   example, duplicating a Web archive at a new location while
   preserving the value of the "Memento-Datetime" header of the
   archived resources. In this example, 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.

2.1.1.1. Values for Accept-Datetime

Values for the "Accept-Datetime" header 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. The datetime MUST be represented in Greenwich Mean Time
(GMT).

Example of an "Accept-Datetime" request header:

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

The user agent uses the MANDATORY datetime value to convey its
preferred datetime for a Memento.

```
   accept-dt-value = rfc1123-date *SP
   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

2.1.1.2. Values for Memento-Datetime

Values for the "Memento-Datetime" headers MUST be datetimes expressed
according to the rfc1123-date construction rule of the BNF in
Figure 1; they MUST be represented in Greenwich Mean Time (GMT).

An example "Memento-Datetime" response header:

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

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 "negotiate" and "accept-datetime" to convey that
datetime negotation is possible.

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

Vary: negotiate, accept-datetime

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

Vary: negotiate, accept-datetime, accept

2.1.3. Location

The "Location" header is used as defined in [RFC2616]. Examples are
given in Section 3 below.

2.1.4. Link

The "Link" response header is specified in [RFC5988]. The Memento framework introduces new Relation Types to convey typed links among Original Resources, TimeGates, Mementos, Redirecting Resources, and TimeMaps. Existing Relation Types, among others, aimed at supporting navigation among a series of ordered resources may also be used in the Memento framework. This is detailed in the next section.

2.2. Link Header Relation Types

2.2.1. Memento Framework 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 is detailed. The use of these Relation Types in TimeMaps and for the purpose of batch discovery is described in Section 3.5 and Section 4, respectively.

The below table summarizes the use of Memento Relation Types in HTTP "Link" headers by Original Resources, TimeGates, Mementos, and Redirecting Resources.

Appendix A shows a Memento HTTP request/response cycle that uses all the Memento Relation Types.

Relation Type	Original Resource	TimeGate	Memento	Redirecting Resource
original	NA, except see Section 3.1.2. 1	REQUIRED, 1	REQUIRED, 1	REQUIRED, 1
timegate	RECOMMENDED, 0 or more	NA	RECOMMENDED, 0 or more	NA
timemap	OPTIONAL, 0 or more	RECOMMENDED, 0 or more	RECOMMENDED, 0 or more	NA
memento	OPTIONAL, 0 or more	REQUIRED, 1 or more	REQUIRED, 1 or more, except see Section 3.3.2. 4	NA

Table 1: The use of Relation Types

2.2.1.1. Relation Type "original"

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

   Use in HTTP "Link" headers: A TimeGate, a Memento, and a Redirecting
   Resource MUST include exactly one link with an "original" Relation
   Type in their HTTP "Link" header.

2.2.1.2. Relation Type "timegate"

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

   Use in HTTP "Link" headers: An Original Resource and a Memento SHOULD
   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.

2.2.1.3. 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. Attemtps 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: A TimeGate and a Memento SHOULD 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 a same TimeMap. An Original Resource MAY include
   one or more "timemap" link in its HTTP header. In all cases, use of

the "from" and "until" attributes is OPTIONAL.

2.2.1.4. 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 SHOULD be a URI.

Use in HTTP "Link" headers: A TimeGate and a Memento MUST include
links in their HTTP "Link" headers with a "memento" Relation Type
and, for the most common case whereby a Memento is selected in a
response to an HTTP requests, the links MUST be as follows:

o One "memento" link MUST be included that has as Target IRI the URI
   of the Memento that was selected or served;

o One "memento" link MUST be included that has as Target IRI the URI
   of the temporally first Memento known to the responding server;

o One "memento" link MUST be included that has as Target IRI the URI
   of the temporally most recent Memento known to the responding
   server.

o One "memento" link SHOULD be included that has as Target IRI the
   URI of the Memento that is previous to the selected Memento in the
   temporal series of all Mementos (sorted by ascending "Memento-
   Datetime" values) known to the server;

o One "memento" link SHOULD be included that has as Target IRI the
   URI the Memento that is next to the selected Memento in the
   temporal series of all Mementos (sorted by ascending "Memento-
   Datetime" values) known to the server.

o Other "memento" links MAY only be included if both the
   aforementioned previous and next links are provided. Each of
   these OPTIONAL "memento" links MUST have as Target IRI the URI of

a Memento other than the ones listed above.

Note that the Target IRI of some of these links may coincide. For
example, if the selected Memento actually is the first Memento known
to the server, only three distinct "memento" links may result. The
value for the "datetime" attribute of these links would be the
datetimes of the first (equal to selected), next, and most recent
Memento known to the responding server.

The use of the "memento" Relation Types for special cases whereby no
Memento is selected is described in Section 3.2.2.5, Section 3.2.2.6,
Section 3.3.2.4, and Section 3.3.2.5.

2.2.2. Other Relation Types

Web Linking [RFC5988] allows for the inclusion of links with
different Relation Types but the same Target IRI, and hence the
Relation Types introduced by the Memento framework MAY be combined
with others as deemed necessary. As the "memento" Relation Type
focuses on conveying the datetime of a linked Memento, Relation Types
that allow navigating among the temporally ordered series of Mementos
known to a server are of particular importance. With this regard,
the Relation Types listed in the below table SHOULD be considered for
combination with the "memento" Relation Type. A distinction is made
between responding servers that can be categorized as systems that
are the focus of [RFC5829] (such as version control systems) and
others that can not (such as Web archives). Note that, in terms of
[RFC5829], the last Memento (URI-Mn) is the version prior to the
latest (i.e. current) version.

Memento Type	RFC5829 system	non RFC5829 system
First Memento (URI-M0)	first	first
Last Memento (URI-Mn)	last	last
Selected Memento (URI-Mj)	NA	NA
Memento prior to selected Memento (URI-Mi)	predecessor-version	prev
Memento next to selected Memento (URI-Mk)	successor-version	next

Table 2: The use of Relation Types

3. **The Memento Framework, Datetime Negotiation component: HTTP
     Interactions**

   This section describes the HTTP interactions of the Memento framework
   for a variety of scenarios. First, 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. Appendix A shows these HTTP interactions in
   detail for the case where the Original Resource resides on one
   server, whereas both the TimeGate and the Mementos reside on another.
   Scenarios also exist in which all these resources are on the same
   server (for example, Content Management Systems) or on different
   servers (for example, an aggregator of TimeGates). Note that, in
   Step 2 and Step 6, the HTTP status code of the response is shown as
   "200 OK", but a series of "206 Partial Content" responses could be
   substituted without loss of generality.

```
1: UA --- HTTP HEAD/GET; Accept-Datetime: Tj ---------------> URI-R
2: UA <-- HTTP 200; Link: URI-G ---------------------------- URI-R
3: UA --- HTTP HEAD/GET; Accept-Datetime: Tj ---------------> URI-G
4: UA <-- HTTP 302; Location: URI-Mj; Vary; Link:
      URI-R,URI-T,URI-M0,URI-Mn,URI-Mi,URI-Mj,URI-Mk -------- URI-G
5: UA --- HTTP GET URI-Mj; Accept-Datetime: Tj ------------> URI-Mj
6: UA <-- HTTP 200; Memento-Datetime: Tj; Link:
      URI-R,URI-T,URI-G,URI-M0,URI-Mn,URI-Mi,URI-Mj,URI-Mk -- URI-Mj
```

              Figure 2: Typical Memento request/response chain

   o Step 1: In order to discover the URI of a TimeGate for an Original
      Resource, the user agent issues an HTTP HEAD/GET request against
      the URI of the Original Resource (URI-R).

   o Step 2: The response from URI-R includes an HTTP "Link" header
      with a Relation Type of "timegate" pointing at a TimeGate for the
      Original Resource (URI-G).

   o Step 3: The user agent starts the datetime negotiation process
      with the TimeGate by issuing an HTTP GET request against its URI-G
      thereby including an "Accept-Datetime" HTTP header with a value of
      the datetime of the desired prior state of the Original Resource.

   o Step 4: The response from URI-G includes a "Location" header
      pointing at the URI of a Memento for the Original Resource
      (URI-Mj). In addition, the response contains an HTTP "Link"
      header with a Relation Type of "original" pointing at the Original
      Resource, and an HTTP "Link" header with a Relation Type of
      "timemap" pointing at a TimeMap (URI-T). Also HTTP Links pointing
      at various Mementos are provided using the "memento" Relation

Type, as specified in Section 2.2.1.4.

o Step 5: The user agent issues an HTTP GET request against the URI
   of the Memento obtained in Step 4 (URI-Mj).

o Step 6: The response from URI-Mj includes a "Memento-Datetime"
   HTTP header with a value of the datetime of the Memento. It also
   contains an HTTP "Link" header with a Relation Type of "original"
   pointing at the Original Resource, with a Relation Type of
   "timegate" pointing at a TimeGate associated with the Original
   Resource, and with a Relation Type of "timemap" pointing at a
   TimeMap. The state that is expressed by the response is the state
   the Original Resource had at the datetime expressed in the
   "Memento-Datetime" header. This response also includes HTTP Links
   with a "memento" Relation Type pointing at various Mementos, as
   specified in Section 2.2.1.4.

The following sections detail the specifics of HTTP interactions with
Original Resources, TimeGates, Mementos, and TimeMaps under various
conditions.

3.1. Interactions with an Original Resource

This section details HTTP HEAD/GET requests targeted at an Original
Resource (URI-R).

3.1.1. Step 1: User Agent Requests an Original Resource

In order to attempt to discover the recommended TimeGate for the
Original Resource, the user agent SHOULD issue an HTTP HEAD or GET
request against the Original Resource's URI. Use of the "Accept-
Datetime" header in the HTTP HEAD/GET request is OPTIONAL.

Figure 3 shows the use of HTTP HEAD to determine a TimeGate for the
Original Resource http://a.example.org.

```
HEAD / HTTP/1.1
Host: a.example.org
Accept-Datetime: Tue, 11 Sep 2001 20:35:00 GMT
Connection: close
```

Figure 3: User Agent Requests Original Resource

3.1.2. Step 2: Server Responds to a Request for an Original Resource

The response of the Original Resource's server to the user agent's
HTTP HEAD/GET request of Step 1, for the case where the Original
Resource exists, is as it would be in a regular HTTP request/response

cycle, but in addition MAY include a "timegate" link in the HTTP
"Link" header that conveys the URI of the Original Resource's
TimeGate as the Target IRI of the link. Multiple "timegate" links
MAY be provided to accommodate situations in which the server is
aware of multiple TimeGates for an Original Resource. The presence
or abscence of an "Accept-Datetime" header in a user agent's HTTP
request MUST NOT influence the presence or abscence of a "timegate"
link in the HTTP "Link" header of the server's response. A response
for this case is illustrated in Figure 4.

```
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 4: Server of Original Resource Responds

Servers that actively maintain archives of their resources SHOULD
include the "timegate" HTTP "Link" header because this link is an
important way for a user agent to discover TimeGates for those
resources. This includes servers such as Content Management Systems,
Control Version Systems, and Web servers with associated
transactional archives [Fitch]. Servers that do not actively
maintain archives of their resources MAY include the "timegate" HTTP
"Link" header as a way to convey a preference for TimeGates for their
resources exposed by a third party archive. This includes servers
that rely on Web archives such as the Internet Archive to archive
their resources.

3.1.2.1. Original Resource is an Appropriate Memento

The "Memento-Datetime" header MAY be applied to an Original Resource
directly to indicate it is a FixedResource (see
[W3C.gen-ont-20090420]), meaning that the state of the Original
Resource has not changed since the datetime conveyed in the "Memento-
Datetime" header, and as a promise that it will not change anymore
beyond it. This may occur, for example, for certain stable media
resources on news sites. In case the user agent's preferred datetime
is equal to or more recent than the datetime conveyed as the value of
"Memento-Datetime" in the server's response in Step 2, the user agent
SHOULD conclude it has located an appropriate Memento, and it SHOULD
NOT continue to Step 3.

Figure 5 illustrates such a response to a request for the resource

with URI http://a.example.org/pic that has been stable since it was
created. Note the use of both the "memento" and "original" Relation
Types for links that have as Target IRI the URI of the Original
Resource.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:02:12 GMT
Server: Apache
Link:
 <http://a.example.org/pic>
   ; rel="original memento"
   ; datetime="Fri, 20 Mar 2009 11:00:00 GMT"
Memento-Datetime: Fri, 20 Mar 2009 11:00:00 GMT
Content-Length: 255
Connection: close
Content-Type: text/html; charset=iso-8909-1
```

Figure 5: Response to a request for an Original Resource that was
created as a FixedResource

Cases may also exist in which a resource becomes stable at a certain
point in its existence, but changed previously. In such cases, the
Original Resource may know about a TimeGate that is aware of its
prior history and hence MAY also include a link with a "timegate"
Relation Type in addition to the previously mentioned links with
"original" and "memento" Relation Types.

3.1.2.2. Server Exists and Original Resource Used to Exist

Servers SHOULD also provide a "timegate" link in the HTTP "Link"
header in responses to requests for an Original Resource that the
server knows used to exist, but no longer does so. This allows the
use of an Original Resource's URI as an entry point to its prior
states even if the resource itself no longer exists. A server's
response for this case is illustrated in Figure 6.

```
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/gone>
   ; rel="timegate"
Content-Length: 255
Connection: close
Content-Type: text/html; charset=iso-8909-1
```

Figure 6: Response to a request for an Original Resource that not
                          longer exists

   In case the server is not aware of the prior existence of the
   Original Resource, its response SHOULD NOT include a "timegate" link
   in the HTTP "Link" header. Section 3.1.2.3 details what the user
   agent's behavior should be in such cases.

3.1.2.3. Missing "timegate" Link in Original Server's Response

   When engaging in a Memento request/response cycle, a user agent
   SHOULD NOT proceed immediately to Step 3 by using a TimeGate of its
   own preference but rather SHOULD always start the cycle by issuing an
   HTTP HEAD/GET against the Original Resource (Step 1, Figure 3) as it
   is an important way to learn about dedicated or preferred TimeGates
   for the Original Resource. Also, cases exist in which the response
   in Step 2 will not provide a "timegate" link in the HTTP "Link"
   header, 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. The discovery mechanisms
   described in Section 4 can support the user agent with this regard.

3.2. Interactions with a TimeGate

   This section details HTTP HEAD/GET requests targeted at a TimeGate
   (URI-G).

3.2.1. Step 3: User Agent Negotiates with a TimeGate

   In order to negotiate in the datetime dimension with a TimeGate, the
   user agent MUST issue an HTTP request with the "Accept-Datetime"
   header, as described in Section 2.1.1.1. This is illustrated in
   Figure 7.

```
GET /timegate/http://a.example.org HTTP/1.1
Host: arxiv.example.net
Accept-Datetime: Tue, 11 Sep 2001 20:35:00 GMT
Connection: close
```

              Figure 7: User agent negotiates with TimeGate

3.2.2. Step 4: Server Responds to Negotiation with TimeGate

In order to respond to a datetime negotiation request (Step 3,
Section 3.2.1), the server uses an internal algorithm to select the
Memento that best meets the user agent's datetime preference, and
redirects to it. The exact nature of the selection algorithm is at
the server's discretion but SHOULD be consistent. A variety of
approaches can be used including selecting the Memento that is
nearest in time (either past or future) or nearest in the past
relative to the requested datetime. The most common scenario for
datetime negotiation with a TimeGate is described in Section 3.2.2.1
but special cases exist, and they are addressed in Section 3.2.2.2
through Section 3.2.2.7.

It is NOT RECOMMENDED to implement TimeGates such that they coincide
with their associated Original Resource, i.e. URI-R and URI-G are
the same. Doing so may cause cache invalidation problems and confuse
Memento clients.

3.2.2.1. Successful Scenario

In cases where the TimeGate exists, and the datetime provided in the
user agent's "Accept-Datetime" header can be parsed, the server
selects a Memento based on the user agent's datetime preference. The
response MUST have a "302 Found" HTTP status code, and the "Location"
header MUST be used to convey the URI of the selected Memento. The
"Vary" header MUST be provided and it MUST include the "negotiate"
and "accept-datetime" values. The "Link" header MUST be provided and
contain links with Relation Types subject to the considerations
described in Section 2.2. The response MUST NOT contain a "Memento-
Datetime" header. Such a response is illustrated in Figure 8.

If a user agent's "Accept-Datetime" header conveys a datetime that is
either earlier than the datetime of the first Memento or later than
the datetime of the most recent Memento known to the server, the
server's response is as just described yet entails the selection of
the first or most recent Memento, respectively.

```
HTTP/1.1 302 Found
Date: Thu, 21 Jan 2010 00:06:50 GMT
Server: Apache
Vary: negotiate, accept-datetime
Location:
 http://arxiv.example.net/web/20010911203610/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="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/web/20000915112826/http://a.example.org>
    ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
 <http://arxiv.example.net/web/20080708093433/http://a.example.org>
    ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
    ; rel="memento"; datetime="Tue, 11 Sep 2001 20:36:10 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
    ; rel="prev memento"; datetime="Tue, 11 Sep 2001 20:30:51 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
    ; rel="next memento"; datetime="Tue, 11 Sep 2001 20:47:33 GMT"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

Figure 8: Server of TimeGate responds

3.2.2.2. Multiple Matching Mementos

Because the finest datetime granularity expressible using the
[RFC1123] format used in HTTP is seconds level, cases may occur in
which a TimeGate server is aware of multiple Mementos that meet the
user agent's datetime preference. This may occur in Content
Management Systems with very high update rates. The response in this
case MUST be handled as in Section 3.2.2.1, with the selection of one
of the matching Mementos.

3.2.2.3. Accept-Datetime and other Accept Headers Provided

When interacting with a TimeGate, 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.

3.2.2.4. Accept-Datetime Not Provided

In case, in Step 3, a user agent issues a request to a TimeGate and
fails to include an "Accept-Datetime" request header, the response
MUST be handled as in Section 3.2.2.1, with a selection of the most
recent Memento known to the responding server.

3.2.2.5. Accept-Datetime Unparseable

In case, in Step 3, a user agent conveys a value for the "Accept-
Datetime" request header that does not conform to the accept-dt-value
construction rule of the BNF in Figure 1, the TimeGate server's
response MUST have a "400 Bad Request" HTTP status code. The use of
the "Vary" header MUST be as described in Section 3.2.2.1. The use
of entries in the "Link" header with "original", "timegate", and
"timemap" Relation Types MUST be as described in Section 2.2.
Entries with the "memento" Relation Type MUST be provided to only
point to the first and most recent Mementos.

3.2.2.6. TimeGate Does Not Exist

Cases may occur in which a user agent issues a request against a
TimeGate that does not exist. This may, for example, occur when a
user agent uses internal knowledge to construct the URI of an
assumed, yet non-existent TimeGate. In these cases, the response
from the target server MUST have a "404 Not Found" HTTP status code.
The response MUST NOT include a "Link" header with any of the
Relation Types introduced in Section 2.2.1, and it MUST NOT contain a
"Memento-Datetime" header.

3.2.2.7. HTTP Methods other than HEAD/GET

It is intended that the safe HTTP methods GET and HEAD are used with
TimeGates, and other methods are currently undefined. A TimeGate
MUST respond to unsupported HTTP methods with a "405 Method Not
Allowed" HTTP status code.

3.2.3. Recognizing a TimeGate

When a user agent issues a HTTP HEAD/GET request against the URI of
an assumed TimeGate for an Original Resource (e.g. the URI is the
Target IRI of a "timegate" link), it SHOULD NOT conclude that the

targeted resource effectively is a TimeGate and hence will behave as described in Section 3.2.2.

A user agent MUST decide it has reached a TimeGate if the response to a HTTP HEAD/GET request against the resource's URI contains a "Vary" header that includes the "negotiate" and "accept-datetime" values. If the response does not, the user agent MUST decide it has not reached a TimeGate and proceed as follows:

o If the response contains a redirection that includes an "original" link in the HTTP "Link" header, the agent MUST conclude it has reached a Redirecting Resource that is part of the Memento infrastructure and SHOULD follow the redirect. Note that a chain of such redirections is possible, e.g. URI-R -> URI-1 (with rel="original") -> URI-2 (with rel="original") -> ... -> URI-G

o If the response does not contain a redirection, or if the redirection does not have an "original" link in the HTTP "Link" header, the user agent SHOULD attempt to determine an appropriate TimeGate for the Original Resource, either automatically or interactively supported by the user. The discovery mechanisms described in Section 4 can support the user agent with this regard.

3.3. Interactions with a Memento

This section details HTTP HEAD/GET requests targeted at a Memento (URI-M).

3.3.1. Step 5: User Agent Requests a Memento

In Step 5, the user agent issues an HTTP GET request against the URI of a Memento. The user agent MAY include an "Accept-Datetime" header in this request, but the existence or absence of this header MUST NOT affect the server's response. The URI of the Memento may have resulted from a response in Step 4, or the user agent may simply have happened upon it. Such a request is illustrated in Figure 9.

```
GET /web/20010911203610/http://a.example.org HTTP/1.1
Host: arxiv.example.net
Accept-Datetime: Tue, 11 Sep 2001 20:35:00 GMT
Connection: close
```

                   Figure 9: User agent requests Memento

3.3.2. Step 6: Server Responds to a Request for a Memento

   This section describes possible responses to a request for a Memento.
   Section 3.3.2.1 discusses the most common scenario. Section 3.3.2.2
   through Section 3.3.2.4 detail special cases whereby Mementos are
   archived copies of HTTP responses with 3xx, 4xx and 5xx status codes.

3.3.2.1. Common Scenario

   If the Memento requested by the user agent in Step 5 exists, and is
   not a special Memento as described in Section 3.3.2.2 and
   Section 3.3.2.2, the server's response MUST have a "200 OK" HTTP
   status code or, where appropriate "206 Partial Content". It MUST
   include a "Memento-Datetime" header with a value equal to the
   archival datetime of the Memento, that is, the datetime of the state
   of the Original Resource that is encapsulated in the Memento. The
   "Link" header MUST be provided and contain links subject to the
   considerations described in Section 2.2.

   Figure 10 illustrates the server's response to the request issued
   against a Memento in Step 5 (Figure 9).

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Tue, 11 Sep 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"
   ; from="Tue, 15 Sep 2000 11:28:26 GMT"
   ; until="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/timegate/http://a.example.org>
   ; rel="timegate",
 <http://arxiv.example.net/web/20000915112826/http://a.example.org>
   ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
 <http://arxiv.example.net/web/20080708093433/http://a.example.org>
   ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="memento"; datetime="Tue, 11 Sep 2001 20:36:10 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="prev memento"; datetime="Tue, 11 Sep 2001 20:30:51 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="next memento"; datetime="Tue, 11 Sep 2001 20:47:33 GMT"
Content-Length: 23364
Content-Type: text/html;charset=utf-8
Connection: close
```

                     Figure 10: Server of Memento responds

The server's response MUST include the "Memento-Datetime" header
regardless whether the user agent's request contained an "Accept-
Datetime" header or not. This is the way by which resources make
explicit that they are Mementos. Due to the sparseness of Mementos
in most archives, 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.

3.3.2.2. 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, and it MUST include a "Memento-
Datetime" header with a value equal to the archival datetime of the
original 3XX response. All other considerations, e.g. pertaining to
the use of "Link" header, expressed in Section 3.3.2.1 apply.

The client's handling of an HTTP response with a 3XX status code is
not affected by the presence of a "Memento-Datetime" header. The
client SHOULD 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 client 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 that case it SHOULD proceed by looking for a Memento of the
selected Original Resource.

For example, Figure 11 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, and this Memento's URI

is http://arxiv.example.net/web/20080411000650/http://a.example.org.
The response to an HTTP GET on this Memento is shown in Figure 12.
In essence, it is a replay of the original response with "Memento-
Datetime" and "Link" headers added, to allow a client to understand
the response is a Memento. In Figure 12, the value of the "Location"
header is the same as in the original response; it identifies an
Original Resource. The client 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 13. In this case, the
client 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 11: Response to the User Agent Request 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",
 <http://arxiv.example.net/web/20000915112826/http://a.example.org>
   ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
 <http://arxiv.example.net/web/20080708093433/http://a.example.org>
   ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/web/20080411000650/http://a.example.org>
   ; rel="memento"; datetime="Fri, 11 Apr 2008 00:06:50 GMT",
 <http://arxiv.example.net/web/20080410203051/http://a.example.org>
   ; rel="prev memento"; datetime="Thu, 10 Apr 2008 20:30:51 GMT",
 <http://arxiv.example.net/web/20080412204733/http://a.example.org>
   ; rel="next memento"; datetime="Sat, 12 Apr 2008 20:47:33 GMT"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

      Figure 12: Response to a User Agent Request for 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",
 <http://arxiv.example.net/web/20000915112826/http://a.example.org>
   ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
 <http://arxiv.example.net/web/20080708093433/http://a.example.org>
   ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/web/20080411000650/http://a.example.org>
   ; rel="memento"; datetime="Fri, 11 Apr 2008 00:06:50 GMT",
 <http://arxiv.example.net/web/20080410203051/http://a.example.org>
   ; rel="prev memento"; datetime="Thu, 10 Apr 2008 20:30:51 GMT",
 <http://arxiv.example.net/web/20080412204733/http://a.example.org>
   ; rel="next memento"; datetime="Sat, 12 Apr 2008 20:47:33 GMT"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

       Figure 13: Response to a User Agent Request for a Memento of a
                       Redirect; leads to a Memento

3.3.2.3. Memento of Responses with Other 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, and it MUST include a "Memento-
   Datetime" header with a value equal to the archival datetime of the
   original response. All other considerations, e.g. pertaining to the
   use of "Link" header, expressed in Section 3.3.2.1 apply.

   For example, Figure 14 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, and this Memento's URI
   is http://arxiv.example.net/web/20080411000650/http://a.example.org.
   The response to an HTTP HEAD/GET on this Memento is shown in
   Figure 15. It is a replay of the original response with "Memento-
   Datetime" and "Link" headers added, to allow a client 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: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

           Figure 14: Response to the User Agent Request 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",
 <http://arxiv.example.net/web/20000915112826/http://a.example.org>
   ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
 <http://arxiv.example.net/web/20080708093433/http://a.example.org>
   ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
 <http://arxiv.example.net/web/20080411000650/http://a.example.org>
   ; rel="memento"; datetime="Fri, 11 Apr 2008 00:06:50 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="prev memento"; datetime="Thu, 10 Apr 2008 20:30:51 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="next memento"; datetime="Sat, 12 Apr 2008 20:47:33 GMT"
Content-Length: 0
Content-Type: text/plain; charset=UTF-8
Connection: close
```

     Figure 15: Response to a User Agent Request for a Memento of a 404
                                 Response

3.3.2.4. Mementos Without a TimeGate

   Cases may occur in which a server that hosts Mementos does not expose
   a TimeGate for those Mementos. 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 at the time this other
   server 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 hosts
   multiple Mementos for an Original Resource but consider exposing
   TimeGates too expensive.

In cases of Mementos without associated TimeGates, responses to a
request for a Memento by a user agent MUST contain a "Memento-
Datetime" response header with a value that corresponds to archival
datetime of the Memento. The use of an HTTP "Link" header to convey
Memento Relation Types is OPTIONAL.

Figure 16 illustrates the server's response to the request issued
against a Memento in Step 5 (Figure 9) for the case that Memento has
no associated TimeGate. In this example, it is also assumed there is
only one Memento for the Original Resource, and hence the links with
Relation Types "memento", "first", "last" all point at the same -
responding - Memento.

```
HTTP/1.1 200 OK
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Tue, 11 Sep 2001 20:36:10 GMT
Link: <http://a.example.org>; rel="original",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="first last memento"
   ; datetime="Tue, 15 Sep 2000 11:28:26 GMT"
Content-Length: 23364
Content-Type: text/html;charset=utf-8
Connection: close
```

Figure 16: Server of Memento without TimeGate responds

Note that a server issuing a response similar to that of Figure 16
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.

3.3.2.5. Memento Does not Exist

Cases may occur in which a TimeGate's response (Step 4) points at a
Memento that actually does not exist, resulting in a user agent's
request (Step 5) for a non-existent Memento. In this case, the
server's response MUST have the expected "404 Not Found" HTTP Status
Code and it MUST NOT contain a "Memento-Datetime" header. Note that
the absence of a Memento in an archive is distinct from the case of
an archived response with a "404 Not Found" HTTP status code as is
described in Section 3.3.2.3

3.3.3. Recognizing a Memento

When following the redirection provided by a confirmed TimeGate (see
Section 3.2.3), a user agent SHOULD NOT assume that the targeted
resource effectively is a Memento and hence will behave as described

   in [Section 3.3.2](#).

   A user agent MUST decide it has reached a Memento if the response to
   an HTTP request against the targeted resource's URI contains a
   "Memento-Datetime" header with a legitimate value. If the response
   does not, the following applies:

   o If the response contains a redirection that includes an "original"
      link in the HTTP "Link" header, the user agent MUST conclude it
      has reached a Redirecting Resource that is part of the Memento
      infrastructure and SHOULD follow the redirect. Note that a chain
      of such redirections is possible, e.g. URI-G -> URI-1 (with
      rel="original") -> URI-2 (with rel="original") -> ... -> URI-M

   o If the response contains no redirection or if a redirection
      (chain) does not lead to a resource that provides a "Memento-
      Datetime" header, the user agent SHOULD attempt to determine an
      appropriate TimeGate for the Original Resource, either
      automatically or interactively supported by the user. The
      discovery mechanisms described in [Section 4](#) can support the user
      agent with this regard.

[3.4](#). Interactions with a Redirecting Resource

   A Redirecting Resource is a resource that issues a redirect to a
   TimeGate, to a Memento, or to another Redirecting Resource, and thus
   plays an active role in the Memento infrastructure. An example of a
   Redirecting Resource is a resource that acts as a front-end to
   multiple TimeGates and redirects to an appropriate TimeGate based on
   the value of the user agent's "Accept-Datetime" header.

   A user agent MUST decide that it has reached a Redirecting Resource
   if the response to an HTTP GET issued against the resource's URI has
   an HTTP status code indicative of redirection, has an "original" link
   in the HTTP "Link" header, yet does not have a "Memento-Datetime" nor
   "Vary" header. A user agent SHOULD follow the redirection provided
   by a Redirecting Resource.

   If, for example, a user agent follows a link to an assumed TimeGate
   and attempts the datetime negotiation illustrated in Figure 7, it
   will expect a response from a TimeGate, which must include a "Vary"
   header. Instead, it receives the response shown in Figure 17. This
   response has an HTTP "302 Found" status code, neither a "Vary" nor
   "Memento-Datetime" header, yet it does have an "original" link in the
   HTTP "Link" header pointing at the Original Resource, indicating it
   is a Redirecting 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 17: Redirecting Resource redirects to a TimeGate

3.5. Interactions with a TimeMap

A TimeMap is introduced to support retrieving a comprehensive list of
all Mementos for a specific Original Resource known to a responding
server. The entity-body of a response to an HTTP GET request issued
against a TimeMap's URI:

o MUST list the URI of the Original Resource that the TimeMap is
   about;

o MUST preferably list the URI and datetime of each Memento for the
   Original Resource known to the responding server, or,
   alternatively support assembling such a list by following links
   with a "timemap" Relation Type provided in the TimeMap;

o SHOULD list the URI of one or more TimeGates for the Original
   Resource known to the responding server;

o SHOULD, for self-containment, list the URI 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 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
   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 of the Original
   Resource, which is provided as the Target IRI of the link with an
   "original" Relation Type.

3.5.1. User Agent Requests a TimeMap

In order to retrieve the link-value serialization of a TimeMap, a
user agent SHOULD use an "Accept" request header with a value set to
"application/link-format". This is shown in Figure 18.

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

Figure 18: Request for a TimeMap

3.5.2. Server Responds to a Request for a TimeMap

If the TimeMap requested by the user agent exists, the server's
response MUST have a "200 OK" HTTP status code (or "206 Partial
Content", where appropriate). Note that a TimeMap is itself an
Original Resource for which Mementos may exist. For example, a
response from a TimeMap could provide a "timegate" Link to a TimeGate
via which prior TimeMap versions are available. In this case, the
use of the "Link" header is subject to all considerations described
in Section 2.2, with the TimeMap acting as the Original Resource.

However, in case a TimeMap wants to explicitly indicate in its
response headers for which Original Resource it is a TimeMap, it MUST
do so by including an HTTP "Link" header with the following
characteristics:

o The Context IRI for the HTTP Link is the URI of the Original
   Resource;

o The Relation Type is "timemap";

o The Target IRI for the HTTP Link is the URI of the TimeMap.

Because the Context IRI of this HTTP Link is not the URI of the
TimeMap, as per [RFC5988], the default Context IRI must be
overwritten by using the "anchor" attribute with a value of the URI
of the Original Resource.

The response from the TimeMap to the request of Figure 18 is shown in

Figure 19. The response header shows the TimeMap explicitly
conveying the URI of the Original Resource for which it is a TimeMap;
for practical reasons the entity-body in the example has been
abbreviated. Note the use of the "self" Relation Type to express the
URI of the TimeMap itself. Note also the use of the "from" and
"until" attributes on that link to express the datetime of the
earliest and most recent Memento listed in the TimeMap. And, note
the use of the "license" attribute introduced in Section 2.2.1.4 on
the "memento" links in the TimeMap.

```
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: 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 19: Response from a TimeMap

Cases exist in which a TimeMap points at several other TimeMaps. In
one such case, a TimeMap could 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. Such a TimeMap can
be considered an index of TimeMaps and is shown in Figure 20.

   Another case is when the number of available Mementos requires
   introducing multiple TimeMaps that can be paged. Such a TimeMap is
   shown in Figure 21. Note that this TimeMap contains links to other
   TimeMaps but actually also lists Mementos. In both examples, the
   "timemap" links have the "from" and "until" attributes to express the
   temporal span of listed Mementos. Since the index TimeMap does not
   list any Mementos, these attributes are not used on the link that
   points at the index TimeMap itself, i.e. the link with the "self"
   Relation Type. 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 20: An 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 21: TimeMap Paging

4. The Memento Framework, Discovery of TimeGates, TimeMaps, Mementos

   Section 3 describes how TimeGates, Mementos, Original Resources, and
   TimeMaps can be discovered by following HTTP Links with Relation
   Types "timegate", "memento", "original", and "timemap", respectively.

   Naturally, some of these links can also be included in
   representations of resources that have a media type that allows
   embedding typed links. For example, an Original Resource that has an
   HTML representation can include a "timegate" link by using HTML's
   LINK element, e.g. <link
   href="http://arxiv.example.net/timegate/http://a.example.org"
   rel="timegate">. The use of such embedded links is also subject to
   the considerations of Section 2.2.

   In this section an additional approach is introduced to support batch
   discovery of TimeGates, TimeMaps, and Mementos. The approach
   leverages the well-known URI [RFC5785] and host-meta [RFC6415]
   specifications. It can be used in cases where URIs of TimeGates,
   TimeMaps, or Mementos have as part of their path-component the URI of
   the associated Original Resource. The approach uses the following
   variables for URI templates used in host-meta files:

o The "uri" variable, as reserved by [RFC6415], which stands for any
   URI in the server's document scope.

o The "anyuri" variable, introduced here, which stands for any URI,
   i.e. not just URIs in the server's document scope.

A server SHOULD make TimeGates discoverable in the following way:

o As per [RFC5785] and [RFC6415], the server publishes a document
   with the name "host-meta" in its /.well-known/ path.

o As per [RFC6415], the host-meta document uses the XRD 1.0 document
   format.

o The host-meta document includes one or more "Link" elements to
   support discovery of TimeGates. Each such Link element has a
   value of "timegate" for its "rel" attribute, and it has a
   "template" attribute that has a URI template as its value. The
   URI template MAY either use the "uri" or "anyuri" variable.

o The URI template MUST be such that, when applying the URI of an
   Original Resource to the "uri" or "anyuri" variable the URI of a
   potential TimeGate for that Original Resource results.

There are no guarantees that these resulting TimeGates exist, but URI
templates should be created to try and maximize chances they do.

The considerations described for TimeGate discovery also apply to
TimeMap discovery. However, for TimeMaps, each Link element has a
value of "timemap" for its "rel" attribute.

Figure 22 illustrates how a server makes TimeGates associated with
its own Original Resources discoverable, whereas Figure 23
illustrates how a web archive that hosts Mementos for Original
Resources originating from various domains makes its TimeGates and
TimeMaps discoverable.

Figure 22 shows a host-meta document published at
http://a.example.org/.well-known/host-meta by a wiki that has
http://a.example.org as its base URI. The document supports
discovery of TimeGates that allow accessing prior versions of the
wiki's Original Resources. The URI template uses the "uri" variable
to stand for a document in the wiki's document range. Assuming
http://a.example.org/w/Clock is the URI of an Original Resource on
the wiki, applying the template to that URI yields
http://a.example.org/Special:TimeGate/http://a.example.org/w/Clock as
its corresponding TimeGate.

```
<?xml version='1.0' encoding='UTF-8'?>
 <XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'
      xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'>
  <Link rel='timegate'
        template='http://a.example.org/Special:TimeGate/{uri}'>
  </Link>
 </XRD>
```

       Figure 22: A host-meta Document Supporting TimeGate Discovery for a
                            Wiki's Original Resources

   Figure 23 shows a host-meta document published at
   http://arxiv.example.net/.well-known/host-meta by a web archive that
   has http://arxiv.example.net/ as its base URI. The document supports
   discovery of TimeGates and TimeMaps that the archive exposes, and
   that are associated with Original Resources for which the archive
   holds Mementos. The URI templates use the "anyuri" variable, which
   is an indication that the web archive holds Mementos for a wide
   variety of domains. Note the use of the "from" and "until"
   attributes to express the time range for which the archive has
   Mementos.

```
<?xml version='1.0' encoding='UTF-8'?>
 <XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'
      xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'>
  <Link rel='timegate'
        template='http://arxiv.example.net/timegate/{anyuri}'>
  </Link>
  <Link rel='timemap'
        template='http://arxiv.example.net/timemap/{anyuri}'
        from='Tue, 20 Jun 2000 18:02:59 GMT'
        until='Wed, 09 Apr 2008 20:30:51 GMT'>
  </Link>
 </XRD>
```

   Figure 23: A host-meta Document Supporting Discovery of TimeGates and
                      TimeMaps Exposed by a Web Archive

   In some cases, Mementos can be made discoverable via a host-meta
   document. Consider, for example, a server with base URI
   http://a.example.org/ that archives its own content once a year and
   makes the result available in a snapshot archive with base URI
   http://arxiv.example.net/. The server can publish a host-meta
   document at http://a.example.org/.well-known/host-meta that points to
   Mementos contained in the annual snapshots. This is shown in
   Figure 24. Note also the use of the "license" attribute that
   associates a Creative Commons license with the Mementos in the
   archive.

```
<?xml version='1.0' encoding='UTF-8'?>
 <XRD xmlns='http://docs.oasis-open.org/ns/xri/xrd-1.0'
      xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'>
  <Link rel='memento'
   template='http://arxiv.example.net/2010/{uri}'
   license='http://creativecommons.org/publicdomain/zero/1.0/'>
  </Link>
  <Link rel='memento'
   template='http://arxiv.example.net/2011/{uri}'
   license='http://creativecommons.org/publicdomain/zero/1.0/'>
  </Link>
 </XRD>
```

   Figure 24: A Server Pointing to its Mementos in a Snapshot Archive

5. **IANA Considerations**

   This memo requires IANA to register the Accept-Datetime and Memento-
   Datetime HTTP headers defined in Section 2.1.1 in the appropriate
   IANA registry.

   This memo requires IANA to register the Relation Types "original",
   "timegate", "timemap", and "memento" defined in Section 2.2.1 in the
   appropriate IANA registry.

   This memo requires IANA to register the "datetime" and "license"
   attributes for the "memento" Relation Type, as defined in
   Section 2.2.1.4, in the appropriate IANA registry.

   This memo requires IANA to register the "from" and "until" attributes
   for the "timemap" Relation Type, as defined in Section 2.2.1.4, in
   the appropriate IANA registry.

6. **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 a
   "timegate" 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.

7. Changelog

v05 2012-09-01 HVDS MLN RS draft-vandesompel-memento-05

o Clarified the section on Memento Relation Types.

o Re-introduced "license" attribute for "memento" Relation Type as
   it will become essential for IIPC.

o Introduced from and until attributes for "timemap" links to
   accomodate paged TimeMap cases.

o Introduced the notion of Redirecting Resource and inserted related
   information in various sections.

o Added discovery of Mementos via host-meta.

o Corrected ambiguous uses of the term "representation".

v04 2012-05-18 HVDS MLN RS draft-vandesompel-memento-04

o Removed the possibility to use an interval indicator in an Accept-
   Datetime header as no one is implementing it.

o Corrected typo in Other Relation Types table.

o Added TimeMap examples to illustrate index of TimeMaps and TimeMap
   paging.

o Changed Discovery component from using robots.txt with Memento-
   specific add-ons to well-known URI and host-meta.

o Removed "embargo" and "license" attributes for links with a
   "memento" Relation Type because no one is using them.

v04 2011-12-20 HVDS MLN RS draft-vandesompel-memento-03

o Added description of Mementos of HTTP responses with 3XX, 4XX and
   5XX status code.

o Clarified that a TimeGate must not use the "Memento-Datetime"
   header.

o Added wording to warn for possible cache problems with Memento
   implementations that choose to have an Original Resource and and
   its TimeGate coincide.

v03 2011-05-11 HVDS MLN RS draft-vandesompel-memento-02

o Added scenario in which a TimeGate redirects to another TimeGate.

o Reorganized TimeGate section to better reflect the difference
   between requests with and without interval indicator.

o Added recommendation to provide "memento" links to Mementos in the
   vicinity of the preferred interval provided by the client, in case
   of a 406 response.

o Removed TimeMap Feed material from the Discovery section as a
   result of discussions regarding (lack of) scalability of the
   approach with representatives of the International Internet
   Preservation Consortium. An alternative approach to support batch
   discovery of Mementos will be specified.

v02 2011-04-28 HVDS MLN RS draft-vandesompel-memento-01

o Introduced wording and reference to indicate a Memento is a
   FixedResource.

o Introduced "Sticky Memento-Datetime" notion and clarified wording
   about retaining "Memento-Datetime" headers and values when a
   Memento is mirrored at different URI.

o Introduced section about handling both datetime and regular
   negotiation.

o Introduced section about Mementos Without TimeGate.

o Made various changes in the section Relation Type "memento",
   including addition of "license" and "embargo" attributes, and
   clarification of rules regarding the use of "memento" links.

o Moved section about TimeMaps inside the Datetime Negotiation
   section, and updated it.

o Restarted the Discovery section from scratch.

v01 2010-11-11 HVDS MLN RS First public version
draft-vandesompel-memento-00

v00 2010-10-19 HVDS MLN RS Limited circulation version

2010-07-22 HVDS MLN First internal version

8. Acknowledgements

9. References

9.1. Normative References

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Appendix A. Appendix: A Sample, Successful Memento Request/Response
             cycle

   Step 1 : UA --- HTTP HEAD/GET; Accept-Datetime: Tj ---------> URI-R

   HEAD / HTTP/1.1
   Host: a.example.org
   Accept-Datetime: Tue, 11 Sep 2001 20:35:00 GMT
   Connection: close

   Step 2 : UA <-- HTTP 200; Link: URI-G ---------------------- URI-R

   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

    Step 3 : UA --- HTTP HEAD/GET; Accept-Datetime: Tj ---------> URI-G

    GET /timegate/http://a.example.org
     HTTP/1.1
    Host: arxiv.example.net
    Accept-Datetime: Tue, 11 Sep 2001 20:35:00 GMT
    Connection: close

    Step 4 : UA <-- HTTP 302; Location: URI-Mj; Vary; Link:
        URI-R, URI-T, URI-M0, URI-Mn, URI-Mi, URI-Mj, URI-Mk ---- URI-G

    HTTP/1.1 302 Found
    Date: Thu, 21 Jan 2010 00:06:50 GMT
    Server: Apache
    Vary: negotiate, accept-datetime
    Location:
     http://arxiv.example.net/web/20010911203610/http://a.example.org
    Link: <http://a.example.org>; rel="original",
     <http://arxiv.example.net/web/20000915112826/http://a.example.org>
       ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
     <http://arxiv.example.net/web/20080708093433/http://a.example.org>
       ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
     <http://arxiv.example.net/timemap/http://a.example.org>
       ; rel="timemap"; type="application/link-format",
     <http://arxiv.example.net/web/20010911203610/http://a.example.org>
       ; rel="memento"; datetime="Tue, 11 Sep 2001 20:36:10 GMT",
     <http://arxiv.example.net/web/20010911203610/http://a.example.org>
       ; rel="prev memento"; datetime="Tue, 11 Sep 2001 20:30:51 GMT",
     <http://arxiv.example.net/web/20010911203610/http://a.example.org>
       ; rel="next memento"; datetime="Tue, 11 Sep 2001 20:47:33 GMT"
    Content-Length: 0
    Content-Type: text/plain; charset=UTF-8
    Connection: close

    Step 5 : UA --- HTTP GET URI-Mj; Accept-Datetime: Tj -------> URI-Mj

    GET /web/20010911203610/http://a.example.org
     HTTP/1.1
    Host: arxiv.example.net
    Accept-Datetime: Tue, 11 Sep 2001 20:35:00 GMT
    Connection: close

    Step 6 : UA <-- HTTP 200; Memento-Datetime: Tj; Link: URI-R,
        URI-T, URI-G, URI-M0, URI-Mn, URI-Mi, URI-Mj, URI-Mk ---- URI-Mj

    HTTP/1.1 200 OK

```
Date: Thu, 21 Jan 2010 00:09:40 GMT
Server: Apache-Coyote/1.1
Memento-Datetime: Tue, 11 Sep 2001 20:36:10 GMT
Link: <http://a.example.org>; rel="original",
 <http://arxiv.example.net/web/20000915112826/http://a.example.org>
   ; rel="first memento"; datetime="Tue, 15 Sep 2000 11:28:26 GMT",
 <http://arxiv.example.net/web/20080708093433/http://a.example.org>
   ; rel="last memento"; datetime="Tue, 08 Jul 2008 09:34:33 GMT",
 <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",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="memento"; datetime="Tue, 11 Sep 2001 20:36:10 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="prev memento"; datetime="Tue, 11 Sep 2001 20:30:51 GMT",
 <http://arxiv.example.net/web/20010911203610/http://a.example.org>
   ; rel="next memento"; datetime="Tue, 11 Sep 2001 20:47:33 GMT"
Content-Length: 23364
Content-Type: text/html;charset=utf-8
Connection: close
```

A successful flow with TimeGate and Mementos on the same server

Authors' Addresses

Herbert VandeSompel
Los Alamos National Laboratory
PO Box 1663
Los Alamos, New Mexico 87545
USA

Phone: +1 505 667 1267
Email: hvdsomp@gmail.com
URI: http://public.lanl.gov/herbertv/

Michael Nelson
Old Dominion University
Norfolk, Virginia 23529
USA

Phone: +1 757 683 6393
Email: mln@cs.odu.edu
URI: http://www.cs.odu.edu/~mln/

    Robert Sanderson
    Los Alamos National Laboratory
    PO Box 1663
    Los Alamos, New Mexico 87545
    USA

    Phone: +1 505 665 5804
    Email: azaroth42@gmail.com
    URI: http://public.lanl.gov/rsanderson/