On influences between software standards and their implementations in open source projects: Experiences from RDFa and its implementation in Drupal

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ABSTRACT
It is widely acknowledged that standards implemented in open source software can reduce the risk for lock-in, improve interoperability, and promote competition on the market. However, there is limited knowledge concerning the relationship between standards and their implementations in open source software. This paper reports from an investigation of influences between software standards and open source software implementations of software standards. The study focuses on the RDFa standard and its implementation in the Drupal project. Specifically, issues in the W3C issue trackers for RDFa and the Drupal issue tracker for RDFa have been analysed. Findings show that there is clear evidence of reciprocal action between RDFa and its implementation in Drupal. The study contributes novel insights concerning effective processes for development and long-term maintenance of software standards and their implementations in open source projects.

Categories and Subject Descriptors
K.6.3 [Software Management]: Software development, K.1 [The Computer Industry]: standards

General Terms
Standardization

Keywords
Open source software, standards, RDFa, Drupal

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1. INTRODUCTION
Many organisations are currently restricted in their choice of software because of restrictions imposed by existing systems, which often results in a lack of interoperability and a risk of different types of lock-in. Use of open standards and open source software (OSS) implementations of standards is a means that can reduce the risk of lock-in, improve interoperability and also stimulate innovation [21, 34]. It is also widely acknowledged that there are challenges in implementing open standards [20, 28] and that standardisation has significant impact in the IT market and is subject to review within the digital agenda in the EU [19]. Open standards, especially when implemented in OSS, have the potential to address challenges such as promoting a healthy and competitive market, reducing the risk for organisations of being technologically locked-in, creating a basis for interoperability, and offering a basis for long-term access and reuse of digital assets [34].

OSS implementations of software standards have contributed significantly to the establishment of standards [1], and it has been stressed in that "the formal specification is inherently incomplete and the actual standard is defined both through the written specification and actual implementations" [27]. We also note that use of work practices involving issue tracking, which has a strong legacy from open source software development, has been adopted by major standardisation organisations including W3C, IETF, and OASIS. Hence, utilising OSS implementations and associated work practices is important for improved standardisation.

Earlier research has primarily focused on different aspects of IT standardisation (e.g. [30]) or alternatively open source software (e.g. [5]), but there is limited knowledge concerning the relationship between software standards and their implementations in open source software [20, 30]. A contributing reason for this may be that "OSS developers and standards people – do hardly share any common background" [30]. Further, development of interoperable software systems need to account for that many different standards are being provided and maintained in a complex ecosystem involving a "multi-vendor, multi-network, multi-service environment" [15].

This study considers how software standards and software implementations of such standards are related. The **overarching goal** of the study is to establish influences between software standards and their implementations in open source software. More specifically, our **objective** is to establish influences between the RDFa standard and its implementation in the Drupal project. Overall, the study has revealed several key findings. First, we find that there is clear evidence of reciprocal action between RDFa and its implementation in Drupal through contributors active in both Drupal and W3C. Second, we find that there is clear evidence of reciprocal action between RDFa and its implementation in Drupal through similarity between issues in the Drupal RDFa issue tracker and issues in the W3C RDFa issue tracker.

There are three novel contributions. First, we characterise issues concerning RDFa and its implementation in Drupal. Second, we establish direct influences between RDFa and its implementation in Drupal through contributors active in both Drupal and W3C. Third, we establish influences between RDFa and its implementation in Drupal through similarity between issues in the Drupal RDFa issue tracker and the W3C RDFa issue tracker.

RDFa was chosen since it constitutes a representative exemplar of a software standard that has been widely adopted in numerous open source licensed (as well as proprietary) software systems. Further, it has been shown that the RDFa (and the related MicroData) format has been widely deployed on the web [2]. The Drupal project was chosen since it constitutes a representative exemplar of an open source project that has been widely deployed in both commercial and public sector contexts [10, 14]. In fact, by October 2013 Drupal has recorded more than one million users in 228 countries speaking 181 languages [8]. Another motivation for focusing on RDFa and Drupal is to extend previous knowledge established in an earlier study that explored Drupal and its use of the software standards RDFa, CMIS and OpenID [25].

The rest of this paper is organised as follows. First, we provide a background to and position our exploration of RDFa and its implementation in Drupal in the broader context of previous research on standards and implementation of standards (section 2). We then clarify our research approach (section 3), and report on our results (section 4). Thereafter, we analyse our results (section 5) followed by conclusions (section 6).

2. BACKGROUND

2.1 RDFa

RDFa (Resource Description Framework in Attributes) is a standard model for interchange of data on the web by embedding of rich metadata within XML based web documents [50]. This is achieved through provision of attributes with associated syntax and processing rules for in-line embedding of RDF in XML-based web documents. Hence, RDFa is related to RDF, which became a W3C recommendation in 1999 [41]. RDFa originated from a W3C note [42], which in 2004 was integrated into a working draft of XHTML 2.0 [43]. Eventually RDFa 1.0 in XHTML became a W3C recommendation in 2008 [45]. RDFa Core 1.1 became a W3C recommendation in 2012 [46]. This version of RDFa was also compatible with HTML, which is described in a W3C working draft document [47]. A second edition of RDFa Core 1.1 was released in 2013 [50]. There is also the reduced RDFa lite specification, which contains a subset of the functionality in RDFa Core 1.1 [49]. The RDFa standard is licensed under royalty-free conditions [48], which allow implementation in GPL licensed OSS projects such as Drupal [20].

RDFa is governed by the W3C (World Wide Web Consortium), which is "an international community where Member organizations, a full-time staff, and the public work together to develop Web standards" [51]. Individuals and all types of organisations can become members (including commercial, educational, and governmental entities). Funding stems from membership fees, research grants and other types of public and private funding, sponsorship, and donations. There are some key components in the organisation of the standardisation process. One of these is the advisory committee, which has one representative from each W3C member and performs different kinds of reviews in the process of standardisation, and also elects an advisory board and the technical architecture group (which primarily works on web architecture development and documentation). Further, the W3C director and CEO assess consensus for decisions of W3C-wide impact. There is a also a set of charted groups (working groups, interest groups, and coordination groups) consisting of member representatives and invited experts, which assist in the creation of web standards, guidelines, and supporting materials.

RDFa 1.0 was initially progressed by the W3C SWD (Semantic Web Deployment) working group, whose mission was to provide "consensus-based guidance in the form of W3C Technical Reports on issues of practical RDF development and deployment practices in the areas of publishing vocabularies, OWL usage, and integrating RDF with HTML documents" [44]. The working group communicated through a public mailing list, bi-weekly telephone meetings, and face-to-face meetings. Minutes from meetings were made public, whereas the meetings were not for the public. The progression of RDFa was taken over by the W3C RDFa working group in 2010, whose mission is to "support the developing use of RDFa for embedding structured data in Web documents in general" [48]. This working group communicates primarily through a public mailing list and bi-weekly telephone meetings.

2.2 Drupal

Drupal is a content management platform written mainly in PHP, which is provided under the GPL v2 (or later) open source license [9]. It can be used to create “broschureware” style web sites as well as web sites involving blogs, forums and other forms of collaborative environments. In terms of developer efforts, there have, at time of writing (Apr. 2014), been 149 committers who have contributed 94012 commits over 1035319 lines of code to Drupal core [38]. The first commit to Drupal core was contributed in May 2000, and the most recent commit in Apr. 2014. There have been seven first level Drupal core releases in the interval Jan. 2001 through Jan. 2011 (v1-3 in 2001, v4 in 2002, v5 in 2007, v6 in 2008, and v7 in 2011). In fact, there have been more than 150 stable releases (evenly distributed in time) in total since v1.0 including second and third level releases. The latest release (v7.26) was made available on 15 Jan. 2014. Version 8 of Drupal core is currently still in its alpha release stage (Drupal 8.0-alpha10 was released on 19 Mar. 2014). There are also a number of modules for extended functionality which have separate developer communities and release schedules.

Drupal is supported by the Drupal Association, which “fosters and supports the Drupal software project, the community and its growth” [12]. This includes maintenance of Drupal related web

infrastructure, facilitation of community participation and contribution, protection of Drupal and its community through advocacy and legal work, organisation of Drupal related events, and promotion of Drupal. Funding is managed by memberships, donations and yield from conferences. Both individuals and organisations can join the Drupal Association for a certain fee. The Drupal association has a board of directors that is nominated and selected by the larger community [13]. Further, there is an international advisory board which assists and advices the board of directors and staff at the Drupal Association. There are monthly board meetings where everyone is invited to listen online. Further, there are currently six different board committees that advice the board in different matters.

The Drupal open source project is built by volunteers from all around the world. Community members can contribute to code in the Drupal core modules (or other associated modules), documentation, user support, marketing, testing, translations, and other activities. Community interaction is achieved through forum, mailing lists, and IRC. There are also various Drupal events during which community members can interact. Additionally, there are a number of specialised user groups that can be joined to further develop and discuss various aspects of Drupal. For developers, software configuration management is handled using Git. Extensive instructions are available on the Drupal website for how to contribute code by setting upp a development environment and use the issue tracker in order to prepare and submit software patches.

Support for RDFa (v1.0) was first incorporated into the core of Drupal 7 [7]. An update in the Drupal 7 core on 3 April 2013 resulted in the software being compatible with RDFa v1.1. RDFa is a separate module in Drupal core. Other separate Drupal core modules include implementations of OpenID, CMIS, PHP, REST, JSON, XML, and XML-RPC [11].

2.3 Previous research

There are studies involving RDFa (or RDF) that are not directly related to the research undertaken in our study. One kind of study involves investigation of web metadata deployment. For example, a quantitative study involving RDFa, MicroData and Microformats concerned the adoption and deployment of such formats at web sites [2]. Similar studies also involved other metadata formats [35, 36]. A different study reports on a query translation approach between RDF and XML applied in the educational domain [37].

There is research involving Drupal that is not directly related to the research undertaken in our study. For example, there are case studies on use of Drupal in library contexts [26, 29]. Another example is a comparative study between the CMS systems Drupal, Joomla and Wordpress with respect to different aspects [39]. A different study explored experiences from incorporating Drupal in an educational context [33]. Another example is a study reporting on an approach for analysis of coding practices in open source projects applied to CMS projects including Drupal [23].

There are studies involving both RDFa (or RDF) and Drupal, but which are not directly related to the research undertaken in our study. For example, Corlosquet et al. [4] presented the RDF CCK plugin for Drupal 6 which, at the time, simplified the use of RDFa and enabled “high-quality RDF output with minimal effort from site administrators”. This plug-in became obsolete with the release of Drupal 7, and the functionality was instead included in Drupal 7 core.

There is research related to the implementation of standards in software systems that include studies that address aspects of compliance and interoperability (e.g. [16, 17, 21]) and licensing conditions for standards and their implementations in open source [21, 27, 40]. However, there is a need for further research with a focus on specific standards and implementations of specifications of standards where the relationship between specifications of standards and associated implementations is explored. Of particular interest are implementations of software standards in open source software. In fact, the openness of standards and their implementations in open source software has been elaborated more than a decade ago [31] and the relationship between standards and their implementations in open source software continues to be an issue for ongoing discussion [3, 18 , 20, 21, 22, 32].

There are a few closely related studies. One of these explored Drupal and its use of the software standards RDFa, CMIS and OpenID [25]. However, this study did not consider the influences between software standards and their implementations. Further, results from another study on implementations of the PDF format indicate that standards can influence implementations of standards, implementations of standards can influence standards, and that implementations of standards can influence other implementations of standards [24]. Therefore, a more in-depth study of influences between the RDFa standard and its implementation in Drupal is motivated.

3. RESEARCH APPROACH

By conduction of a case study of the RDFa standard and its implementation in the Drupal project we investigated influences between software standards and their implementations in open source software.

First, to characterise issues concerning RDFa and its implementation in Drupal (section 4.1), we undertook a quantitative analysis of issue tracker data. In so doing, different metrics were used that consider: to what extent different contributors have been involved in raising issues, raising and closing of issues over time, and duration of issues. Second, to investigate direct influences between RDFa and its implementation in Drupal through contributors active in both Drupal and W3C (section 4.2), we undertook a combined qualitative and quantitative analysis of issue tracker data and mailing list data. Third, to investigate influences between RDFa and its implementation in Drupal through similarity between issues in the Drupal RDFa issue tracker and the W3C RDFa issue tracker (section 4.3), we undertook a combined qualitative and quantitative analysis of issue tracker data.

The issue tracker data for RDFa was collected from the W3C website for RDFa 1.0[1] and RDFa 1.1[2]. Complementary data was collected from the mailing list for the RDFa working group[3]. The data for the RDFa implementation in the Drupal project was collected from the Drupal website [9], where all issues for RDFa

[1] http://www.w3.org/2006/07/SWD/track/issues/

[2] https://www.w3.org/2010/02/rdfa/track/issues

[3] http://lists.w3.org/Archives/Public/public-rdfa-wg/

in Drupal core[4] (versions 6, 7, and 8) were used in the analysis from the date of the first issue posting until 30 Sep. 2013. A follow-up was done on the status of all issues on 20 Mar. 2014 in order to add closing dates for issues that were still open at the time of the initial data collection (Sep. 2013).

The issue data was collected semi-automatically and thereafter parsed and analysed using custom made scripts. More specifically, the timestamp for raising and closing, status, and contributor ID for all issue postings were recorded. In addition, all issues in the issue trackers for RDFa and the Drupal implementation of RDFa were manually inspected in order to identify influences. When identifying influences, each issue in the Drupal issue tracker was used as the starting point and was manually scanned for influences with each issue in the RDFa issue trackers. The RDFa mailing list was used as complementary data in a few cases (in section 4.2) where no influences were identified for any of the issues in the RDFa issue tracker.

4. RESULTS

4.1 RDFa issues in W3C and Drupal

In this section we report on issues concerning RDFa and its implementation in Drupal. At time of data collection (Sep. 2013) the W3C issue tracker for RDFa 1.0 contained 79 issues and the issue tracker for RDFa 1.1 contained 150 issues in total. The Drupal issue tracker for RDFa contained 101 issues (1 issue for Drupal 6, 48 issues for Drupal 7, and 52 issues for Drupal 8). Table 1 shows the number of contributors raising issues (column 2) and the number of issues (column 3) for different issue trackers (column 1) and the proportion of issues raised by the top contributor (column 4) and the top 3 contributors (column 5). It can be observed that a single or few contributors raise the vast majority of issues in RDFa. Issue raising in Drupal is distributed amongst more contributors, but still a single or few contributors raise a clear majority of the issues.

Table 1. Issue contribution statistics

Issue tracker	# raisers	# iss.	#iss. Top 1	#iss. Top 3
W3C RDFa 1.0	6	79	64 (81%)	74 (94%)
W3C RDFa 1.1	12	150	76 (51%)	118 (79%)
Drupal 7 RDFa	16	48	20 (42%)	35 (73%)
Drupal 8 RDFa	17	52	21 (40%)	32 (62%)

We have identified four contributors to issue trackers who are active in both Drupal RDFa and W3C RDFa. The maintainer of the RDFa module in Drupal (P1) is also active in the W3C RDFa working group. The chair of the W3C RDFa working group (P2) has also contributed posts in the Drupal issue tracker. The maintainer of the MicroData module in Drupal (P3) has also contributed to the development of the RDFa module in Drupal and contributed posts in the W3C RDFa issue tracker. A different individual (P4) has contributed to the W3C RDFa issue tracker and has also contributed to the RDFa module in Drupal. This observed dual involvement indicates potential for influence between the standardisation and implementation of RDFa.

In order to further characterise issues for W3C RDFa and Drupal RDFa, figure 1 shows the accumulated number of issues raised over time. It can be noticed that no new issues are raised for W3C RDFa 1.0 once the W3C RDFa 1.1 issue tracker is available. On the contrary, issues are raised in parallel for Drupal 7 RDFa and Drupal 8 RDFa, and the intensity of issue raising decreases over time for Drupal 7 RDFa while it increases over time for Drupal 8 RDFa. Drupal 6 RDFa is not included in the figure since its issue tracker only contains one issue which was raised on 2008-08-11 and closed on 2008-09-22.

At time of writing (Apr. 2014), not all issues have been closed for the different issue trackers. For W3C RDFa 1.0, 60 of the 79 issues have been closed whereas the remaining 19 issues have status "open", "postponed", or "pending". For W3C RDFa 1.1, 133 of the 150 issues are closed whereas the remaining 17 issues have status "postponed" or "raised". For Drupal 7 RDFa, 43 of the 48 issues have been closed whereas the remaining 5 issues have status "needs work", "postponed", or "active". For Drupal 8 RDFa, 39 of the 52 issues are closed whereas the remaining 13 issues have status "active", "needs review", "needs work", or "postponed". Figure 2 shows the accumulated number of closed issues over time.

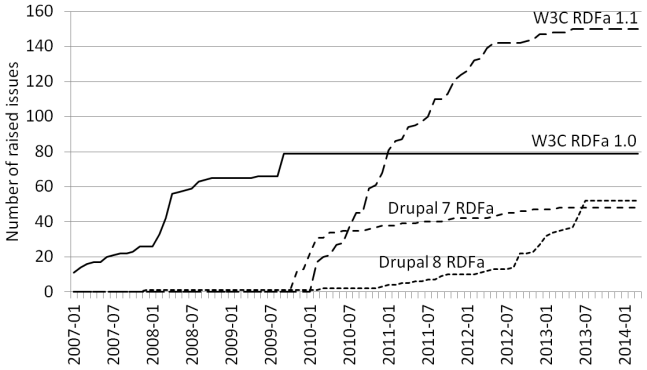

Figure 1. Accumulated number of issues raised in issue trackers

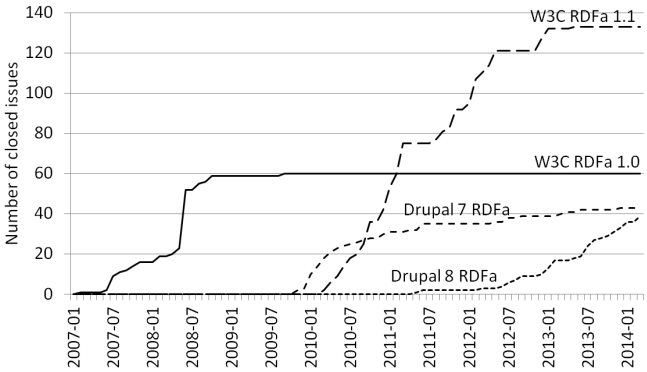

Figure 2. Accumulated number of issues closed in issue trackers

It can be observed that no further issues have been closed in W3C RDFa 1.0 since issues began to be closed in W3C RDFa 1.1. This indicates that the W3C RDFa 1.0 issue tracker was abandoned at the time of introducing RDFa 1.1, leaving a relatively large proportion of issues unresolved. Further, for W3C RDFa 1.0 and W3C RDFa 1.1 it can be observed that the number of closed issues at several points in time steeply increases, e.g. around 2008-05 for W3C RDFa 1.0 and 2011-01 for W3C RDFa 1.1. This behaviour is not observed for Drupal RDFa. In analogy with the raising of issues in Drupal RDFa in figure 1, the closing of issues is done in parallel for Drupal 7 RDFa and Drupal 8 RDFa, and the intensity of issue closing decreases over time for Drupal 7 RDFa while it increases over time for Drupal 8 RDFa, which

[4] https://drupal.org/project/issues/drupal

indicates a transition from working on Drupal 7 to working on Drupal 8.

To further explore the steep increases in number of closed issues for W3C RDFa and issue duration for W3C RDFa and Drupal RDFa, the duration of closed issues is illustrated for W3C RDFa 1.0 (figure 3) and W3C RDFa 1.1 (figure 4). It can be observed that there is a wide spread in terms of issue duration. Several issues only last for one day for both W3C RDFa 1.0 and W3C RDFa 1.1, whereas the longest issue has a duration of 465 days (W3C RDFa 1.0) and 711 days (W3C RDFa 1.1). The average duration is 113 days (W3C RDFa 1.0) and 105 days (W3C RDFa 1.1). We note that multiple issues are often raised at the same point in time for both W3C RDFa 1.0 (especially after approximately 450 days in figure 3) and W3C RDFa 1.1 (especially after approximately 250 days in figure 4). Further, it is evident that multiple issues are often closed at the same point in time for both W3C RDFa 1.0 (especially after approximately 500 days in figure 3) and W3C RDFa 1.1 (especially after approximately 400 days in figure 4). In fact, when inspecting the content of issues more closely we find indications that suggest a working practice where issues are resolved in batch at specific dates, typically in connection with concerted issue reviews.

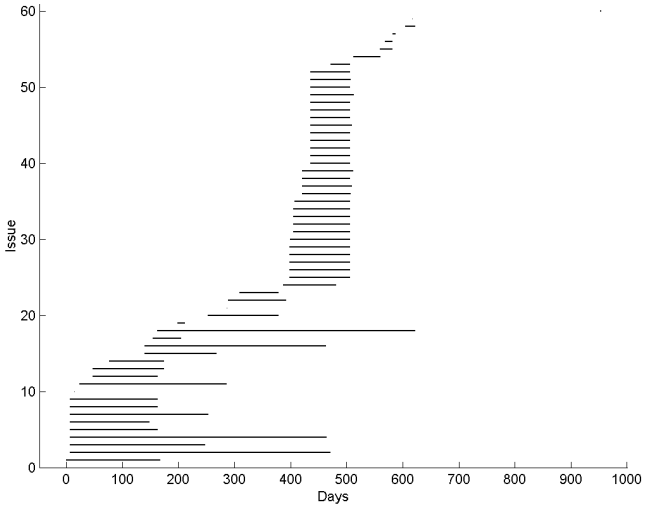

Figure 3. Duration of closed issues in W3C RDFa 1.0

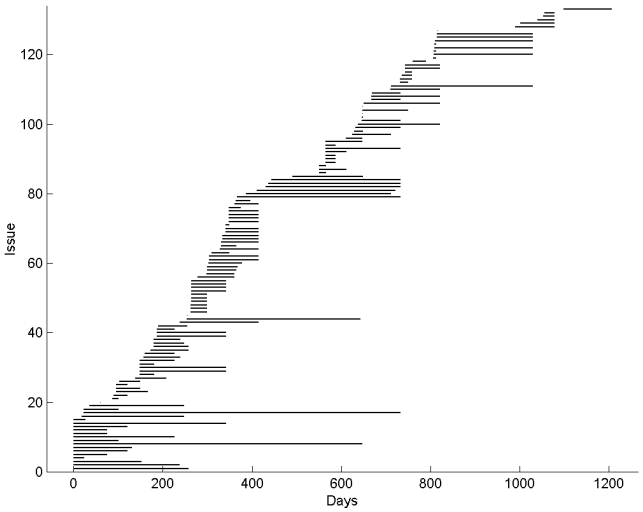

Figure 4. Duration of closed issues in W3C RDFa 1.1

In analogy with W3C RDFa, the duration of closed issues is illustrated for Drupal 7 RDFa (figure 5) and Drupal 8 RDFa (figure 6). Like for W3C RDFa, it can be observed that there is a wide spread in terms of issue duration. One or several issues only last for one day for Drupal 7 RDFa and Drupal 8 RDFa, whereas the longest issue has a duration of 1333 days (Drupal 7 RDFa) and 1673 days (Drupal 8 RDFa). The average duration is 170 days (Drupal 7 RDFa) and 270 days (Drupal 8 RDFa), which suggests that issues are more quickly resolved in W3C RDFa compared to Drupal RDFa. However, we acknowledge that the limited and different number of issues for W3C RDFa and Drupal RDFa does not allow for a reliable statistical comparison. Like for W3C RDFa, we note that multiple issues are raised at the same time in Drupal 8 RDFa (for example, after approximately 1750 days in figure 6). However, the practice of concerted closing of issues is not observed in Drupal RDFa.

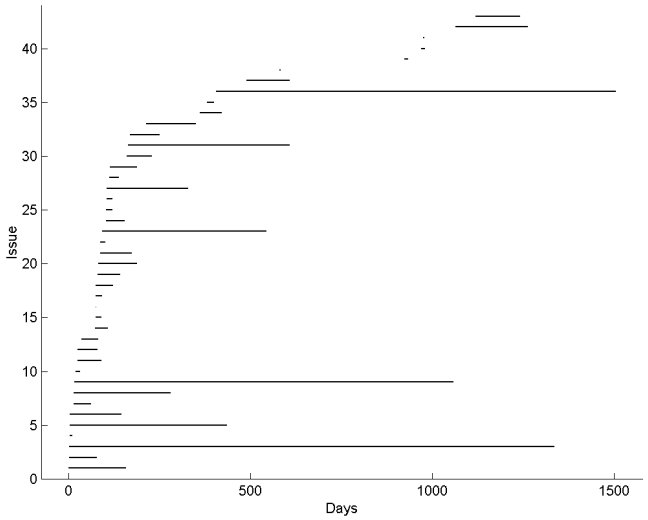

Figure 5. Duration of closed issues in Drupal 7 RDFa

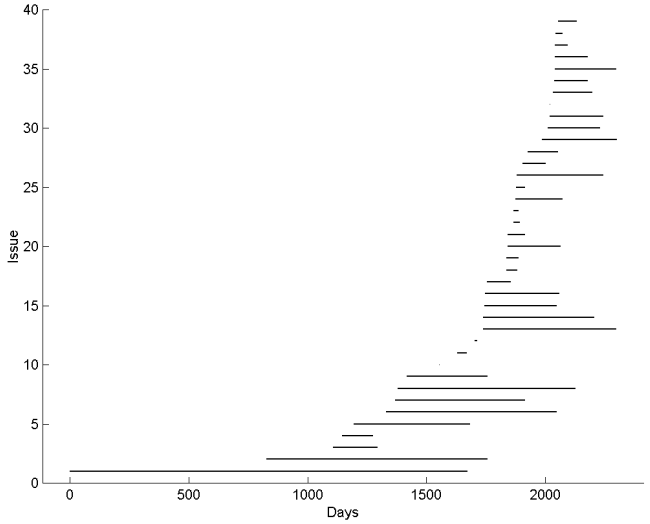

Figure 6. Duration of closed issues in Drupal 8 RDFa

A closer inspection of issue content for the W3C RDFa issue trackers reveals that it is not uncommon that issues are raised on the issue tracker by someone who has observed something on a W3C mailing that has been reported to be problematic by someone else. Hence, in such cases the person who raises the

issue acts as a mediator on behalf of others who (more informally) have reported a problem.

Further, for both W3C RDFa and Drupal RDFa, a closer inspection of issue content often suggests that issues lasting a very short period of time (typically only one day) often stem from mistakes. It can for example be that something was raised as an issue which was not really an issue in the first place, or that a particular issue is redundant, or that the issue already has been solved or addressed in a different issue.

4.2 Direct influences through contributors

In this section we establish direct influences between RDFa and its implementation in Drupal through contributors active in both Drupal and W3C. W3C RDFa issues reported in this section (and section 4.3) are W3C RDFa 1.1 issues if not otherwise stated. Drupal issues reported are from either Drupal 7 or Drupal 8.

Table 2 presents an overview of issues involving direct influence through individuals active in both Drupal RDFa and W3C RDFa (column 1=Drupal RDFa issue number; column 2=W3C RDFa issue, either issue number or issue discussed on mailing list; column 3=order of interaction by contributors to issue; columns 4 & 5=start and end date of issue on format YYMMDD; column 6=relative time pattern for issue combination on row based on date information in columns 4 & 5).

Table 2. Issues involving direct influence through individuals active in both Drupal RDFa and W3C RDFa

Drupal	W3C	Contr.	Start	End	Relative time pattern
1777688		P3,P1	120907	131210	
	105	P3,P1,P2	110825	111115	
1780090		P3,P1	120910	130711	
	135	P1,P2	120424	130121	
1848464		*P5*,P1,P3	121123	130324	
	mlist	P1	100503	100503	
1317456		P1	111021	120922	
	mlist	P1	111020	111021	
1036586	N/A	P3,P2	110122	110529	N/A
N/A	mlist	P1	110609	110617	N/A

We have identified several identical issues in the W3C and Drupal issue trackers for RDFa, with influences through individuals active in both issue trackers. One such issue concerns proposed support in RDFa for an attribute similar to @itemref in Microdata in order to be able to implement certain functionality. The issue was raised in W3C RDFa issue 105 by P3 who is a contributor in the Drupal project. Further, P1 (who is the maintainer of the RDFa implementation in Drupal) also contributed in the discussion around this W3C RDFa issue by explaining how the issue is currently handled in Drupal RDFa. No action was taken because of the technical complexity and the perceived lack of compelling use cases. The Drupal RDFa issue 1777688 is considered to represent the same issue and was raised by P3, who proposed a workaround to compensate for the missing @itemref attribute in RDFa. P1 and P2 were also active in the discussion around this issue. Since the workaround was considered to negatively affect the performance and that the applicable use cases were not considered common enough, the issue was closed without any action taken.

Another issue concerns use of attributes @rel and @rev in combination with the @property attribute in RDFa Lite. W3C RDFa issue 135 was raised by P1 (who earlier contributed to the specification of the attributes in RDFa Lite) in the W3C RDFa issue tracker. The solution is that the @property attribute is prioritised over @rel and @rev. The Drupal RDFa issue 1780090 is considered to represent the same issue and was raised by P3 concerning which of the three attributes (@rel, @rev, and @property) that shall be used by default in Drupal, since statistics presented by Google has shown that it is common that these attributes are used in an erroneous manner. P1 suggests that @property should be used in Drupal, and the issue is thereby closed.

Several identical issues have also been raised in the Drupal RDFa issue tracker for RDFa and the W3C RDFa working group mailing list, with influences through individuals active in both W3C RDFa and Drupal RDFa. One such issue concerns the backwards compatibility of RDFa core v1.1, which was raised by P1 on the W3C RDFa mailing list[5]. It was suspected that applications like Drupal might not be working properly with the new version of RDFa. W3C explained in its RDFa mailing list that RDFa core 1.1 will largely be backwards compatible with the earlier version except for the handling of XML literals. The Drupal RDFa issue 1848464 is considered to represent the same issue and was raised by P5, a contributor who has only contributed to the Drupal project (and so far not to the W3C RDFa community). P1 and P3 were also active in the discussion around this issue. Technically, the problem was that in RDFa 1.1 the @property attribute takes @href as property value by default, while in RDFa 1.0 @property was assigned the value of the "a" element. This incompatibility caused problems for Drupal 7 installations. A patch was subsequently proposed and accepted to solve the problem.

A different issue concerning the default profile in RDFa 1.1 was raised by P1 in the W3C RDFa mailing list[6] and in the Drupal RDFa issue tracker (issue 1317456). P1 suggests on the W3C RDFa mailing list that the "schema.org" namespace should be part of the default profile for RDFa since it is used in Drupal. W3C subsequently chooses to add "schema.org" to the default profile in RDFa 1.1. P1 raises an issue in the Drupal RDFa issue tracker concerning a possible need for patching Drupal in order to avoid redundant use of the "schema.org" namespace. However, the Drupal RDFa issue was closed without any action taken since it was considered unnecessary.

An issue concerning the use of the RDFa attribute @rev in HTML5 was raised in the Drupal RDFa issue 1036586 by P3 from Drupal, who found it unclear whether @rev is deprecated in HTML5 and that the Drupal API in that case should be modified. P2 from W3C participated in the discussion and explained that there is still support for @rev and that a removal of the attribute from the specification would yield a backward compatibility issue. The issue was closed without any action taken.

Related to the issue on default profile in RDFa is a suggestion concerning the "dcterms" prefix in the RDFa core default profile that was made by P1 from Drupal on the W3C mailing list[7], who suggested that "dcterms" is replaced with "dc" as a prefix with the motivation that it would be easier to use for newcomers. After some discussions involving P1 and various W3C representatives,

[5] http://lists.w3.org/Archives/Public/public-rdfa-wg/2010May/0023.html

[6] http://lists.w3.org/Archives/Public/public-rdfa-wg/2011Oct/0080.html

[7] http://lists.w3.org/Archives/Public/public-rdfa-wg/2011Jun/0015.html

it was decided to change the RDFa 1.1 specification to include "dc" as a prefix.

To sum up, we find that there is clear evidence of reciprocal action between RDFa and its implementation in Drupal through contributors active in both Drupal and W3C. It can also be noted that for all issues in table 2 involving communication channels in both W3C and Drupal (top 4 rows), the issue in W3C is raised before the corresponding Drupal issue. There are examples where W3C issues completely precede the Drupal issue with a substantial amount of time in between (row 1 and 3). There is one example of overlapping issues (row 2), where the Drupal issue is raised before the W3C issue is closed. Another example shows a Drupal issue that is raised in direct connection with the raised W3C issue (row 4). In the four top examples in table 2 we also note that the same contributor (or contributors) are involved in both the W3C issue and the corresponding Drupal issue, and in several cases in the same order of interaction. To illustrate, in the top example P3 raises both the W3C issue and the Drupal issue, and P1 subsequently interacts after P3 in both issues. P1 raises both issues in the example in row 4 and is also involved in the examples in rows 2 and 3 either by raising the issue or by subsequent interaction.

4.3 Influences through issue similarity

In this section we establish influences between RDFa and its implementation in Drupal through similarity between issues in the Drupal RDFa issue tracker and the W3C RDFa issue tracker.

Table 3 presents an overview of a mapping of Drupal RDFa issues to W3C RDFa issues by similarity (column 1=Drupal RDFa issue number; column 2=W3C RDFa issue number; column 3= similarity between Drupal issue and W3C issue (same issue, same topic, or similar topic); columns 4 & 5=start and end date of issue on format YYMMDD; column 6=relative time pattern for issue combination on row based on date information in columns 4 & 5).

There is also an issue in the Drupal RDFa issue tracker and several issues in the W3C RDFa issue tracker that are related to use of the @property attribute. Specifically, issue 1780090 in the Drupal RDFa issue tracker is related to problematic use of the @property attribute. Issues 68 and 135 in the W3C RDFa issue tracker are considered to represent the same issue as in Drupal. Further, the @property attribute is discussed in a similar topic in W3C RDFa issue 108. Additionally, discussions take place in W3C RDFa issue 150 on another similar topic concerning what standard should implement property copying.

Further, issue 1777688 in the Drupal RDFa issue tracker and several issues in the W3C RDFa issue tracker are related to the Microdata attribute @itemref. Specifically, the Drupal RDFa issue concerns discussions on workarounds due to that @itemref does not exist in RDFa. The W3C RDFa issues 105 and 144 are considered to represent the same issue as in Drupal RDFa, and concern possible implementation of @itemref in RDFa.

In addition, there is an issue in the Drupal RDFa issue tracker and several issues in the W3C RDFa issue tracker that are related to the RDFa default profile. Specifically, issue 1317456 in the Drupal RDFa issue tracker is related to use of the default profile. For the W3C RDFa issue tracker, issues 69, 73 and 76 are on the same topic and concern implementation of the default profile in RDFa. W3C RDFa issues 36 and 108 are on a similar topic and also discuss implementation of the default profile.

The Drupal RDFa issue 999028 concerns "404" responses in connection with namespace prefix links. A similar topic is represented by W3C RDFa issue 21, which concerns "404" responses for profile documents.

Further, both the Drupal RDFa issue 1036586 and the W3C RDFa issue 130 concern the same issue addressing the use of the @rev attribute and HTML5.

Table 3. Mapping of Drupal- & W3C RDFa issues by similarity

Drupal	W3C	Similar.	Start	End	Relative time pattern
1992954			130512	140304	
	25	same top.	070216	070607	
1780090			120910	130711	
	68	same iss.	101213	110121	
	135	same iss.	120424	121202	
	108	sim. top.	110825	120209	
	150	sim. top.	130528	open	
1777688			120907	131215	
	105	same iss.	110825	111115	
	144	same iss.	121105	130119	
1317456			111021	120922	
	69	same top.	110101	110327	
	73	same top.	110106	110327	
	76	same top.	110113	110327	
	36	sim. top.	100716	100920	
	108	sim. top.	110825	120209	
999028			101215	110617	
	21	sim. top.	100408	100408	
1036586			110122	110529	
	130	same iss.	120220	120507	
683608			100113	100113	
	20	same iss.	100315	101011	
	19	same top.	100301	100517	
	60	same top.	101112	110201	
1848464			121123	130324	
	131	same top.	120220	120305	
694994			100125	100422	
	120	same iss.	080509	080612	
712538			100212	100923	
	11	same iss.	100217	101002	

In addition, there is an issue in the Drupal RDFa issue tracker and several issues in the W3C RDFa issue tracker that are related to XML literals in RDFa. Specifically, issue 683608 in the Drupal RDFa issue tracker is related to the handling of RDFa literals in Drupal. Issue 20 in the W3C RDFa issue tracker concerns handling of XML literals in RDFa and is considered to represent the same issue as in Drupal RDFa. On the same topic, W3C RDFa issues 19 and 60 concern the generation of XML literals.

The Drupal RDFa issue 1848464 concerns how the @href attribute is prioritised in RDFa, and W3C RDFa issue 131 concerns the same topic. Further, Drupal RDFa issue 694994 and W3C RDFa 1.0 issue 120 are considered to be the same since both address the @href (and also @rel) attribute and what RDFa triplets that should be generated.

Finally, Drupal RDFa issue 712538 concerns what prefix declarations that should be included by default in Drupal. The same matter is discussed in W3C RDFa issue 11, where a subset of mandatory prefix declarations are suggested and discussed for inclusion in the RDFa specification.

To sum up, we find that there is clear evidence of reciprocal action between RDFa and its implementation in Drupal through similarity between issues in the Drupal RDFa issue tracker and issues in the W3C RDFa issue tracker. It can also be noted that

for all examples except two (rows 6 and 7) in table 3, the issue in W3C is raised before the corresponding Drupal issue. There are examples where W3C issues completely precede the Drupal issue with a substantial amount of time in between (rows 1, 5, 8, and 9). There are examples of overlapping issues (rows 2, 3, and 4), where the Drupal issue is raised before the W3C issue is closed. There is also an example where the Drupal issue is within the time frame of the W3C issue (row 10). There are also examples of related W3C issues overlapping in time (rows 4 and 7).

5. ANALYSIS

In the results it was observed that several contributors are active in both the standardisation of RDFa in W3C and the implementation of RDFa in Drupal, which indicates potential for influence between the standardisation and implementation of RDFa. Interestingly, none of the organisations which those contributors are (or have been) affiliated with are W3C member organisations which are involved in the W3C RDFa (or RDF) working group. This is in contrast with what can be observed for other W3C standards such as HTML where several W3C member organisations implementing web browsers are involved in the W3C HTML working group (e.g. Google Inc., Mozilla Foundation, and Opera Software).

It was also observed that a single or few contributors raise the vast majority of issues in both W3C RDFa and Drupal RDFa. This is in-line with earlier results [25] and research which show that for OSS projects "the bulk activity, especially for new features, is quite highly centralised" [5] and that in the context of bug fixing processes the "most active users in the projects carried out most of the tasks while most others contributed only once or twice" [6].

Further, it was noted that the activity in the W3C RDFa 1.0 issue tracker ceased at the time when the RDFa 1.1 issue tracker was introduced. The abandoning of issue trackers for older versions of a standard may be due to changed priorities or that the path taken by the old version of the standard did not go in a direction relevant for future needs. On the contrary, it was observed that raising and closing of issues in Drupal 7 RDFa and Drupal 8 RDFa is done in parallel. This behaviour is common in open source software development where there is often concurrent development on a stable branch and on a development branch. Efforts at the end of the life-cycle for the stable branch often consists of less frequent and more basic bug fixing, whereas more frequent and fundamental improvements are made to the development branch. Further, these observations are in-line with previous knowledge on work practices in connection with release management: "releases of OSS occur at more or less arbitrary points in time. Standards, on the other hand, are by and large static, or perhaps semi-dynamic" [30].

There are also observations for W3C RDFa that suggest a work practice where issues are resolved in batch at specific dates, typically in connection with concerted issue reviews, something which is not observed in Drupal RDFa. However, it is not uncommon that concerted issue resolution is employed by companies involved in open source software projects. One potential reason for adopting this practice may be that it is perceived as more efficient to process several issues at a time and that it introduces less overhead.

We found clear evidence of reciprocal action between RDFa and its implementation in Drupal both through contributors active in both Drupal and W3C, and through similarity between issues in the Drupal RDFa issue tracker and issues in the W3C RDFa issue tracker. Further, it was noted that W3C RDFa issues in most cases preceded the corresponding (or similar issue) in Drupal RDFa. In fact, a variety of relative time patterns were observed between issues in W3C RDFa and Drupal RDFa.

We acknowledge some limitations in our study. The lists of identified influences between RDFa and its implementation in Drupal in tables 2 and 3 (sections 4.2 and 4.3) are not claimed to be complete. There may be other influences which have not been captured by our analysis. Further, as mentioned in section 4.1, the limited sets of issues do not allow for a reliable statistical comparison and a more elaborated quantitative analysis.

From our research results in this study and experience from practice, a number of *implications for practice* are evident. We claim that for companies involved in implementation of standards in open source software there are various incentives for interacting with standardisation organisations and for monitoring the evolution of specific standards. Such activities can contribute to improved quality, interoperability, adoption, and deployment of the product. Further, contribution of insights and experiences to standardisation processes makes it possible for practitioners to affect standards in a direction which is beneficial for the company. From a company perspective, the monitoring of standard emergence and evolution can also take place for marketing reasons, since products supporting important and widely deployed standards are likely to be perceived as more attractive. Further, customers who are users of an open source software solution implementing standards experience the effects of the standard implementation and can provide feedback to the company providing the software, and the company can in turn feed back to the standardisation organisation. Hence, there are stakeholders at different levels who can both contribute to and benefit from interaction with standardisation organisations. Overall, it appears that the practice used for handling issues in W3C RDFa and in Drupal RDFa is an agile, transparent and effective way of working. In later years it is evident that open source work practices (such as issue tracking) have been successfully adopted in a number of standardisation organisations and communities.

Further, in company contexts it is often the case that use of standards (and different versions of standards) and their implementations need to meet the expectations from customers and market at large. For example, for companies involved in the implementation of standards it is important to maintain backwards compatibility when new versions of standards emerge. It may also be that a new version of a certain software no longer supports a certain version of a standard. In that case a company may recommend its customers not to upgrade to the new version of the software software for compatibility reasons. Similarly, support for standards in a software system may also significantly impact on any decision concerning adoption of an alternative software system. Further, in complex software systems implementing many standards (such as Drupal) it often problematic to upgrade from one major release to another (e.g. from Drupal 6 to Drupal 7), since there are many complex dependencies to both standards and their implementations.

6. CONCLUSIONS

We conclude that there is clear evidence of reciprocal action between RDFa and its implementation in Drupal both through contributors active in both Drupal and W3C, and through similarity between issues in the Drupal RDFa issue tracker and issues in the W3C RDFa issue tracker.

Our study confirms and further elaborates anecdotal evidence from practice by providing insights from a case involving a widely deployed standard as implemented in a widely deployed software system.

The study reveals an interesting exemplar of an institutionalised continuous process for developing and maintaining standards in an open and transparent process. As such, it may provide an effective supplement that goes beyond traditional (more closed) processes used by organisations for developing standards. Further, such a continuous process may also provide an effective supplement to various "snapshot" initiatives (e.g. plugfests, workshops, and other organised events). Typical for such collaborative efforts is that different stakeholders contribute in an open collaboration to development of standards. In such collaborations specific issues and technical challenges related to specific ICT standards are addressed. Consequently, this way of working demonstrates a largely unexplored potential for how to improve standardisation processes. As such, it illustrates an effective exemplar for how to improve development and maintenance of standards. In turn, this exemplar provides opportunities for broader adoption amongst different standardisation organisations active in the ICT area. Such a transparent process may be particularly effective in any usage scenario involving development of complex software systems. Especially since such systems involve multiple standards provided by multiple standardisation organisations that are being adopted by multiple software systems provided by multiple providers.

The findings from our analysis of the RDFa standard as implemented in the Drupal project constitute an important contribution towards a deeper understanding of challenges concerning effective processes for development and long-term maintenance of software standards and their implementations in open source projects.

7. ACKNOWLEDGEMENTS

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