Memento: Time Travel for the Web

http://www.mementoweb.org

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Acknowledgments

• At the Los Alamos National Laboratory, Prototyping Team:
  o Robert Sanderson
  o Lyudmilla Balakireva
  o Harihar Shankar

• At Old Dominion University, Web Science and Digital Library Research Group:
  o Scott Ainsworth
Time-travelling browsers navigate the web’s past

Finding old versions of web pages could become far simpler thanks to a "time-travelling" web browsing technology being pioneered at the Los Alamos National Laboratory in New Mexico.

Bookmarking a page takes you to its current version – but earlier ones are harder to find (to see an award-winning 1990s incarnation of newscientist.com, see our gallery of web pages past, right). One option is to visit a resource like the Internet Archive’s Wayback Machine. There, you key in the URL of the site you want and are confronted with a matrix of years and dates for old pages that have been cached. Or, if you want to check how a Wikipedia page has evolved, you can hit the "history" tab on a page of interest and scroll through in an attempt to find the version of the page on the day you’re interested in.

It’s a lot of hassle. But it shouldn’t be, says Herbert Van de Sompel, a computer

Four short links: 18 November 2009

Web Time Travel, UK Map Data Liberation, Streetview Mashups, 3D Retail

by Nat Torkington | @gnat | comments: 0

1. **Memento: Time Travel for the Web** -- clever versioning hack that uses HTTP's content negotiation to negotiate about the date!

2. **Ordnance Survey Maps to Go Online** -- The prime minister said that by April he hoped a consultation would be completed on the free provision of Ordnance

Soon, 'time-travelling' browsing technology to navigate web's past

China National News
Tuesday 17th November, 2009
(ANI)

London, Nov 17: A 'time-travelling' web browsing technology is being pioneered at the Los Alamos National Laboratory in New Mexico to make it simpler to find old versions of web pages.

Called Memento, the system Herbert Van de Sompel, a computer scientist at Los Alamos, is developing alongside colleagues from Old Dominion University in Norfolk, Virginia, gives browsers a "time-travel" mode, allowing users to find web pages from particular dates and times without having to navigate through archives.
Looking at the Past can be Fun

Cheney prays for hunt victim

Feb 14 2006
Looking at the Past can be Fun

Feb 14 2006

Press Attacks Cheney

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OCLC DSS, Dublin, OH - November 18 2009
And Memento wants to make it Easy
W3C Web Architecture: Resource – URI - Representation

URI

Identifies

Resource

Represents

derefence

Representation
W3C Web Architecture: Resource – URI - Representation

URI

Identifies

Resource

Represents

Representation 1

Represents

Representation 2

dereference

content negotiation

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Resources
Resources have Representations
Resources have Representations that Change over Time
Only the Current Representation is Available from a Resource
Old Representations are Lost Forever

the old representations are lost forever
There is no Time Dimension to HTTP, the Web

Resource state may evolve over time. Requiring a URI owner to publish a new URI for each change in resource state would lead to a significant number of broken references. For robustness, Web architecture promotes independence between an identifier and the state of the identified resource.

Archived Resources Exist

the old representations
are lost forever

well, that is not
not entirely true

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Archived Resources


Finding Archived Resources

Go to http://www.archive.org/ and search http://cnn.com


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Finding Archived Resources

Go to http://en.wikipedia.org/wiki/September_11_attacks and click History

Revision history of September 11 attacks

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Navigating Archived Resources


http://en.wikipedia.org/wiki/The_Pentagon

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Current and Past Web are Not Integrated

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This is Where Memento comes in ...
This is Where Memento comes in …

Memento Experiment

Experiment conducted in the course of September and October 2009 by:

Los Alamos National Laboratory, Research Library. Prototyping Team: Lyudmila Balakireva, Robert Sanders, Harsh Shankar, Herbert Van de Sompel

Old Dominion University, Computer Science Department: Scott Ainsworth, Michael Nelson

From LANL and ODU transactional archives

Oct 11 2009, 00:00:01 UTC

Oct 10 2009, 18:00:01 UTC

Oct 10 2009, 16:00:01 UTC

http://lanlsource.lanl.gov/hell o

Oct 11 2009, 05:30:33 UTC

Web Archiving

Oct 11 2009, 05:30:33 UTC

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This is Where Memento comes in ...

http://en.wikipedia.org/wiki/Web_Archiving

Oct 11 2009, 05:30:33 UTC
This is Where Memento comes in ...


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This is Where Memento comes in …

http://www.robotstxt.org/

Oct 11 2001, 05:30:33 UTC

From Internet Archive

Nov 09 2007, 06:21:04 UTC
In order to help understand how Memento introduces time travel for the Web, we present a brief recap of Transparent Content Negotiation (conneg) in HTTP.

HTTP GET on URI A

GET A HTTP/1.1
HTTP/1.1 200 OK
Content-Location: A
Content-Type: text/html
Content-Language: en

client

server

HTML

USA flag
GET with conneg on URI T – Server Choice – 200 OK

HTTP/1.1 200 OK
TCN: choice
Vary: negotiate, accept, accept-language
Content-Location: A
Content-Type: text/html
Content-Language: en
Alternates: {"A" 1.0 {type text/html}}
{language en}}, {"B" ...}, {"C" ...}

client

GET T HTTP/1.1
Accept: text/html, application/pdf; q=0.8
Accept-Language: en-US, fr; q=0.7, de; q=0.5

server
GET with conneg on URI T – Server Choice – 302 Found – Step 1

GET T HTTP/1.1
Accept: text/html, application/pdf;q=0.8
Accept-Language: en-US, fr;q=0.7, de;q=0.5

HTTP/1.1 302 Found
TCN: choice
Location: A
Content-Type: text/html
Content-Language: en
Alternates: {"A" 1.0 {type text/html}}
{languge en}}, {"B" ...}, {"C" ...}
GET with conneg on URI T – Server Choice – 302 Found – Step 2

client

GET A HTTP/1.1
Accept: text/html, application/pdf; q=0.8
Accept-Language: en-US, fr; q=0.7, de; q=0.5

server

HTTP/1.1 200 OK
Content-Location: A
Content-Type: text/html
Content-Language: en

T

A

HTML

B

PDF

C

PDF

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GET with conneg on URI T – Server List – 406 Not Acceptable
Now, we are ready to introduce the components of the Memento Solution:

- Content Negotiation in the datetime dimension.
- An API for archives that allows requesting a list of all archived versions it holds for a given URI.
We introduce the term *Memento* to refer to an archived version of a resource.

A Memento for a resource URI-R (as it existed) at time \( t_i \) is a resource URI-M\(_i\) \([\text{URI-R}@t_i]\) for which the representation at any moment past its creation time \( t_c \) is the same as the representation that was available from URI-R at time \( t_i \), with \( t_c \leq t_i \). Implicit in this definition is the notion that, once created, a Memento always keeps the same representation.
DT-conneg: Content Negotiation in the datetime dimension

- RFC 2295 introduces conneg in the following dimensions: media type, language, compression, character set, e.g.:
  
  Accept-Language: en-US

- Memento introduces conneg in the datetime dimension:

  X-Accept-Datetime: {Mon, Oct 12 2009 14:20:33 GMT}

- This means that somewhere, we will need transparently negotiable resources to get to appropriate Mementos.

- This will be discussed for 2 classes of servers.
Class 1 Servers: With Internal Archival Capabilities

- This type includes:
  - Content Management Systems
  - Version Control Systems
  - TTApache
  - Servers that archive resource representations in the cloud and keep track of the URIs and datetimes of remotely archived resources.

- These servers have all the essential information (URI-Ms, and associated datetimes) to respond to a DT-conneg request.

Dec 20 2001, 4:51:00 UTC

Dec 31 2004, 20:46:00 UTC

Dec 20 2008, 22:21:00 UTC

http://en.wikipedia.org/w/index.php?
title=September_11_attacks&oldid=259237305

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Terminology Intermission

We introduce the term *TimeGate* to refer to a transparently negotiable resource that supports the datetime dimension.

A TimeGate for an original resource URI-R is a transparently negotiable resource URI-G[URI-R] for which all variant resources are Mementos URI-M$_i$[URI-R@$t_i$] of the resource URI-R. Since multiple archives may host versions of URI-R, multiple TimeGates may exist for any given resource, i.e. one per archive.
DT-conneg with URI-G/URI-R to get URI-M

original resource

same

transiently negotiable resource

TimeGate

Mementos

variant resources
Servers With Internal Archival Capabilities: Successful Flow

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### Servers With Internal Archival Capabilities: Other Scenarios

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Client issues request without datetime content negotiation against original resource URI-R that functions as its own TimeGate.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GET URI-G HTTP 1.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 2</th>
<th>Server that is the target of request [1] responds:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>URI-R exists.</td>
</tr>
<tr>
<td></td>
<td>HTTP/1.1 200 OK</td>
</tr>
<tr>
<td></td>
<td>Content-Location: URI-R</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 2</th>
<th>URI-R does not exist.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HTTP/1.1 404 Not Found</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 3</th>
<th>Client issues datetime content negotiation request against Memento URI-M for original resource URI-R.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GET URI-M HTTP 1.1</td>
</tr>
<tr>
<td></td>
<td>X-Accept-Datetime: (datetime_start) - (datetime_end)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 4</th>
<th>Memento server (same as server of original resource URI-R) that is the target of request [3] responds:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Server detects X-Accept-Datetime &amp; URI-M exists.</td>
</tr>
<tr>
<td></td>
<td>HTTP/1.1 200 OK</td>
</tr>
<tr>
<td></td>
<td>Content-Location: URI-M</td>
</tr>
<tr>
<td></td>
<td>X-Archive-Interval: (datetime_first) - (datetime_last)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case 4</th>
<th>Server does not detect X-Accept-Datetime &amp; URI-M exists.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HTTP/1.1 404 Not Found</td>
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<tr>
<th>Case 4</th>
<th>Server does not detect X-Accept-Datetime &amp; URI-M does not exist.</th>
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<td></td>
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<th>Case 3</th>
<th>Client issues request without datetime content negotiation against Memento URI-M for original resource URI-R.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GET URI-G HTTP 1.1</td>
</tr>
</tbody>
</table>

Class 2 Servers: Without Internal Archival Capabilities

• This type includes:
  o Servers that are crawled by a web archive
  o Servers with an associated transactional archive

• These servers do not have the essential information (URI-Ms, and associated datetimes) to respond to a DT-conneg request.

• But they can still be really constructive by redirecting (HTTP 302) a client to an archive that can respond to the DT-conneg request.
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http://lanlsource.lanl.gov/hello

Oct 04 2009, 12:00:01 UTC
Oct 10 2009, 12:00:03 UTC
Oct 21 2009, 12:00:01 UTC

http://mementoarchive.lanl.gov/store/ta/20091021
120001/http://lanlsource.lanl.gov/hello
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DT-conneg with URI-G to get URI-M

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How to redirect from Original Resource to its (external) TimeGate

• Q1: Which archive to redirect to?
  
  o The archive with the best coverage for the server at hand.
    - There are quite a few nuances, here.
  
  o Always redirect to an Aggregator (see later)

• Q2: What is the TimeGate URI-G for URI-R on the chosen archive?
  
  o Convention for syntax of URI-G as function of URI-R.
  
  o Always redirect to an Aggregator (see later)
Servers Without Internal Archival Capabilities: Successful Flow

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### Servers Without Internal Archival Capabilities: Other Scenarios

<table>
<thead>
<tr>
<th>Case</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TimeGate server detects X-Accept-Datetime &amp; URI-G exists &amp; date can be parsed &amp; date is in range for which server has Mementos for original resource URI-R.</td>
</tr>
<tr>
<td>2</td>
<td>TimeGate server detects X-Accept-Datetime &amp; URI-G exists &amp; date can be parsed &amp; date is outside range for which server has Mementos for original resource URI-R.</td>
</tr>
<tr>
<td>3</td>
<td>TimeGate server detects X-Accept-Datetime &amp; URI-G exists &amp; date cannot be parsed.</td>
</tr>
<tr>
<td>4</td>
<td>TimeGate server detects X-Accept-Datetime &amp; URI-G does not exist.</td>
</tr>
</tbody>
</table>

**Case 1:**
```
GET URI-G HTTP 1.1
X-Accept-Datetime: {datetime_}
```

**Case 2:**
```
HTTP/1.1 406 Not Acceptable
Vary: negotiate, X-Accept-Datetime
Content-Length: 0
```

**Case 3:**
```
HTTP/1.1 400 Bad Request
X-Accept-Datetime: {datetime_start} - {datetime_end}
Content-Length: 0
```

**Case 4:**
```
HTTP/1.1 404 Not Found
```

---

See [http://www.mementoweb.org/guide/http/remote](http://www.mementoweb.org/guide/http/remote)
HTTP Response Headers for DT-conneg: Datetime Ranges

- **X-Archive-Interval**: Indicates the entire datetime interval for which the archival server has Mementos for URI-R.

- **X-Datetime-Validity**: Indicates the datetime interval during which the provided representation was valid.
  - Can reliably be provided by transactional archives, CMS, …
  - Can typically not reliably be provided by crawler-based archives.
The Memento Solution

We have covered this component of the Memento Solution:

• Content Negotiation in the datetime dimension.

Now up to the next one:

• An API for archives that allows requesting a list of all archived versions it holds for a given URI.
Why an API?

- Mementos for any given URI-R are distributed across archives.

- In order to get a correct perspective of available Mementos, different archives need to be consulted.

- Can do so in distributed consultation mode (slooow), or by consulting an aggregator.
Terminology Intermission

We introduce the term *TimeBundle* to refer to a resource via which an overview of all Mementos for an original resource URI-R is available.

A TimeBundle for a resource URI-R, is a resource URI-B[URI-R] that is an aggregation of:

(a) All Mementos URI-Mi [URI-R@t_i] available from an archive,
(b) The archive's TimeGate URI-G for URI-R,
(c) The original resource URI-R itself.
Original resource

Memento

URI-R

URI-M₁

URI-M₂

URI-M₃
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Memento DT-conneg component

Original resource → TimeGate → Memento → TimeBundle

Memento DT-conneg component
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HTTP Response Headers for DT-conneg: All Mementos

- **Alternates**: RFC 2295 requires listing all variant resources.
  - Impractical for DT-conneg: many variants may exist.
  - Alternates lists limited amount of variants, centered on the datetime requested by the client.

- **Link**: To compensate for the incomplete list of variants in Alternates, an HTTP Link header points to the TimeBundle via which a list is available of all variant resources (Mementos), and their associated metadata.

- **Example TimeMap in RDF/XML**:
  - [http://www.mementoweb.org/guide/api/map1.rdf](http://www.mementoweb.org/guide/api/map1.rdf)
All Mementos: For Discovery, Cross-Archive Services

• Archive uses common approaches to make TimeBundles/TimeMaps discoverable:
  ○ SiteMaps,
  ○ Atom Feeds,
  ○ OAI-PMH.

• Aggregator harvests and merges TimeMaps. Based on this information, the Aggregator exposes its own TimeGates.
  ○ Cross-archive
  ○ Finer datetime granularity
  ○ Better chances of matching a client’s datetime preference.
  ○ Can become a shared target for redirection for many web servers.
Aggregation of Archival Metadata

Exposed archival metadata per Memento:

- Memento URI
- Datetime of Memento
- Media type, extent, language
- Digest
- Validity (datetime-interval)
- # times the representation was served
- Estimation of inlinks for representation
Aggregation of Archival Metadata

Exposed archival metadata per Memento:

- DRI of Memento in archive
- Datetime of Memento
- media type, extent, language
- digest
- Validity-Enumeration-Interval
- # times the representation was served
- estimate # inlinks for representation
Leveraging the aggregated archival metadata for time travel.
Leveraging the aggregated archival metadata for time travel
The Memento Solution

We have covered both components of the Memento Solution:

• Content Negotiation in the datetime dimension.
• An API for archives that allows requesting a list of all archived versions it holds for a given URI.

Up to some show-off now …
The Memento Experiment

- Servers at LANL and ODU:
  - Support of 302 redirect upon detection of DT-conneg header
  - Redirection is to respective transactional archive per server. These servers support TimeGates, TimeBundles

- Great illustration of the distributed nature of the Memento approach.
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The Memento project researches new ideas related to Web Archiving, focusing on the integration of Web Archives in regular Web navigation.

This Memento experiment is supported by the Library of Congress under the National Digital Information Infrastructure and Preservation Program. Visit the Digital Preservation site for more information about the Program.

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The Memento Experiment

- Servers at Library of Congress:
  - Support of 302 redirect upon detection of DT-conneg header
  - Redirection is to an aggregator that support TimeGates, TimeBundles.
  - Aggregator collects (dynamically, screen scraping) metadata from IA, Archive-It, WebCite, Canadian Archive.
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Memento: Time Travel for the Web
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OCLC DSS, Dublin, OH - November 18 2009
Redirect to TimeGate Aggregator

http://digitalpreservation.gov
The Memento Experiment

- Wikipedia:
  - No support of 302 redirect upon detection of DT-conneg header
  - Memento client intercepts the “unexpected” 200 OK response.
  - Client requests from Wikipedia Proxy that supports TimeGates, TimeBundles.
  - TimeGate on Wikipedia Proxy redirects client to Memento in Wikipedia.

- Also created Memento plug-in for Mediawiki. Adoption currently under discussion.

http://www.mediawiki.org/wiki/Extension:Memento
Clock

From Wikipedia, the free encyclopedia
(Redirected from Clocks)

For other uses, see Clock (disambiguation).

A clock is an instrument used to indicate, measure, keep, and co-ordinate time. The word clock is derived ultimately (via Dutch, Northern French, and Medieval Latin) from the Celtic words clagan and clocca meaning "bell". For horologists and other specialists the term clock continues to mean exclusively a device with a striking mechanism for announcing intervals of time acoustically, by ringing a bell, a set of chimes, or a gong. A silent instrument lacking such a mechanism has traditionally been known as a timepiece. In general usage today a "clock" refers to any device for measuring and displaying the time. Watches and other timepieces that can be carried on one's person are often distinguished from clocks.

Contents

1 History
   1.1 Sundials and other devices
   1.2 Water clocks
   1.3 Early mechanical clocks
      1.3.1 A new mechanism
      1.3.2 Early astronomical clocks
   1.4 Later developments
2 How clocks work
   2.1 Power source
   2.2 Oscillator
      2.2.1 Synchronized or slave clocks
   2.3 Controller
   2.4 Counter chain

http://en.wikipedia.org/wiki/Clocks
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   2.4 Counter chain

For your great, great, great grandson

For other uses, see Clock (disambiguation).

Platform clock at King's Cross railway station, London.

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Clock

A clock is an instrument for measuring and indicating the time. The word "clock" is derived ultimately (via Dutch, Northern French, and Medieval Latin) from the Celtic words clegan and clocia meaning "bell". For horologists and other specialists the term "clock" continues to mean exclusively a device with a striking mechanism for announcing intervals of time acoustically, by ringing a bell, a set of chimes, or a gong. A silent instrument lacking such a mechanism has traditionally been known as a timepiece. In general usage today, however, a "clock" refers to any device for measuring and displaying the time which, unlike a watch, is not worn on the person.

Contents

1 History
   1.1 Sundials and other devices
   1.2 Water clocks
   1.3 Early clocks
      1.3.1 A new mechanism
      1.3.2 Early astronomical clocks
      1.3.3 Elements of the mechanical clock
   1.4 Later developments
2 Types
   2.1 Time display methods
      2.1.1 Analog clocks
      2.1.2 Digital clocks
      2.1.3 Auditory clocks
   2.2 Timekeeping methods

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Memento: Time Travel for the Web
Herbert Van de Sompel, Michael L. Nelson
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Discussion: Memento and Lost Causes (1)

• URI-R vanishes, but the server that used to serve it is still operational:
  
  o In this case, the server should still issue the redirect to a TimeGate upon detection of the DT-conneg request.
  o This allows seamless access to a Memento of URI-R, even if the server no longer hosts the original.
Discussion: Memento and Lost Causes (2)

- A domain vanishes:
  - The client is looking for a current representation of URI-R that was hosted by the domain, but fails.
  - The client resorts to interaction with archives (or with a TimeBundle aggregator) and arrives at the most recent Memento of the resource.
Discussion: Memento and Lost Causes (3)

- A domain is taken over by a new custodian:
  
  o The new custodian adheres to other policies regarding which archive to redirect a DT-conneg request.
  o The client understands from the X-Archive-Interval returned by that archive of choice, that it does not cover the time range in which the previous custodian operated the domain.
  o The client resorts to interaction with other archives (or with a TimeBundle aggregator) and arrives at an appropriate Memento.
Discussion: Memento and Caching

• Caches do not take X-Accept-Datetime header into account.

• Hence, in order to avoid retrieving current representation of URI-R, caches between client and server (included) must be bypassed when doing datetime content negotiation.

• Currently enforced by:
  
  o Cache-Control: no-cache => force cache revalidation
  o If-Modified-Since: Thu, 01 Jan 1970 00:00:00 GMT => make sure that revalidation fails

• Clearly needs a more elegant solution.
Discussion: Memento and Web Archives

• Web Archives rewrite URLs in archived pages, in order to avoid:
  
  o Serving current representations of embedded resources;
  o Linking to current representations of resources

• The upside: Archived pages are self-contained.

• The downside: Cannot navigate beyond the archive’s content, even if other archives may have archived version of embedded or linked resource.

• Would be interesting to explore novel strategies with this regard.
If You Think Memento is Cool …

- Install Apache rewrite rule that redirects when X-Accept-Datetime is present.
  - http://mementoweb.org/tools/apache
- Implement Memento natively for a CMS platform.
  - http://mementoweb.org/guide/http/local
- Join memento-dev Google Group
  - http://groups.google.com/group/memento-dev
- Use ModifyHeaders FireFox extension to test.
- Watch video
  - http://www.youtube.com/watch?v=LnkBp-FfoJw
- Read paper
- Soon: Memento FireFox plug-in.

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Memento wants to make Browsing the Past Easy

http://www.mementoweb.org