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Memento: Time Travel for the Web

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Memento: Time Travel for the Web



The Memento Team

Herbert Van de Sompel

Michael L. Nelson

Robert Sanderson

Lyudmila Balakireva

Scott Ainsworth

Harihar Shankar

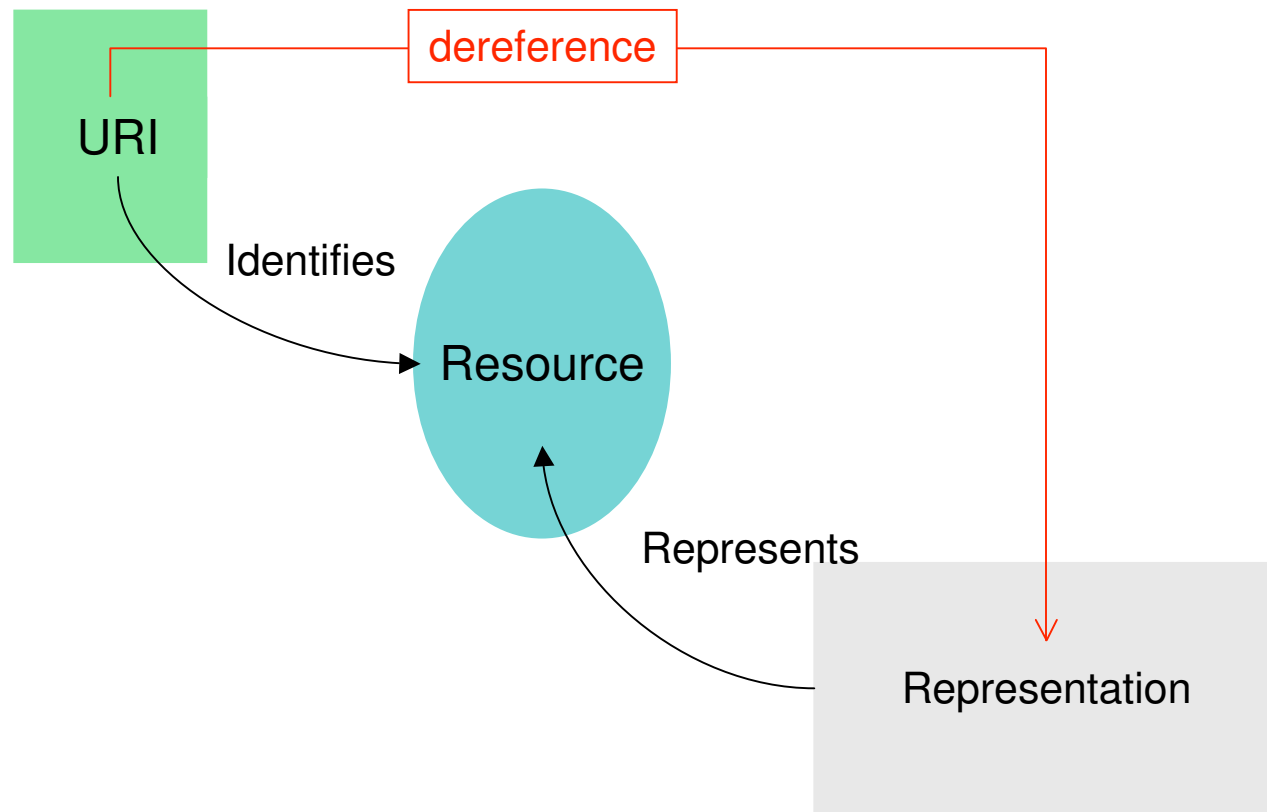
Memento is partially funded by the
Library of Congress



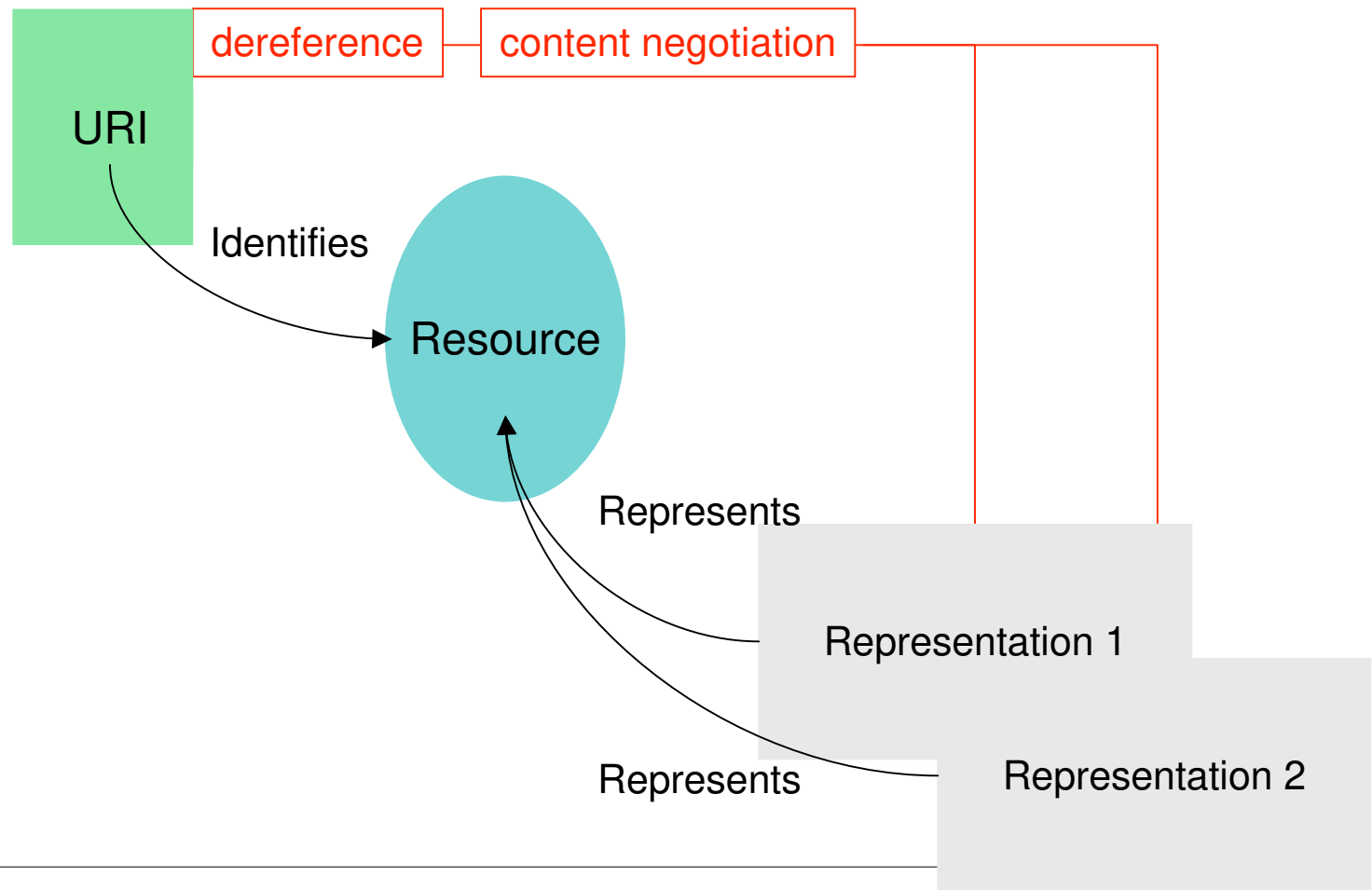
Memento: Time Travel for the Web
UNC Scholarly Communications Working Group, November 10 2010



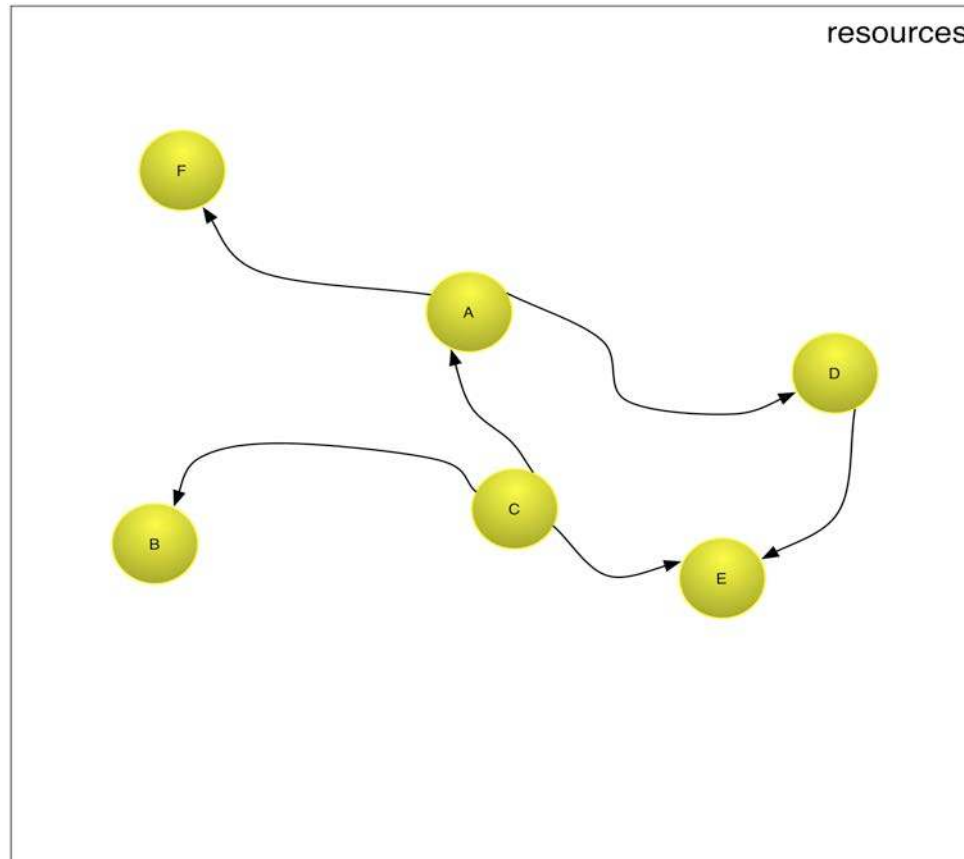
W3C Web Architecture: Resource – URI - Representation



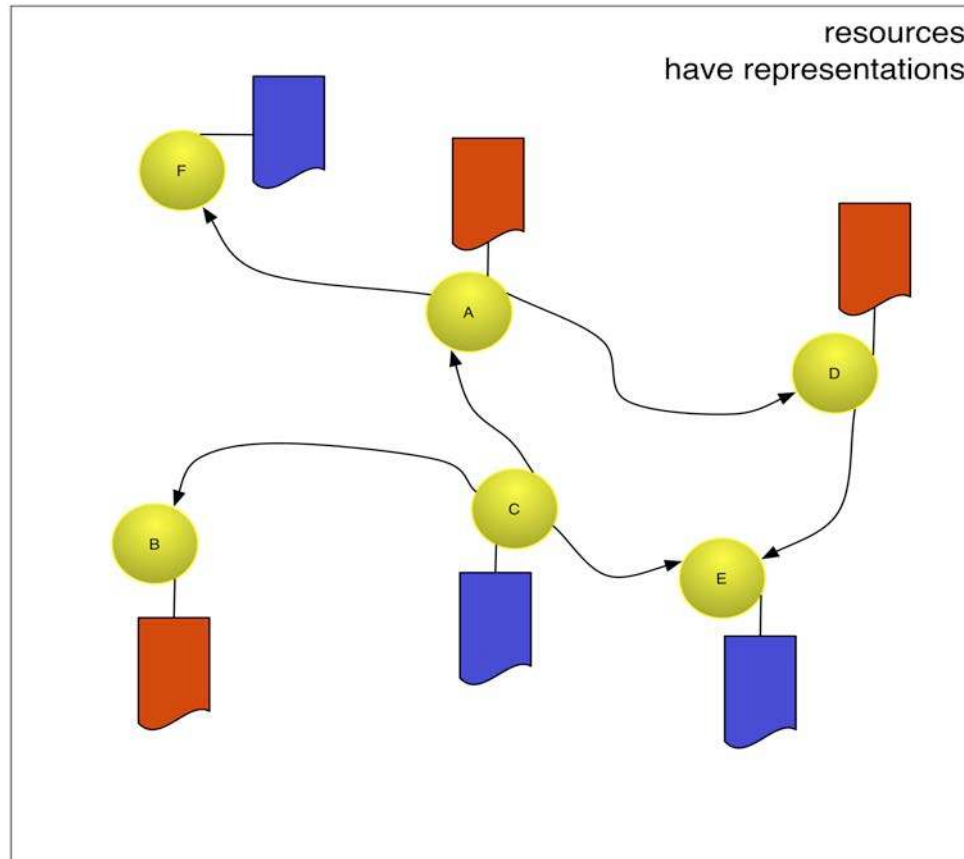
W3C Web Architecture: Resource – URI - Representation



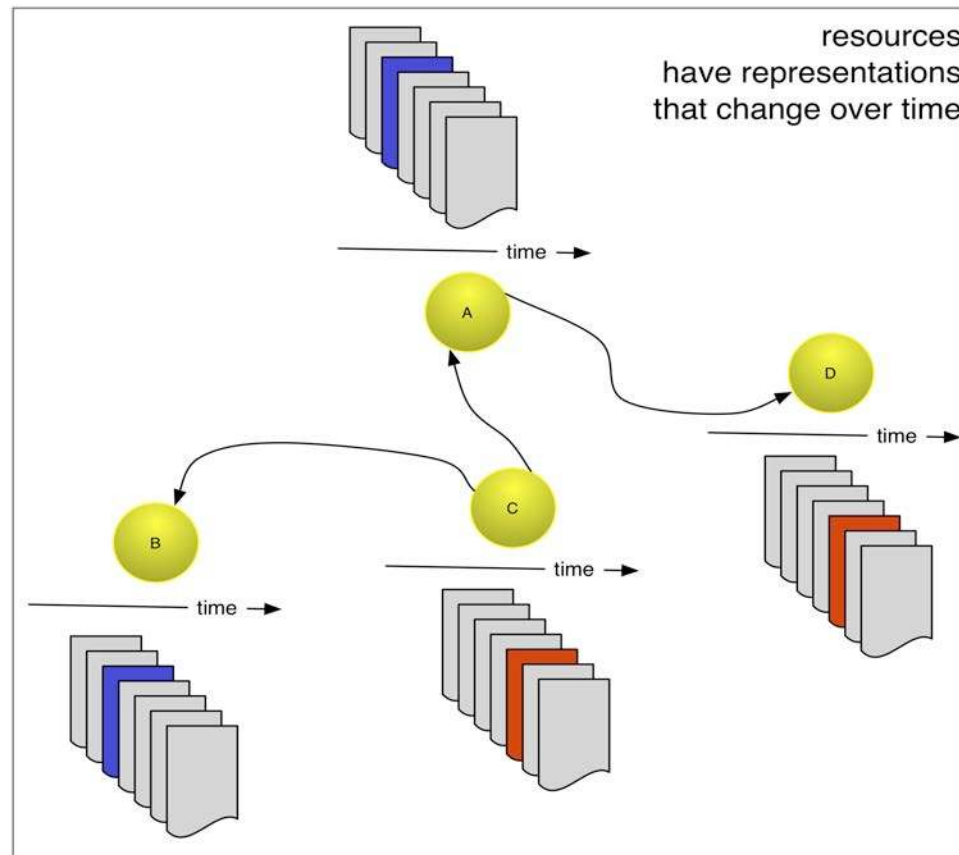
Resources



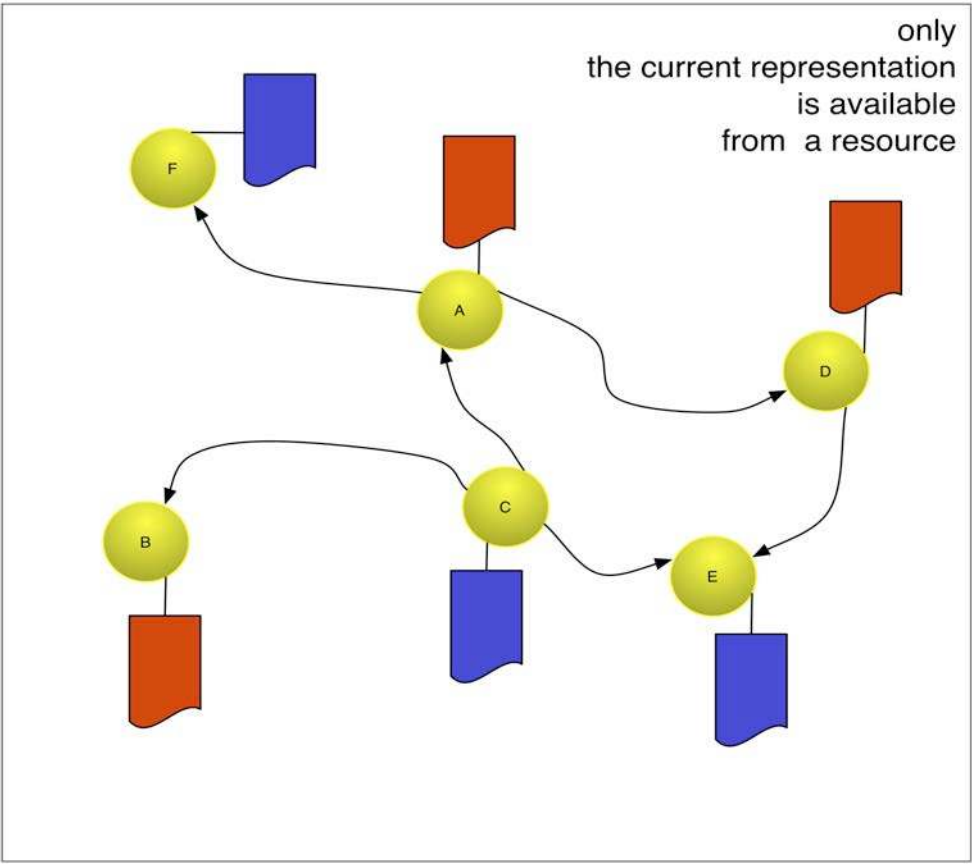
Resources have Representations



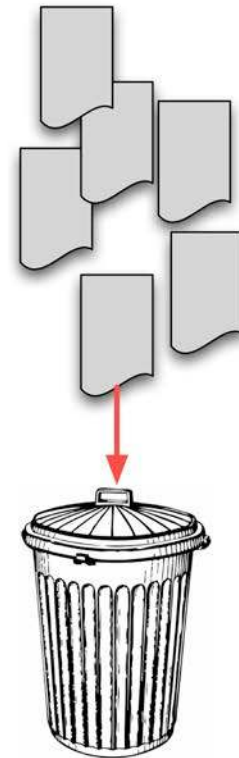
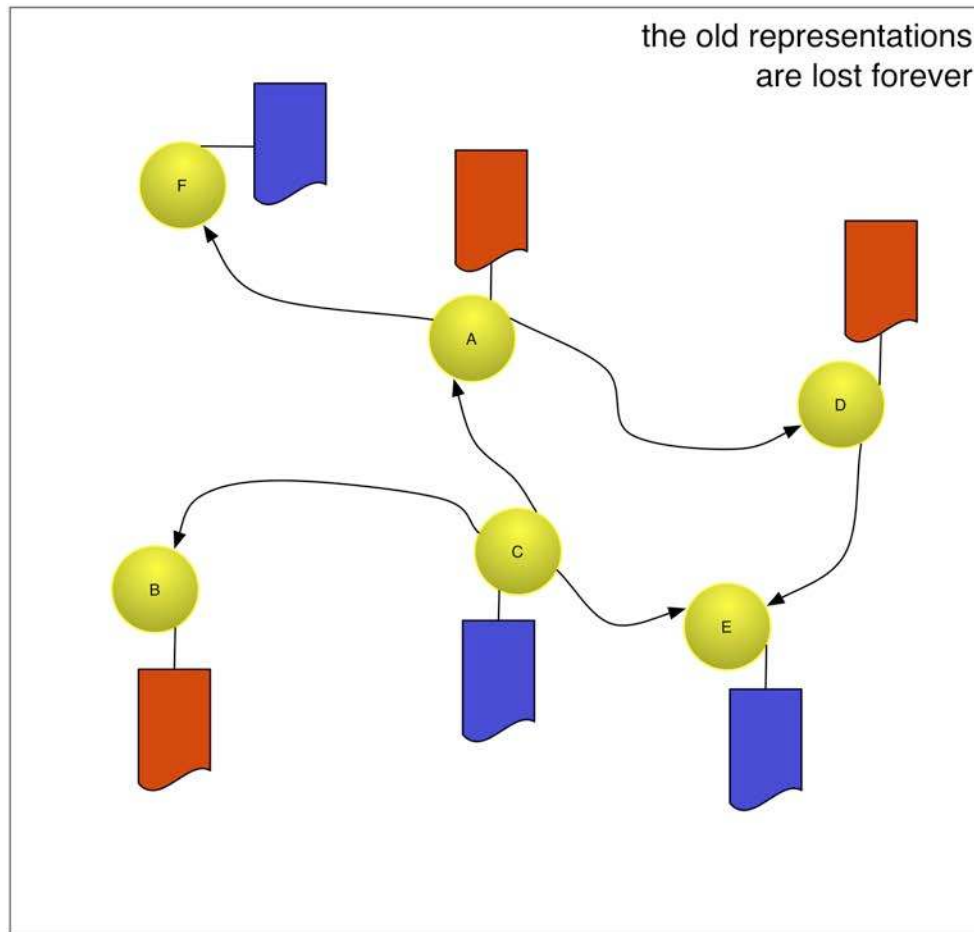
Resources have Representations that Change over Time



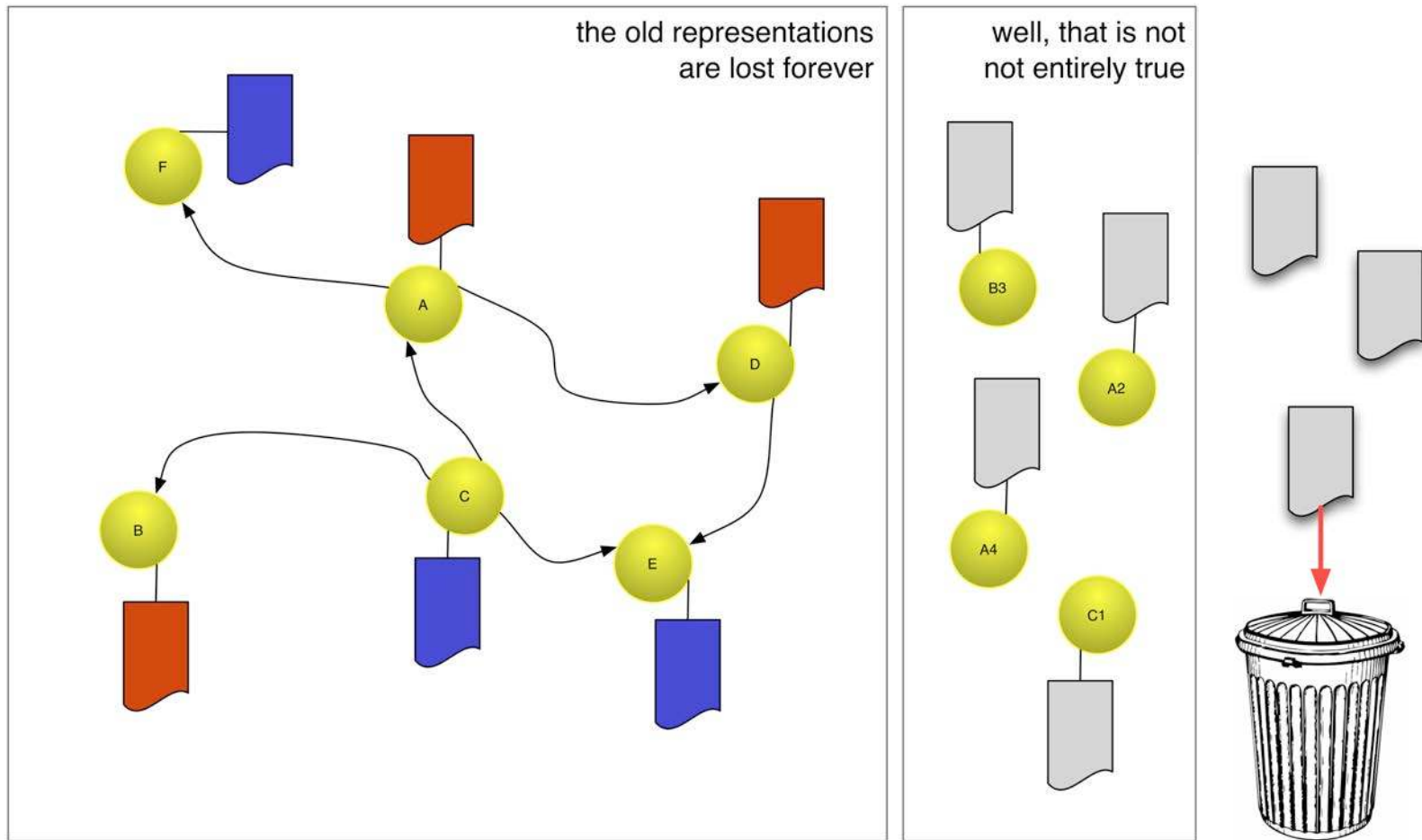
Only the Current Representation is Available from a Resource



Old Representations are Lost Forever



Archived Resources Exist



Sep 11 2001, 20:36:10 UTC

Dec 20 2001, 4:51:00 UTC

Archived Resources

CNN.com SPECIAL REPORT

Updated: 5:42 p.m. EDT -- 11 September 2001

AMERICA UNDER ATTACK
CNN EXCLUSIVE

Terrorists strike New York, D.C.
At 8:45 a.m. EDT, the first of two airliners crashed into the World Trade Center, opening a horrifying and apparently coordinated terrorist attack on the United States, which saw the collapse of the two 110-story towers into surrounding Manhattan streets and a later attack on the Pentagon.

COMPLETE COVERAGE

- World Trade Center towers collapse after hit
- Crash destroys part of Pentagon
- White House, Capitol evacuated
- American, United confirm losing planes
- Bush: 'We'll hunt them down' | Statement
- U.S. officials: More attacks can't be ruled out
- Attacks strike financial markets

U.S. SCENE

- FAA grounds all U.S. flights until noon Wednesday
- U.S. military on 'high alert'
- Major sports events postponed

WORLD SCENE

- Taliban statement: 'Afghanistan feels your pain'
- World in shock | Evacuations amid chaos
- Middle East, Asia condemn attacks

RESOURCES AND RESCUE

- Giuliani: 1,500 'walking wounded' in New York
- Emergency contact information

VIDEO
Watch video of second plane crash at World Trade Center
[More audio/video >>](#)

PHOTO GALLERY
Aftermath of the attacks in New York and Washington

CHRONOLOGY
At 8:45 a.m. EDT, day of disaster begins
[Map of attacks](#)

EXTRA INFO
[World Trade Center, Pentagon, 767](#)

September 11 attacks

From Wikipedia, the free encyclopedia

This is an old revision of this page, as edited by The Cunctator (talk | contribs) at 04:51, 20 December 2001. It may differ significantly from the current revision.

(diff) ← Previous revision | Current revision (diff) | Never revision → (diff)

In Memoriam, September 11, 2001

On the morning of September 11, 2001, what might well be the most devastating terrorist attack in the history of the world occurred concurrently in New York City, Washington, D.C. and near Pittsburgh. Four passenger jets were hijacked and then deliberately crashed into the World Trade Center and the Pentagon. Both towers of the World Trade Center subsequently collapsed, and part of the Pentagon was destroyed in the ensuing fire. Casualties are expected to be in the thousands: 265 on the planes; about 3000 people (early estimates ranged as high as 6500 people), including hundreds of firefighters who had rushed in, at the World Trade Center; and 125 at the Pentagon.

Some passengers on the doomed flights were able to make phone calls reporting on events on board. They reported that there were more than one hijacker on each plane and that they took control of the planes using box-cutter knives. It appears that the passengers on the fourth jet tried to overpower the hijackers and that the plane crashed in a sparsely populated area as a result, thereby missing its intended target, which may have been the White House.

The attack had immediate and deep global political effects and economic effects and inspired an international outpouring of memorials and services. The massive undertaking of rescue and recovery, and of providing assistance to the survivors and victims, is ongoing. There will be a great need for donations for a long time.

Though no group has claimed responsibility, the U.S. government immediately launched a full-scale response, stating its intentions to go to war against those responsible. On October 7, a coalition led by the United States launched an attack in Afghanistan. See 2001 U.S. Attack on Afghanistan.

Following the attack, the United States has been on heightened alert for new terrorist attacks. In late September, cases of anthrax started breaking out; although, no connection to the September 11 attack has been found. See 2001 anthrax attack.

<http://web.archive.org/web/20010911203610/http://www.cnn.com/> archived resource for <http://cnn.com>

http://en.wikipedia.org/w/index.php?title=September_11_attacks&oldid=282333 archived resource for http://en.wikipedia.org/wiki/September_11_attacks



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UNC Scholarly Communications Working Group, November 10 2010



Finding Archived Resources

able here 6 months after collection. [See FAQ.](#)

Search Results for Jan 01, 1996 - May 14, 2009							
2000	2001	2002	2003	2004	2005	2006	2007
30 pages	2734 pages	231 pages	156 pages	625 pages	1186 pages	886 pages	953 pages
Jun 20, 2000	Mar 01, 2001	Jan 23, 2002	Jan 29, 2003	Jan 01, 2004	Jan 01, 2005	Jan 01, 2006	Jan 01, 2007
Jun 21, 2000	Mar 02, 2001	Feb 02, 2002	Jan 31, 2003	Jan 02, 2004	Jan 01, 2005	Jan 01, 2006	Jan 01, 2007
Jun 21, 2000	Mar 05, 2001	Feb 09, 2002	Feb 01, 2003	Jan 03, 2004	Jan 02, 2005	Jan 02, 2006	Jan 02, 2007
Jun 21, 2000	Mar 07, 2001	Feb 10, 2002	Feb 01, 2003	Jan 10, 2004	Jan 02, 2005	Jan 02, 2006	Jan 02, 2007
Jun 21, 2000	Mar 09, 2001	Feb 11, 2002	Feb 02, 2003	Jan 11, 2004	Jan 03, 2005	Jan 03, 2006	Jan 02, 2007
Jul 05, 2000	Mar 31, 2001	Feb 13, 2002	Feb 02, 2003	Jan 12, 2004	Jan 04, 2005	Jan 03, 2006	Jan 03, 2007
Jul 07, 2000	Apr 10, 2001	Feb 13, 2002	Feb 03, 2003	Jan 12, 2004	Jan 05, 2005	Jan 03, 2006	Jan 03, 2007
Jul 11, 2000	Apr 13, 2001	Feb 14, 2002	Feb 05, 2003	Jan 13, 2004	Jan 06, 2005	Jan 04, 2006	Jan 04, 2007
Aug 04, 2000	Apr 13, 2001	Feb 15, 2002	Feb 06, 2003	Jan 15, 2004	Jan 06, 2005	Jan 04, 2006	Jan 05, 2007
Aug 15, 2000	Apr 13, 2001	Feb 16, 2002	Feb 07, 2003	Jan 16, 2004	Jan 06, 2005	Jan 04, 2006	Jan 05, 2007
Aug 15, 2000	Apr 14, 2001	Feb 20, 2002	Feb 10, 2003	Jan 17, 2004	Jan 07, 2005	Jan 04, 2006	Jan 06, 2007
Aug 15, 2000	Apr 14, 2001	Feb 22, 2002	Feb 10, 2003	Jan 20, 2004	Jan 07, 2005	Jan 05, 2006	Jan 06, 2007
Aug 15, 2000	Apr 14, 2001	Feb 22, 2002	Feb 11, 2003	Jan 20, 2004	Jan 08, 2005	Jan 05, 2006	Jan 06, 2007
Aug 16, 2000	Apr 18, 2001	Feb 23, 2002	Feb 12, 2003	Jan 20, 2004	Jan 09, 2005	Jan 05, 2006	Jan 07, 2007
Aug 16, 2000	May 03, 2001	Feb 23, 2002	Feb 12, 2003	Jan 24, 2004	Jan 09, 2005	Jan 06, 2006	Jan 07, 2007
Aug 17, 2000	May 03, 2001	Feb 23, 2002	Jan 27, 2003	Jan 27, 2004	Jan 10, 2005	Jan 06, 2006	Jan 07, 2007
Aug 17, 2000	May 03, 2001	Feb 24, 2002	Feb 15, 2003	Jan 28, 2004	Jan 10, 2005	Jan 06, 2006	Jan 07, 2007
Aug 18, 2000	May 03, 2001	Feb 26, 2002	Mar 20, 2003	Jan 30, 2004	Jan 10, 2005	Jan 06, 2006	Jan 07, 2007
Aug 28, 2000	May 03, 2001	Feb 27, 2002	Jan 30, 2003	Jan 30, 2004	Jan 11, 2005	Jan 07, 2006	Jan 08, 2007
Sep 20, 2000	May 03, 2001	Mar 27, 2002	Mar 21, 2003	Jan 31, 2004	Jan 11, 2005	Jan 07, 2006	Jan 08, 2007
Sep 30, 2000	May 03, 2001	Mar 29, 2002	Mar 24, 2003	Feb 02, 2004	Jan 12, 2005	Jan 07, 2006	Jan 08, 2007
Oct 18, 2000	May 04, 2001	May 25, 2002	Mar 25, 2003	Feb 02, 2004	Jan 12, 2005	Jan 07, 2006	Jan 08, 2007
Nov 09, 2000	May 04, 2001	May 27, 2002	Mar 26, 2003	Feb 03, 2004	Jan 13, 2005	Jan 08, 2006	Jan 08, 2007
Nov 10, 2000	May 04, 2001	May 27, 2002	Mar 29, 2003	Feb 04, 2004	Jan 13, 2005	Jan 09, 2006	Jan 08, 2007
Nov 10, 2000	May 04, 2001	May 28, 2002	Mar 29, 2003	Feb 07, 2004	Jan 13, 2005	Jan 09, 2006	Jan 08, 2007
Nov 17, 2000	May 04, 2001	May 29, 2002	Mar 30, 2003	Feb 10, 2004	Jan 14, 2005	Jan 10, 2006	Jan 08, 2007
Nov 18, 2000	May 04, 2001	May 30, 2002	Mar 31, 2003	Feb 10, 2004	Jan 14, 2005	Jan 10, 2006	Jan 09, 2007
Dec 04, 2000	May 04, 2001	May 30, 2002	Apr 01, 2003	Feb 11, 2004	Jan 14, 2005	Jan 10, 2006	Jan 09, 2007
Dec 04, 2000	May 04, 2001	May 30, 2002	Apr 04, 2003	Feb 13, 2004	Jan 15, 2005	Jan 10, 2006	Jan 09, 2007
Dec 04, 2000	May 05, 2001	May 31, 2002	Apr 04, 2003	Feb 13, 2004	Jan 15, 2005	Jan 10, 2006	Jan 09, 2007
May 05, 2001	Jun 02, 2002	Apr 05, 2003	Apr 05, 2003	Feb 14, 2004	Jan 15, 2005	Jan 10, 2006	Jan 10, 2007
May 05, 2001	Jun 02, 2002	Apr 08, 2003	Apr 08, 2003	Feb 14, 2004	Jan 16, 2005	Jan 10, 2006	Jan 10, 2007
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May 05, 2001	Jul 03, 2002	Apr 23, 2003	Apr 23, 2003	Mar 07, 2004	Jan 19, 2005	Jan 12, 2006	Jan 13, 2007

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

On http://web.archive.org/web/*/http://cnn.com, select desired datetime



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Finding Archived Resources

The screenshot shows the main article page for "September 11 attacks". The title is "September 11 attacks" and it includes a sub-section titled "September 11, 2001 Attacks" with an image of the Twin Towers burning. The article text describes the coordinated suicide attacks by Al-Qaeda on September 11, 2001, in the United States. It mentions the hijacking of four commercial passenger jet airliners, the collapse of the World Trade Center and the Pentagon, and the resulting deaths and injuries. The article also notes the international response, including the USA PATRIOT Act and the War on Terrorism.

The screenshot shows the "Revision history of September 11 attacks" page. It lists several revisions with their dates and authors. The most recent revision is from 18:20 on 9 November 2009 by InnerParty. The page also includes a search bar for browsing history and a list of external tools for further exploration.



Go to

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

Browse History



Memento: Time Travel for the Web
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Dec 20 2001, 4:51:00 UTC

current

Navigating Archived Resources

http://en.wikipedia.org/w/index.php?title=September_11_attacks&oldid=282333 archived resource for
http://en.wikipedia.org/wiki/September_11_attacks3

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



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Sep 11 2001, 20:36:10 UTC

Sep 11 2001, 21:38:55 UTC

Navigating Archived Resources

CNN.com SPECIAL REPORT

Updated: 5:42 p.m. EDT -- 11 September 2001

AMERICA UNDER ATTACK
CNN EXCLUSIVE

Terrorists strike New York, D.C.
At 8:45 a.m. EDT, the first of two airliners crashed into the World Trade Center, opening a horrifying and apparently coordinated terrorist attack on the United States, which saw the collapse of the two 110-story towers into surrounding Manhattan streets and a later attack on the Pentagon.

COMPLETE COVERAGE

- World Trade Center towers collapse after hit
- Crash destroys part of Pentagon
- White House, Capitol evacuated
- American, United confirm losing planes
- Bush: 'We'll hunt them down' | Statement
- U.S. officials: More attacks can't be ruled out
- Attacks strike financial markets

U.S. SCENE

- FAA grounds all U.S. flights until noon Wednesday
- U.S. military on 'high alert'
- Major sports events postponed

WORLD SCENE

- Taliban statement: 'Afghanistan feels your pain'
- World in shock | Evacuations amid chaos
- Middle East, Asia condemn attacks

RESOURCES AND RESCUE

Giuliani: 1,500 'walking wounded' in New York
[Emergency contact information](#)

VIDEO
Watch video of second plane crash at World Trade Center
[More audio/video >>](#)

PHOTO GALLERY
Aftermath of the attacks in New York and Washington

CHRONOLOGY
At 8:45 a.m. EDT, day of disaster begins
[Map of attacks](#)

EXTRA INFO
[World Trade Center, Pentagon, 767](#)

SPACE

CNN.com / SPACE

Updated: 04:56 PM EDT 20:56 GMT -- 11 Sep 2001

Cool star chills stellar theories

A star besieged by unbelievably hot waves of nuclear explosions is ten times cooler than expected, forcing astronomers to rethink their ideas about stellar physics.

TOP STORIES

- NASA shuts down in wake of attacks
- Sleuths try to unmask new spy satellites
- Probe limps to close encounter with comet
- Report: Plane tracking satellites can be jammed

ALPHA EXTRA
Space correspondent Miles O'Brien on the space station tour

SCENES FROM SPACE
A NASA telescope is marking a milestone

RESOURCES:

SPACE AGENCY NEWS
The latest news releases from worldwide space agencies.
[Hit the links](#)

SPACE CALENDARS
Calendars of upcoming launches and other events from worldwide space agencies.
[Calendar list](#)

INTERACTIVE LIBRARY
Your window to the universe -- launch video, 360-degree photo tours and more.

NASA WEBCAMS
Live pictures of NASA projects.
[Launch it](#)

SPACE PROBES
A guide to active unmanned missions.
[Probe list](#)

MORE NEWS

<http://web.archive.org/web/20010911203610/http://www.cnn.com/> archived resource for <http://cnn.com>

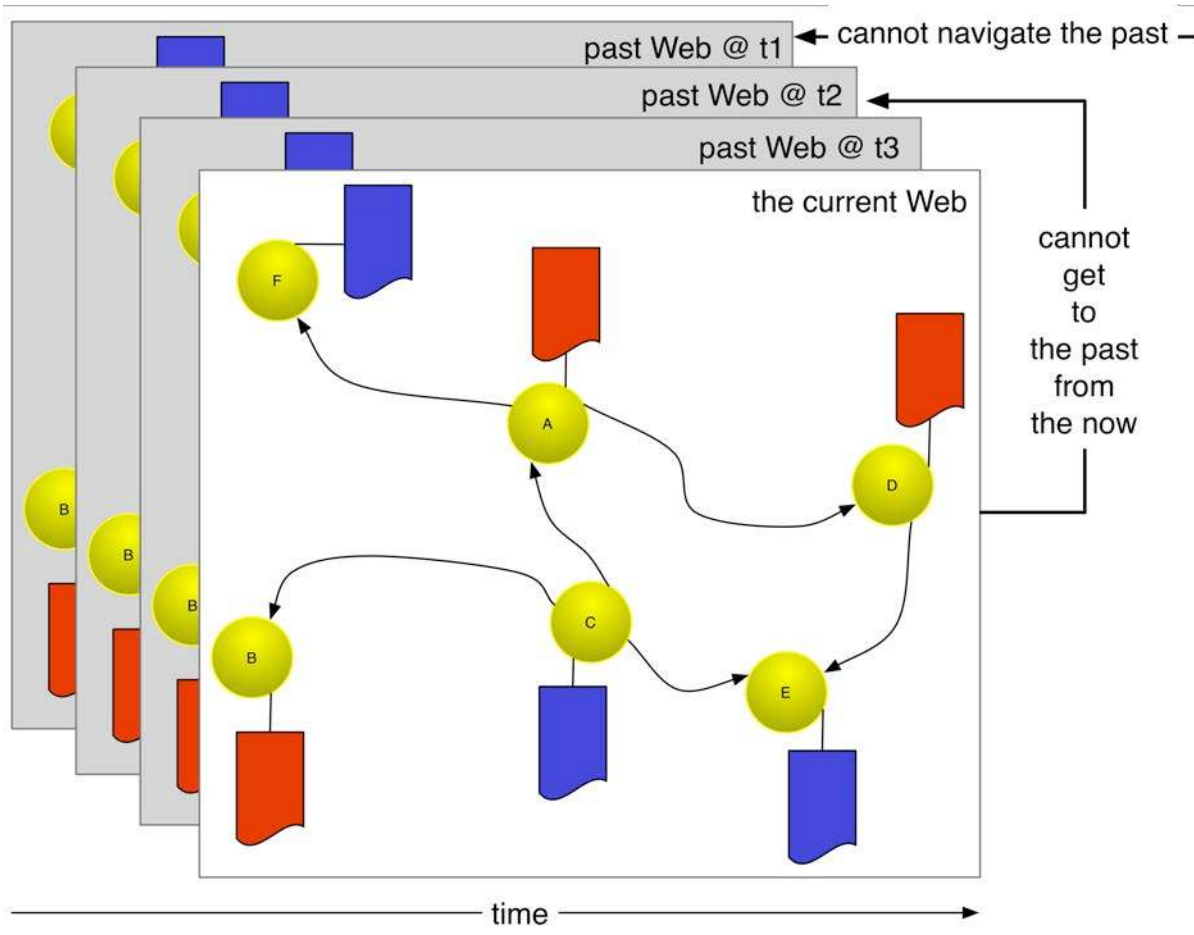
<http://web.archive.org/web/20010911213855/www.cnn.com/TECH/space/>



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Current and Past Web are Not Integrated



- Current and Past Web based on same technology.
- But, going from Current to Past Web is a matter of (manual) discovery.
- Memento wants to make going from Current to Past Web a (HTTP) protocol matter.
- Memento wants to integrate Current And Past Web.



TBL on Generic vs. Specific Resources

resources too, and there is a relationship of genericity between the generic and the relatively specific resource.

As an example, successively specific resources might be

1. The Bible
2. The Bible, King James Version
3. The Bible, KJV, in English
4. A particular ASCII rendering of the KJV Bible in English

Each resource may have a URI. The authority which allocates the URI is the authority which determines to what it refers: Therefore, that authority determines to what extent that resource is generic or specific.

This model is more of an observation of a requirement than an implementation decision. Multilevel genericity clearly exists in all our current life with books and electronic documents. Adoption of this model simply follows from the rule that Web design should not arbitrarily seek to constrain life in general for its own purposes.

Dimensions of genericity

When we discuss electronic resources, an interesting fact is that a small number of dimensions of genericity emerge.

Time	A resource may vary with time. For example, "The Wall Street Journal" varies with time. Each issue is a time-specific resource, which does not change with time. Most home pages on the Web change with time, in a less periodic way.
Language	When a document is translated, it is useful to be able to refer to it either in the generic, or to a particular specific translation.
Representation	A given resource may have many ways in which it can be represented on the wire, using different Content-types (in HTTP terms). As an example, an image may be represented in PNG or JFIF format.

The fact that there are such a small number of dimensions currently apparent suggests that Web software should handle them individually in its interface with the user, even though the architecture should handle them as a single concept.

Find: Next Previous Highlight all Match case

Done

<http://www.w3.org/DesignIssues/Generic.html>



In The Beginning... there was the inode

```
struct stat {
    dev_t      st_dev;      /* ID of device containing file */
    ino_t      st_ino;     /* inode number */
    mode_t     st_mode;    /* protection */
    nlink_t    st_nlink;   /* number of hard links */
    uid_t      st_uid;     /* user ID of owner */
    gid_t      st_gid;     /* group ID of owner */
    dev_t      st_rdev;    /* device ID (if special file) */
    off_t      st_size;    /* total size, in bytes */
    blksize_t  st_blksize; /* blocksize for filesystem I/O */
    blkcnt_t   st_blocks;  /* number of blocks allocated */
    time_t     st_atime;   /* time of last access */
    time_t     st_mtime;   /* time of last modification */
    time_t     st_ctime;   /* time of last status change */
};
```



Limited Time Semantics...

```
% telnet www.digitalpreservation.gov 80
Trying 140.147.249.7...
Connected to www.digitalpreservation.gov.
Escape character is '^]'.
HEAD /images/ndiipp_header6.jpg HTTP/1.1
Host: www.digitalpreservation.gov
Connection: close

HTTP/1.1 200 OK
Date: Mon, 19 Jul 2010 21:41:04 GMT
Server: Apache
Last-Modified: Thu, 18 Jun 2009 16:25:54 GMT
ETag: "1bc861-10935-dca24880"
Accept-Ranges: bytes
Content-Length: 67893
Connection: close
Content-Type: image/jpeg

Connection closed by foreign host.
```



Time Semantics Becoming Less, Not More Available

```
% telnet www.digitalpreservation.gov 80
Trying 140.147.249.7...
Connected to www.digitalpreservation.gov.
Escape character is '^]'.
HEAD / HTTP/1.1
Host: www.digitalpreservation.gov
Connection: close
```

```
HTTP/1.1 200 OK
Date: Mon, 19 Jul 2010 21:36:00 GMT
Server: Apache
Accept-Ranges: bytes
Connection: close
Content-Type: text/html
```

```
Connection closed by foreign host.
```



The Past Links to the Present...

WebCite query result

http://webcitation.org/query?id=1257028234035091

Requested Date: 1996 2010 07/19/2010

WebCite query result

Showing WebCite for URL: <http://www.digitalpreservation.gov/> [Permalink to this cache]
Cached: 2009-10-31 18:30:35

skip navigation

ASK A LIBRARIAN DIGITAL COLLECTIONS LIBRARY CATALOGS

GO Options

The Library of Congress > Digital Preservation

DIGITAL PRESERVATION

Search this site GO

- [Digital Preservation Home](#)
- [News & Events](#)
- [Partners](#)
- [Tools & Services](#)
- [Publications](#)
- [Video Presentations](#)
- [Personal Archiving](#)
- [About the Program](#)
- [Contact Us](#)

Related Resources

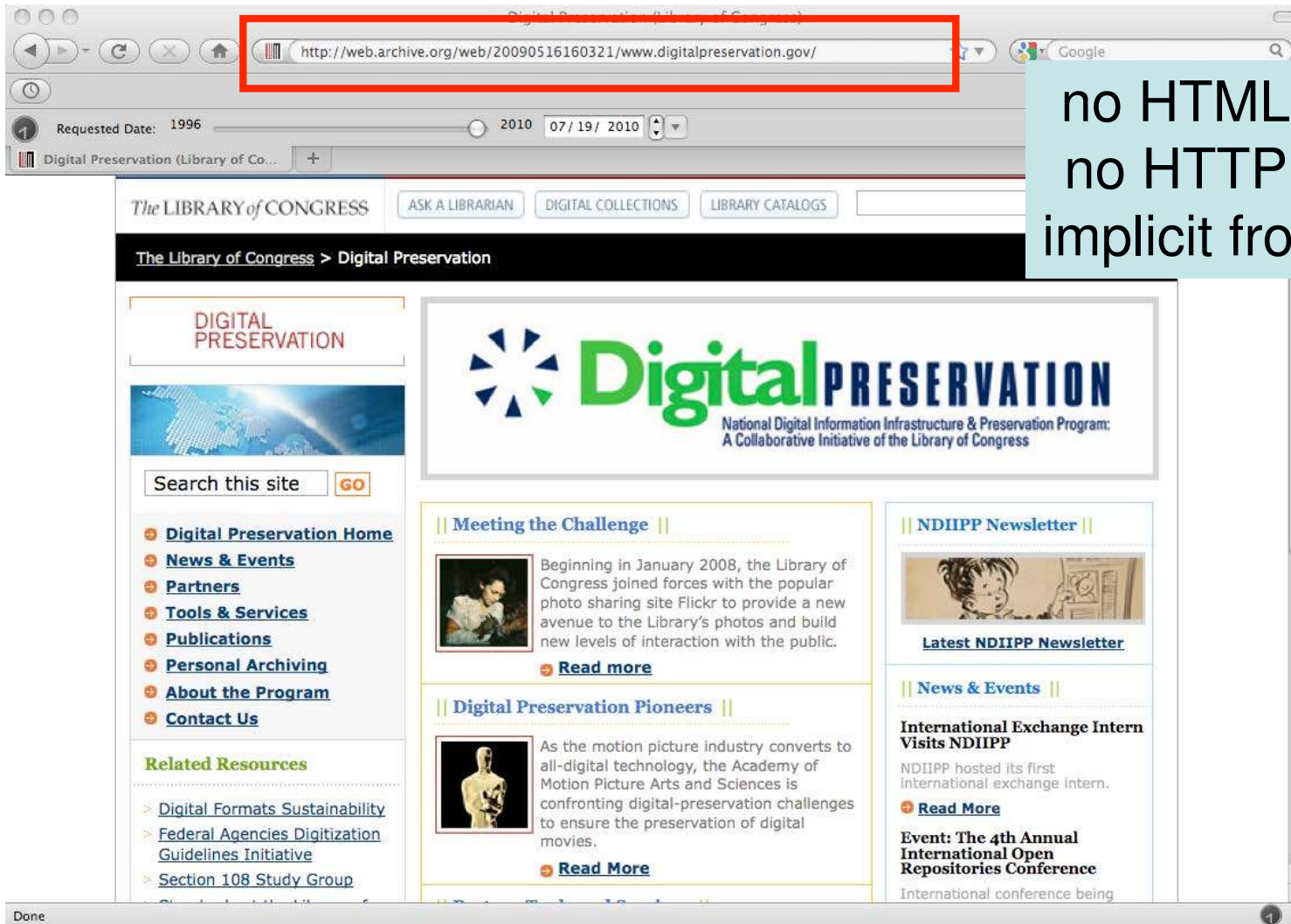
- [Digital Formats Sustainability](#)
- [Federal Agencies Digitization Guidelines Initiative](#)
- [Section 108 Study Group](#)
- [Standards at the Library of Congress](#)

Done

explicit HTML link;
no HTTP links;
opaque URI



The Past Links to the Present...



no HTML links;
no HTTP links;
implicit from URI



But the Present Does Not Link to the Past

no hints in HTML, HTTP, or URI

```
% telnet www.digitalpreservation.gov 80
Trying 140.147.249.7...
Connected to www.digitalpreservation.gov.
Escape character is '^]'.
HEAD / HTTP/1.1
Host: www.digitalpreservation.gov
Connection: close

HTTP/1.1 200 OK
Date: Mon, 19 Jul 2010 21:36:00 GMT
Server: Apache
Accept-Ranges: bytes
Connection: close
Content-Type: text/html

Connection closed by foreign host.
```




Jane Greenberg homepage, School of Library and Information Science, University of North Carolina at Chapel Hill

http://ils.unc.edu/~janeg/

Requested Date: 1996 2010 01/17/2001

Jane Greenberg homepage, School...



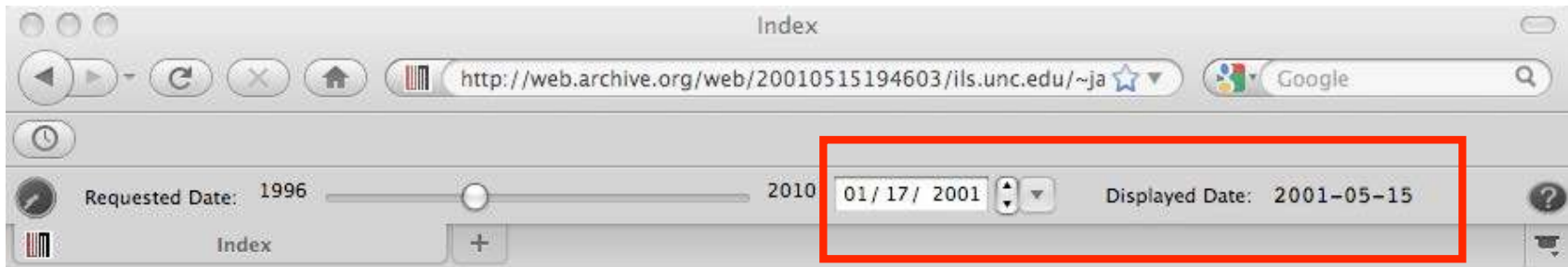
Jane Greenberg, Professor and Director, [SILS Metadata Research Center](#)
 School of Information and Library Science
 University of North Carolina at Chapel Hill
 205 Manning Hall, CB # 3360
 Chapel Hill, NC 27599-3360
 Phone: (919)962-8066
 Fax: (919)962-8071
 Email janeg@email.unc.edu

- ◆ [SILS Metadata Research Center <MRC>](#)
- ◆ [Metadata Research Center's photostream](#)
- ◆ [Spring 2008: INLS 890-092, Seminar in Knowledge Organization](#)
- ◆ [Vitae](#)

Find: Next Previous Highlight all Match case

Done

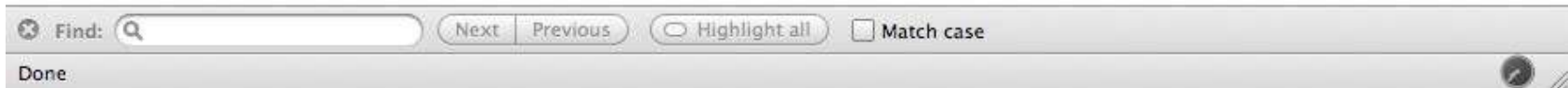




Jane Greenberg, Assistant Professor
School of Information and Library Science
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CB #3360, 100 Manning Hall
Chapel Hill, NC 27599-3360

Tel: (919)962-7024
E-mail: janeg@ils.unc.edu
Fax: (919)962-8071

- [Biographical Statement](#)
- [Research](#)
- [Vitae](#)
- [Teaching](#)



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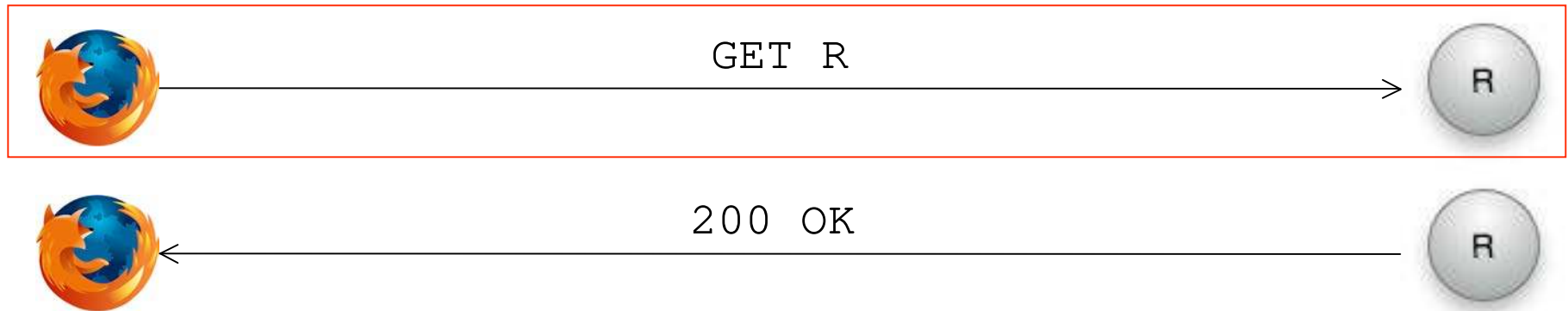


Linking the Past and the Present

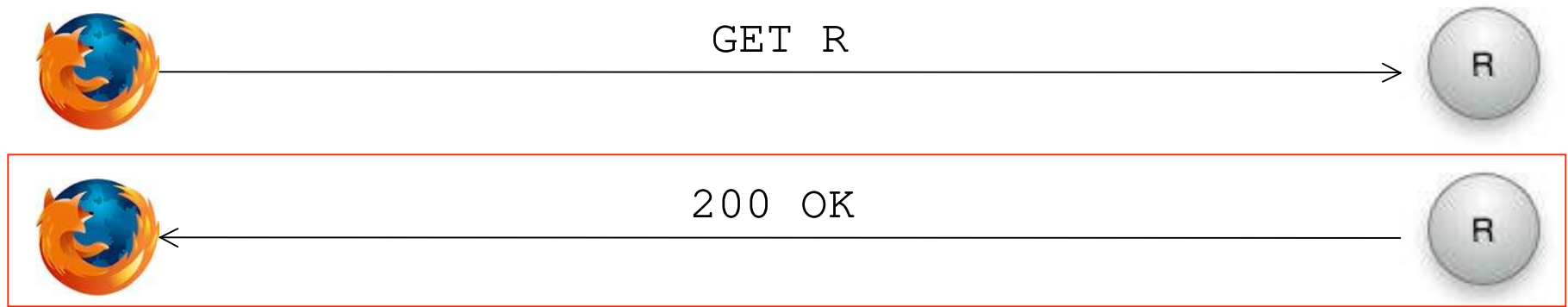
- Codify existing methods to create linkage from the past to the present
 - easy: an archived version knows for which URI it is an archived version
- Create a linkage from the present to the past
 - hard: solve with a level of indirection from present to past



Normal HTTP Flow



Normal HTTP Flow



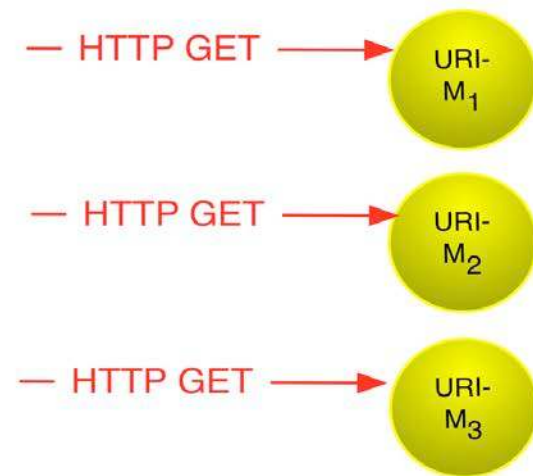
The Web without a Time Dimension



Original
resource



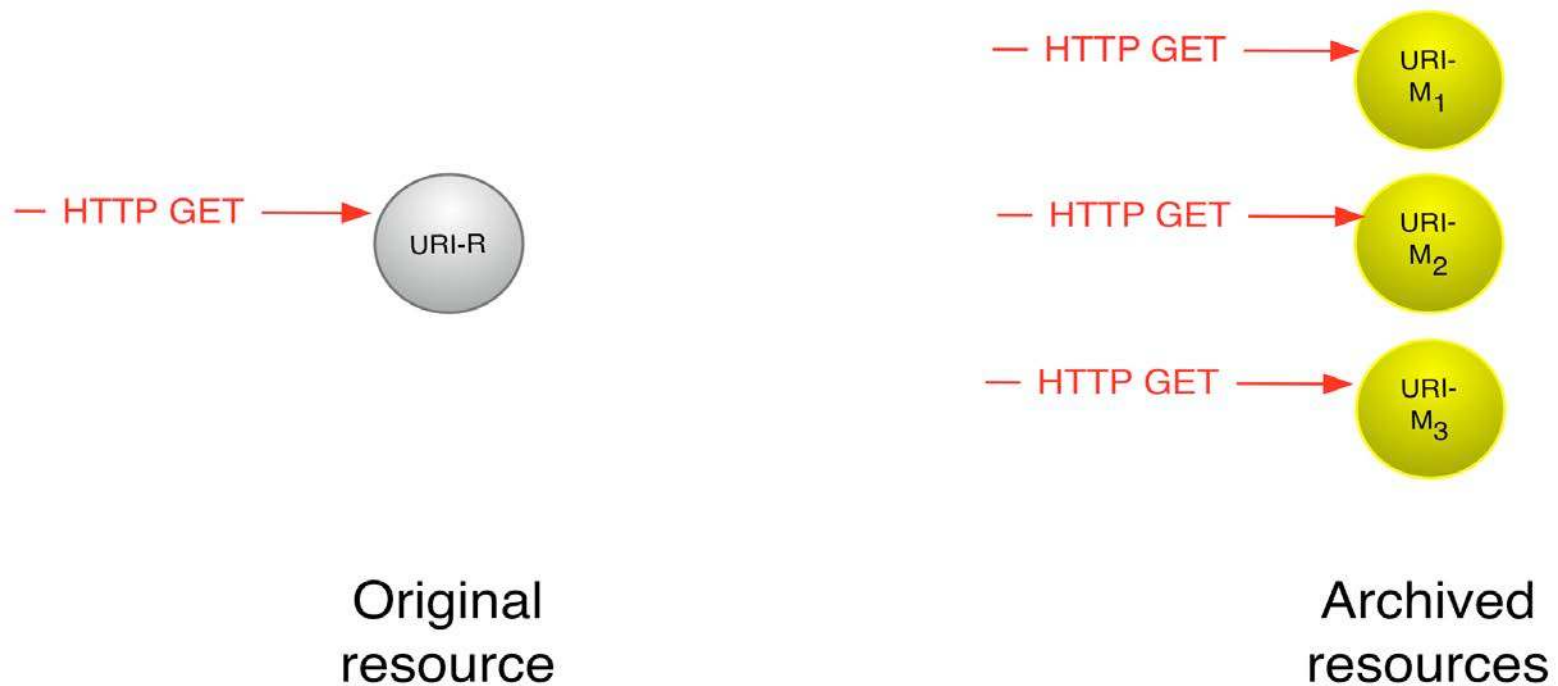
The Web without a Time Dimension



Archived
resources



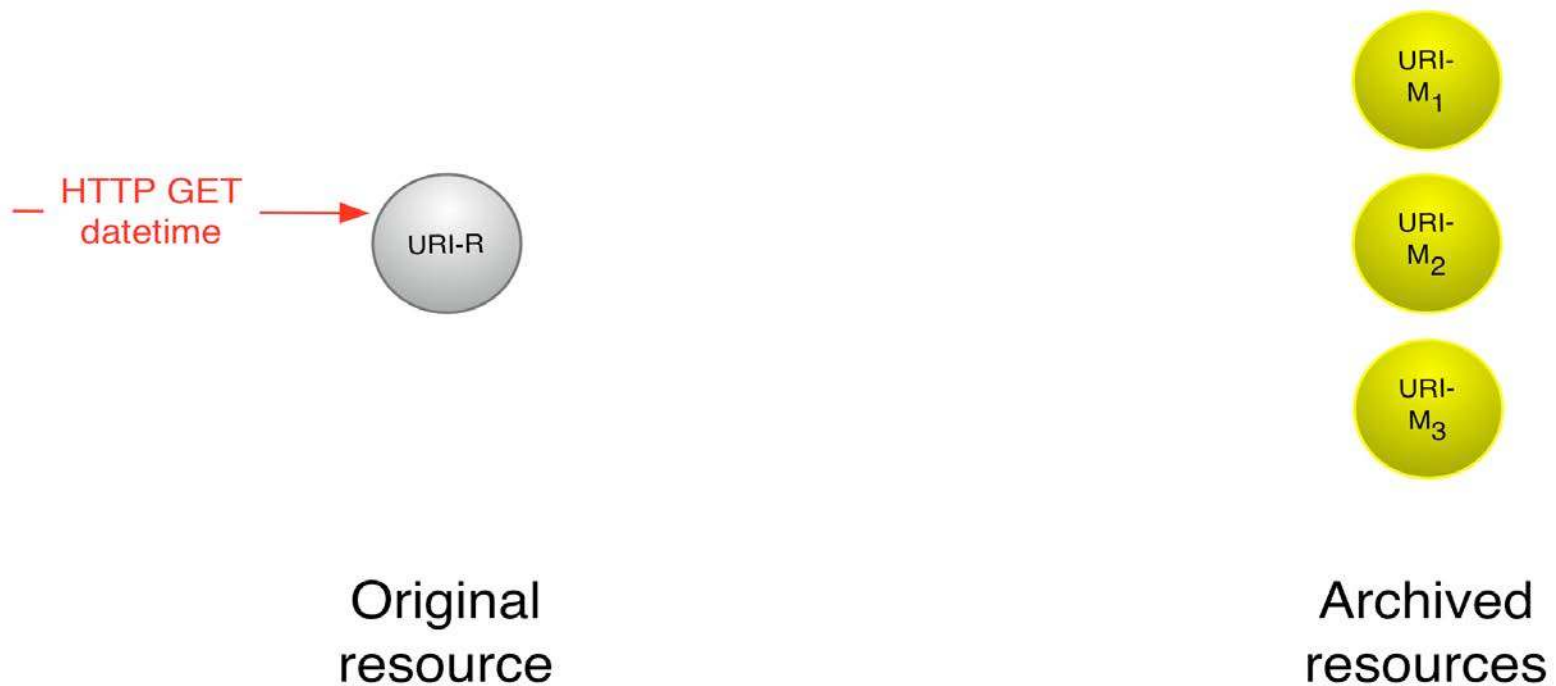
The Web without a Time Dimension



Need to use a different URI to access archived versions of a resource and its current version



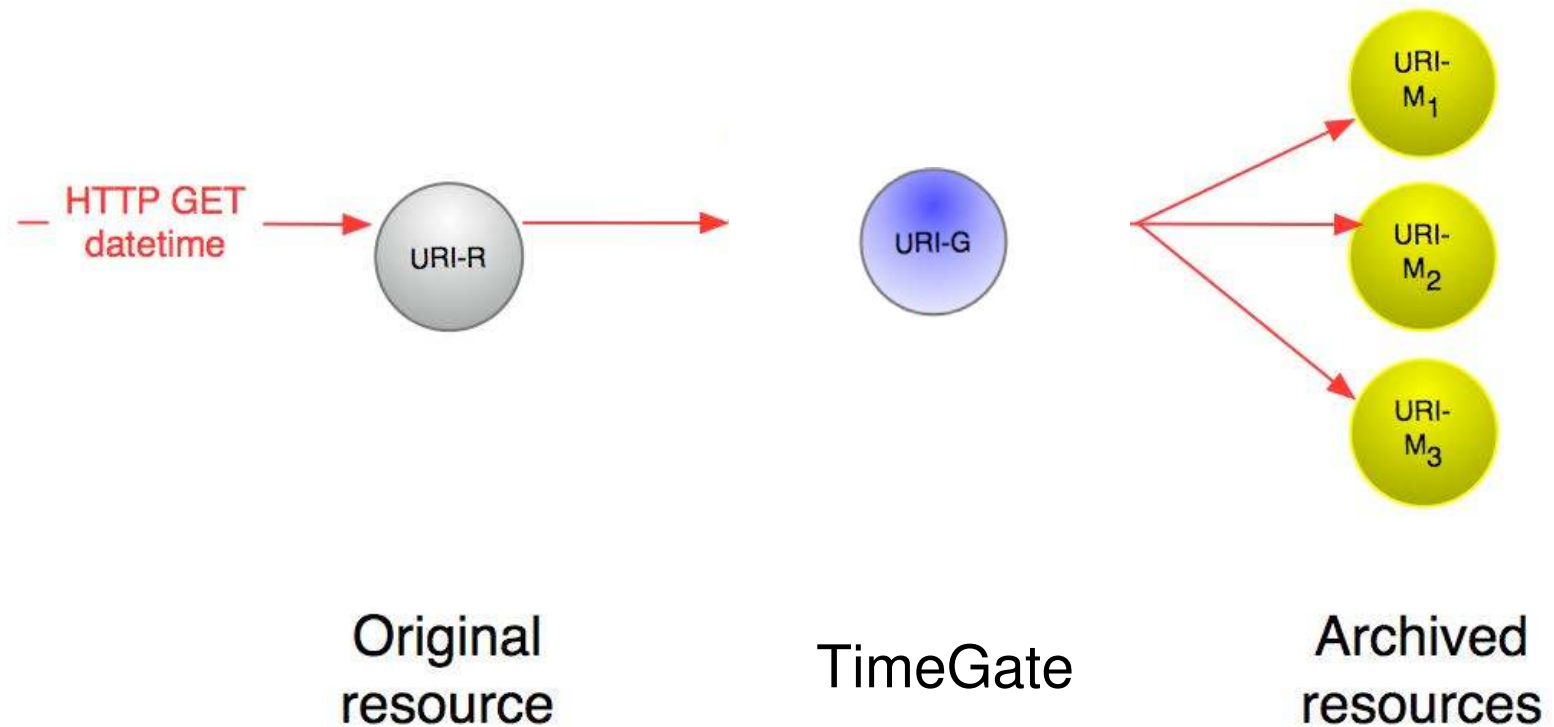
The Web with Time Dimension added by Memento



In Memento: use URI of the current version to access archived versions, but qualify it with datetime



The Web with Time Dimension added by Memento



... and arrive at an archived version via level of indirection

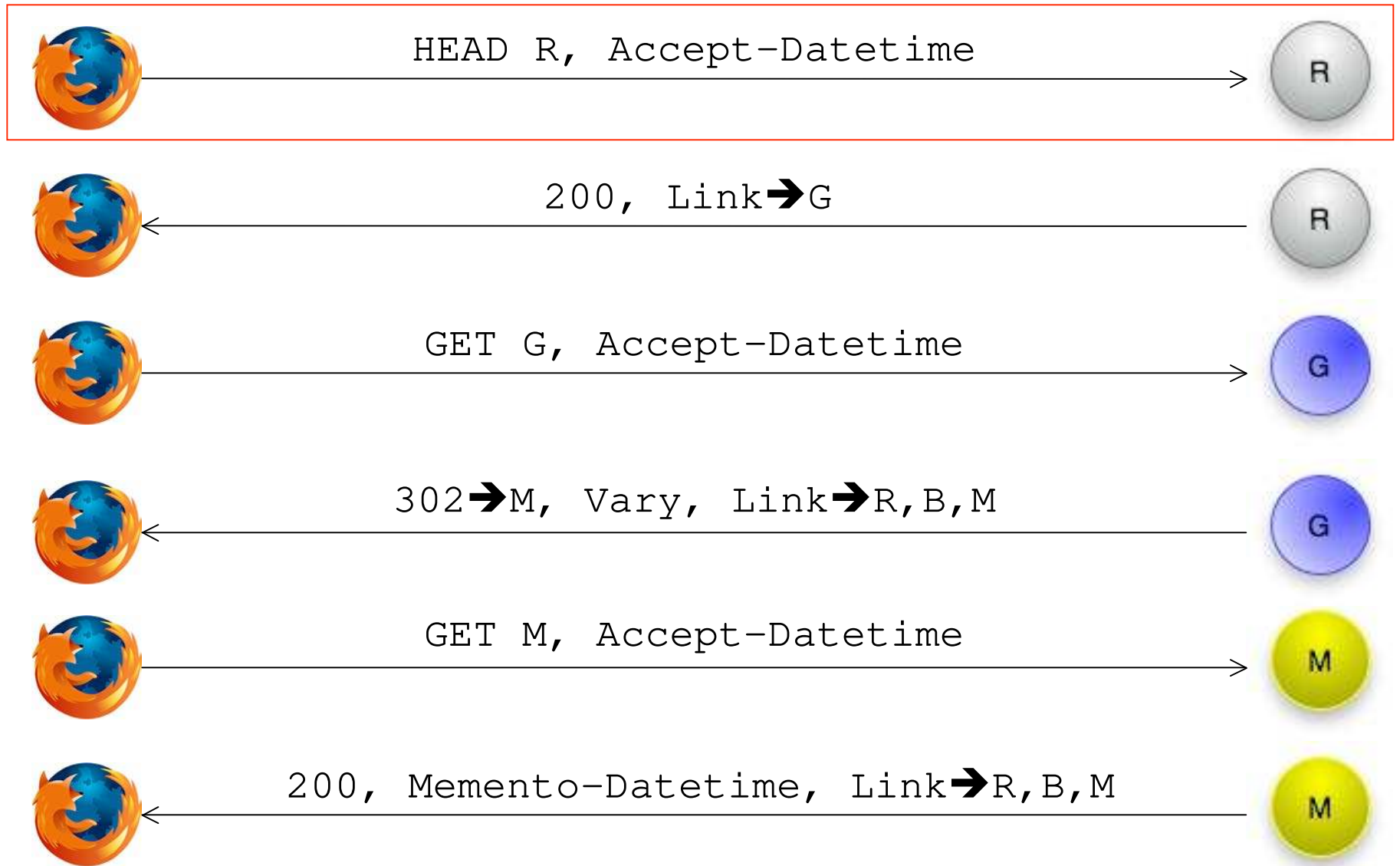


Content Negotiation in the datetime dimension

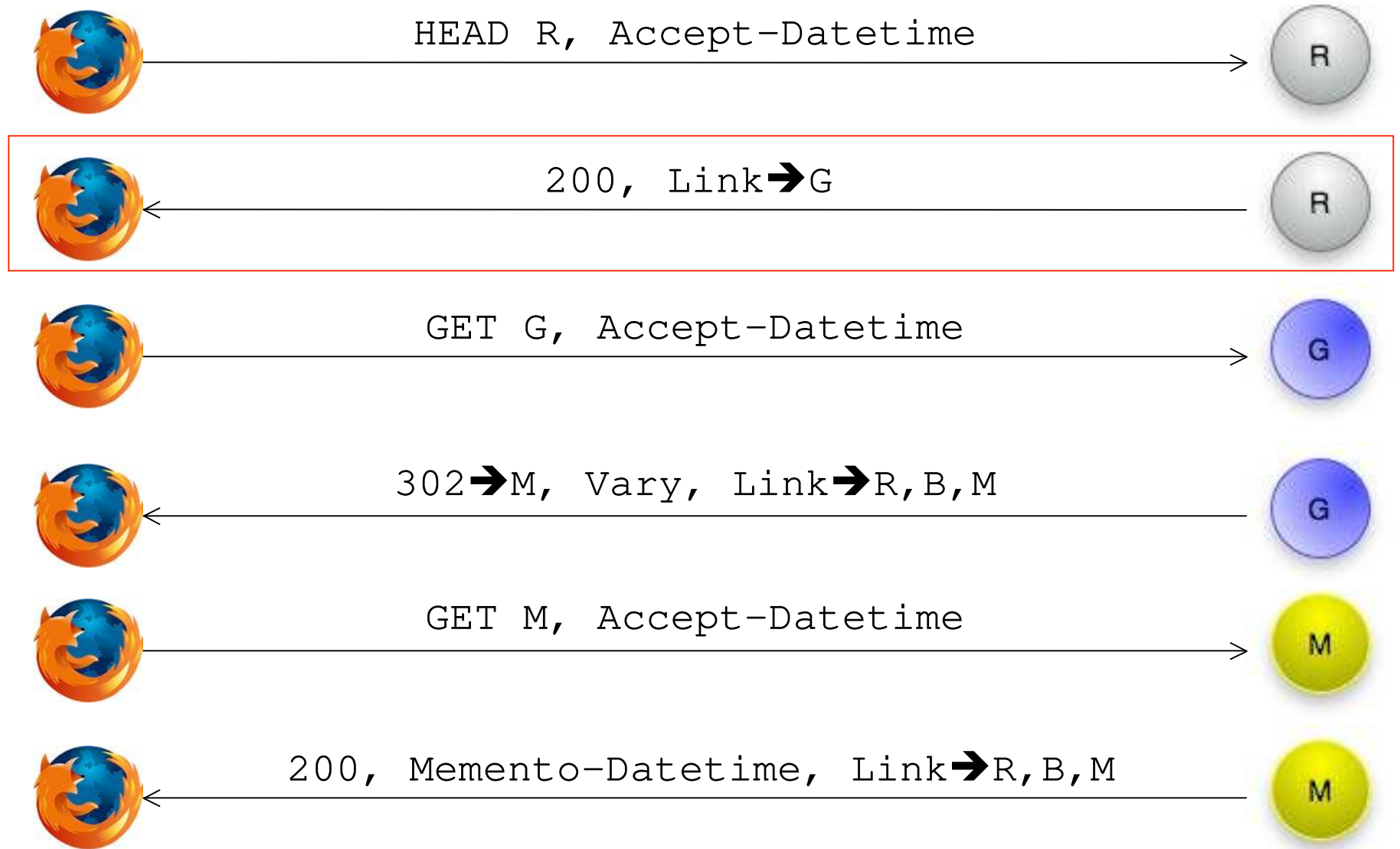
- Many systems support content negotiation for media type:
 - Your client by default asks for HTML and gets HTML;
 - But it could get PDF *via the same URI*.
- Memento proposes a new dimension for content negotiation – time:
 - Your client by default asks for the current time, and gets it
 - But it could get an older version *via the same URI*
- Can be accomplished with two new HTTP headers:
 - Request header: `Accept-Datetime`
 - Conveys datetime of content requested by client
 - Response header: `Memento-Datetime`
 - Conveys datetime of content returned by server



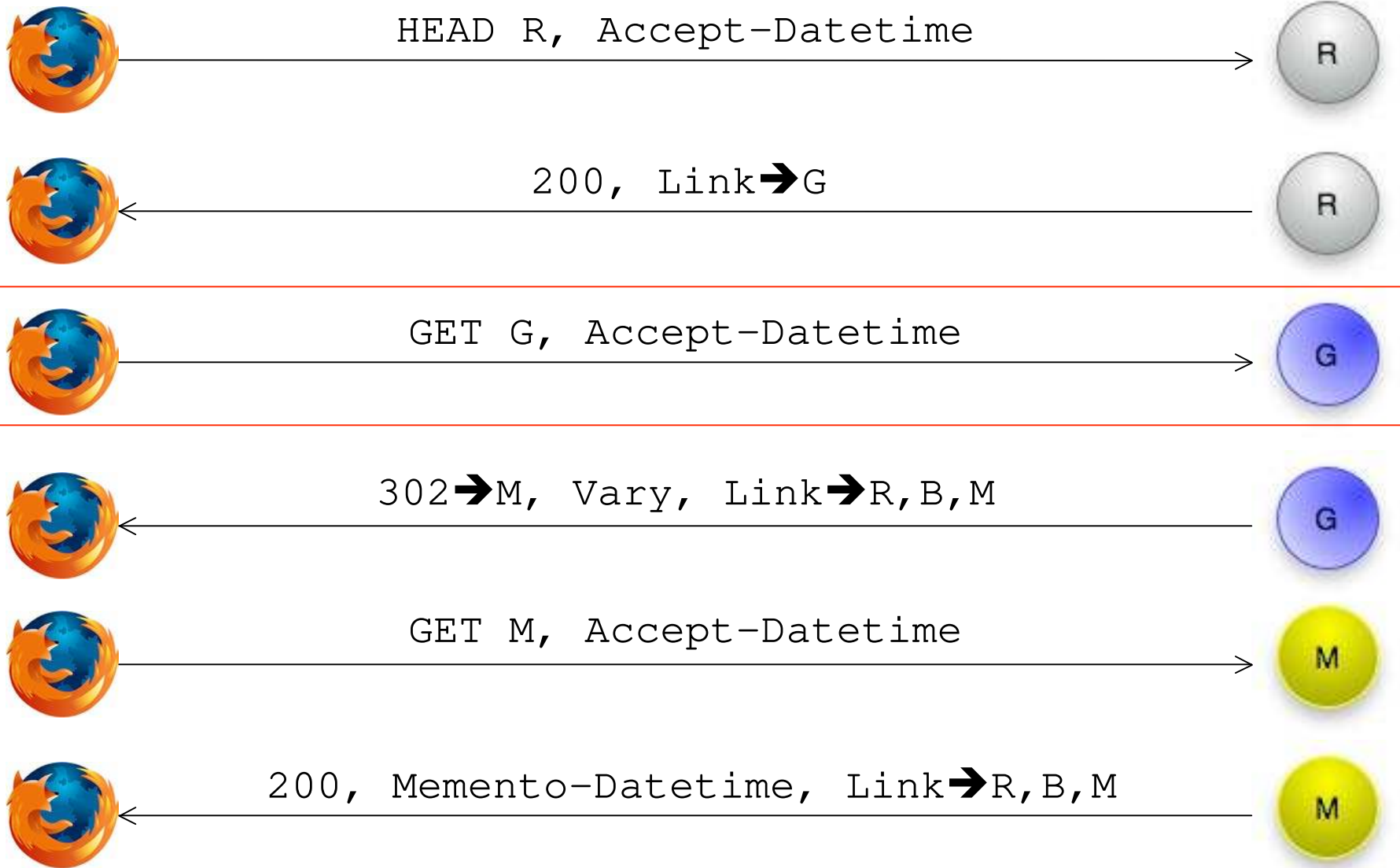
Memento HTTP Flow



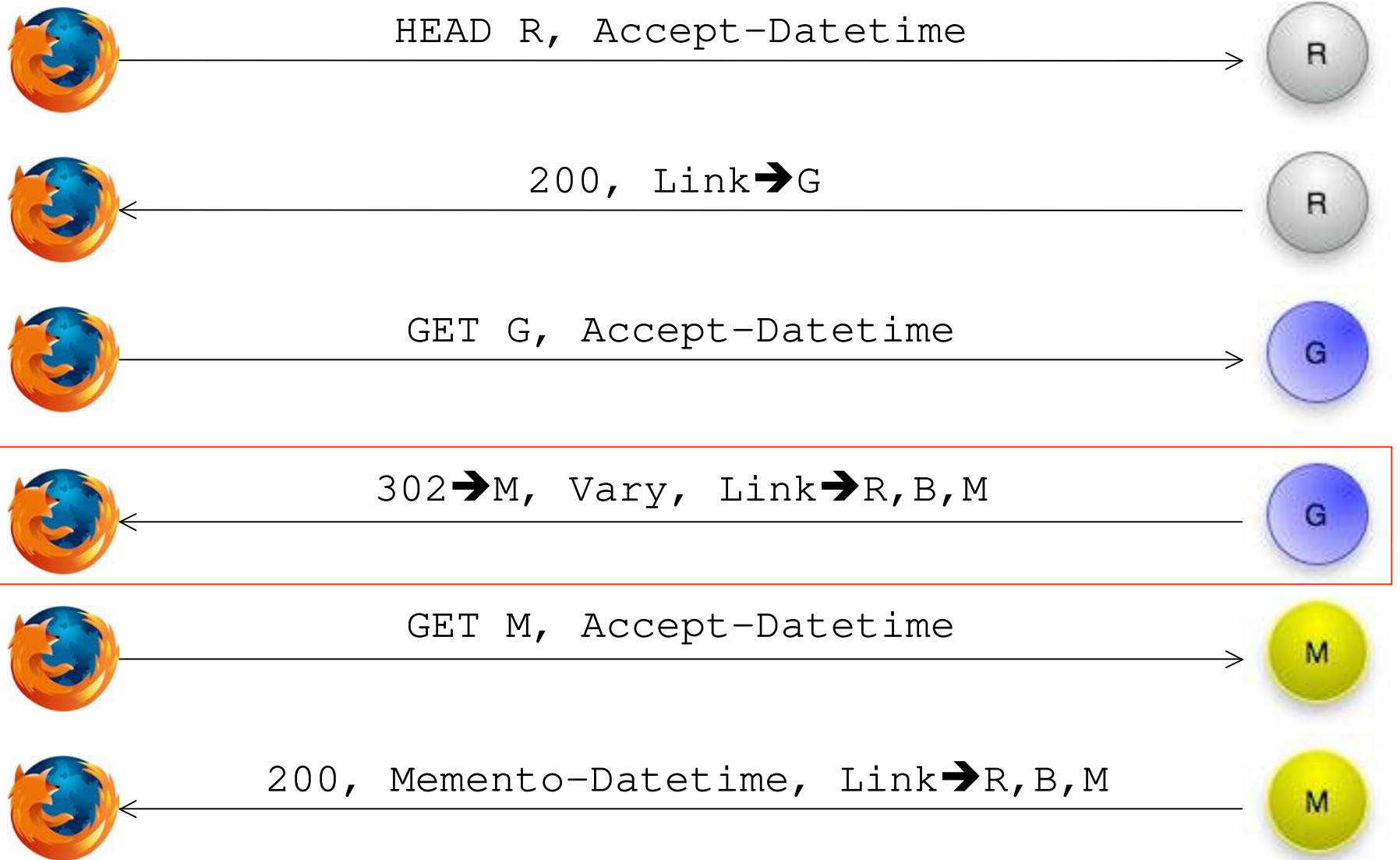
Memento HTTP Flow



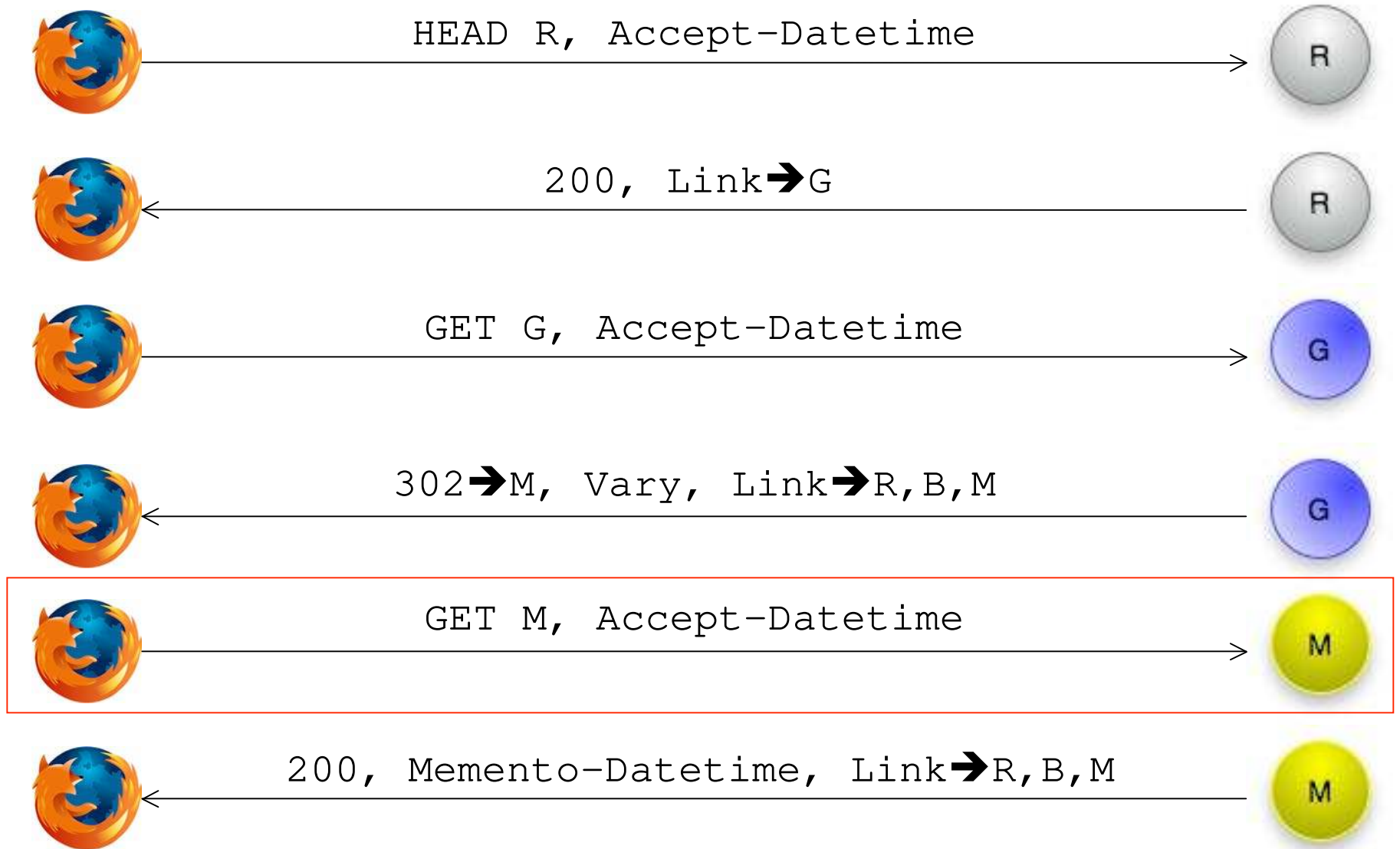
Memento HTTP Flow



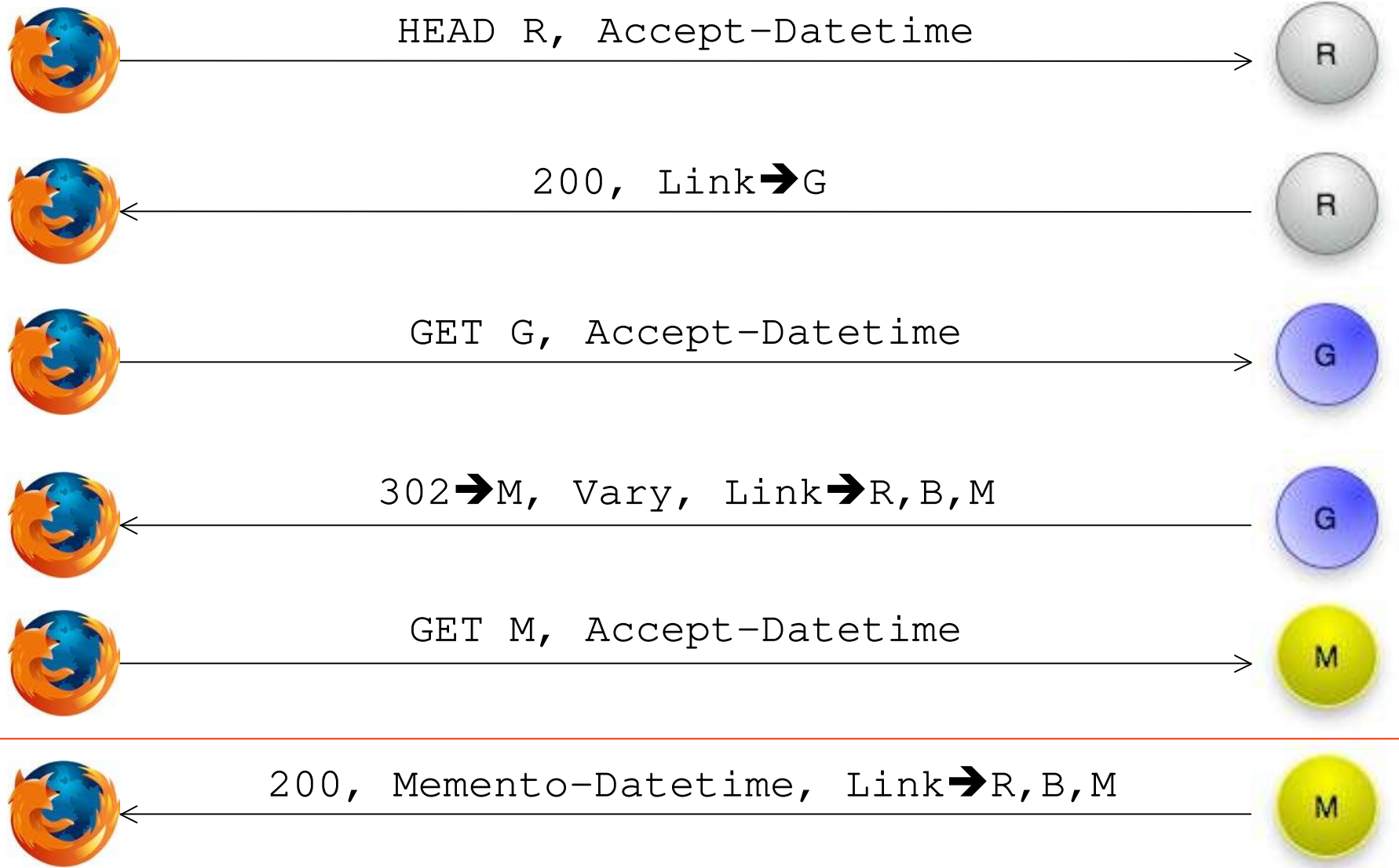
Memento HTTP Flow



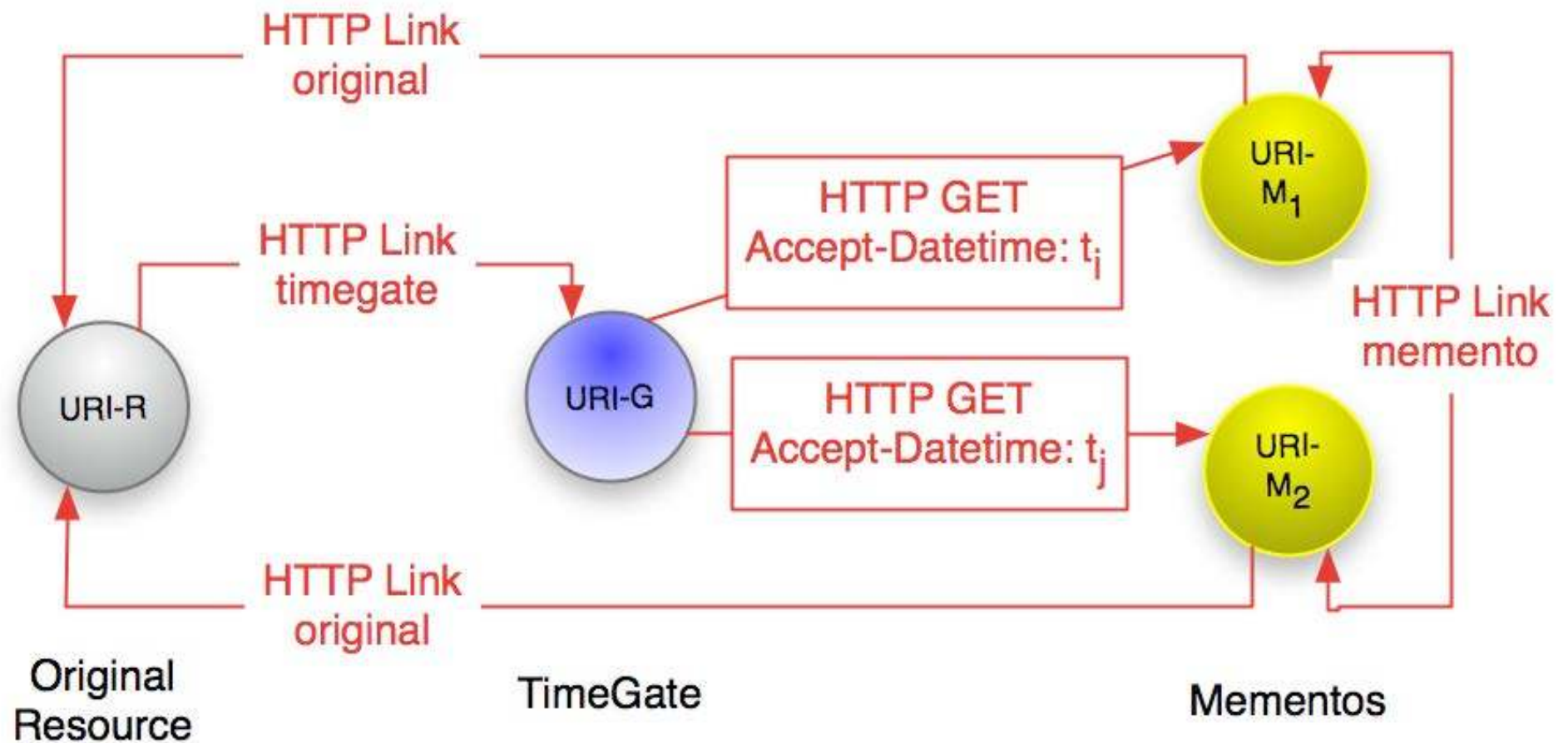
Memento HTTP Flow



Memento HTTP Flow



The Memento Framework

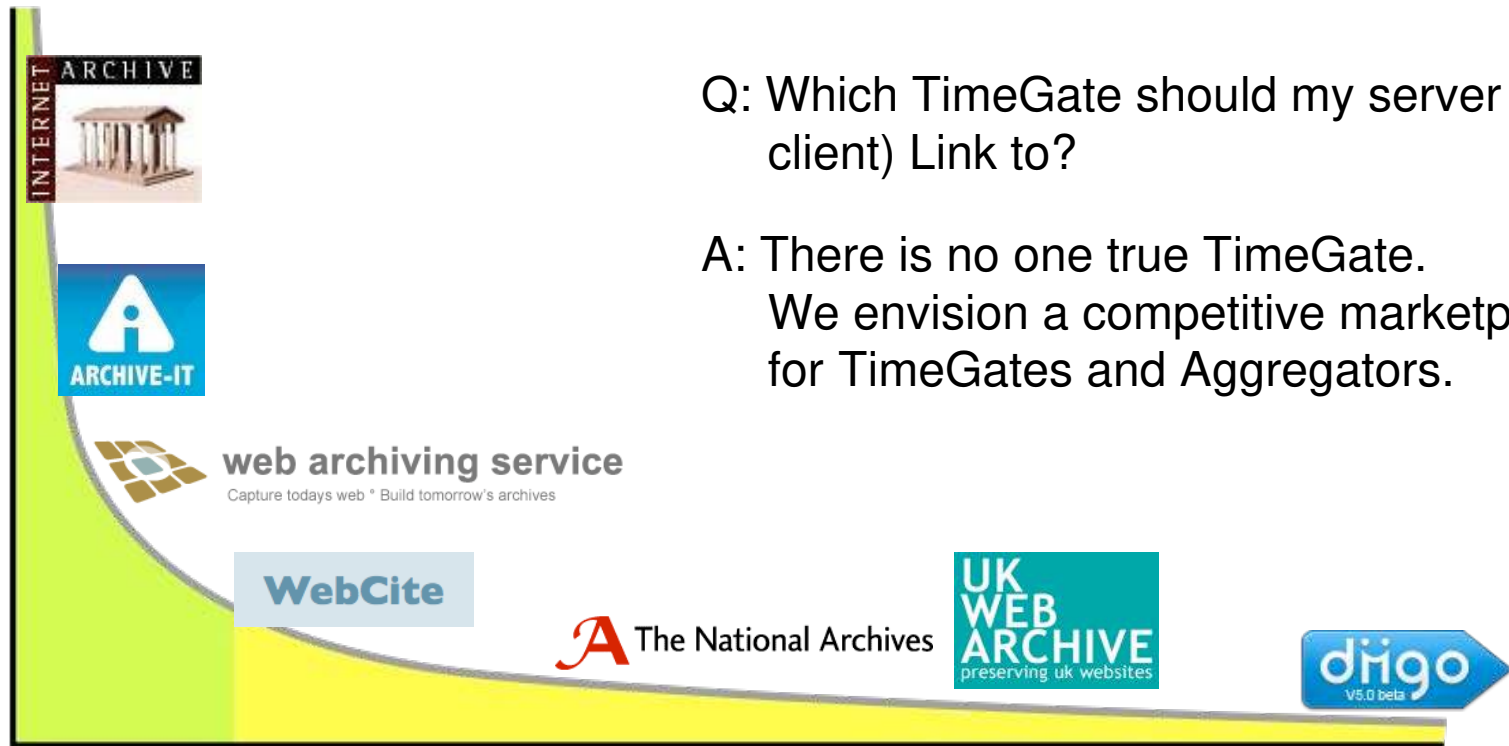


Why Not Bypass URI-R and Go Directly to TimeGate?

- The Original Resource (URI-R) might know a "better" TimeGate than the default client value
 - a CMS (e.g., a wiki) or transactional archive will always have the most complete archival coverage for a URI-R
 - the client can always ignore the URI-R's TimeGate suggestion
- Summary: it is good design to check with URI-R before using the default the TimeGate



Long Tail of Archives



Q: Which TimeGate should my server (or client) Link to?

A: There is no one true TimeGate.
We envision a competitive marketplace for TimeGates and Aggregators.

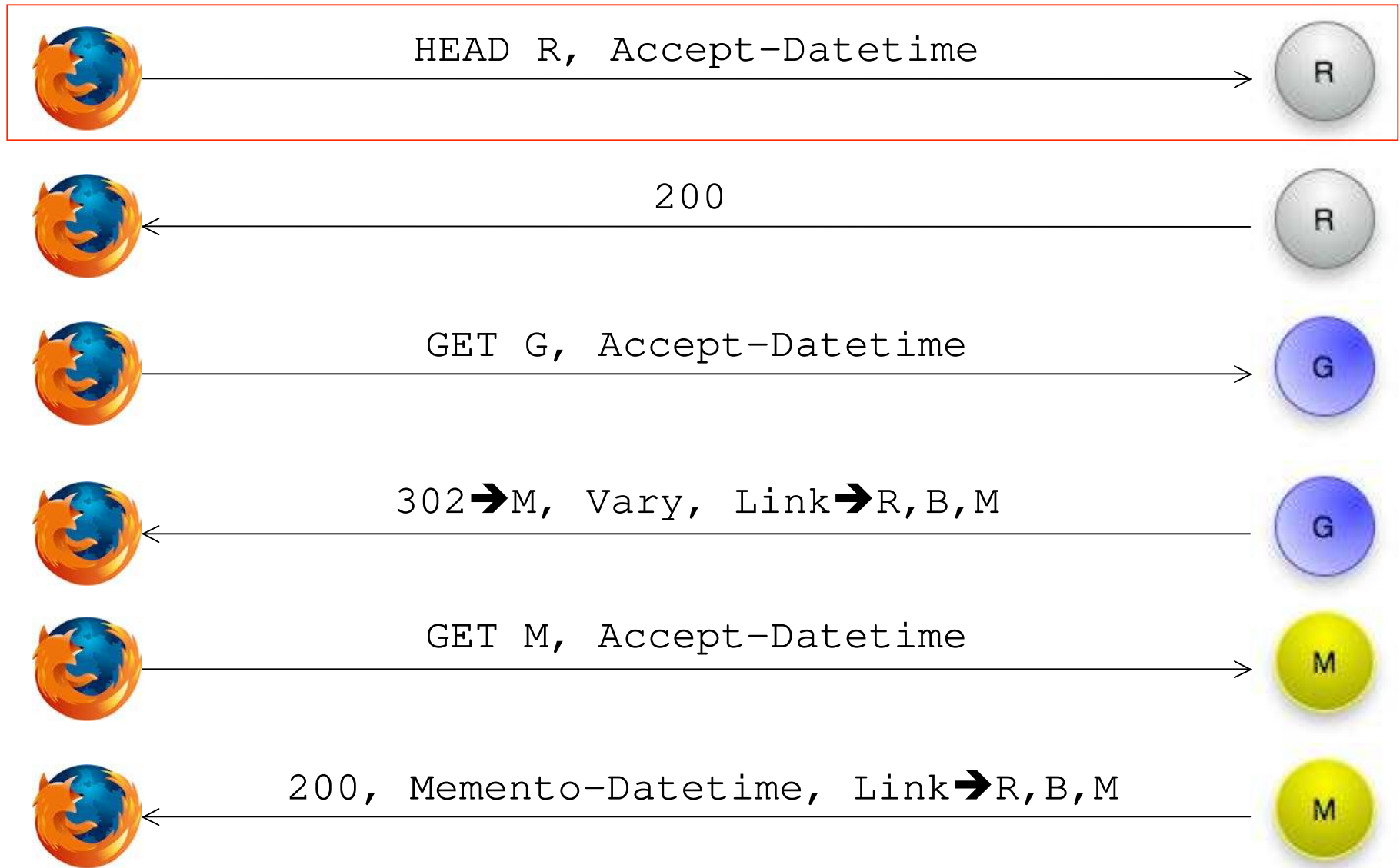


Transition Period

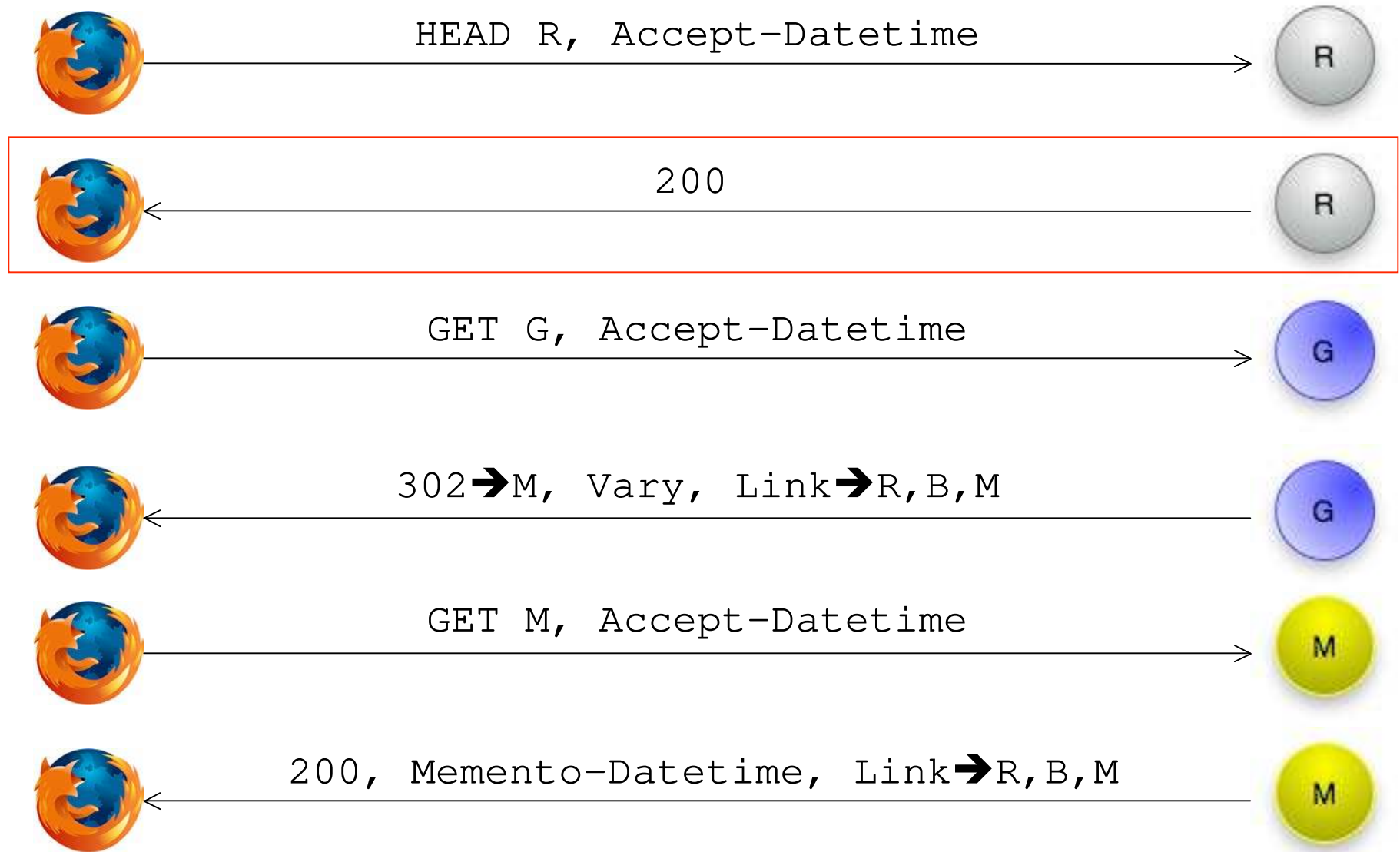
- Up until now, we've presented the scenario where both the client and server are compliant with the Memento framework
- Good news: Memento elegantly handles scenarios where either the client or the server are not (yet) compliant



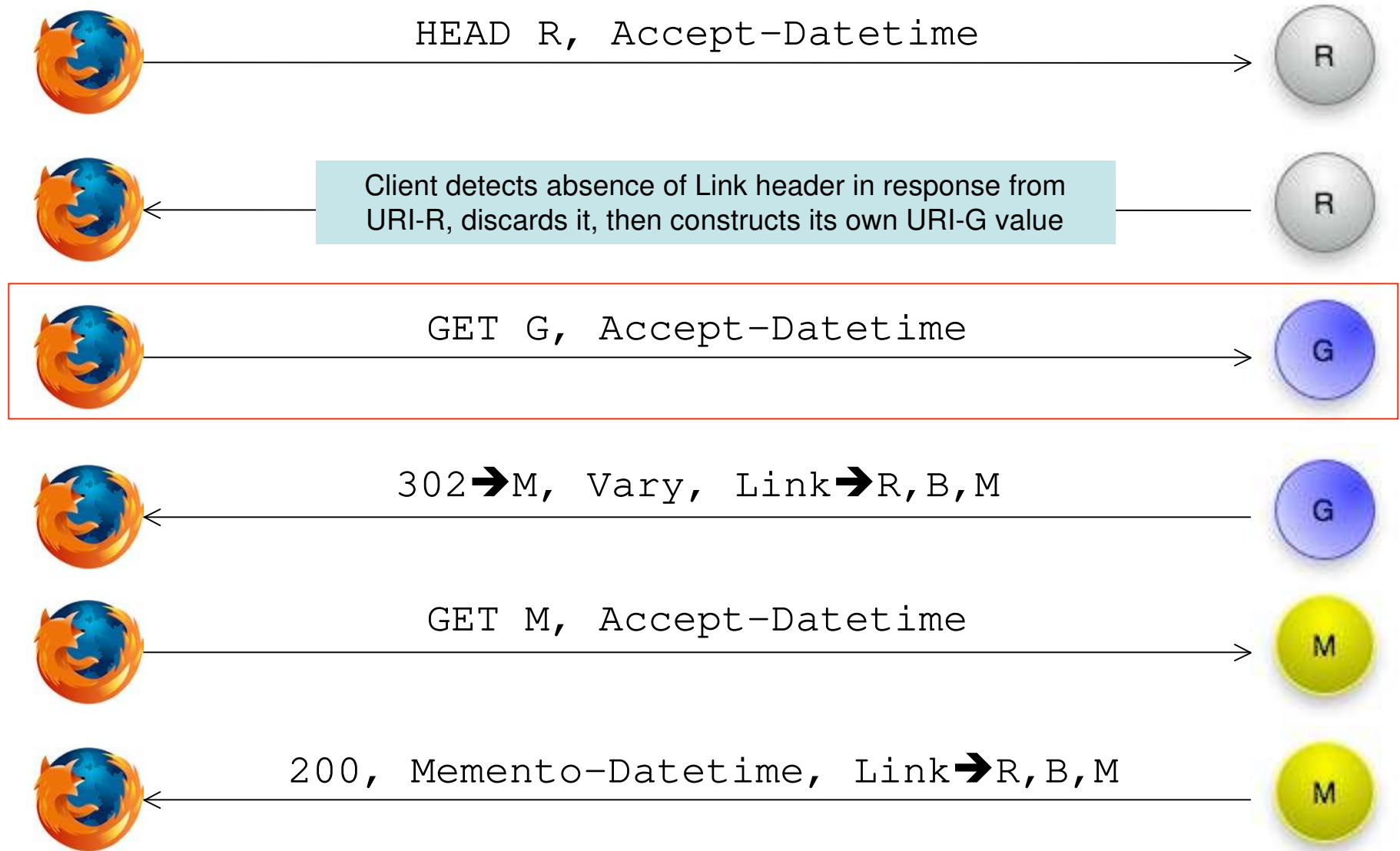
Compliant Client, Non-Compliant Server



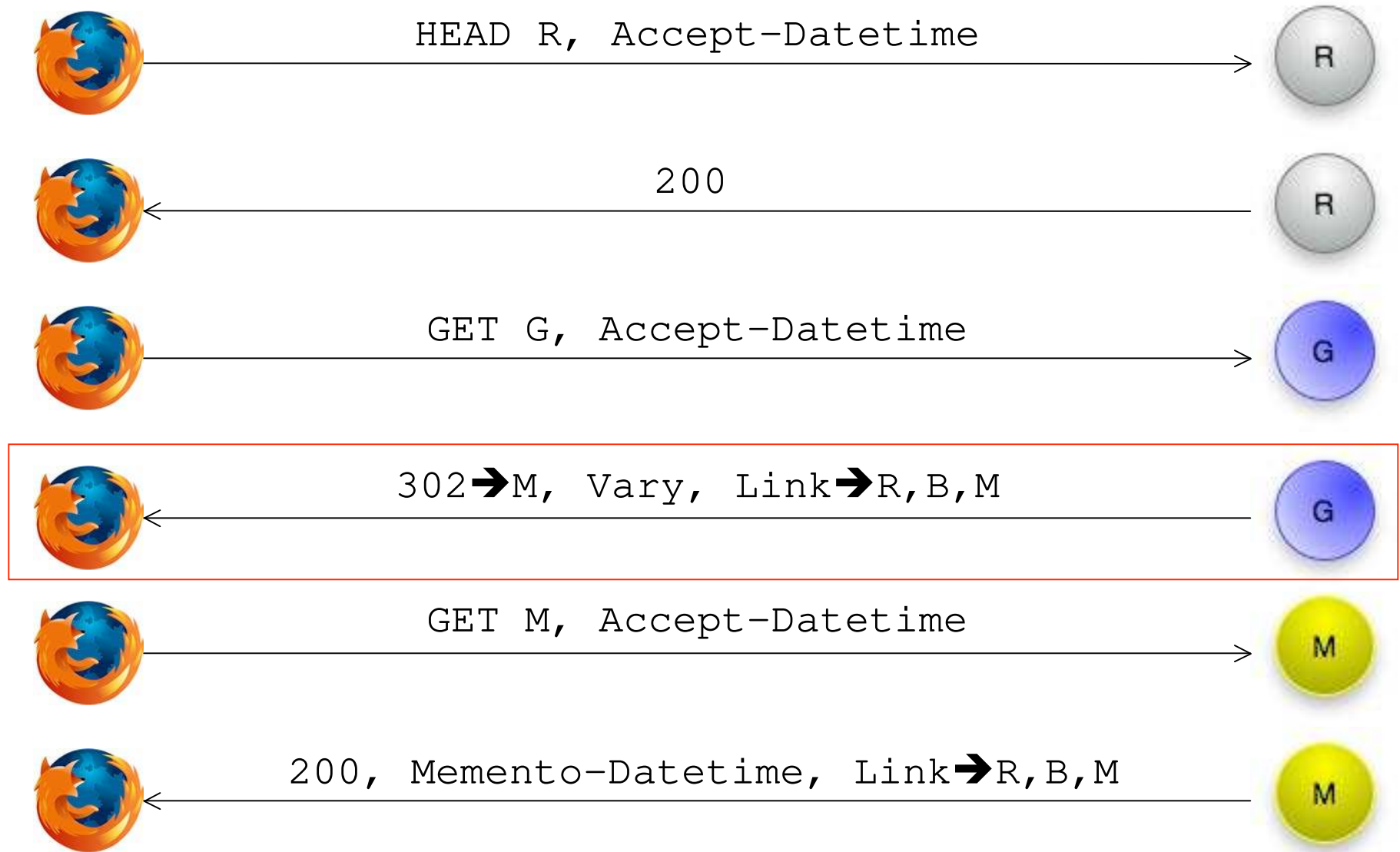
Compliant Client, Non-Compliant Server



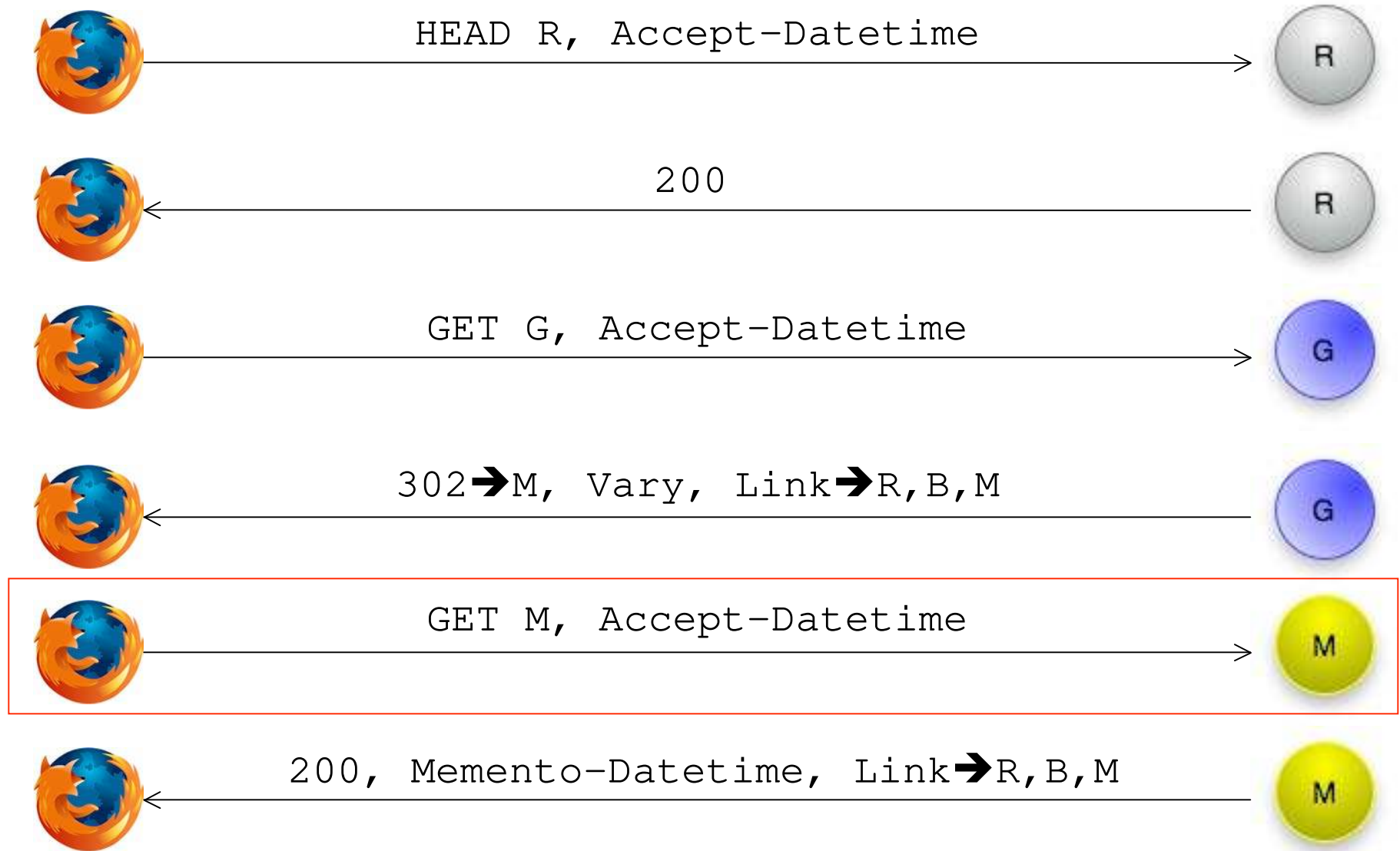
Compliant Client, Non-Compliant Server



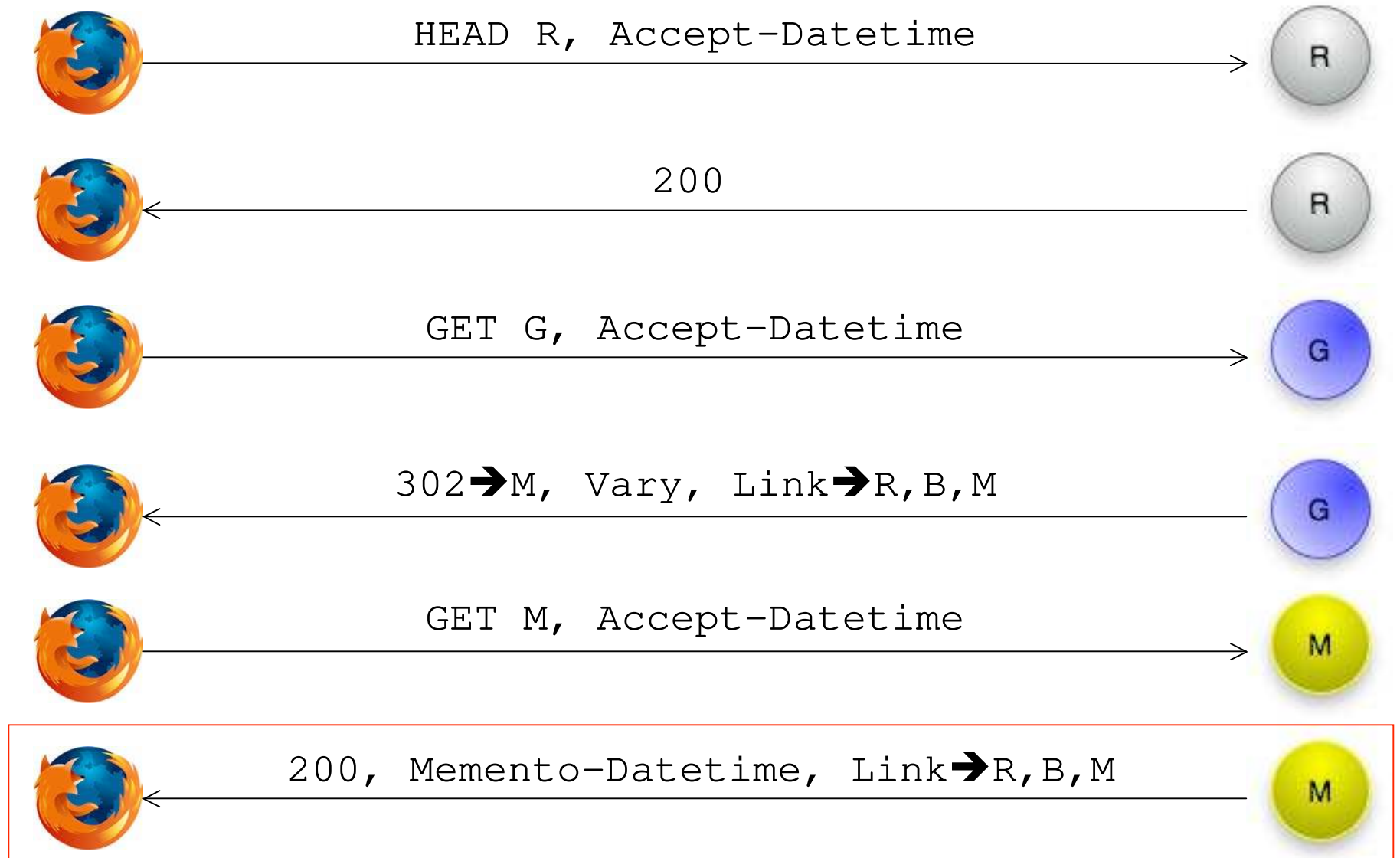
Compliant Client, Non-Compliant Server



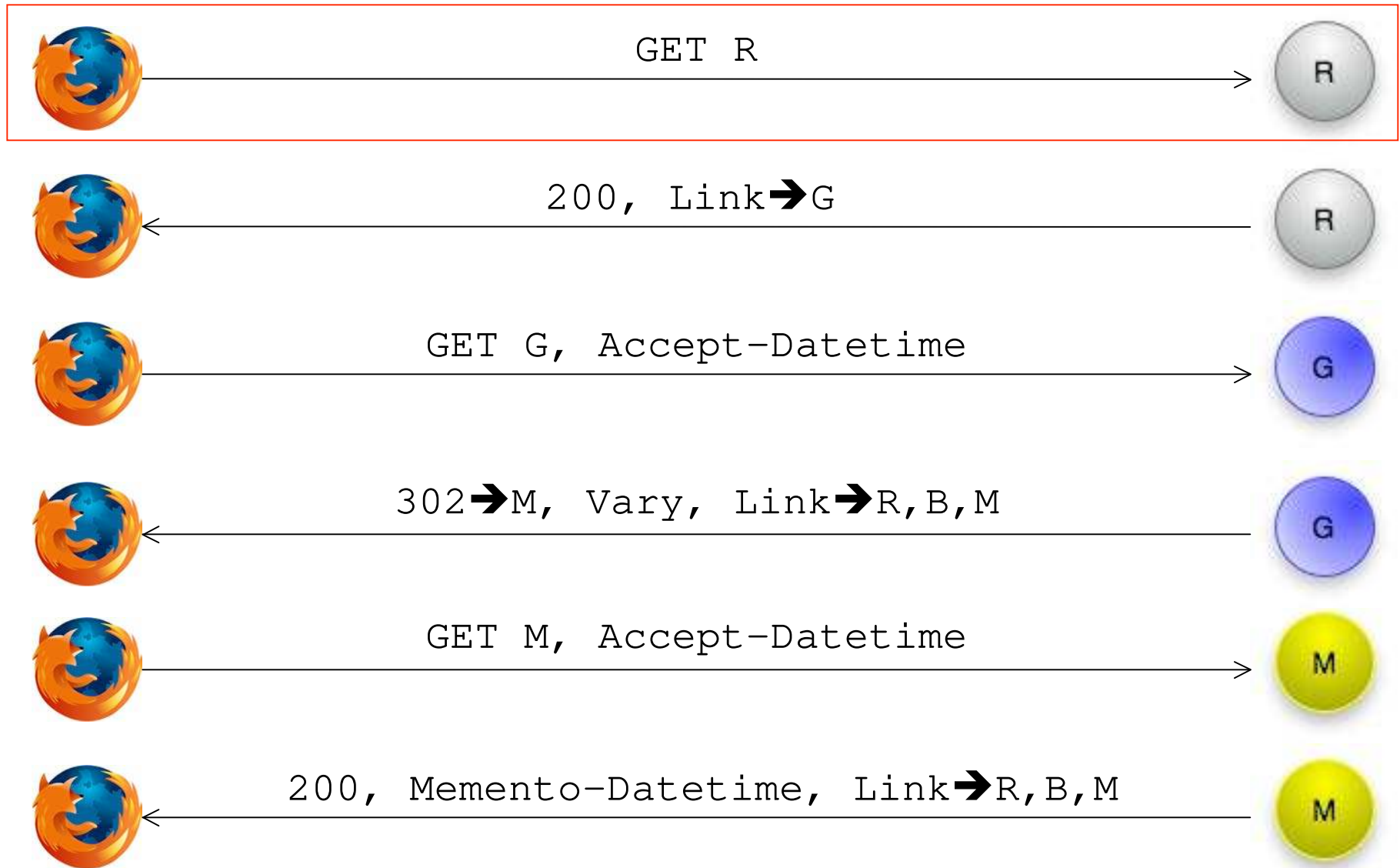
Compliant Client, Non-Compliant Server



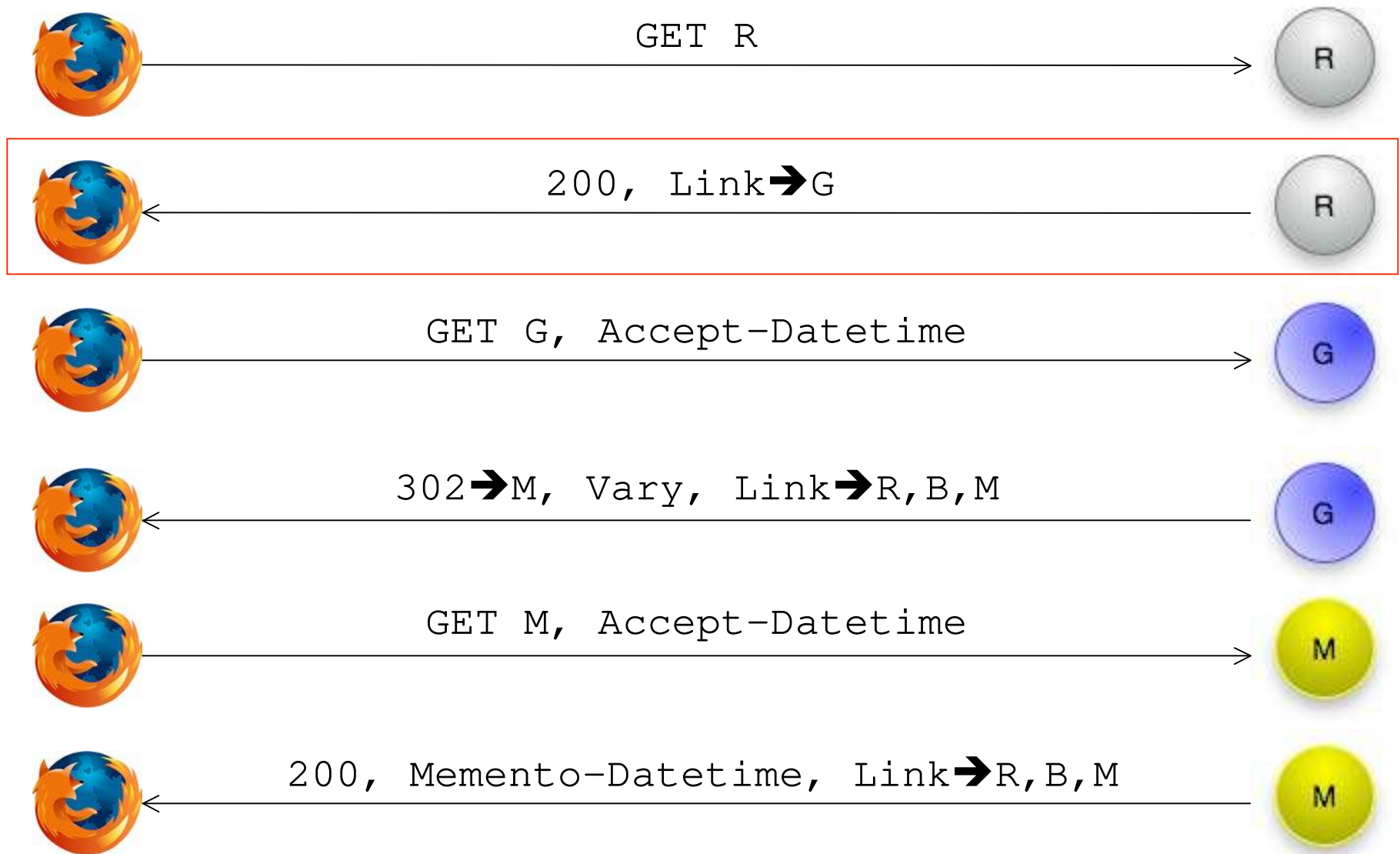
Compliant Client, Non-Compliant Server



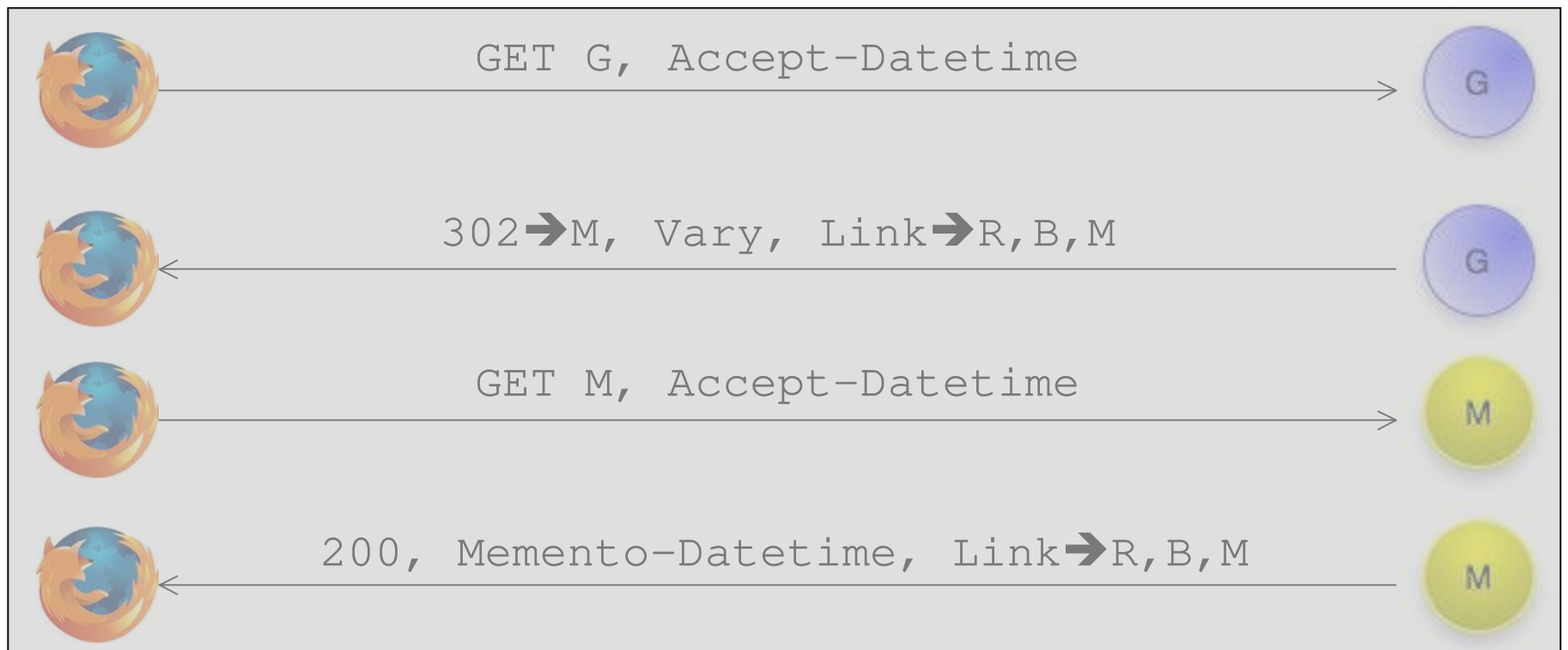
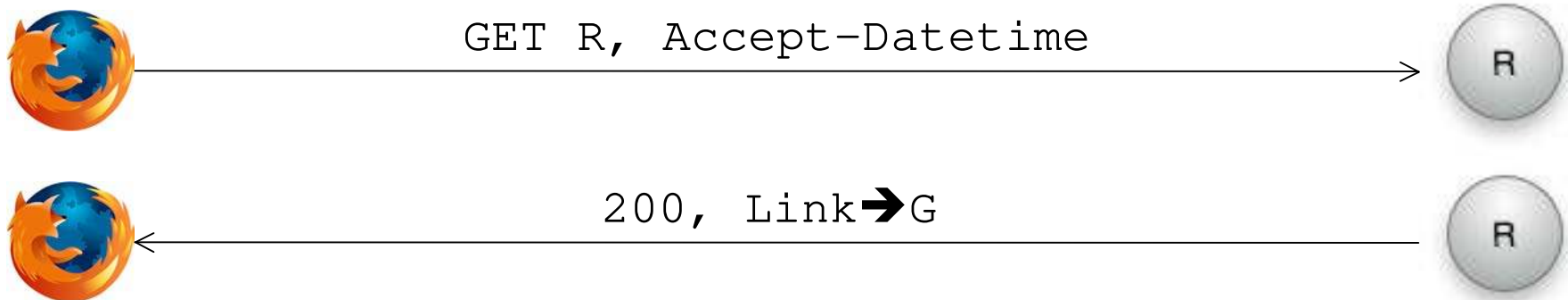
Compliant Server, Non-Compliant Client



Compliant Server, Non-Compliant Client



Compliant Server, Non-Compliant Client

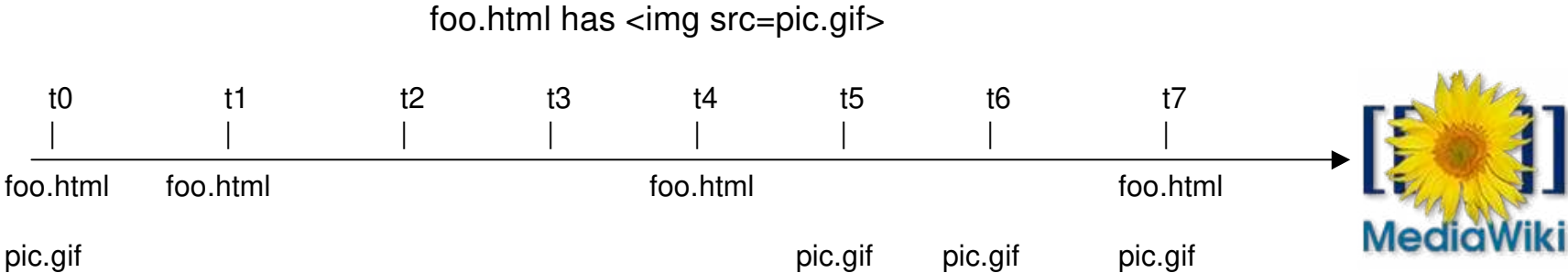


Some Issues

- Observational uncertainty
- Different notions of time
- When is the past?

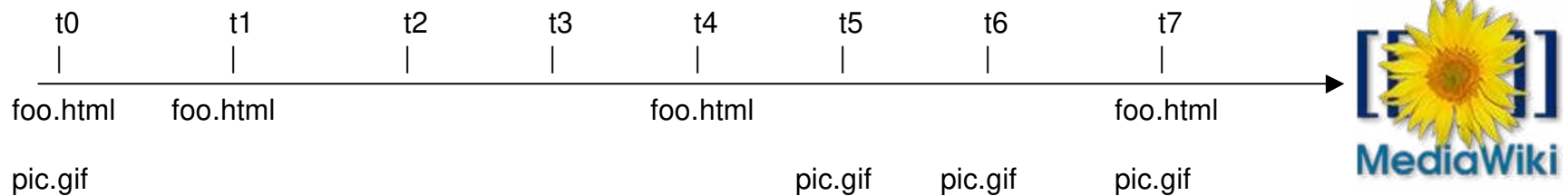


No Uncertainty With Self-Archiving Systems



foo.html @ t4

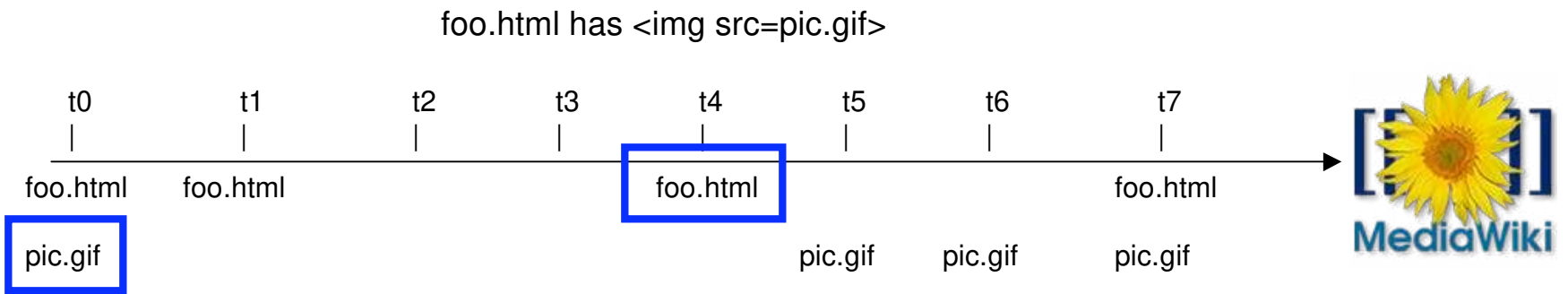
foo.html has



<pre>GET /foo.html Accept-Datetime: t4 HTTP/1.1 200 OK Memento-Datetime: t4</pre>	<pre>GET /pic.gif Accept-Datetime: t4 HTTP/1.1 200 OK Memento-Datetime: t0</pre>
--	---



foo.html @ t4



```
GET /foo.html
Accept-Datetime: t4

HTTP/1.1 200 OK
Memento-Datetime: t4
```

foo.html correct

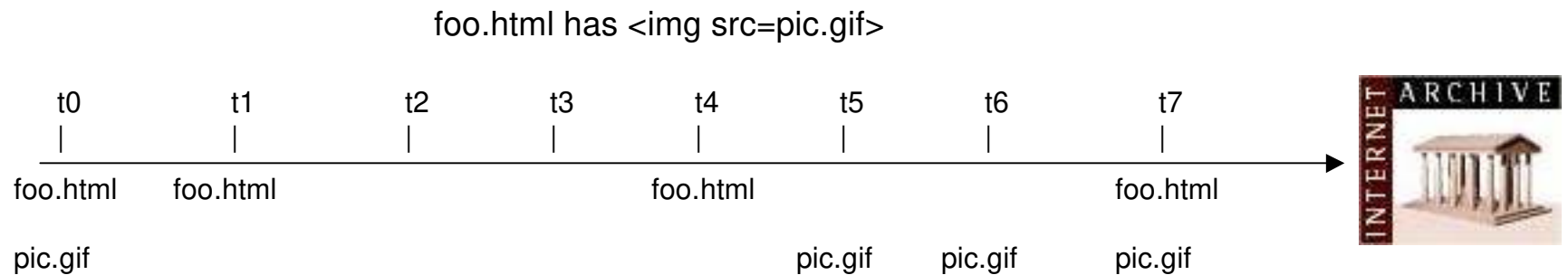
```
GET /pic.gif
Accept-Datetime: t4

HTTP/1.1 200 OK
Memento-Datetime: t0
```

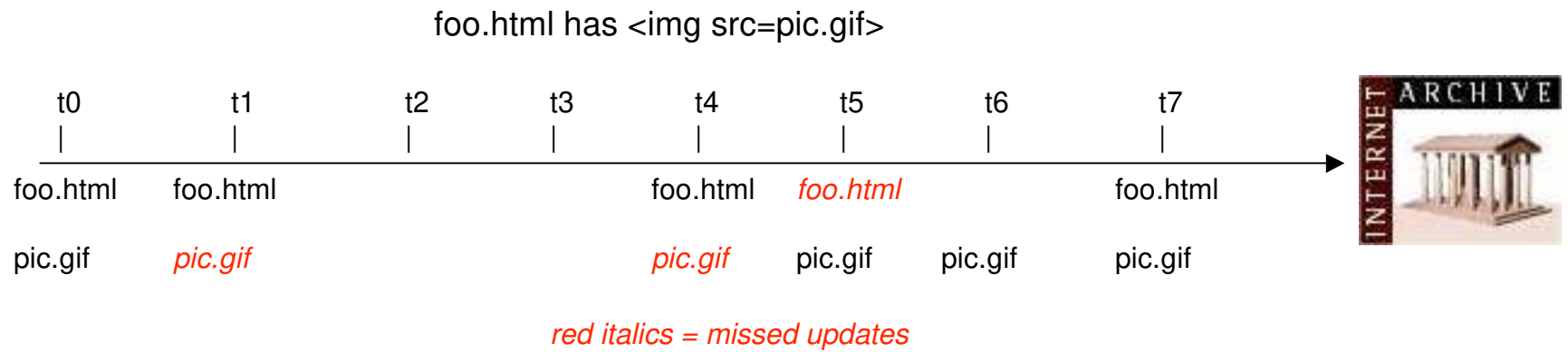
pic.gif correct



Uncertainty in Third-Party Archives



Missed Updates



foo.html @ t4

foo.html has

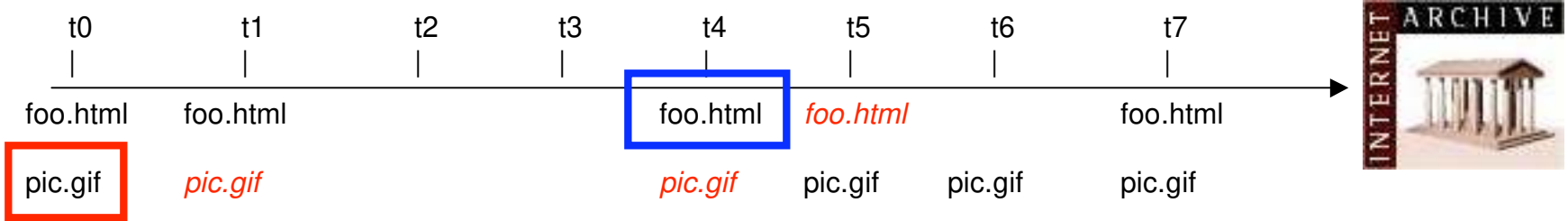


<pre>GET /foo.html Accept-Datetime: t4 HTTP/1.1 200 OK Memento-Datetime: t4</pre>	<pre>GET /pic.gif Accept-Datetime: t4 HTTP/1.1 200 OK Memento-Datetime: t0</pre>
--	---



foo.html @ t4

foo.html has



```
GET /foo.html
Accept-Datetime: t4

HTTP/1.1 200 OK
Memento-Datetime: t4
```

foo.html correct

```
GET /pic.gif
Accept-Datetime: t4

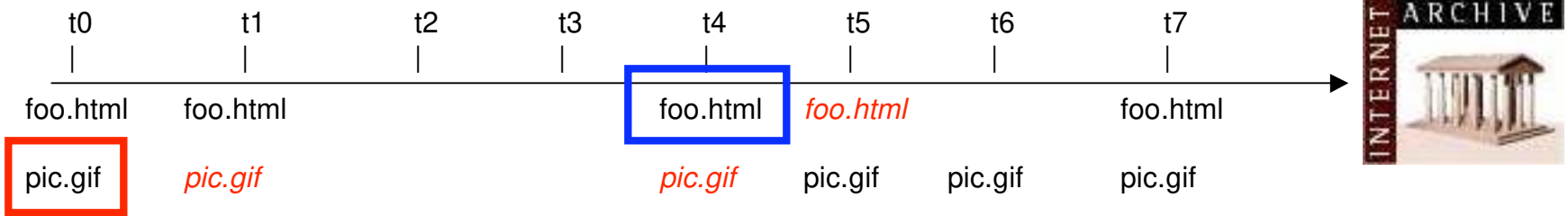
HTTP/1.1 200 OK
Memento-Datetime: t0
```

pic.gif incorrect
(should be t4)



foo.html @ t4

foo.html has



```
GET /foo.html
Accept-Datetime: t4

HTTP/1.1 200 OK
Memento-Datetime: t4
```

foo.html correct

```
GET /pic.gif
Accept-Datetime: t4

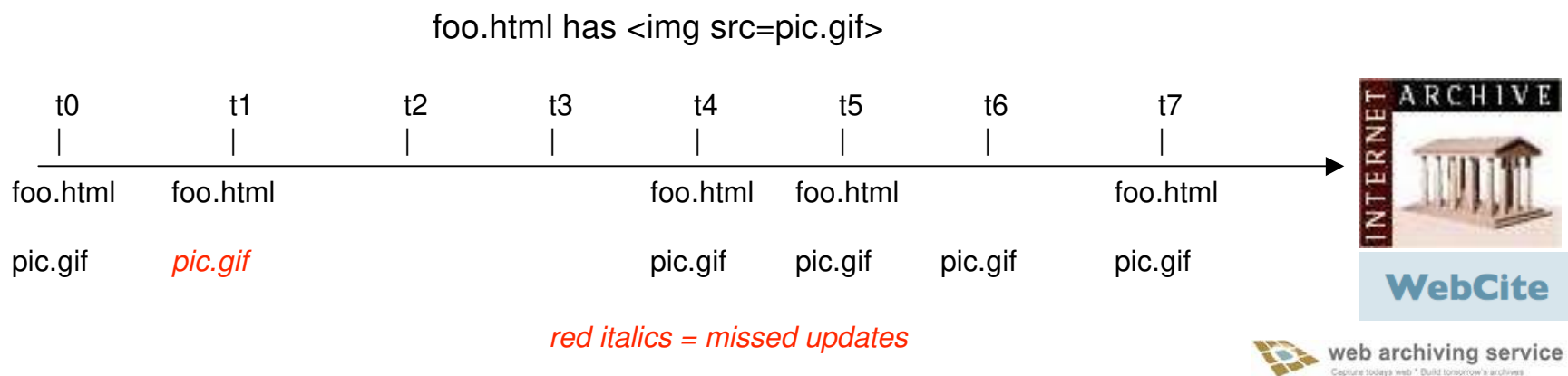
HTTP/1.1 200 OK
Memento-Datetime: t0
```

pic.gif incorrect
(should be t4)

this combination (foo@t4, pic@t0) never existed!



Decrease Uncertainty With More Observations?



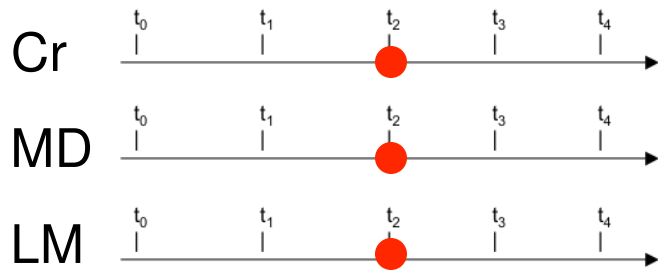
Three Notions of Time: Cr, LM, MD

- Creation (Cr): datetime when the resource first came into being
- Last-Modified (LM): when the resource was last changed
- Memento-Datetime (MD): the datetime that the resource was (meaningfully) observed *on the web*
 - not the same as the datetime that the resource is "about"; i.e. there is no

"Memento-Datetime: Thu, 04 Jul 1776 14:37:00"



Cr == MD == LM



Internet Archive Wayback Machine

ns11mm Web Archive (National September 11 Memorial Museum)

ARCHIVE-IT

INTERNET ARCHIVE waybackmachine

Enter Web Address: All

Searched for http://www.nyu.edu/fas/projects/vcb/case_911_FLASHcontent.html 1 Result [RSS](#)

[Look up URL](#) in general Internet Archive web collection [Proxy Mode Help](#)

* denotes when page was updated

Search Results for Jan 1, 2005 - Dec 31, 2010					
2005	2006	2007	2008	2009	2010
0 pages	0 pages	0 pages	1 page Mar 6, 2008 *	0 pages	0 pages

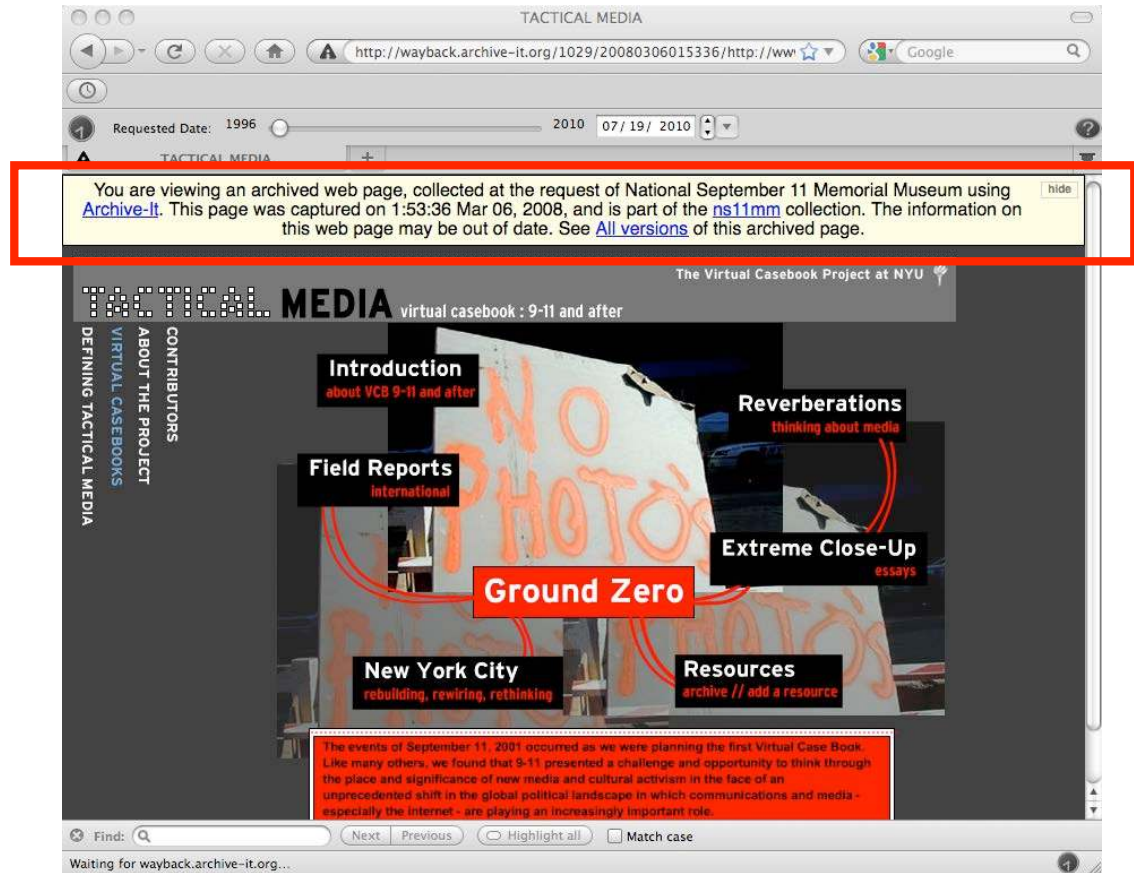
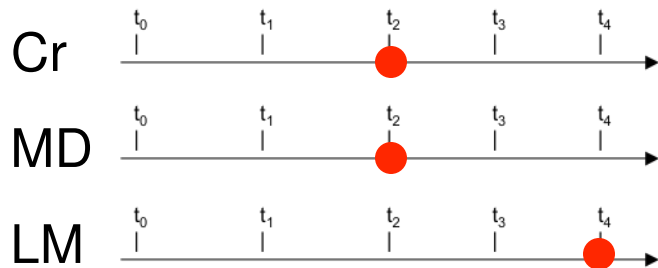
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Find: Match case

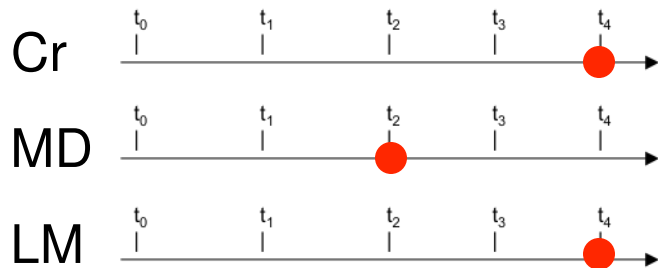
Done.



$$Cr == MD < LM$$



$$MD < Cr \leq LM$$



Internet Archive Wayback Machine

Requested Date: 1996 2010 07/19/2010

Search Results for <http://www.cs.odu.edu/~mln/> 35 Results

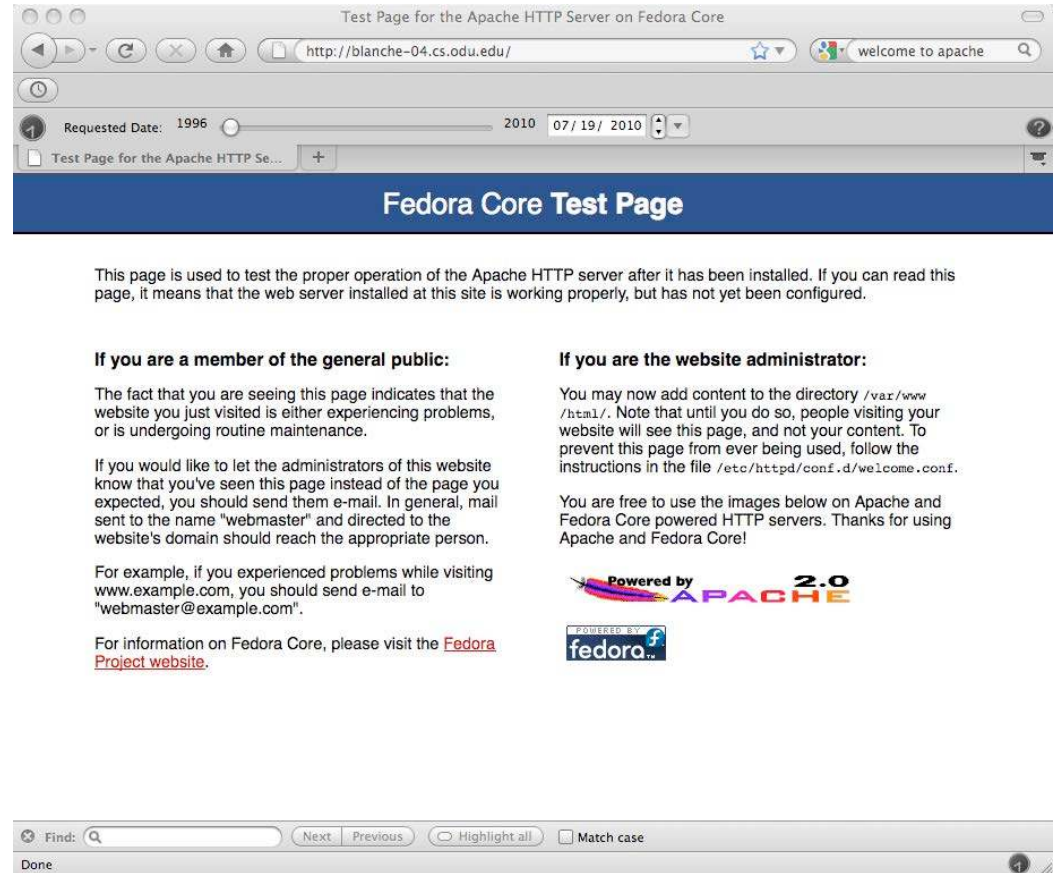
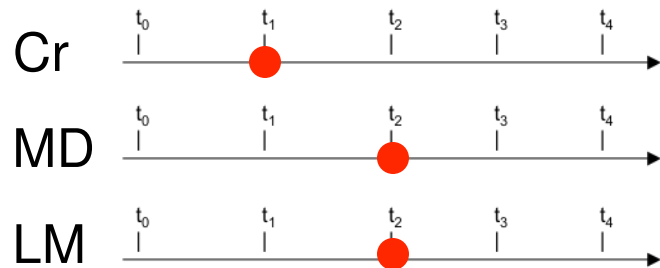
Note some duplicates are not shown. [See all.](#)
* denotes when site was updated.

Search Results for Jan 01, 1996 - Jul 20, 2010														
1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0 pages	0 pages	0 pages	0 pages	0 pages	0 pages	5 pages	6 pages	8 pages	7 pages	5 pages	1 pages	0 pages	0 pages	0 pages
						May 26, 2002 * May 28, 2002 * Jul 24, 2002 * Oct 05, 2002 * Nov 22, 2002 *	Apr 26, 2003 * Jun 25, 2003 * Aug 03, 2003 * Oct 20, 2003 * Oct 24, 2003 * Dec 06, 2003	May 13, 2004 * Jun 03, 2004 * Jun 09, 2004 * Jul 01, 2004 * Aug 26, 2004 * Aug 28, 2004 * Sep 30, 2004 * Dec 02, 2004	Feb 05, 2005 * Feb 06, 2005 * Feb 13, 2005 * Mar 10, 2005 * Apr 03, 2005 * Aug 29, 2005 * Dec 05, 2005	Feb 05, 2006 * Feb 11, 2006 * Mar 03, 2006 * Apr 17, 2006 * Apr 27, 2006	Dec 15, 2007 *			

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$$Cr < MD \leq LM$$



When is the Past?

The screenshot shows a Bing search for 'derek jeter' on 07/19/2010. The search results include a player statistics table, a list of related searches, a search history, and several sponsored links for 'Derek Jeter Jersey' and 'Derek Jeter Memorabilia'. Annotations in colored boxes highlight specific elements: a red box at the top right says 'cf. the "chronoscope" in Asimov's "The Dead Past"'; a green box around the search bar says 'doable but hard'; a red box around the 'Sign in' link says 'yikes!'; a blue box around the 'RELATED SEARCHES' and 'SEARCH HISTORY' lists says 'challenging'; an orange box around the player stats table says 'tough'; a green box around the first search result says 'easy'; and another blue box around the 'Derek Jeter Memorabilia' link says 'challenging'.

Requested Date: 1996 2010 07/19/2010

derek jeter - Bing

Sign in Norfolk, Virginia Preferences

bing Web

derek jeter

Web Videos Images Wikipedia

doable but hard

ALL RESULTS 1-4 of 2,960,000 results - Advanced

Derek Jeter SS, #2 New York Yankees

	OPP	AB	R	H	HR	RBI	BB	K	SB
Jul 16	TB, W5-4	5	0	0	0	0	0	1	0
Jul 17	TB, L5-10	5	0	1	0	0	0	1	0
Jul 18	TB, W9-5	5	2	2	0	1	0	0	1

Jul 20 - Angels at Yankees · 7:05 PM ET

Season: GP 89 · AVG .271 · HR 8 · RBI 44 · Runs 62 · SB 10

Player Stats · FOX Sports on MSN · Statistics provided by STATS, Inc. © 2010

Derek Jeter tops survey as MLB's "most marketable" - Game On ...
Derek Jeter ranks as MLB's "most marketable" player, according to a survey of sports executives and news media conducted by SportsBusiness Daily.
content.usatoday.com/communities/gameon/post/2010/07/derek-jeter-tops-survey-as-mlbs-most...
Cached page

Derek Jeter honored Steinbrenner, Sheppard with speech, but we expect ...
Derek Jeter has made a career of doing the right thing on and off the field, and Friday night he handled himself eloquently, which is why it seemed out of character for him not to ...
www.nydailynews.com/sports/baseball/yankees/2010/07/17/2010-07-17_jeter_a_hit_with_words...

Derek Jeter is MLB's 'most marketable player':... 12 hours ago
Derek Jeter is the most marketable baseball player in the country, according to a new survey released today.
www.nypost.com/p/news/local/derek_jeter_is_mlb_most_marketbale_DsXWr1vgOeyiHaawgyqjCMP=...
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Derek Jeter Jerseys
Shop Derek Jeter Jerseys. Get 20% Off - Use Code: TEAM20STORE.
www.TeamStore.com

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100% Certified Derek Jeter Gear \$4.99 Shipping on All Orders!
sportsmemorabilia.com

Derek Jeter Jerseys
See our Sporting Goods store. More than 30,000 Products 40% Off
amazon.com/sports

See your message here

challenging

Done



Why Care About The Past?

From an anonymous reviewer (*emphasis mine*):

"Is there any statistics to show that many or a good number of Web *users would like to get obsolete data or resources?*"



Replaying the Experience...

...can be more compelling than a summary



Memento: Time Travel for the Web
UNC Scholarly Communications Working Group, November 10 2010



Requested Date: 1996 2010 07/02/2010



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Special Reports

CNN's coverage of Katrina and the aftermath won a [2006 Peabody Award](#), the oldest honor in electronic media.



Hurricane Katrina

**HURRICANE KATRINA
MAIN PAGE**

Editor's Note: This special report was archived in September 2006.

Voices from the Gulf Coast

August 29, 2005: Hurricane Katrina made landfall on the Gulf Coast, destroying lives, leveling homes and leaving thousands of survivors with the same story: We lost everything. One year later, many still coped with Katrina's devastation. Some had moved forward, but for others recovery was at a standstill. CNN.com visited the region to get their stories.

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VS.

(thanks to Michele Weigle for the following Memento selection)



Memento: Time Travel for the Web
UNC Scholarly Communications Working Group, November 10 2010



Updated: 11:16 a.m. EDT (15:16 GMT), August 27, 2005

Strengthening Katrina to hammer Gulf Coast



Blamed for at least seven deaths in Florida, powerful Hurricane Katrina is becoming stronger as it churns in the Gulf of Mexico. Forecasts say it's poised to deal a hammer blow to the Mississippi Gulf Coast and southeast Louisiana as a possible Category 4 storm early next week. Meanwhile, residents of southeast Florida are cleaning up after Katrina cut across the state packing strong winds and dumping heavy rain.

FULL STORY

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NAS	▼ -13.60	2,120.77
S&P	▼ -7.29	1,205.10

ON CNN TV [Schedule](#)

Dead Wrong: Inside an Intelligence Meltdown

How did U.S. intelligence get it so wrong? CNN investigates how faulty intelligence led to the Iran

Updated: 11:07 p.m. EDT (03:07 GMT), August 27, 2005

Katrina drives people away from Gulf Coast



People leaving New Orleans pack highways.

Tourists and New Orleans residents are leaving the city as Hurricane Katrina churns closer to Louisiana and Mississippi. Officials fear New Orleans is vulnerable because it sits an average of 6 feet below sea level. Katrina could be a category 4 when it makes landfall. "This is a very, very dangerous hurricane," says hurricane center Director Max Mayfield.

FULL STORY

• Watch: 'Very concerned' 'L' 'Big Easy' prepares

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DNA has cleared some innocent people. But forensic

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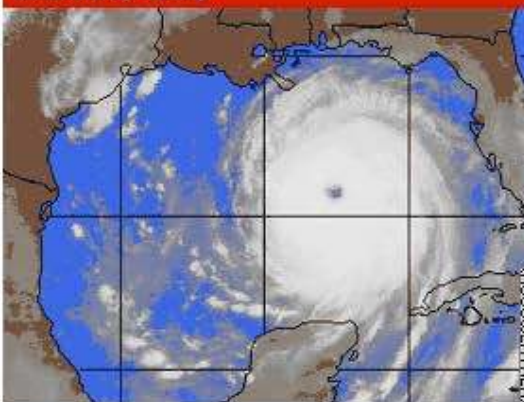
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Updated: 10:56 a.m. EDT (14:56 GMT), August 28, 2005

New Orleans orders mandatory evacuation

BREAKING NEWS



With powerful and strengthening Hurricane Katrina headed straight for his city, the mayor of New Orleans today ordered the mandatory evacuation of residents. The Category 5 storm has maximum sustained winds near 175 mph and has already been blamed for nine deaths in South Florida. Looking ahead, Max Mayfield of the National Hurricane Center said: "It has the potential for a large loss of life."

DEVELOPING STORY

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Updated: 7:58 p.m. EDT (23:58 GMT), August 29, 2005

Killer Katrina heading inland

Residents in New Orleans struggle to keep above the rising flood waters.

Killer Katrina heading inland

- Mississippi: Three dead, "unprecedented damage"
- More than 50 rescued from floods in New Orleans
- Katrina downgraded to tropical storm
- Parts of six Louisiana parishes "devastated"
- Oil rig breaks loose, hits Mobile River bridge
- "Life-threatening storm surge flooding" occurring

DEVELOPING STORY

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Updated: 5:33 a.m. EDT (09:33 GMT), August 30, 2005

54 DEAD IN MISSISSIPPI

Levee breached in New Orleans

Residents struggle to keep above the rising flood waters.

Levee breached in New Orleans

- Estimated 50 dead in 1 Mississippi county, officials say
- Levee breach in New Orleans forces hospital evacuation
- 1.3 million without power
- Tens of thousands to be homeless for months
- American Red Cross launching its largest relief operation

FULL STORY

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Up close on the devastation in New Orleans (1:57)



A tour of the damage in New Orleans (2:42)



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Updated: 1:44 p.m. EDT (17:44 GMT), August 30, 2005

STATES OF DEVASTATION

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Floodwaters from Hurricane Katrina cover a portion of New Orleans today.

Death toll rising in Katrina's wake

- **Impact:** [Katrina's toll leaves Gulf Coast reeling](#) | [Watch](#)
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(1:19)



[Now in The News \(1:31 p.m. ET\):](#) Your quick news update

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Updated: 6:14 a.m. EDT (10:14 GMT), August 31, 2005

SLIPPING INTO CHAOS



A shotgun-toting New Orleans police officer has a word with a man on Canal Street.

Unrest grows in New Orleans

- Water still rising in Crescent City, with no way out
- Looting, shootings reported
- New Orleans mayor blasts failure to patch levees
- Louisiana governor declares day of prayer
- Critical patients being airlifted, shelters being evacuated
- Paint marks indicate Mississippi homes with bodies

FULL STORY

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- Special Report: [Trail of destruction](#) | [Gallery](#) | [Map](#) | [Blog](#)
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[Hurricane Katrina's ongoing aftermath](#) (4:00)



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Updated: 3:44 p.m. EDT (19:44 GMT), August 31, 2005

HEALTH EMERGENCY



Survivors on an apartment building roof try to get the attention of rescuers.

Health fears as bodies lie in water

- Public health emergency declared; cholera, typhoid fears
- Katrina death toll so far estimated at least 120
- New Orleans mayor says toll in his city will be hundreds
- Superdome evacuees moving to Astrodome

FULL STORY

- Watch: [Saved by a tree](#) | [Dome must be evacuated](#)
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Updated: 9:51 p.m. EDT (01:51 GMT), August 31, 2005

GETTING OUT



Buses leave New Orleans with evacuees who had been holed up in the Superdome.

Evacuation of survivors begins

- Public health emergency declared; cholera, typhoid fears
- First evacuee buses leave New Orleans
- Bush: "One of the worst national disasters"
- Extra 10,000 National Guard troops called up

FULL STORY

- Watch: [Heartbreaking trip home](#) | [Searching for bodies](#)
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Updated: 12:30 p.m. EDT (16:30 GMT), September 1, 2005

DESPERATION AND DANGER



Storm victims are stuck without food or water at the New Orleans Convention Center.

Boat rescues suspended

- Boat rescuers asked to stand down due to dangers
- Huge crowd spotted at New Orleans convention center
- Gunfire, looting, small fires disrupt Superdome evacuation
- Citizens holed up in high-rises throng to buses
- Major buildings "pancaking" in Mississippi

DEVELOPING STORY

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- [CNN/Money: Bush: 'Zero tolerance' on gouging](#)
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FEMA suspends rescue operations
(2:34)



Anger and outrage
(3:38)



[Now In The News \(11:48 a.m. ET\):](#) Your quick news update

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Updated: 12:29 a.m. EDT (04:29 GMT), September 3, 2005

AID IN, PEOPLE OUT

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Some hope returns to New Orleans

- Food and medicine arrives for desperate survivors
- 40,000 patients airlifted from hospitals
- Bush sees destruction – and meets angry mayor
- But thousands still stranded in homes and centers

DEVELOPING STORY

- **Watch:** [Fires and floods](#) | [Aid rolls in](#)
- **Watch:** [Bush: It seems dark right now](#) | [The military mission](#)
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Military personnel distribute food and water Friday at the convention center in New Orleans.

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Updated: 6:08 p.m. EDT (22:08 GMT), September 4, 2005

HELICOPTER HEROES



A U.S. Air Force rescuer is dropped onto a rooftop to help trapped Katrina victims.

Rescuers going roof-to-roof

- AP: Army engineers say police shoot dead its contractors
- Helicopters dropping supplies, picking up survivors
- Convention center mostly evacuated
- Mayor: Police, firefighters traumatized

DEVELOPING STORY

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[Now In The News \(5:52 p.m. ET\)](#): Your quick news update

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<http://www.mementoweb.org>

<http://groups.google.com/group/memento-dev>



Memento: Time Travel for the Web
UNC Scholarly Communications Working Group, November 10 2010

