



Investigating Reference Rot in Web-Based Scholarly Communication

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@hvdcomp

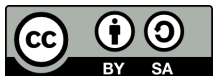
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Los Alamos National Laboratory
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<http://hiberlink.org> #hiberlink
<http://mementoweb.org> #memento

Hiberlink is funded by the Andrew W. Mellon Foundation

Hiberlink Project Partners

- Los Alamos National Laboratory:
 - Research Library: Martin Klein, Robert Sanderson, Herbert Van de Sompel
- University of Edinburgh:
 - Edina: Peter Burnhill, Neil Mayo, Muriel Mewissen, Christine Rees, Tim Stickland, Riachard Wincewicz
 - Language Technology Group: Beatrice Alex, Claire Grover, Richard Tobin, Ke “Adam” Zhou
- Funding: Andrew W. Mellon Foundation



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Acknowledgments

- Primary datasets: arXiv, Chesapeake Project, Elsevier, PubMed Central, PLoS, ... (many more to come)
- Secondary datasets: Ex Libris, MS Academic, SerialsSolutions
- Technology support: CrossRef Labs, CrossRef Prospect, Elsevier
- Liaisons: archive.is, CrossRef, Internet Archive, Old Dominion University Web Science & Digital Library Research Group, perma.cc



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Reference Rot



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Problem Domain

- Web-based scholarly communication links to, references, Web resources:
 - Formal citing of scholarly resources
 - Referencing “Web at Large” resources needed or created in research activities e.g. project websites, software, ontologies, workflows, online debate, slides, blogs, videos, etc.

Problem Domain

- Links to web resources are subject to Reference Rot:
 - Link Rot: Link stops working, e.g. HTTP 404
 - Content Decay: Linked content changes over time

References in Web-Based Scholarly Communication

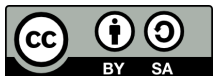
	To Scholarly Resources	To Web at Large Resources
Link Rot		
Content Decay		



an increasingly blurry boundary

References in Web-Based Scholarly Communication

	To Scholarly Resources	To Web at Large Resources
Link Rot	DOI, HTTP version of DOI	
Content Decay		



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References in Web-Based Scholarly Communication

	To Scholarly Resources	To Web at Large Resources
Link Rot	DOI, HTTP version of DOI	
Content Decay	Fixity of content	

References in Web-Based Scholarly Communication

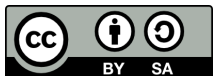
	To Scholarly Resources	To Web at Large Resources
Link Rot	DOI, HTTP version of DOI	
Content Decay	Fixity of content	
	Archiving: CLoCKSS, LoCKSS, Portico, Keepers Registry, ...	

References in Web-Based Scholarly Communication

	To Scholarly Resources	To Web at Large Resources
Link Rot	DOI, HTTP version of DOI	
Content Decay	Fixity of content	
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↑
There are issues here too, see

↓
David Rosenthal blog post <http://blog.dshr.org/2013/11/patio-perspectives-at-anadp-ii.html>



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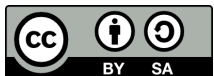
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References in Web-Based Scholarly Communication

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Hiberlink focus



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References to “Web at Large” Resources

- Hiberlink focuses on the wide variety of web resources needed or created in research activities
- These resources:
 - Are not necessarily under the custodianship of a party that cares about long term integrity, access
 - Do not necessarily have the same sense of fixity that e.g. journal articles have
- Reference Rot makes it impossible to adequately recreate the temporal context for scholarly discourse

D-Lib Magazine
September 2004

Volume 10 Number 9

ISSN 1082-9873

Rethinking Scholarly Communication

Building the System that Scholars Deserve

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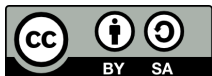
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Herbert Van de Sompel, et al. (2004) <http://dx.doi.org/10.1045/september2004-vandesompel>



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References

!Exist

Atkins, D. et al.. 2003. National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure, *Revolutionizing Science and Engineering through Cyber-infrastructure*, <http://www.communitytechnology.org/nsf_ci_report/>.

Archived

Exist

Brody, T., Kampa, S., Harnad, S., Carr, L. and Hitchcock, S. 2003. Digitometric Services for Open Archives Environments. In *Proceedings of European Conference on Digital Libraries 2003*, pages pp. 207-220, Trondheim, Norway. <<http://eprints.ecs.soton.ac.uk/archive/00007503/>>.

Archived

Frey, J., De Roure, D. and Carr, L. 2002. *Publication at Source: Scientific Communication from a Publication Web to a Data Grid*. <<http://eprints.ecs.soton.ac.uk/archive/00007852/>>.

Henry, G. 2003. On-line publishing in the 21-st Century: Challenges and Opportunities. *D-Lib Magazine*, Volume 9, Issue 10. <doi:10.1045/october2003-henry>.

!Exist

Lynch, C. 2003. Institutional Repositories: Essential Infrastructure for Scholarship in the Digital Age. *ARL Bimonthly Report* 226. February 2003, <<http://www.arl.org/newsltr/226/ir.html>>.

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!Exist

Payette, S., and Staples, T. 2002. The Mellon Fedora Project: Digital Library Architecture Meets XML and Web Services. *European Conference on Research and Advanced Technology for Digital Libraries*, Rome, Italy, September 2002. <<http://www.fedora.info/documents/ecdl2002final.pdf>>.

!Archived

Pöschl, U. 2004. Interactive Journal Concept for Improved Scientific Publishing and Quality Assurance. *Learned Information*, Volume 17, Number 2, pp 105-113. <doi:10.1087/095315104322958481>.

Reich, V. and Rosenthal, D. 2001. LOCKSS: A Permanent Web Publishing and Access System. *D-Lib Magazine*, Volume 7, Issue 6. <doi:10.1045/june2001-reich>.

Exist

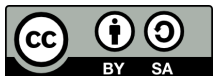
Roosendaal, H., and Geurts, P. 1997. Forces and functions in scientific communication: an analysis of their interplay. *Cooperative Research Information Systems in Physics*, August 31 — September 4 1997, Oldenburg, Germany. <<http://www.physik.uni-oldenburg.de/conferences/crisp97/roosendaal.html>>.

Archived



Hiberlink: Investigating Reference Rot

- Hiberlink explores references to Web at Large resources:
 - Quantifies Reference Rot
 - Explores potential solutions to Reference Rot
 - Focuses on links in electronic journal articles
 - But has the big picture in mind: dynamic, interdependent, web-based scholarly assets
 - See Herbert Van de Sompel, From the Version of Record to a Version of the Record, CNI Spring 2013 plenary talk - <http://www.youtube.com/watch?v=fhrGS-QbNVA>



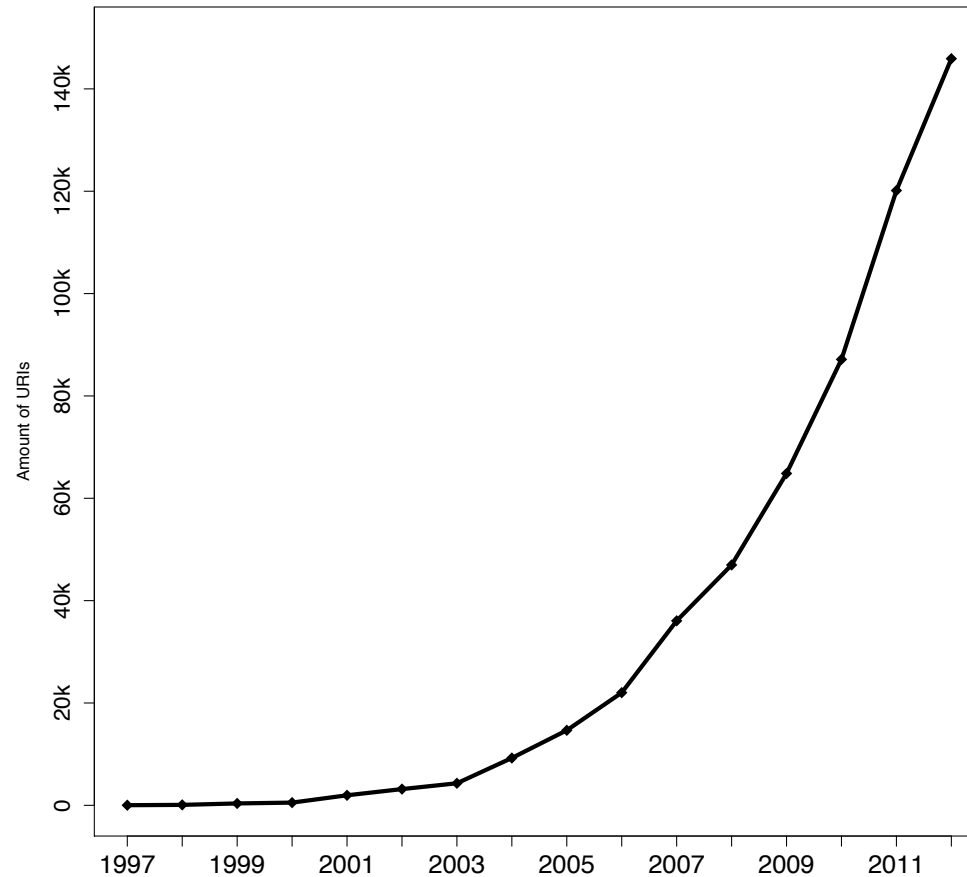
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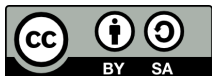


Is it worth our time to study this?

Articles Increasingly Link to Web Resources



URIs extracted from PubMed papers – links to Web at Large resources



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The New York Times Cares

SIDEBAR

In Supreme Court Opinions, Web Links to Nowhere

By ADAM LIPTAK

Published: September 23, 2013

WASHINGTON — Supreme Court opinions have come down with a bad case of link rot. According to [a new study](#), 49 percent of the hyperlinks in Supreme Court decisions no longer work.

 Enlarge This Image



Stephan Savola/Associated Press
Justice Samuel A. Alito Jr.

This can sometimes be amusing. A link in [a 2011 Supreme Court opinion](#) about violent video games by Justice Samuel A. Alito Jr. now leads to [a mischievous error message](#).


“Aren’t you glad you didn’t cite to this Web page?” it asks. “If you had, like Justice Alito did, the original content would have long since disappeared and someone else might have come along and purchased the domain in order to make a comment about the transience of linked information in the Internet age.”

The prankster has a point. The modern Supreme Court opinion is increasingly built on sand.


Hyperlinks are a huge and welcome convenience, of course, said [Jonathan Zittrain](#), who teaches law and computer science at Harvard and who prepared the study with [Kendra Albert](#), a law student there. “Things are readily accessible,” he said, “until they aren’t.”


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<http://www.nytimes.com/2013/09/24/us/politics/in-supreme-court-opinions-clicks-that-lead-nowhere.html>



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Quantifying Reference Rot



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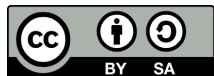


Quantifying Reference Rot

- Reference Rot has been studied before:
 - For the web at large
 - For scholarly communication
 - For government documents
- What is different with Hiberlink?
 - Investigates Reference Rot not just link rot, i.e. includes the aspect of changing content not just rotting links
 - Investigates coverage of referenced resources in web archives
 - Operates at a massive scale regarding number of journal articles, referenced URIs, web archive lookups

STUDY Author (Date)	Year of Publication of Citations	# URIs	#URIs looked up in web archives
Lawrence (2001)	1993-1999	67,577	-
Casserly (2003)	1999-2000	500	500
Casserly (2007)	1999-2000	500	500
Rumsey (2002)	1997-2001	3,406	-
Davis (2002)	1999-2001	688	-
Wren (2004)	1994-2002	1,630	-
Sellitto (2005)	1995-2003	1,043	-
Goh (2005)	1997-2003	2,516	-
Dimitrova (2007)	2000-2003	1,126	-
McCown (2005)	1995-2004	4,387	-
Wagner (2009)	2002-2004	2,011	2,011
Parker (2007)	2002-2005	1,229	-
Duda (2008)	1997-2005	2,100	-
Falagas (2007)	2003-2006	1,417	-
Russell (2008)	1999-2006	510	-
Wren (2008)	1994-2007	6,154	-
Moghaddam (2010)	1995-2008	1,761	1,761
Sanderson (2011)	1993-2010	162,052	162,052

Sanderson, R., Phillips, M., and Van de Sompel, H. (2011) <http://arxiv.org/abs/1105.3459>

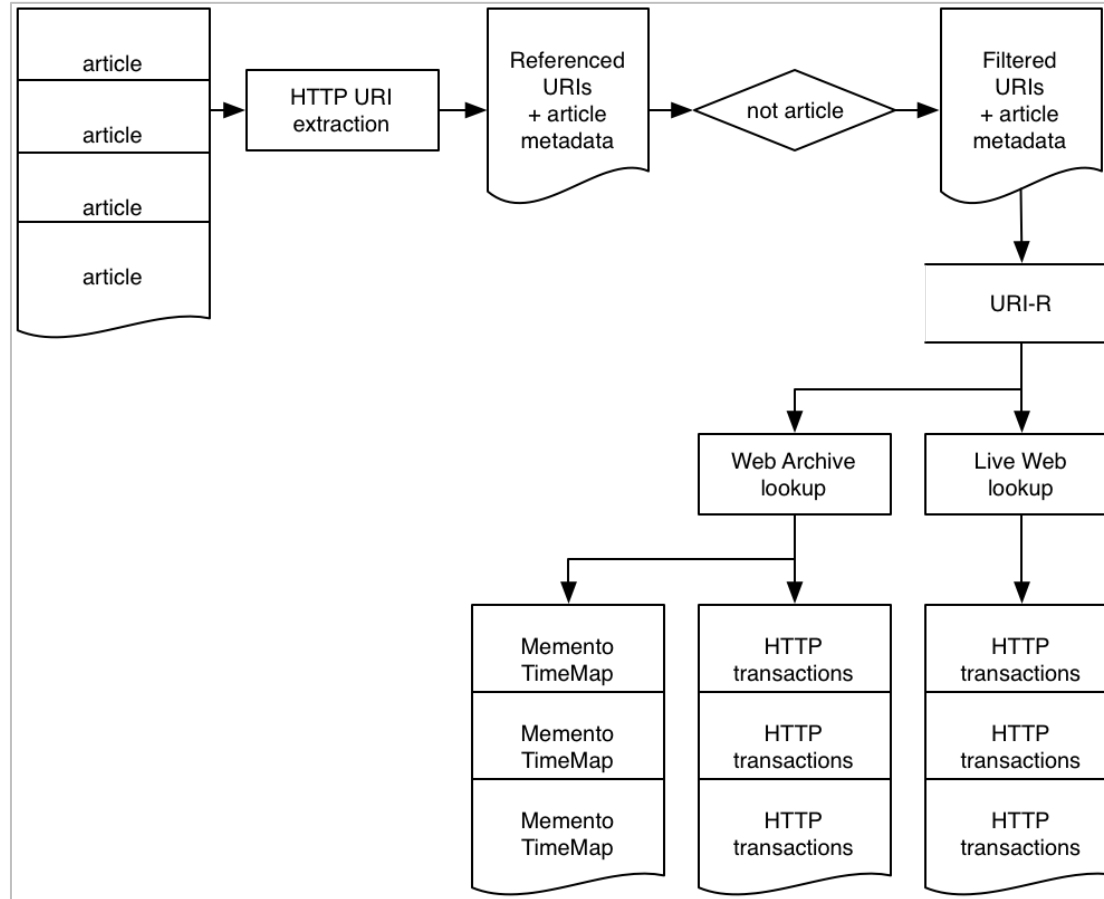


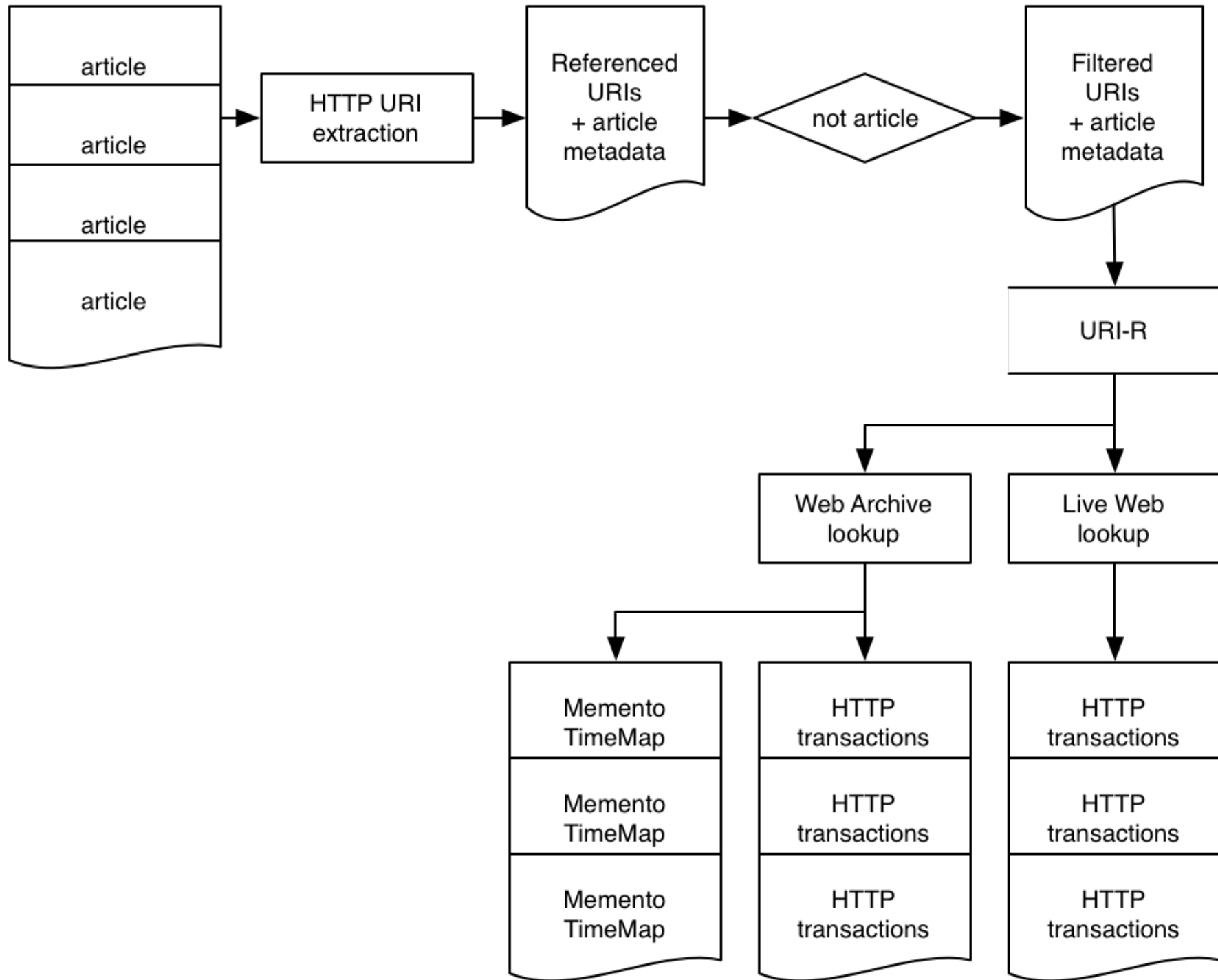
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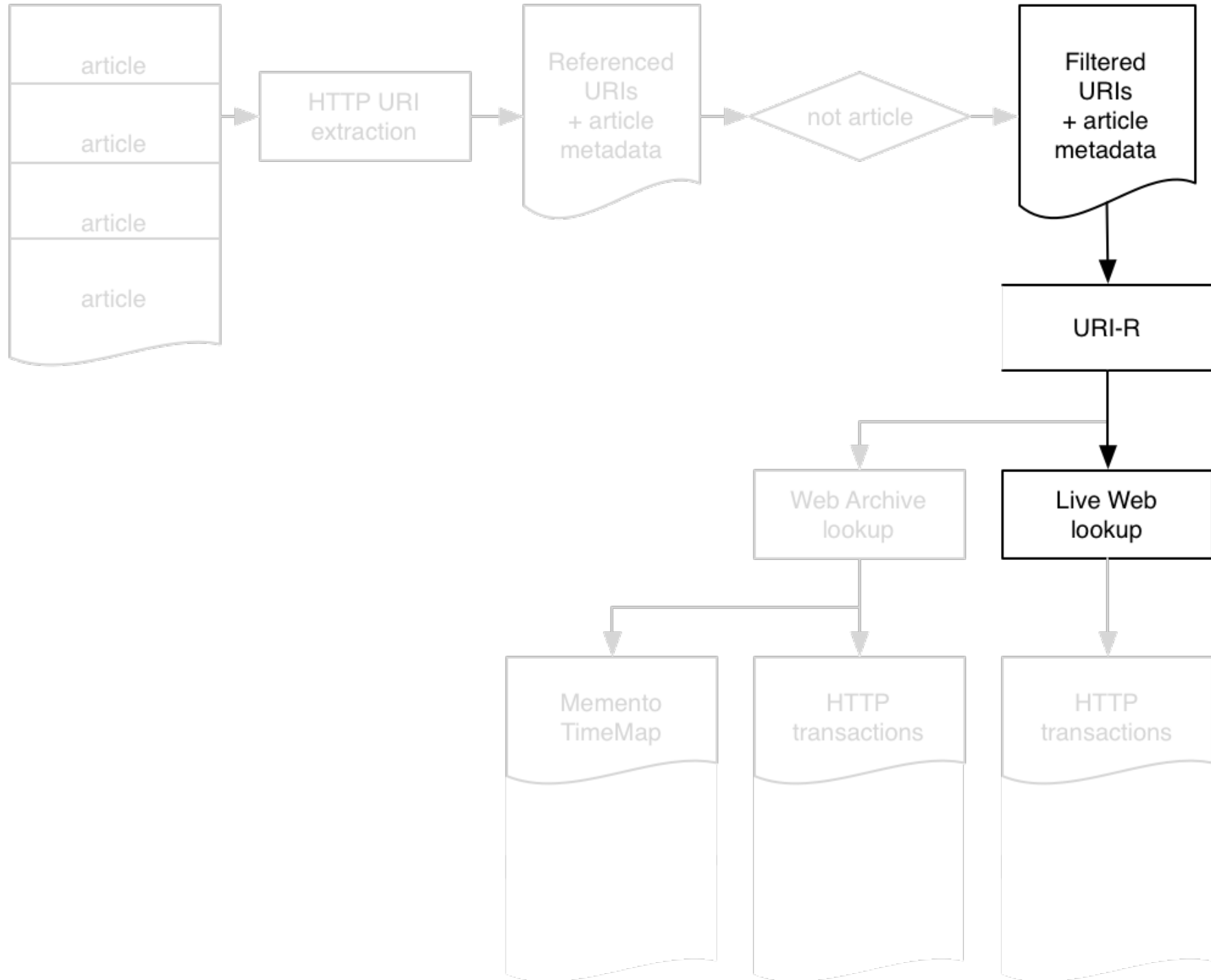


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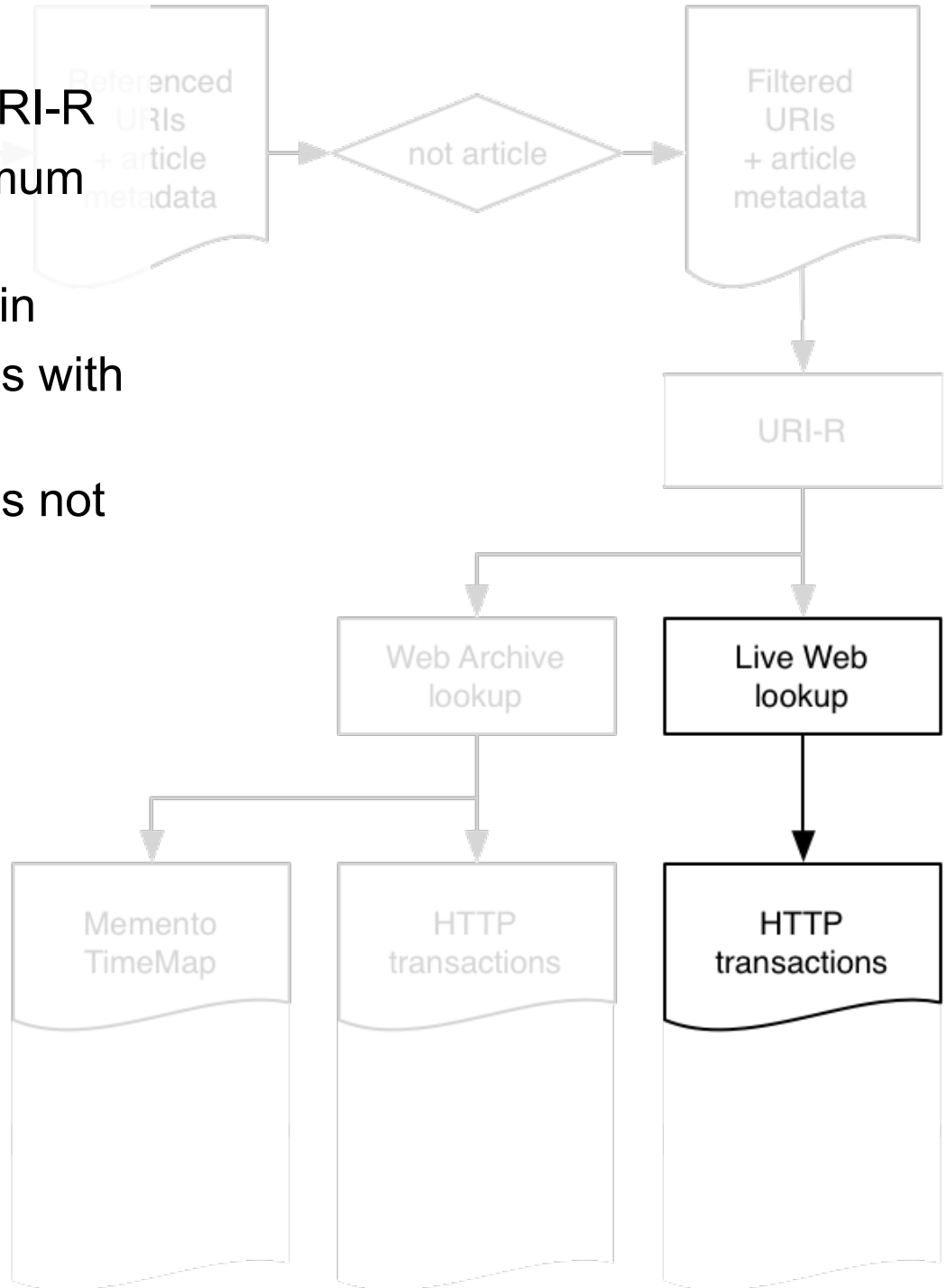
Quantifying Reference Rot - Methodology



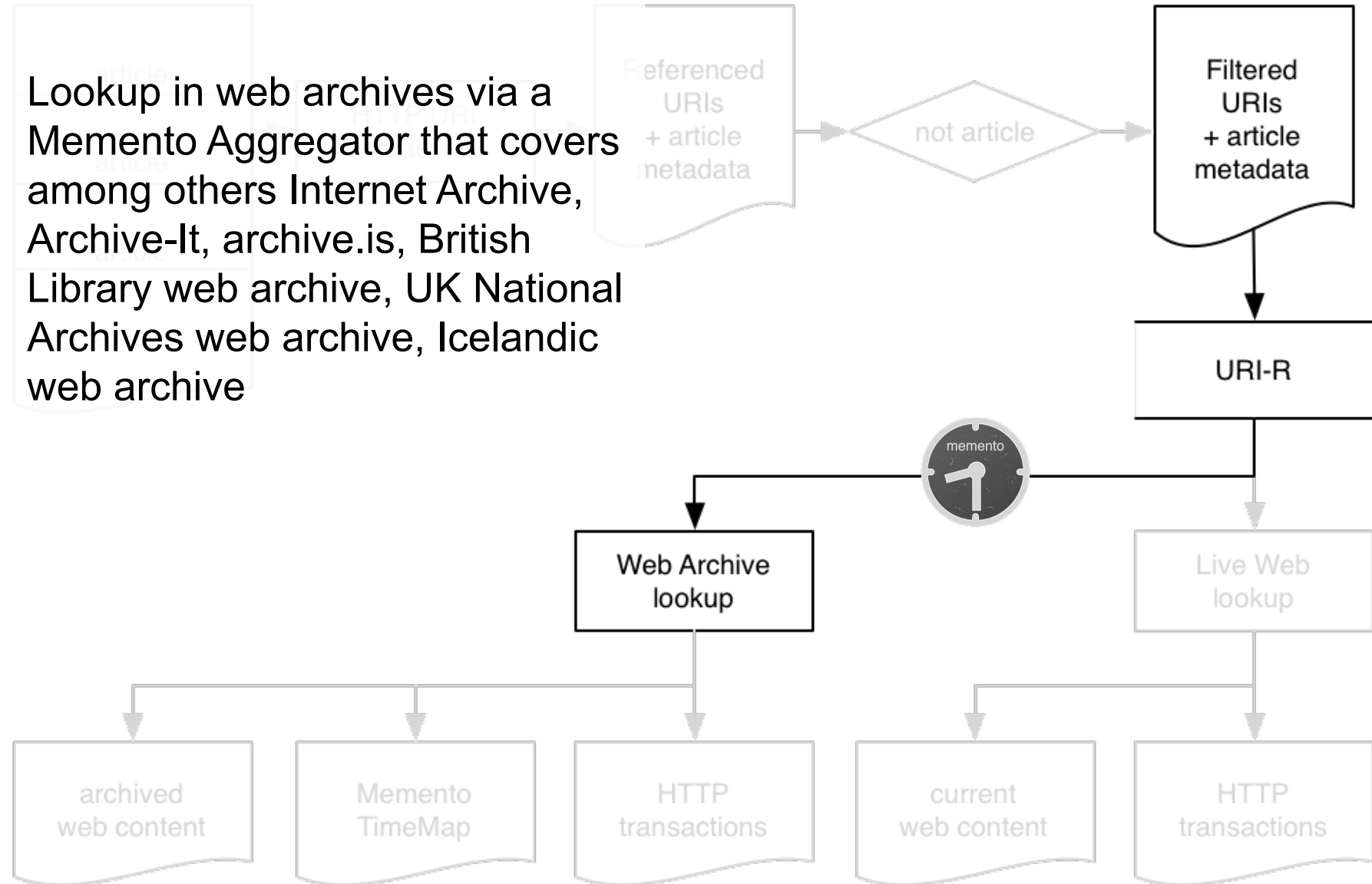




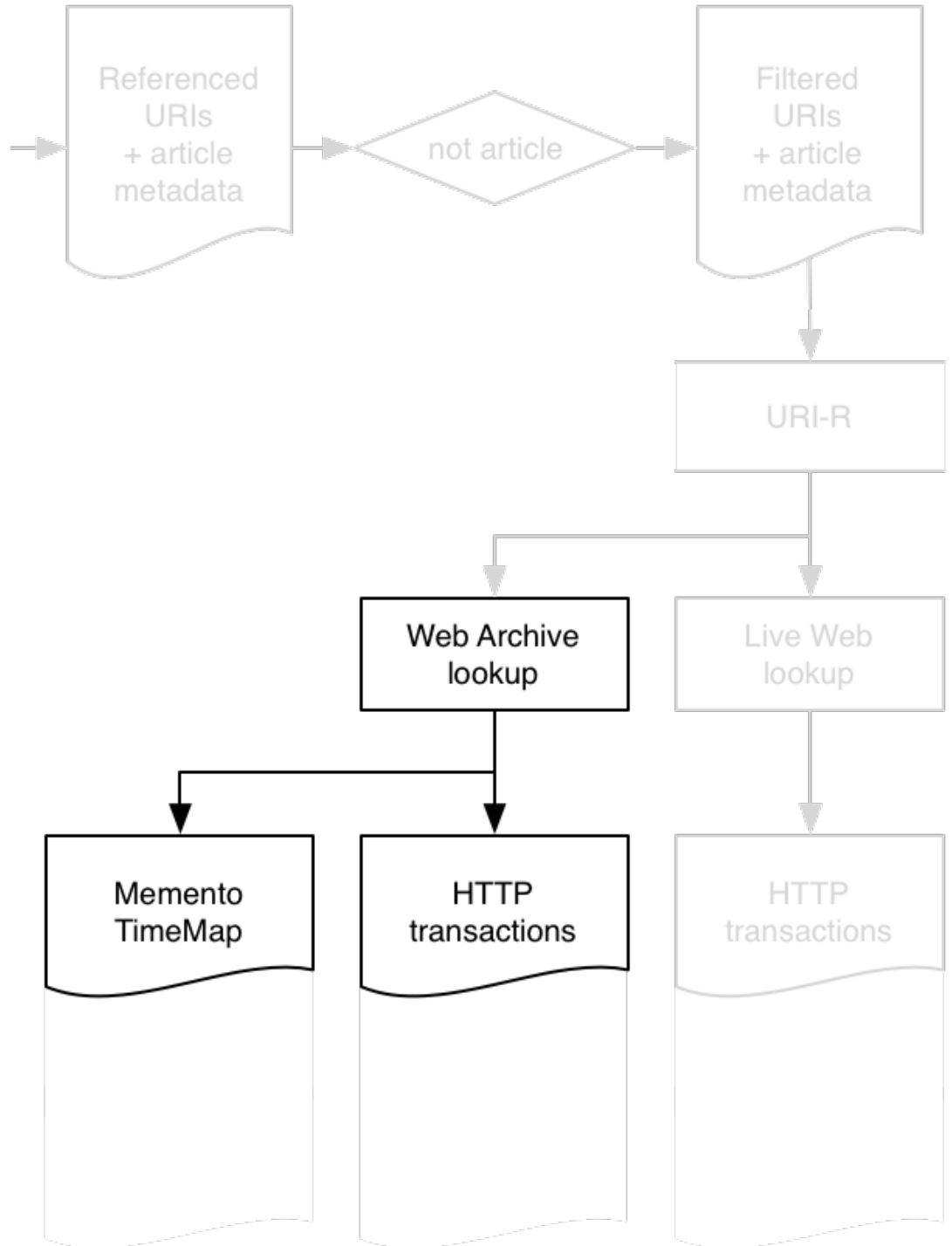
- HTTP HEAD on referenced URI-R
- Follow redirects up to a maximum of 50
- Record HTTP transaction chain
- If HTTP transaction chain ends with 2XX status code: **Exists**
- If HTTP transaction chain does not end with 2XX: **!Exist**

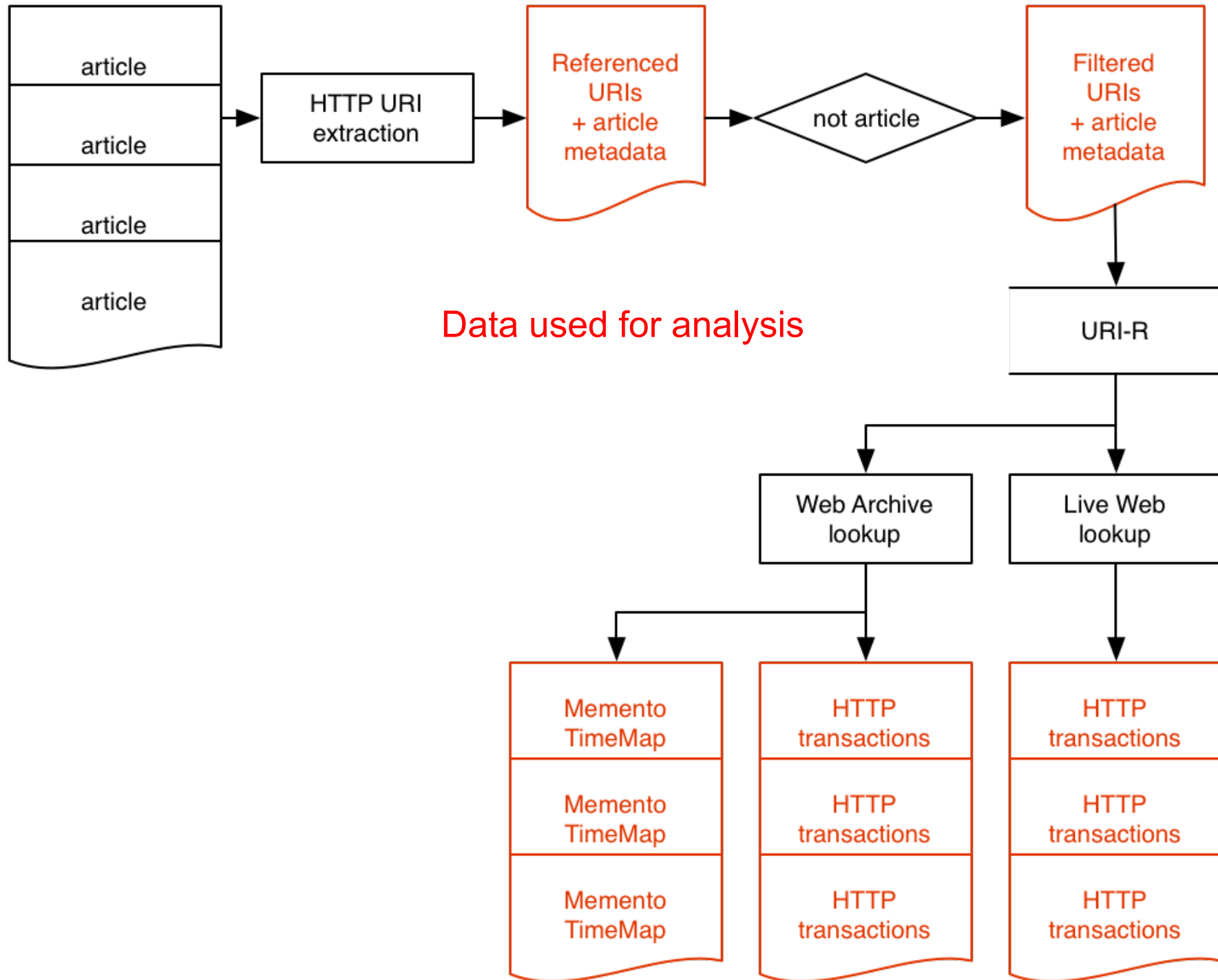


- Lookup in web archives via a Memento Aggregator that covers among others Internet Archive, Archive-It, archive.is, British Library web archive, UK National Archives web archive, Icelandic web archive

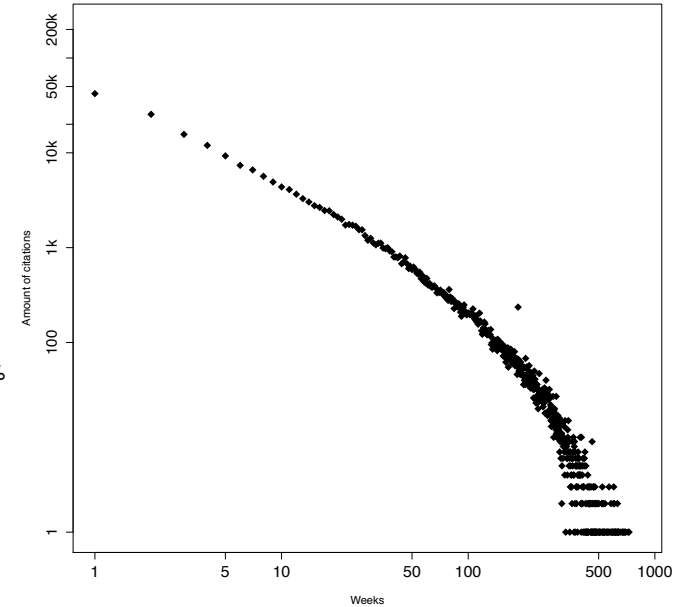
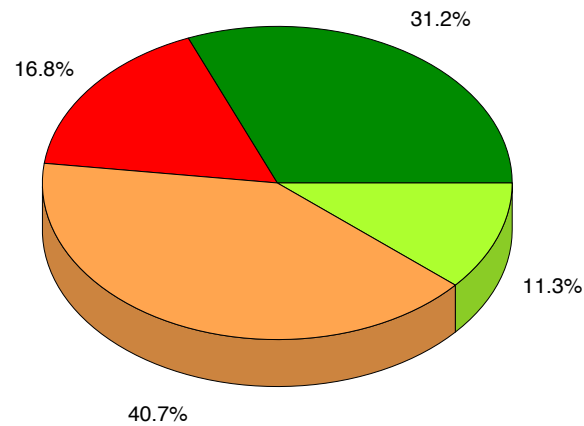
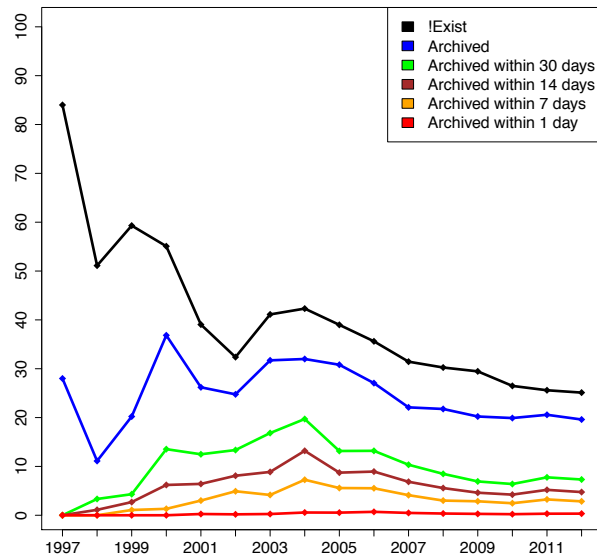


- Obtain TimeMap per URI
- If TimeMap does not exist:
!Archived
- If TimeMap exists, select Memento URI-M closest to article publication date
- HTTP HEAD on URI-M
- Follow archived redirects up to a maximum of 50
- Record HTTP transaction chain
- If HTTP transaction chain ends 2XX: **Archived**
- If HTTP transaction chain does not end with 2XX:
!Archived



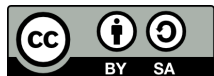


Quantifying Reference Rot – Early Results



Study: PubMed Central Corpus 01/1997 - 12/2012

- Articles processed: 494,785
- Articles that contain Web at Large URIs: 176,527
- References to Web at Large URIs: 557,432
- Unique referenced Web at Large URIs: 327,782

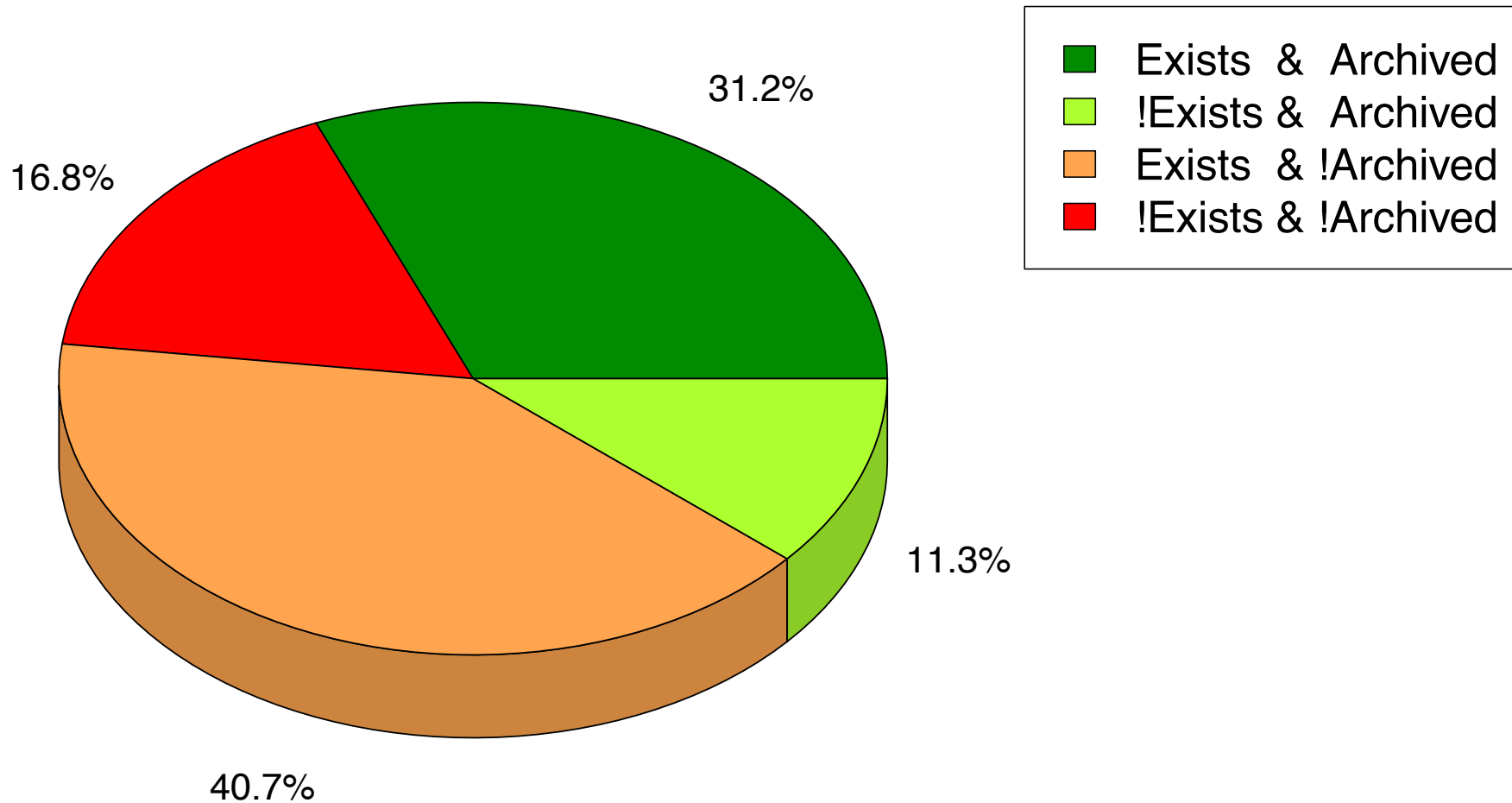


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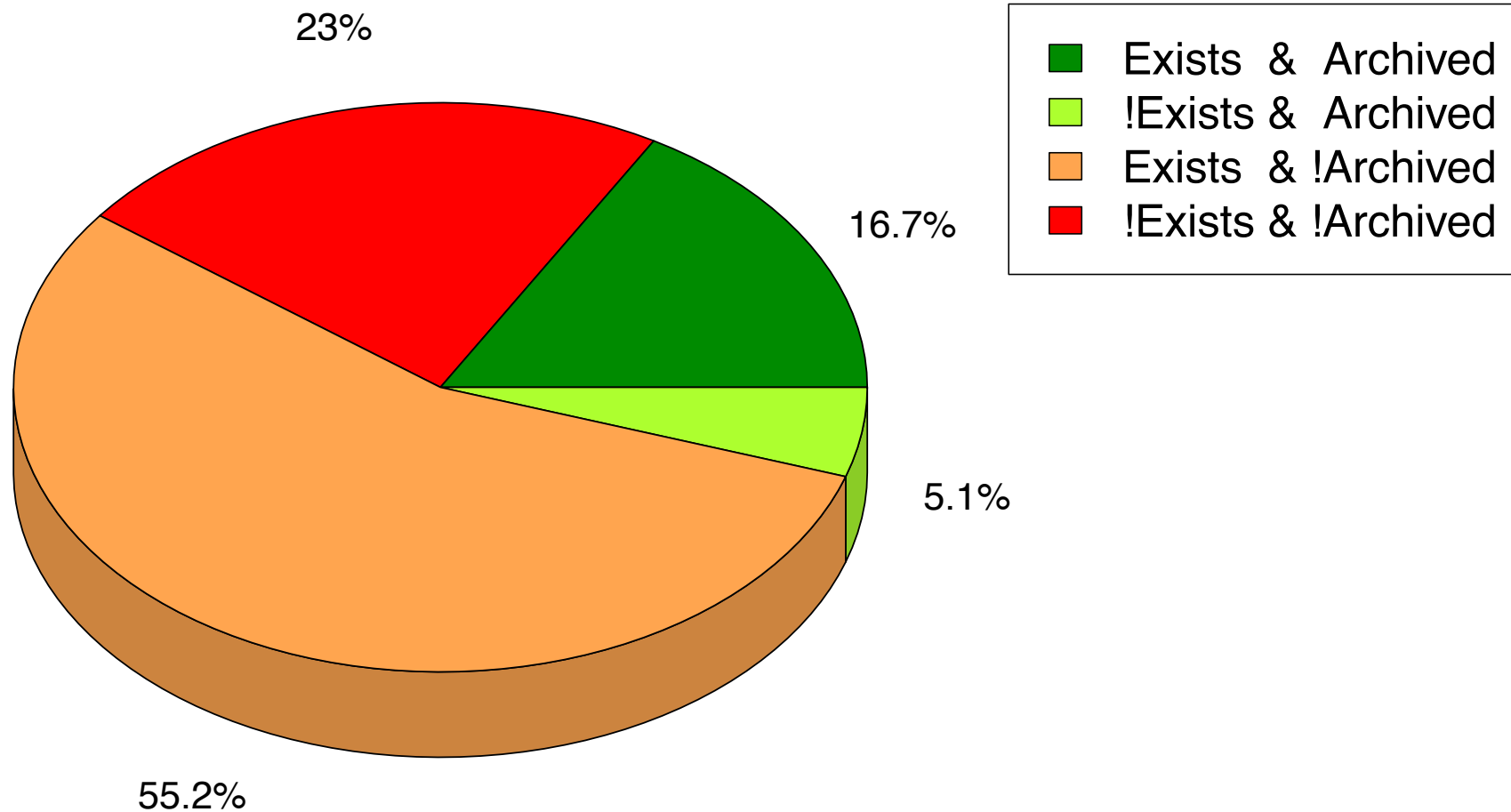
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Percentage Exists & Archived Referenced URIs



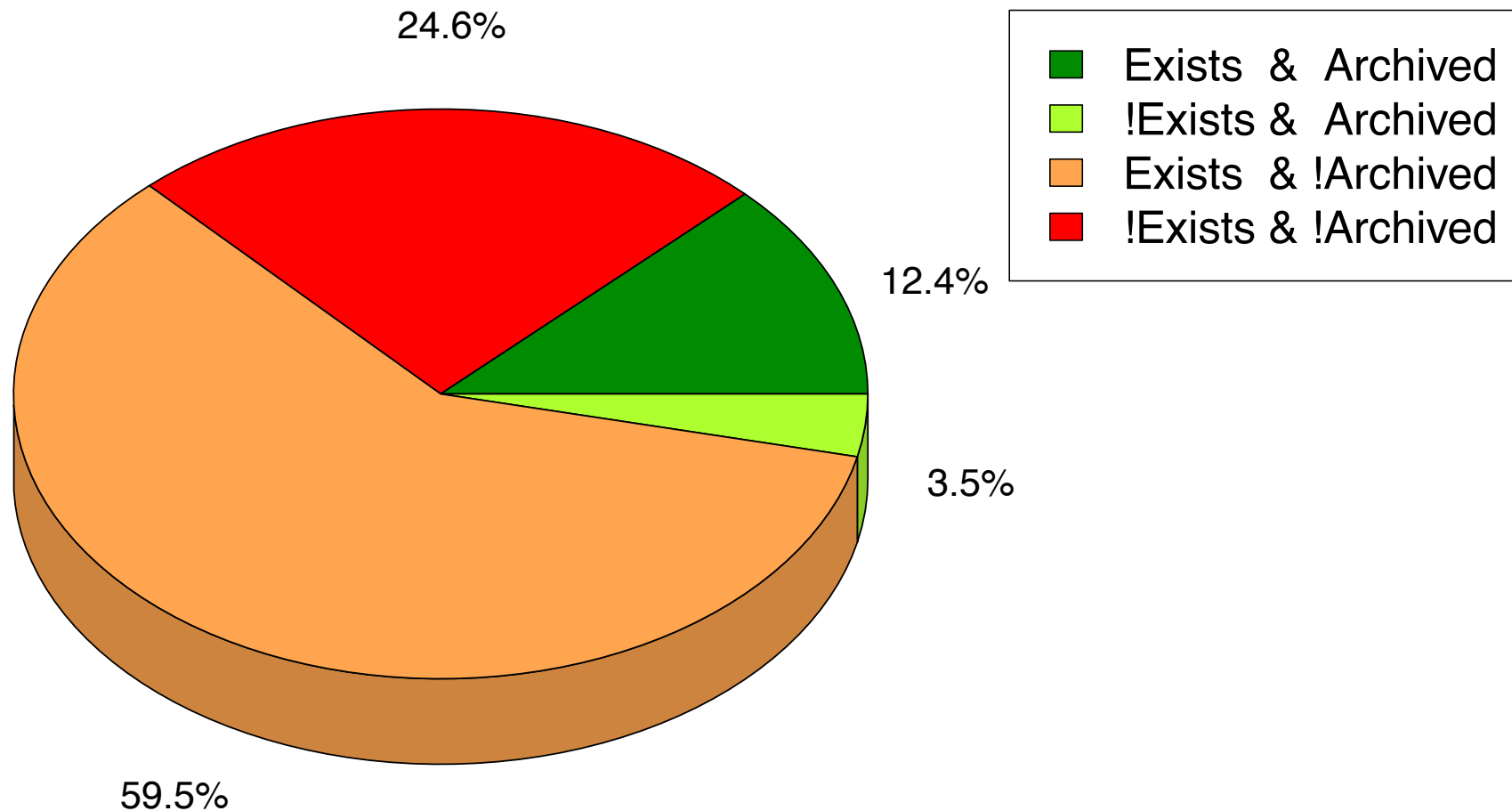
URIs extracted from PubMed papers – links to Web at Large resources

Percentage Exists & Archived in **30** Day Window



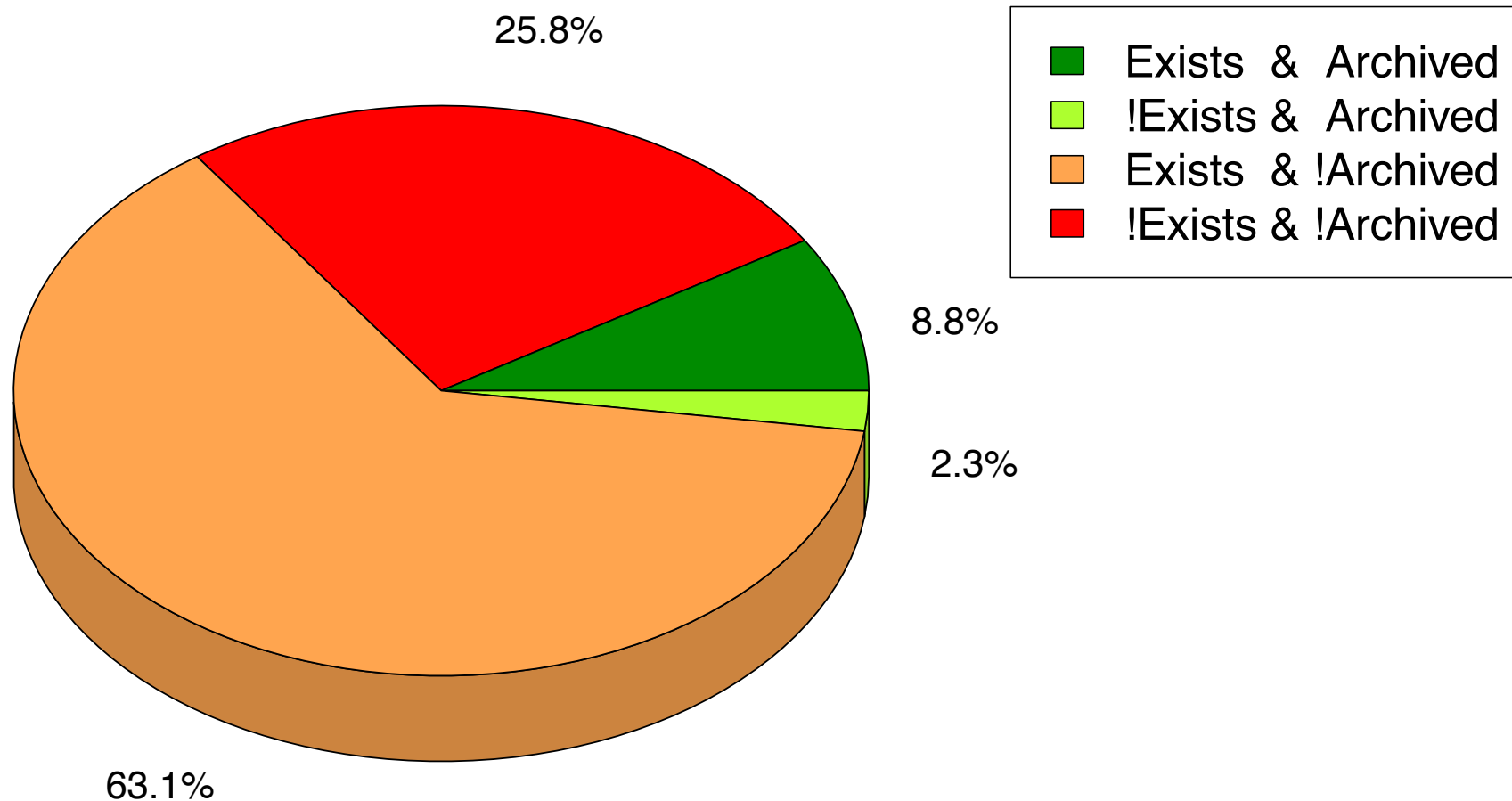
URIs extracted from PubMed papers – links to Web at Large resources

Percentage Exists & Archived in **15** Day Window



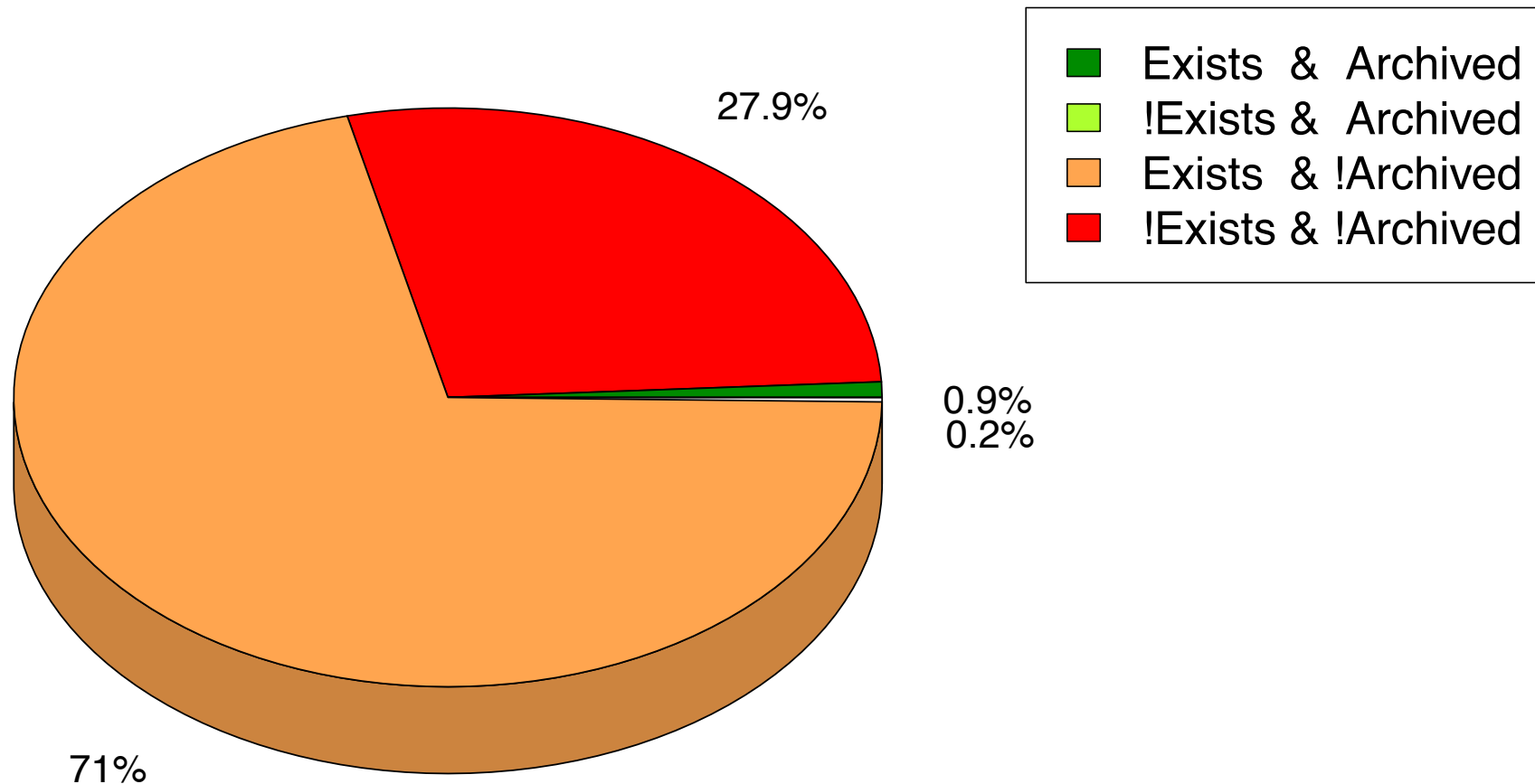
URIs extracted from PubMed papers – links to Web at Large resources

Percentage Exists & Archived in **07** Day Window



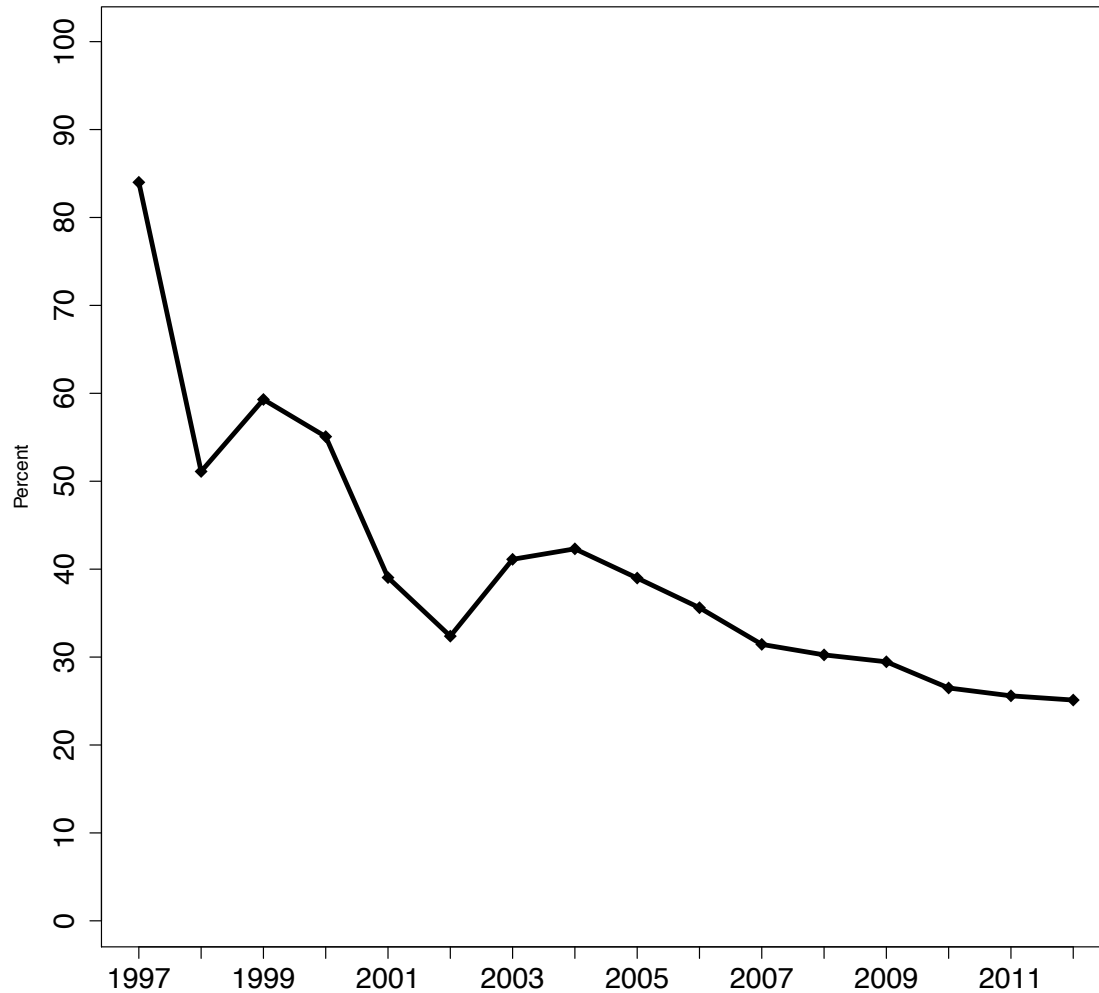
URIs extracted from PubMed papers – links to Web at Large resources

Percentage Exists & Archived in 01 Day Window

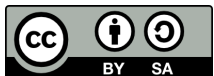


URIs extracted from PubMed papers – links to Web at Large resources

Percentage of !Exists per Year



URIs extracted from PubMed papers – links to Web at Large resources

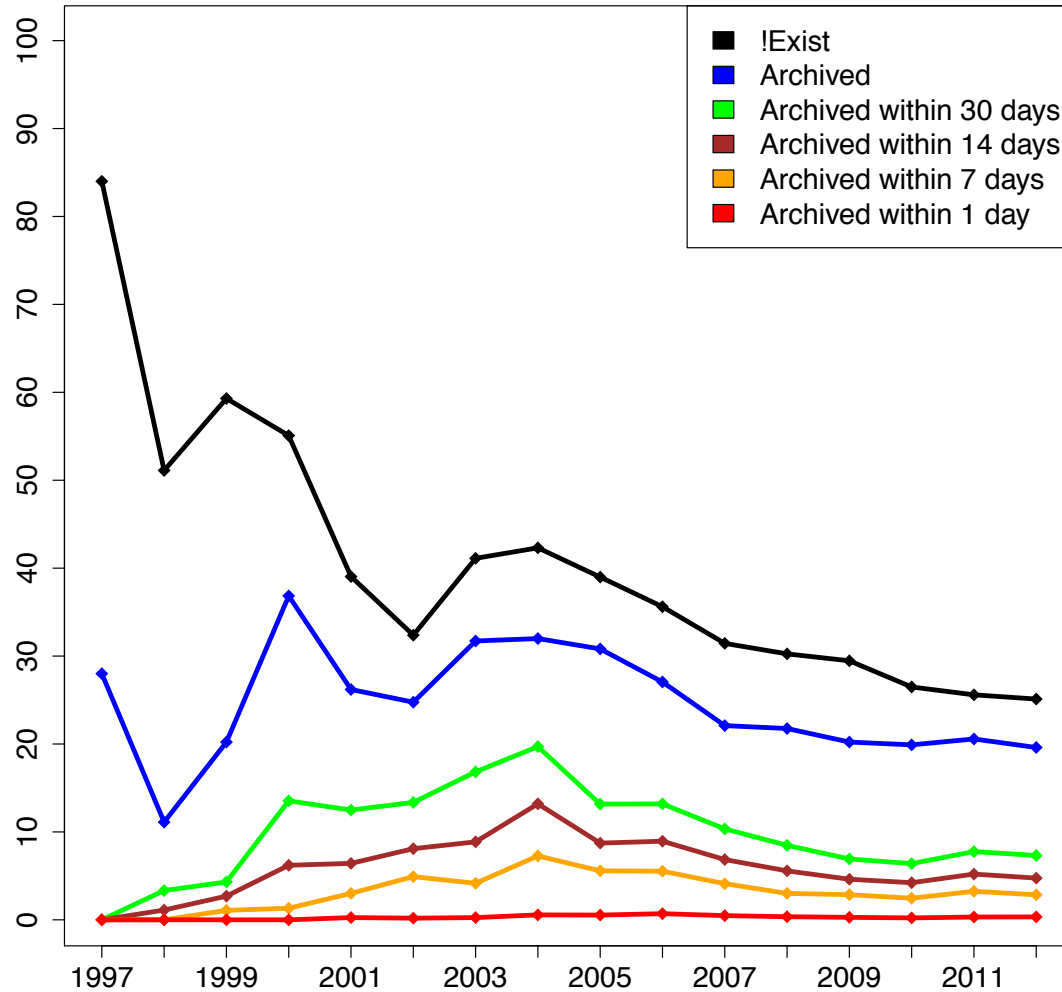


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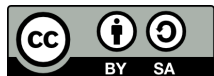
Percentage of !Exists, Archived per Year



URIs extracted from PubMed papers – links to Web at Large resources



Solving Reference Rot



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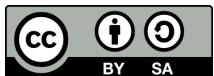
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Link Rot	DOI, HTTP version of DOI	
Content Decay	Fixity of content	-
	Archiving: CLoCKSS, LoCKSS, Portico, Keepers Registry, ...	

Addressing Content Decay

- Aim for a more pro-active approach to collect snapshots of web resources (likely to be) referenced in scholarly communication
- A system that hosts resources that are likely to be referenced in scholarly communication can create snapshots of itself by:
 - Using CMS, wikis, datawikis with solid versioning mechanisms
 - Subscribing to on-demand self web archiving service
 - Using transactional web archives, cf. SiteStory
- Referenced resources can be web archived on-demand:
 - By authors during note taking, authoring
 - By platforms involved in the publication process, e.g. archiving linked resources at the time of manuscript submission



References in Web-Based Scholarly Communication

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	Archiving: CLoCKSS, LoCKSS, Portico, Keepers Registry, ...	Web archiving Content Versioning Systems Self archiving

The New York Times

Politics

Search All NYTimes.com



It's investing.
streamlined.

Stay on top of your bank and
retirement accounts with one login

Bank with Bank of America.
Invest with Merrill Edge.

Learn more

Investment products:

Are Not FDIC Insured

Are Not Bank Guaranteed

May Lose Value

SIDEBAR

In Supreme Court Opinions, Web Links to Nowhere

By ADAM LIPTAK

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Enlarge This Image



This can sometimes be amusing. A link in [a 2011 Supreme Court opinion](#) about violent video games by Justice Samuel A. Alito Jr. now leads to [a mischievous error message](#).

“Aren’t you glad you didn’t cite to this

FACEBOOK

TWITTER

GOOGLE+

SAVE

E-MAIL

SHARE

PRINT

REPRINTS

MOST E-MAILED

RECOMMENDED FOR YOU

1. BITS
Disruptions: If It Looks Like a Bubble and Floats Like a Bubble ...
2. The Chatter for Sunday, Nov. 24
3. Founder of Reddit and the Internet's Own Cheerleader
4. BITS
Corporate Incubators Popping Up in Europe
5. BITS
An Untick in the Hiring of Women for

Click link to blog post

<http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/>



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THE FUTURE OF THE INTERNET

AND HOW TO STOP IT

JONATHAN ZITTRAIN

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Perma: Scoping and addressing the problem of “link rot”

September 22nd, 2013 | by z | Published in [Future of the Internet](#) | [23 Comments](#)

Kendra Albert, Larry Lessig and I are finishing up a [study](#) of link rot, available at <http://papers.ssrn.com/abstract=2329161>. Link rot is the phenomenon by which material we link to on the distributed Web vanishes or changes beyond recognition over time. (Wiki discusses link rot [here](#).) This is a particular problem for academic scholarship, which is increasingly linking out to the Web rather than more formal, library-curated sources. That kind of linking makes clear sense, but having materials easily accessible right until they vanish means that academic work (government documents, such as judicial opinions) can end up

Blog

• **New Harvard Law School
Manager Positions for In
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The HLS Library, in conj
[Berkman Center for Inter](#)
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positions. The newly pos
(LT) [Project Manager](#) will**

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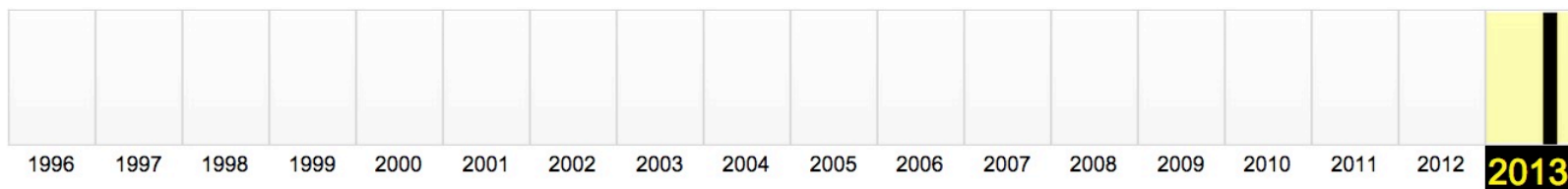


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20	21	22	23	24	25	26	17	18	19	20	21	22	23	17	18	19	20	21	22	23	21	22	23	24	25	26	27
27	28	29	30	31			24	25	26	27	28			24	25	26	27	28	29	30	28	29	30				

Search and find Mementos in Internet Archive for
<http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/>



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CNI Fall 2013, Washington, DC, December 9 2013



http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/

search

search examples:

- blogs.law.harvard.edu for all snapshots from the host
- *.law.harvard.edu for list of subdomains
- <http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/> for exact url
- http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/* for url prefix

Oldest shot

Newest shot

List of URLs, ordered from newer to older



24 Nov 2013 22:17

<http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/>

Search and find a Memento in archive.is for
<http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/>

www.nytimes.com/2013/09/24/us/politics/in-supreme-court-opinions-clicks-that-lead-nowhere.html

date each site was last visited, and its clerk keeps a hard copy of those materials. In an interview, Ms. Liebler said the court should do more.







“It’s a half measure to put a piece of paper in a court file,” she said. “This is the Supreme Court, and it’s their responsibility to make these things available.”


The United States Court of Appeals for the Ninth Circuit, in San Francisco, could serve as a model. It maintains an [electronic archive](#) of what it calls “webcites” in the PDF format.

Professor Zittrain and his colleagues are at work on a more ambitious solution, [Perma.cc](#), a platform built and run by a consortium of law libraries. It allows writers and editors to capture and fix transient information on the Web with [a new, permanent link](#).

The project is initially focused on legal scholarship. And there is no reason, Professor Zittrain said, why it could not also work for the Supreme Court.

A version of this article appears in print on September 24, 2013, on page A13 of the New York edition with the headline: In Supreme Court Opinions, Web Links to Nowhere.

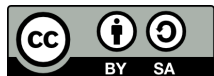
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Click `perma.cc` link to Memento of blog post
`http://perma.cc/0Hg62eLdZ3T`



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THE FUTURE OF THE INTERNET AND HOW TO STOP IT JONATHAN ZITTRAIN

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Perma: Scoping and addressing the problem of "link rot"

September 22nd, 2013 | by z | Published in *Future of the Internet* | 23 Comments

Kendra Albert, Larry Lessig and I are finishing up a [study](#) of link rot, available at <http://papers.ssrn.com/abstract=2329161>. Link rot is the phenomenon by which material we link to on the distributed Web vanishes or changes beyond recognition over time. (Wiki discusses link rot [here](#).) This is a particular problem for academic scholarship, which is increasingly linking out to the Web rather than more formal, library-curated sources. That kind of linking makes clear sense, but having materials easily accessible right until they vanish means that academic work (government documents, such as judicial opinions) can end up with sources that can't be checked or followed up upon by readers.

We found that half of the links in all Supreme Court opinions no longer work. And more than 70% of the links in such journals as the Harvard Law Review (in that case measured from 1999 to 2012), currently don't work. As time passes, the number of non-working links increases.

Our work builds on other great link rot studies such as that by Raizel Liebler and June Liebert in the Yale Journal of Law and Technology, available [here](#) (PDF).

In response, the [Harvard Library Innovation Lab](#) has pioneered a project to unite libraries so that link rot can be mitigated. We are joined by about [thirty law libraries around the world](#) to start [Perma.cc](#), which will allow those libraries on direction of authors and journal editors to store permanent caches of otherwise ephemeral links. Libraries are the ideal partners for this task: they think on a long timescale; they take user trust and service seriously; and they are non-commercial. You can see more about the system at [perma.cc](#). The amazing [Internet Archive](#) has lent its archiving engine to the effort, and [Instapaper](#) has generously provided an alternative path to parse Web pages to be saved. [CloudFlare](#) has kindly ensured that the the system at

Blog

■ **New Harvard Law School Library Project Manager Positions for Innovative Projects w/the Berkman Center for Internet & Society**
 The HLS Library, in conjunction with the [Berkman Center for Internet & Society](#), is pleased to announce two new project manager positions. The newly posted [Library Technology \(LT\) Project Manager](#) will be responsible for design, implementation, and management of special and ongoing projects across the HLS Library. The recently posted [Academic Technology \(AT\) Project Manager](#) will be based in the [Teaching, Learning and Curriculum](#) team at the HLS library and coordinate and promote new technologies and digital solutions for legal classrooms. Both project managers will take part in Berkman Center Geek Hours, learn the latest project management practices and tools, participate in brainstorming sessions and give feedback for Berkman developers working to create a new generation of academic digital

Built & Run by Libraries

Receive Memento from perma.cc
<http://perma.cc/0Hg62eLdZ3T>



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<http://perma.cc/0Hg62eLdZ3T>

Latest

Show All

Hrm.

Wayback Machine doesn't have that page archived.

Search and do not find Mementos in Internet Archive for
<http://perma.cc/0Hg62eLdZ3T>

search examples:

- [perma.cc](#) for all snapshots from the host
- [*.perma.cc](#) for list of subdomains
- <http://perma.cc/0Hg62eLdZ3T> for exact url
- http://perma.cc/0Hg62eLdZ3T* for url prefix

No results

Search and do not find Mementos in archive.is for
`http://perma.cc/0Hg62eLdZ3T`

What Happened?

- Good news: The number of archived copies of the blog post was increased by pro-actively creating a Memento in perma.cc
- Bad news: The possibility of finding Mementos for the blog post in other web archives was undermined by **replacing** the Original URI-R with the Memento URI-M
 - The Memento URI-M is a key in only one archive
 - The Original URI-R is a key in all web archives
- Using the Memento URI-M in a link requires the permanent existence/uptime of the archive that issued it
- **One link rot problem was replaced by another ...**

Web Archives Less Permanent than Permanent?

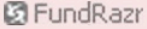
← → ↻ www.webcitation.org

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WebCite will stop accepting new submissions end of 2013, unless we reach our fundraising goals to modernize and expand this service.

Please support our crowdfunding campaign. If you are interested in keeping this service alive, please give generously - or at least share our campaign on Facebook. Funders supporting us with \$250 or more will be acknowledged by name on our redesigned website.

<http://fnd.us/c/aQMp7>

The Problem

Authors increasingly cite webpages and other digital objects on the Internet, which can "disappear" overnight. In one study published in the journal *Science*, 13% of Internet references in scholarly articles were inactive after only 27 months. Another problem is that cited webpages may change, so that readers

<http://webcitation.org>



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Web Archives Less Permanent than Permanent?

ws-dl.blogspot.com/2013/11/2013-11-21-conservative-party-speeches.html

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Web Science and Digital Libraries Research Group

Research and Teaching Updates from the Web Science and Digital Libraries Research Group at Old Dominion University.

Thursday, November 21, 2013

2013-11-21: The Conservative Party Speeches and Why We Need Multiple Web Archives



Michael L. Nelson
@phonedude_mln

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11:43 AM - 13 Nov 2013

3 RETWEETS

Web Science and Digital Libraries

This blog is used to communicate research and education updates from the Web Science and Digital Libraries Research Group at Old Dominion University.

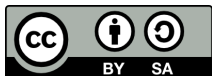
Please see the web page of Michael L. Nelson for more information:
<http://www.cs.odu.edu/~mln/>

Contributors

[Fany SalahEldeen](#)

[Sawood Alam](#)

<http://ws-dl.blogspot.com/2013/11/2013-11-21-conservative-party-speeches.html>



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Web Archives Less Permanent than Permanent?

← → ↻ richmondsfblog.com/2013/11/06/part-of-internet-archive-building-badly-burned-in-early-morning-fire/ ☆ ☁ ⓘ ☰

richmondsfblog.com

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Nov-6-2013

Part of Internet Archive building badly burned in early morning fire

At about 3:45am this morning, SEED responded to a fire at the Internet Archive at 1100 Clement between 12th Avenue

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RECENT POSTS

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- It's time for the Stanford v. Cal Big Game, played at 7th & Lake in 1902, 1903
- Police Blotter – November 22, 2013
- Photos: Paul's Hot Works opens a second location in Louisville, Kentucky
- Photo: Stow Lake at dawn
- "Another Hole in the Head" indie horror fest at the Balboa, Nov. 29 – Dec. 5
- History minute video: The back story on the 9th Avenue parking lot
- "Clementine Microhood"

<http://richmondsfblog.com/2013/11/06/part-of-internet-archive-building-badly-burned-in-early-morning-fire/>



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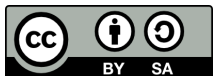
What To Do?

- Need an approach for referencing archived resources that supports lookups in many web archives, not just one
- Since the Original URI-R is a key in all web archives, the linking approach needs to necessarily include it
- Hence, two URIs are required:
 - The Original URI-R
 - The Memento URI-M, e.g. the perma.cc URI
- But a link in HTML only carries one URI!
 - It is understandable that the Memento URI-M is used for the link: the approach works with existing web infrastructure
 - Yet, an approach to address link rot that itself is subject to link rot is ... err... problematic

The Missing Link Proposal

- Extend the link to the Original URI-R with temporal context:
 - Memento URI-M in a specific archive
 - Dates:
 - date of page that contains the link
 - date of the link, cf. “accessed at” in citations of web resources
- Provide the Original URI-R and the temporal context in a machine-actionable manner so it can be used by user and machine agents to retrieve Mementos from various web archives

<http://mementoweb.org/missing-link/>

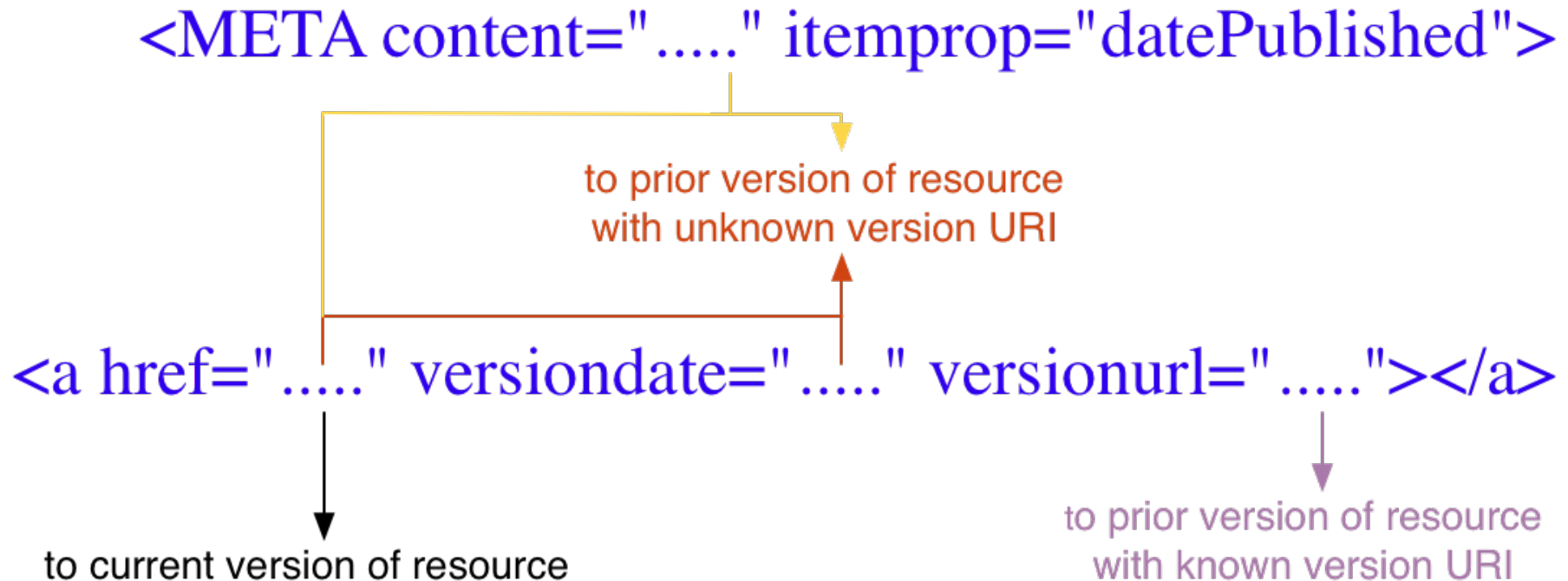


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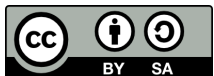


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The Missing Link Proposal



<http://mementoweb.org/missing-link/>



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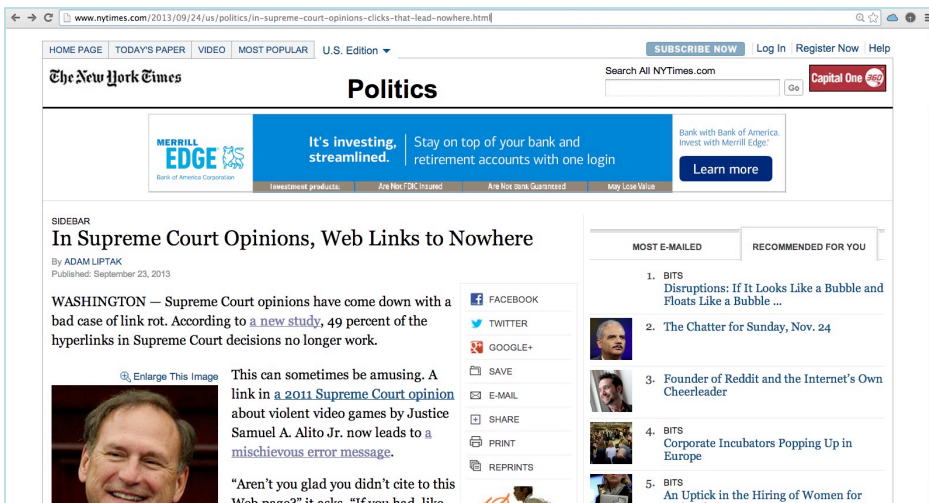
How to Make Missing Link Happen?

- The existing approach works out of the box but is problematic
- Missing Link requires infrastructure changes but generally contributes to increased web persistence:
 - HTML
 - META for page date: no problem, already in use
 - Attributes for <a> to convey URI-M and link date:
 - data- extensibility mechanism in HTML5 can be used but is not intended for cross-site applications
 - In 1995, HTML had the URN attribute for <a> as a means to address web persistence concerns
 - Browser, tool support

References in Web-Based Scholarly Communication

	To Scholarly Resources	To Web at Large Resources
Link Rot	DOI, HTTP version of DOI	Missing Link proposal
Content Decay	Fixity of content	-
	Archiving: CLoCKSS, LoCKSS, Portico, Keepers Registry, ...	Web archiving Content Versioning Systems Self archiving

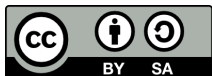
Demo: Application Using Temporal Context for Links



The screenshot shows the New York Times website with the Politics section selected. The main article is titled "In Supreme Court Opinions, Web Links to Nowhere" by Adam Liptak, published on September 23, 2013. The article discusses the problem of link rot in Supreme Court opinions, citing a study that found 49 percent of hyperlinks in such decisions no longer work. A sidebar on the right lists "MOST E-MAILED" and "RECOMMENDED FOR YOU" articles. The article text includes a quote from Justice Samuel A. Alito Jr. about a "mischievous error message" and a link to a 2011 Supreme Court opinion.



The screenshot shows the website "THE FUTURE OF THE INTERNET AND HOW TO STOP IT" by Jonathan Zittrain. The main article is titled "Perma: Scoping and addressing the problem of 'link rot'" and is dated September 22nd, 2013. The article discusses the problem of link rot and the need for a permanent archive. A sidebar on the right lists "Blog" entries, including "New Harvard Law School Library Project Manager Positions for Innovative Projects" and "Berkman Center for Internet & Society".



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Investigating Reference Rot in Web-Based Scholarly Communication

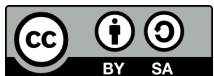
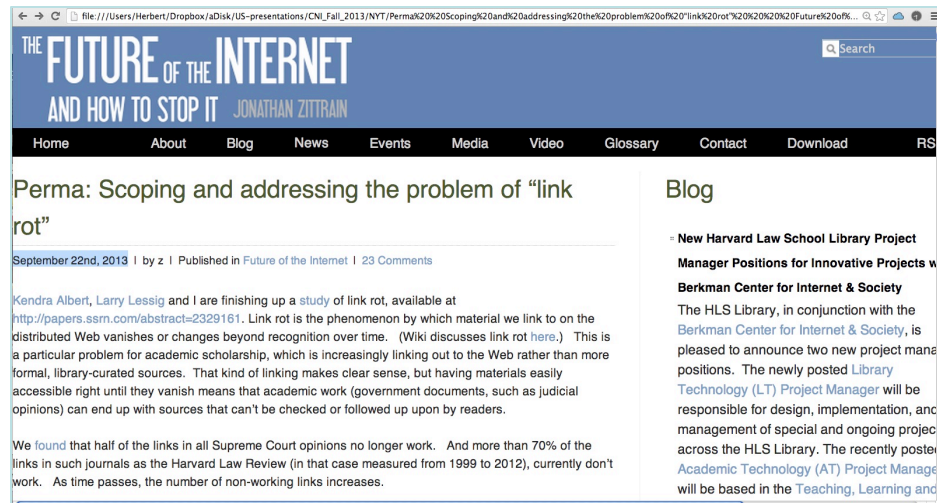
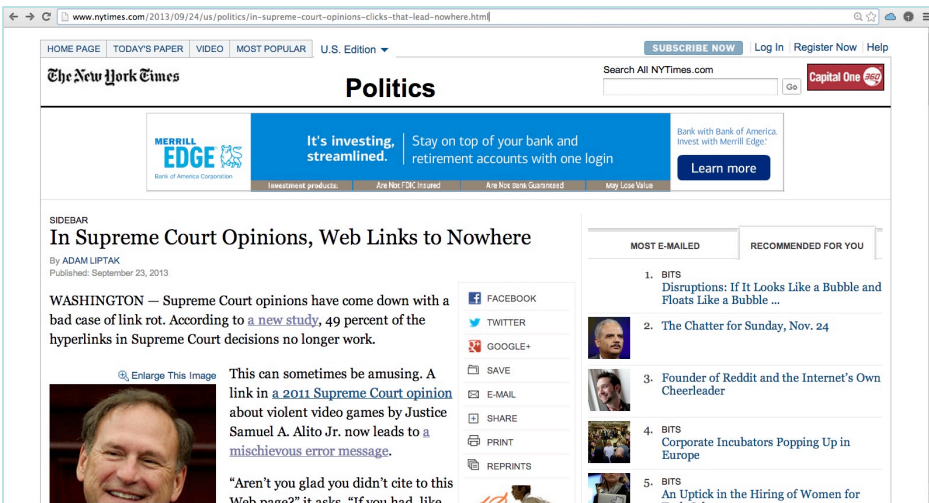
Herbert Van de Sompel
Los Alamos National Laboratory
@hvdcomp

Martin Klein
Los Alamos National Laboratory
@mart1nkle1n

<http://hiberlink.org> #hiberlink
<http://mementoweb.org> #memento

Hiberlink is funded by the Andrew W. Mellon Foundation

Demo: Application Using Temporal Context for Links



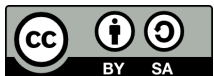
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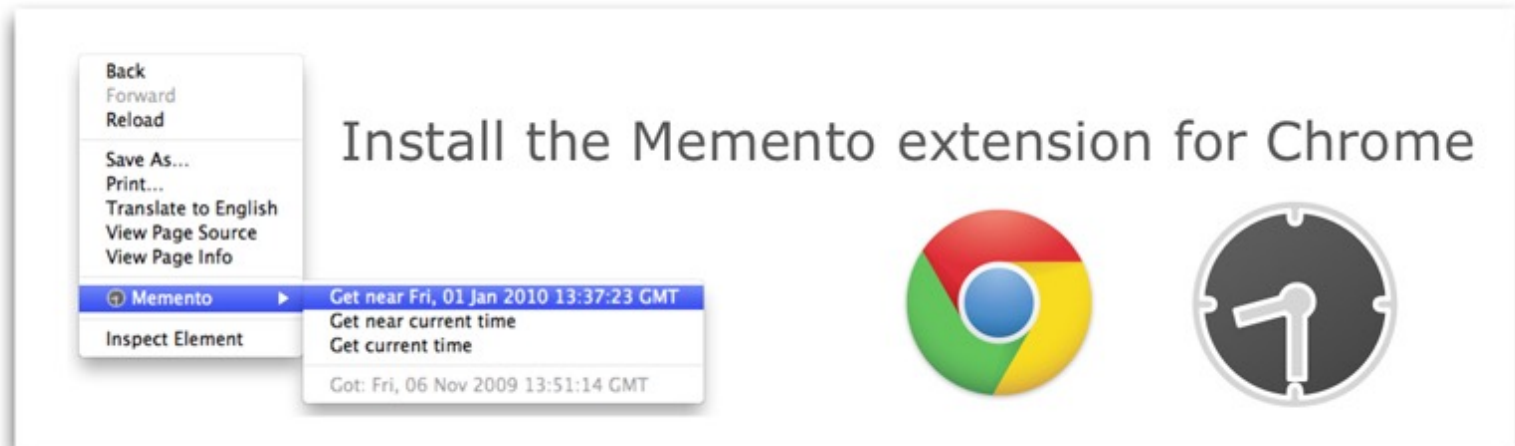
- Memento for Chrome is an application that uses Original URI-R and dates to access Mementos in various web archives
 - Memento around the date selected in user interface calendar
 - Most recently archived Memento



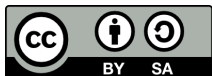
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Memento Time Travel for Chrome



<http://bit.ly/memento-for-chrome>

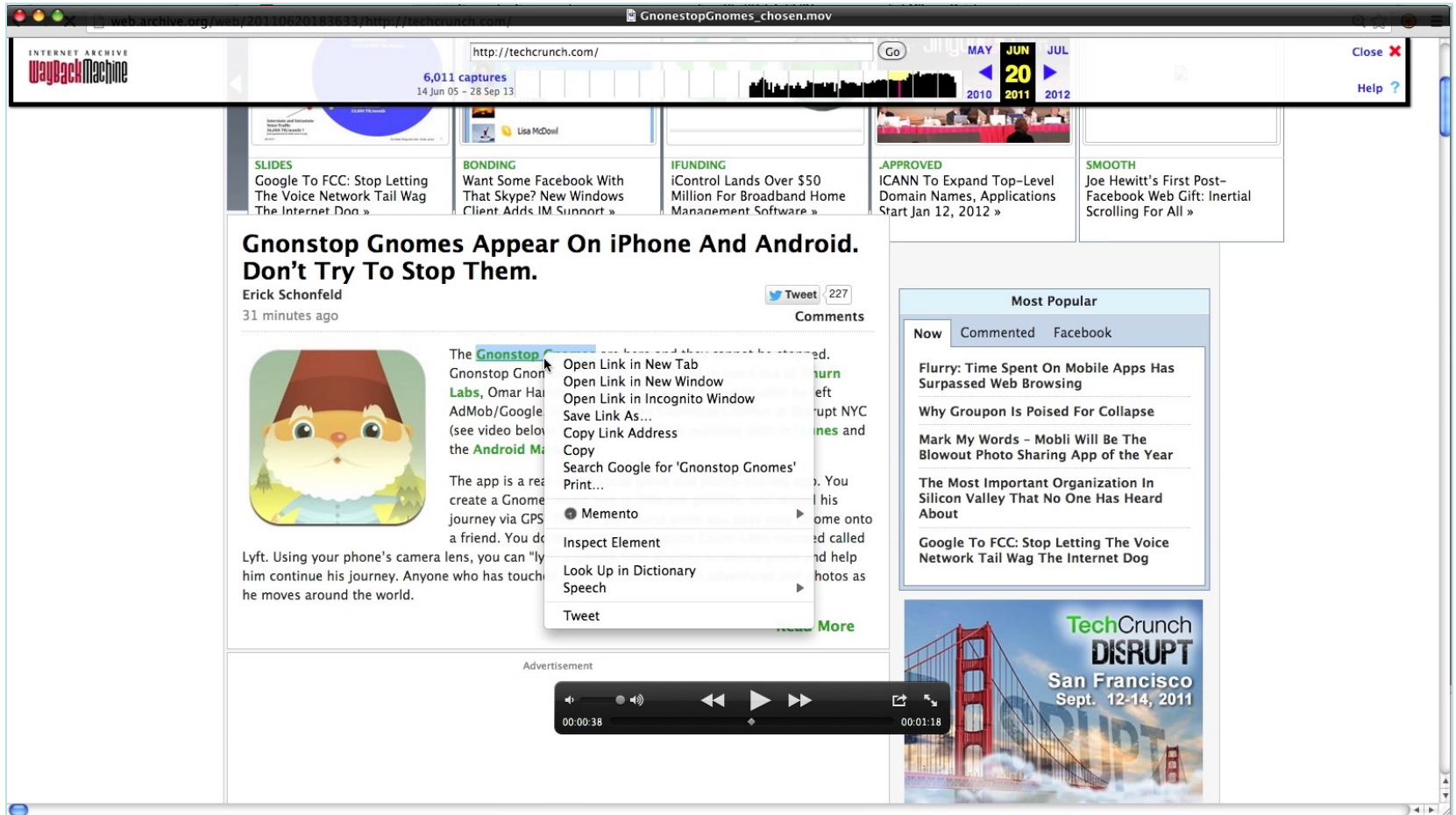


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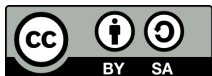
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Memento Time Travel for Chrome



http://www.youtube.com/watch?v=0_70IQPOOIg

<http://www.youtube.com/watch?v=WtZHKeFwjzk>



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Application Using Temporal Context for Links

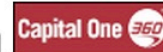
- An experimental version of Memento for Chrome also uses Missing Link information (Original URI-R, URI-M, and dates) to access Mementos in various web archives:
 - Memento around the date selected in user interface calendar
 - Most recently archived Memento
 - Memento around the date of the page that contains the link
 - Memento around the date of the link
 - Memento URI-M in a specific archive
- A Memento client is just one example of an application that can use temporal context provided for links. Other applications, including search engines, can use it too

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In Supreme Court Opinions, Web Links to Nowhere

By ADAM LIPTAK

Published: September 23, 2013

NYT has <META itemprop="datePublished" content="2013-09-23">

WASHINGTON — Supreme Court opinions have come down with a bad case of link rot. According to [a new study](#), 49 percent of the hyperlinks in Supreme Court decisions no longer work.

Enlarge This Image



This can sometimes be amusing. A link in [a 2011 Supreme Court opinion](#) about violent video games by Justice Samuel A. Alito Jr. now leads to [a mischievous error message](#).

"Aren't you glad you didn't cite to this Web page?" it asks. "If you had, like

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Disruptions: If It Looks Like a Bubble and Floats Like a Bubble ...

2. The Chatter for Sunday, Nov. 24

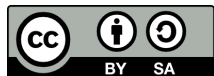
3. Founder of Reddit and the Internet's Own Cheerleader

4. BITS Corporate Incubators Popping Up in Europe

5. BITS An Uptick in the Hiring of Women for

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WASHINGTON — Supreme Court opinions have come down with a bad case of link rot. According to a new study, about 10 percent of the hyperlinks in Supreme Court decisions no longer work.

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This can so link in a 20 about violer Samuel A. A mischievous

"Aren't you

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Open Link in Incognito Window
Save Link As...
Copy Link Address
Copy
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Get near current time

Get at current time

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September 22nd, 2013 | by z | Published in [Future of the Internet](#) | [23 Comments](#)

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Blog

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Receive Memento from archive.is, Nov 24 2013

<http://archive.is/20131124221749/http://blogs.law.harvard.edu/futureoftheinternet/2013/09/22/perma/>



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CNI Fall 2013, Washington, DC, December 9 2013

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Perma: Scoping and addressing the problem of "link rot"

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September 22nd, 2013 | by z | Published in [Future of the Internet](#) | 3 Comments

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• The generativity of programming languages:

Why "open source" is about expressive power

[I feature this thoughtful contribution from Leonid Grinberg, who's been working with me this summer at the Berkman Center.]

In his famous dystopian novel *Nineteen Eighty-Four*, George Orwell conceived "Newspeak," a language specifically constructed to make it impossible to express any thoughts that are contrary to the interests of the state. One can think of this as a totalitarian application of the strong [Sapir-Whorf Hypothesis](#), which posits that language can determine thought: "Every concept that can ever be needed, will be expressed by exactly one word, with its meaning rigidly defined and all its subsidiary meanings rubbed out and forgotten." (*Nineteen Eighty-Four*, chapter 5)

Natural languages are nothing like Newspeak — not

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SIDEBAR

In Supreme Court Opinions, Web Links to Nowhere






By **ADAM LIPTAK**
Published: September 23, 2013

WASHINGTON — Supreme Court opinions have come down with a bad case of link rot. According to [a new study](#), 10 percent of the hyperlinks in Supreme Court decisions no longer work.

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This can sometimes be a problem. In a 2011 opinion about violence, Justice Samuel A. Alito wrote, “Aren’t you going to Web page?” it asks. “If you had like

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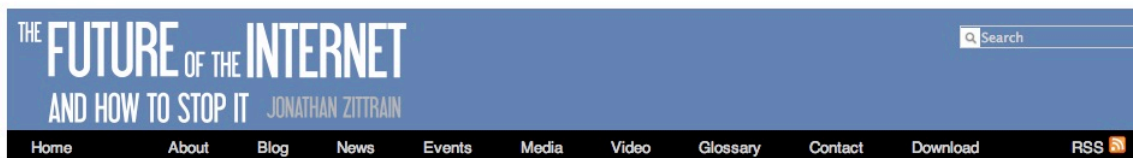
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www.nytimes.com/2013/09/24/us/politics/in-supreme-court-opinions-clicks-that-lead-nowhere.html

date each site was last visited, and its clerk keeps a hard copy of those materials. In an interview, Ms. Liebler said the court should do more.







“It’s a half measure to put a piece of paper in a court file,” she said. “This is the Supreme Court, and it’s their responsibility to make these things available.”


The United States Court of Appeals for the Ninth Circuit, in San Francisco, could serve as a model. It maintains an [electronic archive](#) of what it calls “webcites” in the PDF format.

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The project is initially focused on legal scholarship. And there is no reason, Professor Zittrain said, why it could not also work for the Supreme Court.

A version of this article appears in print on September 24, 2013, on page A13 of the New York edition with the headline: In Supreme Court Opinions, Web Links to Nowhere.

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For broken links in Wikipedia, see [Wikipedia:Linkrot](#), [Wikipedia:Using the Wayback Machine](#), and [Special:BrokenRedirects](#).

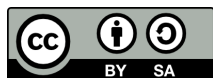
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9. ^ "Peeep.us". Peeep.us. 2009-09-30. Retrieved 2013-10-07.
10. ^ "Remember everything with Evernote, Skitch and our other great apps". Evernote. Retrieved 2013-10-07.
11. ^ "Internet Archive: Digital Library of Free Books, Movies, Music & Wayback Machine". Archive.org. 2001-03-10. Retrieved 2013-10-07.

External links [edit]

- [Future-Proofing Your URIs](#)
- [Jakob Nielsen](#), "Fighting Linkrot", *Jakob Nielsen's Alertbox*, June 14, 1998.
- [Warrick](#) - a tool for recovering lost websites from the [Internet Archive](#) and search engine caches
- [UndeadLinks.com](#) - user-contributed databases of moved URLs
- [W3C Link Checker](#)
- [mod_brokenlink](#) - [Apache](#) module that reports broken links.
- [Perma.cc](#) - Perma.cc archives a copy of the referenced content, and generates a link to an unalterable hosted instance of the site.



The Wikibook *Authoring Webpages* has a page on the topic of: ***Preventing link rot***

Categories: [Uniform resource locator](#) | [Data quality](#)

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Shows Perma.cc link, added October 22 2013, a month after the blog post

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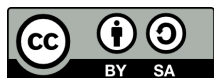
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7. ^ "DeadURL.com"  Retrieved 2011-03-17. "Just type deadurl.com/ in front of a link that doesn't work, and hit Enter."
8. ^ 404-Error ? :: Add-ons for Firefox 
9. ^ peeeep.us 
10. ^ evernote.com 
11. ^ archive.org 

External links

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Perma's founding partners are:

• Pence Law Library, Washington College of Law, American University

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"With the library collaborating on projects with the Berkman Center, we have opportunities for breakthrough innovation we might not be able to reach separately. The Library Technology Project Manager will work with Berkman developers and project managers to move ideas to execution and back again in a virtuous cycle."

Link in blog was:

```
<a href="http://librarylab.law.harvard.edu">
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<a href="http://librarylab.law.harvard.edu" data-versiondate="2010-09-22">
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"With the library collaborating on projects with the Berkman Center, we have opportunities for breakthrough innovation we might not be able to reach separately. The Library Technology Project Manager will work with Berkman developers and project managers to move ideas to execution and back again in a virtuous cycle."

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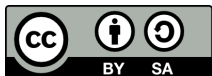


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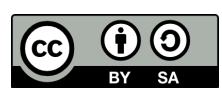
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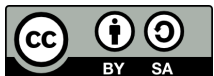


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The Harvard Library Innovation Laboratory

at the Harvard Law School

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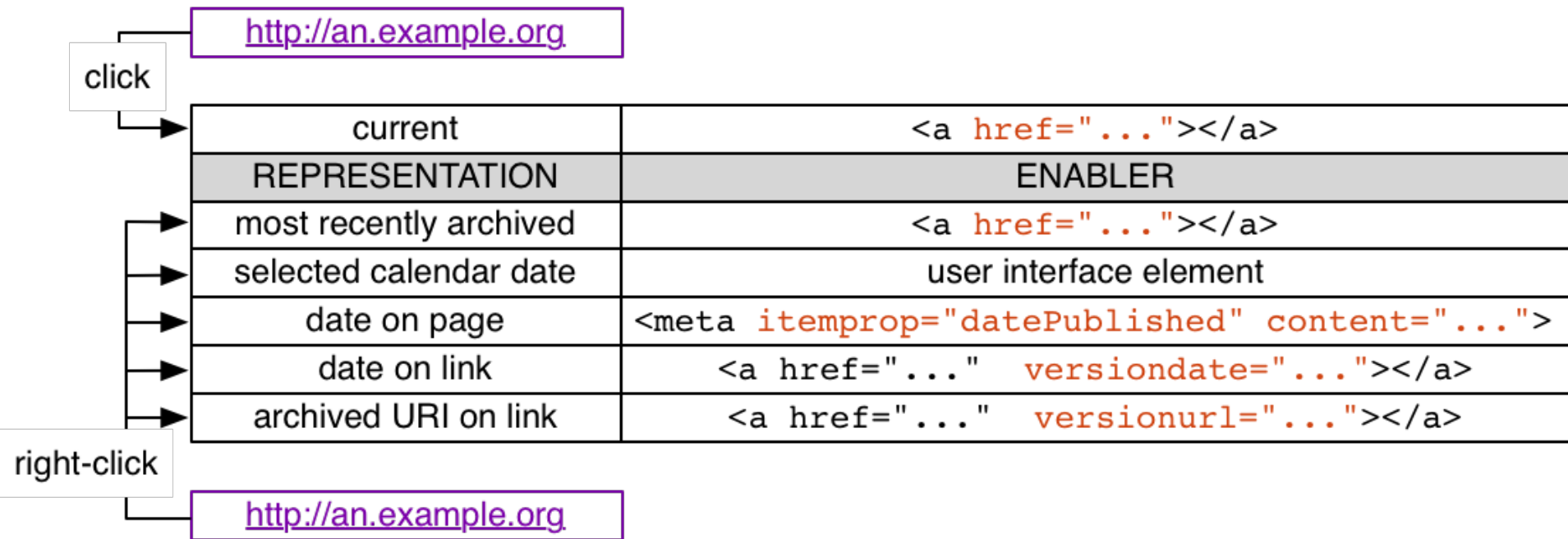


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