Persistent URIs Must Be Used To Be Persistent

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ABSTRACT

We quantify the extent to which references to papers in scholarly literature use persistent HTTP URIs that leverage the Digital Object Identifier infrastructure. We find a significant number of references that do not, speculate why authors would use brittle URIs when persistent ones are available, and propose an approach to alleviate the problem.

Keywords

Digital Object Identifier, Scholarly Communication, URI References

1. INTRODUCTION AND MOTIVATION

Motivated by a desire to achieve persistence when linking to web resources, various solutions have been introduced aimed at decoupling the identification and location of a web resource by means of HTTP URIs; a comprehensive overview is available from [1]. Solutions such as PURL, W3ID, identifiers.org, and DOI make use of a resolver infrastructure to achieve this goal. They use an **identifying HTTP URI** to persistently identify a web resource, and a **locating HTTP URI** for the resource's current web location. The custodian of a web resource maintains the correspondence between the identifying URI and the locating URI in the resolver's look-up table as the resource's location changes over time. When a client accesses the identifying URI, it is redirected to the locating URI.

This solution is attractive, especially when it is to be expected that the domain where a resource is located may change over time. This is, for example, the case with academic journals that move hands between publishers as acquisitions and mergers take place. The solution comes at a price because it requires operating a resolver infrastructure and maintaining the look-up table that powers it. But, as long as the identifying URI is used to link to a resource, the solution achieves its goal of link persistence.

In 2014, we conducted a large-scale study about reference rot[1] in web-based scholarly communication [2]. The focus of our study was on links to so-called **web-at-large** resources found in scholarly articles, that is, links to resources that are themselves not scholarly papers. Our intuition suggested that, in order to filter out links to scholarly articles, we only would have to remove links targeted at the DOI resolver, i.e. with baseURL `dx.doi.org`. After all, academic publishers started assigning DOIs to papers about two decades ago, and the practice has been the norm across disciplines for many years. However, when eyeballing the result of this DOI-based filtering, we were stunned to be left with many links with baseURLs that were clearly associated with academic publishers, for example `biomedcentral.com`, `sciencedirect.com`, and `link.springer.com`. To put it differently, we found a significant number of references to papers linked by their locating URI instead of their identifying URI. For these links, the persistence intended by the DOI persistent identifier infrastructure was not achieved. In this poster, we determine how widespread this problem is, we speculate on the origin of the problem, and propose a possible way to address it.

2. METHODOLOGY

For the aforementioned reference rot study, we collected more than 1.8 million papers published between 1997 and 2012, in three scholarly corpora: the entire arXiv.org preprint collection, a sizable sample of papers in Elsevier journals, and all papers submitted to PubMed Central. We extracted almost 4 million URI references using advanced regular expression techniques [3] from all sections of those papers including footnotes, tables, and references. We dismissed 1.7 million URI references because they were to license statements such as `creativecommons.org/licenses/` or to miscellaneous resources such as `127.0.0.1` and `www.example.org`. The data is available via [2].

For this poster, we take the remaining, approximate 2.2 million, URI references as a starting point, and use them to determine how commonly scholarly papers are referenced by means of their locating URIs instead of their persistent, DOI-based, identifying URIs. We observe that Elsevier papers hardly contain any DOI references, an artefact of the formatting of papers obtained via the CrossRef Text and Data Mining API[2]; DOI references are added on-the-fly by Elsevier's dissemination platform. This observation leads us

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[1] http://mementoweb.org/missing-link/
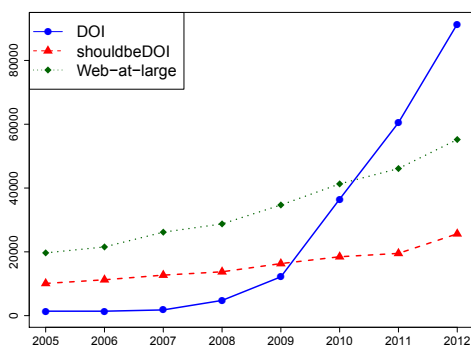[2] http://tdmsupport.crossref.org/
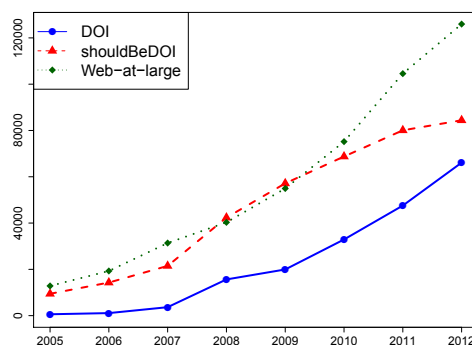
Figure 1: arXiv

Figure 2: PMC

to exclude the Elsevier corpus from this study. We proceed to categorize the remaining 1.6 million URI references from arXiv and PubMed Central as follows:

- **DOI** : Scholarly paper referenced by means of an identifying DOI-based URI - Selecting these references is trivial as they all have `dx.doi.org` as their baseURL.

- **shouldBeDOI**: Scholarly paper referenced by means of a locating URI - In order to select these references, we use a list of hash values of publisher baseURLs provided by CrossRef[3]. If the hash of a baseURL of an extracted reference matches a hash in CrossRef's list, a reference is added to this category.

- **web-at-large**: Web resource referenced – references that do not fall into the DOI nor the shouldBeDOI category.

3. RESULTS

Following the aforementioned methodology, we end up with $397,412$ DOI, $505,647$ shouldBeDOI, and $737,847$ web-at-large references. We depict the distribution of these references in function of the publication date of the referencing paper in Figure 1 for arXiv and Figure 2 for PubMed Central. DOI references are blue, shouldBeDOI red, and web-at-large green. The publication date on the x-axis ranges from 2005 to 2012.

In both figures, each category grows over time, consistent with the continuous growth of paper publications per year and the increased use of HTTP URI references [2]. In the arXiv corpus, shouldBeDOI grows slowly and steadily whereas DOI makes a sudden jump around 2009, possibly related to the provision of DOIs in downloadable references for Physics, Mathematics, and Statistics, which constitute the majority of this corpus. From 2009 onwards, DOI outnumbers shouldBeDOI but a significant number of shouldBeDOI references remain, for example, about $20,000$ in 2012. The pattern in PubMed Central is quite different. Growth for all categories kicks off in 2008, consistent with NIH submission mandates[4]. But, for all publication years, shouldBeDOI outnumbers DOI, and web-at-large tops both. An astonishing number of papers are referenced by means of their location

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[3] `http://labs.crossref.org/reverse-domain-lookup/`
[4] `http://sciencecommons.org/weblog/archives/2009/03/17/nih-mandate-made-permanent/`

URI instead of their DOI-based identifying URI, for example, about $80,000$ in 2012.

These results must be interpreted subject to two caveats. First, the list of hash values of publisher baseURLs is an approximation as it represents the current state of location URIs in the CrossRef resolver. As a result, some shouldbeDOI references may have been categorized as web-at-large because a location URI used years ago is no longer in use today. Second, lacking public information as to when publishers started assigning DOIs to papers, some references may have wrongly been categorized as shouldbeDOI because a publisher did not yet use DOIs prior to a certain publication date. However, given the widespread adoption of DOIs by scholarly publishers in recent years, we feel confident that our analysis is reliable for the depicted timeframe.

4. DISCUSSION AND CONCLUSIONS

We quantified the widespread use of location URIs instead of DOI-based identifying URIs for referencing papers in scholarly literature. We do not know why authors choose brittle links over persistent ones. But, being authors ourselves, we speculate that it has to do with the use of the location URI when bookmarking and creating entries in citation management tools. After all, the paper and associated information is available at the location URI, not the identifying URI. In order to alleviate this problem, we propose the use of a Link[5] header field in the HTTP response of the location URI that conveys a link pointing with an appropriate relation type - **canonical** comes to mind - to the identifying URI. Bookmarks and citation managers could use this Link information to record the identifying URI and make links that were intended to be persistent actually persistent.

5. REFERENCES

[1] R. Duerr and R. Downs et al. On the Utility of Identification Schemes for Digital Earth Science Data: An Assessment and Recommendations. *Earth Science Informatics*, 4(3):139–160, 2011.

[2] M. Klein and H. Van de Sompel et al. Scholarly Context Not Found: One in Five Articles Suffers from Reference Rot. *PLoS ONE*, 9(12), 2014.

[3] K. Zhou and C. Grover et al. No More 404s: Predicting Referenced Link Rot in Scholarly Articles for Pro-Active Archiving. In *Proceedings of JCDL '15*, pages 233–236, 2015.

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[5] `http://www.ietf.org/rfc/rfc5988.txt`