Research Articles in Simplified HTML: a Web-first format for HTML-based scholarly articles

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Purpose: this paper introduces the Research Articles in Simplified HTML (or RASH), which is a Web-first format for writing HTML-based scholarly papers; it is accompanied by the RASH Framework , i.e. a set tools for interacting with RASH-based articles. The paper also presents an evaluation that involved authors and reviewers of RASH articles, submitted to the SAVE-SD 2015 and SAVE-SD 2016 workshops.

Design: RASH has been developed in order to: be easy to learn and use; share scholarly documents (and embedded semantic annotations) through the Web; support its adoption within the existing publishing workflow

Findings : the evaluation study confirmed that RASH can already be adopted in workshops, conferences and journals and can be quickly learnt by researchers who are familiar with HTML.

Research limitations: the evaluation study also highlighted some issues in the adoption of RASH, and in general of HTML formats, especially by less technical savvy users. Moreover, additional tools are needed, e.g. for enabling additional conversion from/to existing formats such as OpenXML.

Practical implications: RASH (and its Framework) is another step towards enabling the definition of formal representations of the meaning of the content of an article, facilitate its automatic discovery, enable its linking to semantically related articles, provide access to data within the article in actionable form, and allow integration of data between papers.

Social implications: RASH addresses the intrinsic needs related to the various users of a scholarly article: researchers (focussing on its content), readers (experiencing new ways for browsing it), citizen scientists (reusing available data formally defined within it through semantic annotations), publishers (using the advantages of new technologies as envisioned by the Semantic Publishing movement).

Value: RASH focuses strictly on writing the content of the paper (i.e., organisation of text + semantic annotations) and leaves all the issues about it validation, visualisation, conversion, and semantic data extraction to the various tools developed within its Framework.

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ABSTRACT

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RASH version: `https://w3id.org/people/essepuntato/papers/rash-peerj2016.html`.

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INTRODUCTION

In the last months of 2014, several posts within technical mailing lists of the Web[1] and Semantic Web[2] community have discussed an evergreen topic in scholarly communication, i.e., how could authors of research papers submit their works in HTML rather than, say, PDF, MS Word or LaTeX. Besides the obvious justification of simplification and unification of data formats for drafting, submission and publication, an additional underlying rationale is that the adoption of HTML would ease the embedding of semantic annotations, thus making a step towards the improvement of research communications thanks to already existing W3C standards such as RDFa (Sporny, 2013), Turtle (Prud'hommeaux and Carothers, 2014) and JSON-LD (Sporny et al., 2014). This open complex and exciting scenarios that the Semantic Publishing community has promised us in terms of increased discoverability, interactivity, openness and usability of the scientific work (Bourne et al., 2011) (Shotton et al., 2009).

Nonetheless HTML is still primarily used as output format only: the authors write their papers in LaTeX or MS Word and submit sources to the typesetters, who are responsible for producing the final version, that eventually will be printed or read on the Web. Appropriate tools in the publishing toolchain are used to convert papers among multiple formats.

The interest in *Web-first research papers* - that are natively designed, stored and trasferred in HTML - is increasing. Just to cite a few research efforts: Scholarly HTML[3] defines a set of descriptive rules to use a reduced amount of HTML for describing the metadata and content of scholarly articles; Dokieli[4] is a Web application that allows authors to create HTML-based scholarly articles directly on the browser, adding annotations and many other sophisticated features.

This paper introduces a novel approach towards the same goal: providing authors with a customized version of HTML for Web-first papers. The format is called RASH, *Research Articles in Simplified HTML*, and consists of a subset of 32 HTML elements only. This format is also accompanied by the *RASH Framework*, i.e. a set of specifications and tools for RASH documents.

There are two key differences between RASH and other similar proposals. First of all, RASH adopts a *simplified pattern-based data model*. The number of markup elements to be used by authors was reduced down to the bare minimum, and the elements themselves were chosen in order to minimize the cognitive effort of authors when writing documents. Secondly, RASH does not come with a full authoring environment but is meant to be produced from MS Word, ODT and LaTeX sources. The basic idea is to allow authors to keep using their own word processors, that are well known and allow them to prepare articles in an easily and well-understood way, and to provide them with multi-format converters. These converters are included in the RASH Framework, whose architecture is modular and extensible for handling new formats in the future.

RASH is in fact designed to write the content of the papers only (i.e., organisation of text + semantic annotations), handling all the issues about validation/presentation/conversion of RASH documents to the various tools developed within its Framework. This is a well-established principle in scientific publishing: *clear separation of concerns*. The authors must focus on organising the content and structure only, and the format should not require authors to worry about how the content is presented on screen and print. The publishers will then take care of creating the final formatting to best render the content in the style of their publications.

This lead us to a further critical point valid for any HTML-based language to be used for scientific writing: *good rendering and acceptance by the publishers*. Any new HTML-based format should be beneficial for publishers as well. Of course publishers, conference and workshop organisers, would like to manage new formats in the same way they already do for those formats they already support, such as LaTeX. To this end, the new format should guarantee the possibility of developing tools for its conversion and rendering into specific layouts, such as ACM ICPS[5] and Springer LNCS[6]; RASH adopts a *pragmatic approach* to solve this issue: while we are interested in a full-fledged native RASH authoring environment, we implemented a set of converters, in the RASH Framework, that are easily integrable (and were integrated) with existing publishing platforms.

[1] https://lists.w3.org/Archives/Public/public-lod/2014Nov/0003.html
[2] https://lists.w3.org/Archives/Public/public-lod/2014Oct/0058.html
[3] http://scholarlyhtml.org
[4] http://dokie.li
[5] http://www.acm.org/sigs/publications/proceedings-templates
[6] http://www.springer.com/computer/lncs?SGWID=0-164-6-793341-0

The goal of this paper is in fact to describe the outcomes of some experimentations on the use of RASH, so as to understand:

1. if it can be adopted as HTML-based submission format in academic venues (workshops, conferences, journals);
2. if it is easy to learn and use;
3. if it can be used to add semantic annotations; in particular, what are the most widely adopted vocabularies and how they were adopted in RASH papers;

The rest of the paper is structured as follows. In Section we introduce some of the most relevant related works in the area, providing a functional comparison of the various works. In Section we introduce the rationale for the creation of a new Web-first format for scholarly publication, discussing the importance of *minimality*. In Section and Section we introduce the theoretical background of RASH, and then provide an introduction of the language and the main tools included in its Framework. In Section , as a case study, we discuss the use of RASH as one of the formats for submitting papers to the SAVE-SD 2015[7] and SAVE-SD 2016[8] workshops. Finally, in Section we conclude the paper sketching out some future developments.

RELATED WORKS

The growing interest in the publication of Web-first research papers have resulted in the release of some interesting projects related to RASH. In the following subsections we discuss all the most important contributions in this area by splitting them in two main categories: (i) HTML-based formats and (ii) WYSIWYG editors for HTML documents.

Note that we do not discuss in detail some other efforts that have been recently done by means of non-HTML languages, and are equally relevant for the community. ScholarlyMarkdown[9] (Lin and Beales, 2015), for instance, is a syntax to produce scholarly articles according to a Markdown[10] input. ShareLaTeX[11] is a Web-based real-time collaborative editor for LaTeX documents.

In Table 1 we briefly summarize the features and capabilities of the formats presented, in order to highlight the main differences between them.

HTML-based formats

One of the first documented contributions that has proposed an HTML-based format for scholarly articles has been Scholarly HTML[30]. It is not defined as a formal grammar, rather by a set of descriptive rules which allows one to specify just a reduced amount of HTML tags for describing the metadata and content of a scholarly article. It is the main intermediate format used in ContentMine[31] for describing the conversion of PDF content into HTML.

Along the same lines, PubCSS[32] is a project which aims at pushing the use of HTML+CSS for writing scholarly articles. It does not define a formal grammar for the HTML element set to use. Rather it provides some HTML templates according to four different CSS styles, which mimic four document LaTeX stylesheets for Computer Science articles, i.e. ACM SIG Proceedings, ACM SIGCHI Proceedings, ACM SIGCHI Extended Abstracts, and IEEE Conference Proceedings.

HTMLBooks[33] is an O'Reilly's specification for creating HTML documents (books, in particular) by using a subset of all the (X)HTML5 elements. This is one of the first public works by a publisher for pushing HTML-like publications, even if the status of its documentation (and, consequently, of its schema) is still "unofficial".

Another project, that shares the same name of one of the previous ones, i.e. Scholarly HTML[34], is a work by the science.ai[35] company that aims at providing a domain-specific data format based on open

[7] http://cs.unibo.it/save-sd/2015/index.html
[8] http://cs.unibo.it/save-sd/2016/index.html
[9] http://scholarlymarkdown.com/
[10] http://daringfireball.net/projects/markdown/
[11] https://www.sharelatex.com/
[30] http://scholarlyhtml.org
[31] http://contentmine.org
[32] https://github.com/thomaspark/pubcss/
[33] https://github.com/oreillymedia/HTMLBook/
[34] https://github.com/scienceai/scholarly.vernacular.io
[35] http://science.ai

Table 1. A comparison among existing HTML-oritented formats for scholarly papers according to seven distinct categories.

Format	Syntax	Documentation	Formal grammar	Semantic annotations	CSS for different formats	WYSIWYG editor	Conversion tools
RASH[12]	HTML	Available online[13]	RelaxNG[14]	RDFa, RDF/XML, Turtle, JSON-LD	Web-based and Springer LNCS	OpenOffice	From: ODT To: LaTeX ACM ICPS and Springer LNCS
Scholarly HTML (2011)[15]	HTML	Available online[16]	None	RDFa	None	None	From: PDF (via Content-Mine - Norma[17])
PubCSS[18]	HTML	Available online[19]	Informal (via HTML templates)	None	ACM SIG Proceedings, ACM SIGCHI Proceedings, ACM SIGCHI Extended Abstracts, and IEEE Conference Proceedings	None	To: PDF (via browser interface)
HTMLBooks[20]	HTML	Available online[21]	XML Schema[22]	None	CSS files for PDF printing and EPUB/MOBI-compatible device visualisations	None	None
Scholarly HTML (2015)[23]	HTML	Available online[24]	None	RDFa, JSON-LD	Web-based	Microsoft Word (as referenced online[25])	From: DOCX
Scholarly HTML (2016)[26]	HTML	Available online[27]	None	RDFa, JSON-LD	Web-based	None	None
dokieli format	HTML	None	Informal (via HTML templates)	RDFa, Turtle, JSON-LD, TRiG	Web-based, Springer LNCS, ACM ICPS	dokieli[28]	To: PDF (via browser interface)
Fiduswriter format	HTML	None	None	None	Web-based	Fiduswriter[29]	To: HTML, EPUB, LaTeX

standards (among which HTML5) for enabling "the interoperable exchange of scholarly articles in a manner that is compatible with off-the-shelf browsers" (Berjon and Ballesteros, 2015). While the format it is not defined by any particular formal grammar, it has a well-described documentation (Berjon and Ballesteros, 2015) that teaches how to produce scholarly documents by using a quite large set of HTML tags, accompanied by schema.org[36] annotations for describing specific structural roles of documents as well as basic metadata of the paper. In services made available by the company would enable also the conversion from Microsoft Word document into such ScholarlyHTML format.

One of the authors of the previous work is also the chair of a W3C community group called "Scholarly HTML"[37] which aims at developing a HTML vernacular[38] for the creation of a Web-first format

[36] http://schema.org
[37] https://www.w3.org/community/scholarlyhtml/
[38] https://github.com/w3c/scholarly-html

for scholarly articles. It involves several people from all the aforementioned specifications (including RASH), and the group work should result in the release of a community-proposed interchange HTML format. As of August 10, 2016, the online documentation[39] is mainly a fork of the Scholarly HTML specification proposed by science.ai discussed above.

HTML-oriented WYSIWYG editors

One of the most important and recent proposals which is compliant with the principles introduced as part of the *Linked Research*[40] project[41] (Capadisli et al., 2015) is *dokieli*[42]. Dokieli is Web applications (still under-development) that allows one to create HTML-based scholarly articles directly on the browser, and implement several features among which annotations (in RDF), a notification system, and other features. The application makes available also available some HTML templates and a series of widgets for navigating, visualising (in different formats) and printing research documents easily by using common browsers.

Fidus Writer[43] is another Web-based application for creating HTML scholarly documents by means of a wordprocessor-like interface. While the particular format used is not explicitly specified, it allows one to convert the HTML documents created within the application in two different formats, i.e. EPUB and LaTeX (alongside with HTML).

WHICH “WEB-FIRST” FORMAT FOR RESEARCH ARTICLES?

The term ”Web-first” format indicates the possibility of using HTML as primary language to write, store and transfer research articles, and not only to make these articles available on the Web. Some questions naturally arise in this context: shall we use the full HTML? If we limit to a subset, which elements should we consider? Shall we demand specific rules for using the language?

Some works, e.g. (Capadisli et al., 2015), suggest not to force any particular HTML structure for research papers. This choice would allow authors to use whatever HTML structure they want for writing papers, and would reduce (even, eliminate) the fear for the *template bottleneck*, i.e., the fact that users will not adopt a particular language because they would be obliged to follow specific rules. However, leaving the user (i.e., the author) the freedom of using, potentially, the whole HTML specification may affect, in some way, the whole writing and publishing process of articles.

First of all, the author of a paper is free to use any possible kinds of HTML *linearisations* for her scholarly text, e.g.: using elements `div` instead of elements `section`, using elements `table` for presentational behaviour and not for presenting tabular data, and the like. This freedom could, thus, result in two main kinds of issues:

- *visualisation bottleneck* – it may affect the correct use of existing, well-developed and pretty standard CSSs (e.g., Capadisli’s CSSs developed for Dokieli[44]) for both screen and print media, resulting in writing new code for handling paper visualisation correctly;
- *less focus on the research content* – the fact that a certain paper is not visualised in a browser very well (or, worse, in a way that is not the one the author expects) could bring the author to work on the presentation of the text, rather than on focussing on the actual research context of the text.

Another point against the use of any HTML syntax for writing papers concerns the possibility of enabling an easy way for sharing the paper to others (e.g., co-authors) who, potentially, may not use HTML in the same way. If all the co-authors of a paper are able to use the full HTML, they may not understand other users’ specific uses of some HTML tags — “why did she use the elements `section` instead of `div`?”; “what is this freaky use of elements `table`?”. Hence, the advantages of using a common HTML format is quite evident: only one syntax and only one possible semantics.

There is a further issue worth mentioning. Having a simple and acceptable format would facilitate conversions from/into other complex ones (e.g., ODT (JTC1/SC34 WG 6., JTC1/SC34 WG 6.),

[39] `https://w3c.github.io/scholarly-html/`
[40] `http://linkedresearch.org`
[41] The main aim of the LinkedResearch project is to propose principles for enabling researchers to share and reuse research knowledge by means of existing Web and Semantic Web technologies towards a future world where researchers can publish and consume human-friendly and machine-readable (e.g., by using RDFa (Sporny, 2013)) scholarly documents.
[42] `http://dokie.li`
[43] `https://www.fiduswriter.org/`
[44] `http://dokieli.io`

OOXML (JTC1/SC34 WG 4., JTC1/SC34 WG 4.), DocBook (Walsh, 2009), JATS (National Information Standards Organizatio, 2012)), thus enabling authors to use their own text editors or word-processors to modify the articles. The conversion is instead much more complex, error-prone and imprecise on the full HTML.

To complicate an already complex scenario is the *necessary* involvement of publishers. Leaving the authors of using their own HTML format could be also counterproductive from a publisher's perspective, in particular when we speak about the possibility of adopting such HTML formats for regular conference/journal camera ready submissions. From a recent discussion on the Force11 mailing list[45], it appears clear that publishers are willing to adopt HTML for submissions *if and only if* it is a clear community need. It means that they will include HTML formats in the publishing workflow only once a number of conference organisers decide to deliver HTML as camera ready versions of accepted papers[46]. However, using one clear Web-first format, rather than a plethora of possible variations allowed by the full HTML schema, would certainly decrease the effort of publishers for including HTML within the publishing workflow. This inclusion could be additionally supported by the community itself if it would be made available a series of services (e.g., converters, enhancers, visualisers) for facilitating the use of such Web-first format within the existing publishing environment.

Last but not least, using a controlled subset of HTML is more appropriate for *Semantic Publishing* applications (Shotton et al., 2009) (Peroni, 2014). The development of scripts and applications to extract, for instance, RDF statements directly from the markup structure of the text is a sort of nightmare if different authors use HTML in different manners. For instance, what happen if we would like to extract the rhetorical organisation of a scientific paper according to the Document Component Ontology (DoCO)[49] (Constantin et al., 2016) from two HTML documents that use HTML tags in different ways? Is an HTML element `table` an actual table (containing tabular data)? What are the tags identifying sections? These analyses are all easier on a controlled subset of HTML.

WRITING SCHOLARLY ARTICLES IN HTML WITH RASH

The subset of HTML we propose in RASH is strictly compliant to a *patterns theory*, we developed in the past years. In this section we briefly introduce these theoretical foundations and then we go into the details of RASH.

Theoretical foundations: structural patterns

While we have plenty of tools and languages for creating new markup languages (e.g. RelaxNG (Clark and Makoto, 2001) and XMLSchema (Gao et al., 2012)), they usually do not provide any particular guideline for fostering the development robust and well-shaped document languages. In order to fill that gap, in the last decade we have experimented the use of a *theory of structural patterns* for markup documents (Di Iorio et al., 2014), that then has been already applied in a bunch of national and international standards, e.g. OASIS LegalDocumentML[50][51], which is a legal document standard for the specification of parliamentary, legislative and judicial documents, for their interchange between institutions in different countries.

The basic idea behind this theory is that each element of a markup language should comply with one and only one structural pattern, depending on the fact that the element:

- can or cannot contain text (+*t* in the first case, -*t* otherwise);
- can or cannot contain other elements (+*s* in the first case, -*s* otherwise);
- is contained by another element that can or cannot contain text (+*T* in the first case, -*T* otherwise).

By combining all these possible values – i.e. $\pm t$, $\pm s$, and $\pm T$ – we basically obtain eight core structural patterns, namely (accompanied by a plausible exemplar within the HTML elements):

[45] https://groups.google.com/forum/#!topic/forcnet/g4BNAOOMjMM

[46] Note that accepting HTML as format for submissions in conferences/workshops is a totally different issue, since this choice is normally taken by the organisers. For instance, see the SAVE-SD 2015 call for papers[47] and the various editions of SePublica[48].

[49] http://purl.org/spar/doco

[50] https://www.oasis-open.org/committees/legaldocml/

[51] OASIS LegalDocumentML is the standardisation of AkomaNtoso[52], which is a set of simple technology-neutral electronic representations in XML format of parliamentary, legislative and judiciary documents, and has been already adopted by several parliaments in European Union, Africa, and South America.

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1. inline [+t+s+T], e.g. the element `em`;
2. block [+t+s-T], e.g. the element `p`;
3. popup [-t+s+T], e.g. the element `aside`;
4. container [-t+s-T], e.g. the element `section`;
5. atom [+t-s+T], e.g. the element `abbr`;
6. field [+t-s-T], e.g. the element `title`;
7. milestone [-t-s+T], e.g. the element `img`;
8. meta [-t-s-T], e.g. the element `link`.

Instead of defining a large number of complex and diversified structures, the idea is that a small number of structural patterns are sufficient to express what most users need. Therefore, the two main aspects related to such patterns are:

- orthogonality – each pattern has a specific goal and fits a specific context. It makes it possible to associate a single pattern to each of the most common situations in document design. Conversely, for every situation a designer encounters in the creation of a new markup language, the corresponding pattern is immediately selectable and applicable;
- assemblability – each pattern can be used only in some contexts within other patterns. This strictness provides expressiveness and non-ambiguity in the patterns. By limiting the possible choices, patterns prevent the creation of uncontrolled and misleading content structures.

Such patterns allow authors to create unambiguous, manageable and well-structured markup languages and, consequently, documents, and basically allow to increase the reusability (e.g., inclusion, conversion, etc.) among different languages. Also, thanks to the regularity they provide, it is possible to perform easily complex operations on pattern-based documents even when knowing very little about their vocabulary (automatic visualisation of document, inferences on the document structure, etc.). Thus designers can implement more reliable and efficient tools, can make hypothesis regarding the meanings of document fragments, can identify singularities and can study global properties of sets of documents.

We applied these guidelines for restricting HTML – which is not pattern-based at all, since it allows the creation of arbitrary and, sometimes, quite ambiguous structures – and define RASH, so as to select a good subset that is enough expressive to capture the typical components of a scholarly article and that is also well-designed, easy to reuse and robust at the same time.

RASH: Research Article in Simplified HTML

The *Research Articles in Simplified HTML* (*RASH*) format is a markup language that restricts the use of HTML[53] elements to only *32 elements* for writing academic research articles. It allows authors to use RDFa[54] annotations (Sporny, 2013) within any element of the language[55]. In addition to RDFa, RASH makes available another way to add RDF statements to the document, i.e., the use of an element `script` (with the attribute `type` set to “application/rdf+xml”, “text/turtle” or to “application/ld+json”) within the element `head` for adding plain RDF/XML (Gandon and Schreiber, 2014), Turtle (Prud’hommeaux and Carothers, 2014) or JSON-LD content (Sporny et al., 2014). In addition, RASH strictly follows the Digital Publishing WAI-ARIA Module 1.0 (Garrish et al., 2016) (which is currently a working draft) for expressing structural semantics on various markup elements used.

Any RASH documents begins as a simple (X)HTML5 document[56], by specifying the generic HTML DOCTYPE followed by the document element `html` with the usual namespace (i.e, “http://www.w3.org/1999/xhtml”) and with additional (and mandatory) prefix declarations through the attribute `prefix`[57]. The element `html` contains the element `head` for defining metadata of the document according to

[53] `http://www.w3.org/TR/html5/`

[54] `http://www.w3.org/TR/rdfa-syntax/`

[55] Technically speaking, this is a meta-article, since it has been actually written by using RASH itself as markup language. Thus it is possible to easily access the HTML code of this article to understand how the various elements are rendered by the browser.

[56] Please refer to the official RASH documentation, available at `http://cs.unibo.it/save-sd/rash`, for a complete introduction of all the elements and attributes that can be used in RASH documents.

[57] The following prefixes are always mandatory in any RASH document:

- `schema: http://schema.org/`
- `prism: http://prismstandard.org/namespaces/basic/2.0/`

the DCTERMS[58] and PRISM[59] standards, and the element `body` for including the whole content of the document. On the one hand, the element `head` of a RASH document must/should include some information about the paper, i.e., the paper title (element `title`), at least one author and other related information (i.e., affiliations, keywords, categories, by using the elements `meta` and `link`). On the other hand, the element `body` mainly contains textual elements (e.g., paragraphs, emphases, links, and quotations) for describing the content of the paper, and other structural elements (e.g., abstract, sections, references, and footnotes) used to organised the paper in appropriate blocks and to present specific complex structures (e.g., figures, formulas, and tables).

In the following subsection we provide a quick discussion about pattern-usage in RASH, and we introduce the tools used for developing its grammar.

Development and patterns

As already mentioned, the development of RASH started from the whole HTML5 grammar, and proceeded by removing and restricting the particular use of HTML elements, so as to be enough expressive for representing the structures of scholarly papers and to have the language totally compliant with the theory on *structural patterns* for XML documents (Di Iorio et al., 2014) introduced in Section

As already introduced, the systematic use of these structural patterns is an added value in all stages of the documents' lifecycle: they can be guidelines for creating well-engineered documents and vocabularies, rules to extract structural components from legacy documents, indicators to study to what extent documents share design principles and community guidelines. All these characteristics have allowed us to simplify, at least to some extent, the handling of all the requirements introduced in Section and Section in RASH. Table 2 shows what is the current pattern assignment for each element in RASH.

Table 2. The use of structural patterns in RASH.

Pattern	RASH element
inline	`a`, `code`, `em`, `math`, `q`, `span`, `strong`, `sub`, `sup`, `svg`
block	`figcaption`, `h1`, `p`, `pre`, `th`
popup	*none*
container	`blockquote`, `body`, `figure`, `head`, `html`, `li`, `ol`, `section`, `table`, `td`, `tr`, `ul`
atom	*none*
field	`script`, `title`
milestone	`img`
meta	`link`, `meta`

As shown, we do not use some of the patterns presented in Section , i.e. *atom* and *popup*. The elements compliant with the former pattern are usually defined for describing textual content in discursive blocks (e.g. paragraphs) but prohibit to contain additional elements. Considering the context of scholarly writings, this is a quite odd situation, since usually any element used for emphases, links, and other in-sentence elements can always contain additional ones.

A different discourse can be done for the pattern *popup*, which is used for any structure that, while still not allowing text content inside itself, is nonetheless found in elements with a mixed content context [t+s+], and it is meant to represent complex substructures that interrupt but do not break the main flow of the text, such as footnotes (Di Iorio et al., 2014). In particular, in developing RASH, we discussed which of the following two possible approaches for defining footnotes had to be more reasonable for our needs.

The first, is a *container*-based behaviour, also suggested by JATS (National Information Standards Organizatio, 2012) by means of the element `fn-group`, that allows one to specify footnotes (through the element `ft`) by using a tag that is totally separated from the main text from which it is referenced (usually through XML attributes), as shown in the following excerpt:

```
<-- A paragraph referring to a footnote -->
<p>
```

[58] http://dublincore.org/documents/dcmi-terms/

[59] http://www.prismstandard.org/

```
    In this paragraph there is an explicit reference to the
    second footnote<xref rid="n2"></xref>.
</p>

<-- The group containing all the footnotes -->
<fn-group>
    <fn id="n1">
        <p>This is a paragraph within a footnote.</p>
    </fn>
    <fn id="n2">
        <p>This is a paragraph in another footnote.</p>
        <p>
            All the footnotes are contained in a group, so as
            to collect them together.
        </p>
    </fn>
    ...
</fn-group>
```

The alternative is, in fact, a *popup*-based behaviour, used as default in LaTeX (by using the marker `\footnote{}`) and even possible in JATS (which is a very permissive language by design), where a paragraph can be abruptly interrupted by one or more paragraphs specified in a footnote, as shown in the following excerpt:

```
<-- A paragraph containing a footnote -->
<p>
    In this paragraph the footnote <fn id="n3"><p>That is
    what we call popup-based behaviour!.</p></fn> has been
    defined directly within it.
</p>
```

In RASH, we considered the latter approach a bit confusing, since it actually decreases the readability of the HTML source where footnotes are needed, and thus decided to adopt a solution similar to the JATS `fn-group` element, introduced as follows:

```
<-- A paragraph referring to a footnote -->
<p>
    In this paragraph there is an explicit reference to the
    second footnote<a href="#fn2"></a>.
</p>

<-- The group containing all the footnotes -->
<section role="doc-footnotes">
    <section role="doc-footnote" id="fn1">
        <p>This is the text of a footnote.</p>
    </section>
    <section role="doc-footnote" id="fn2">
        <p>This is the text of another footnote.</p>
    </section>
    ...
</section>
```

Grammar and peculiarities

The formal grammar of RASH[60] (current version: 0.5) has been developed by means of RelaxNG (Clark and Makoto, 2001), which is a simple, easy to learn, and powerful schema language for XML. The grammar has been logically organised in four distinct logical blocks of syntactic rules, defining respectively elements, attributes, content models[61] for the elements and their related attribute lists, as summarised in the following excerpt:

```
...
<define name="p">
    <element name="p">
        <ref name="attributes_html_element_no_role" />
        <ref name="cm_inline" />
    </element>
</define>
...
<define name="aClass">
    <attribute name="class">
        <data type="NMTOKENS" />
    </attribute>
</define>
```

[60] `https://raw.githubusercontent.com/essepuntato/rash/master/grammar/rash.rng`

[61] The *content model* of an element is the particular organisation of its content in terms of text, attributes and elements that it can contain.

```
...
<define name="cm_inline">
    <zeroOrMore>
        <choice>
            <text />
            <ref name="a" />
            <ref name="aRef" />
            <ref name="img" />
            <ref name="svg" />
            <ref name="math" />
            <ref name="img_math" />
            <ref name="span_latex" />
            <ref name="span" />
            <ref name="code" />
            <ref name="sub" />
            <ref name="sup" />
            <ref name="em" />
            <ref name="strong" />
            <ref name="q" />
        </choice>
    </zeroOrMore>
</define>
...
<define name="attributes_html_element_no_role">
    <ref name="attributes_html_generic" />
    <optional>
        <ref name="aClass" />
    </optional>
    <ref name="attributes_rdfa" />
</define>
...
```

Starting from the latest versions of the language, there has been a clear shift so as to use more HTML5 semantic elements, despite the fact they are not back-compatible with possible (and more generic) alternatives in HTML4. In particular, the elements `section`, `figure`, and `figcaption` have been adopted so as to clearly refer to paper sections and boxes with tables, figures, listings and formulas, accompanied by a particular caption.

While this choice has fostered the readability of the source, the use of these HTLM5 elements was not enough to guarantee a proper semantics and accessibility to the RASH source. Thus, in order to improve the user experience in terms of accessibility of such HTML-based papers, RASH reuses some items from the W3C Accessible Rich Internet Applications 1.1 (Diggs et al., 2015), and also exploits several roles introduced in the Digital Publishing WAI-ARIA Module 1.0 (Garrish et al., 2016), which allows “digital publisher to apply the structural semantics they need to drive the authoring process while getting accessibility for free”[62]. The use of such semantics is implemented by means of the attribute `@role`[63], that can be used on certain RASH elements, e.g. sections, and it is very useful for specifying a clear structural semantics where it is not formally defined. For instance, all the references are organised in a list within a special section defined by using the element `section` with the attribute `@role` set to “doc-bibliography”. This special section contains one list with a bibliographic reference for each list item (i.e., the element `li` accompanied by the attribute `@id` for referencing to it within the text and the attribute `@role` set to “doc-biblioentry”), as shown in the following excerpt:

```
<section role="doc-bibliography">
    <h1>References</h1>
    <ol>
        <li id="Per2014" role="doc-biblioentry">
            <p>Write here the reference entry.</p>
        </li>
        ...
    </ol>
</section>
```

Formulas have been taken in particular consideration, since different ways are possible so as to implement them. The standard specification for representing mathematics on the Web is MathML (Carlisle et al., 2014). Even if MathML is the best accessible way for writing mathematical formulas, the organisation of the elements for defining even a quite simple formula is quite verbose and this is a reasonable obstacle to its direct adoption, as shown in the following excerpt for describing the formula r^2:

```
<math xmlns="http://www.w3.org/1998/Math/MathML">
```

[62] `https://lists.w3.org/Archives/Public/public-dpub-aria/2016Feb/0032.html`

[63] In the paper, for the sake of readability, we use the prefix “@” when we name attributes (e.g. the attribute named “role” is introduced as `@role`), while we just name elements with their name (e.g. `section`).

```
    <mi></mi>
    <mo><!-- &InvisibleTimes; --></mo>
    <msup>
        <mi>r</mi>
        <mn>2</mn>
    </msup>
</math>
```

So as to help the creator of RASH documents in dealing with formulas, RASH adds other two ways for writing formulas in addition to MathML. The first one is to use an image (element `img`), which is a very simple way to include maths in a paper. On the other hand, it is not accessible at all since the various elements of the formula are not marked-up properly so as to distinguish them. Another option would be to use LaTeX, which is one of the most common ways to write formulas in many scientific papers. Both the options are specifiable in RASH by using either the element `img` or the element `span` respectively, accompanied by the attribute `@role` set to “math”, as shown in the following excerpt:

```
<-- Specifying a formula through the element 'img' -->
<img role="math" src="formula.png" alt="rˆ2" />

<-- Specifying a formula in LaTeX through the element 'span' -->
<span role="math">\pi rˆ2</span>
```

The rendering of any LaTeX formula and the multi-browser support for MathML is implemented by using MathJax[64], which is a Javascript display engine for mathematics that works in all browsers. Of course, it is necessary to explicitly import it in the element `head` if any rendering of formulas is actually needed, as shown as follows:

```
<!-- MathJax for multi-browser support of LaTeX formulas and MathML -->
<script src="https://cdn.mathjax.org/mathjax/latest/MathJax.js?config=TeX-AMS-MML_HTMLorMML"> </
     script>
```

RASH has been developed in order to allow anyone to add RDFa annotations (Sporny, 2013) to any element of the document. For instance, this paragraph contains the following RDF statements (in Turtle (Prud’hommeaux and Carothers, 2014)):

```
@prefix cito: <http://purl.org/spar/cito/> .
<> cito:credits <http://www.w3.org/TR/rdfa-syntax/> .
```

That was implemented by using specific RDFa attributes (`@property` and `@resource`, in this case) within the paragraph content, while the prefixes were defined in the element `html`, as shown in the following excerpt:

```
<html prefix="cito: http://purl.org/spar/cito/">
    ...
    <p>
        RASH has been developed in order to allow anyone to add
        <span
            property="cito:credits"
            resource="http://www.w3.org/TR/rdfa-syntax/">RDFa</span>
        annotations to any element of the document.
    </p>
    ...
</html>
```

In addition to RDFa, RASH makes available another way to inject RDF statements (Cyganiak et al., 2014) to the document, by means of an element `script` (within the element `head`):

- with the attribute `type` set to “text/turtle” for adding plain Turtle content (Prud’hommeaux and Carothers, 2014);
- with the attribute `type` set to “application/ld+json” for adding plain JSON-LD content (Sporny et al., 2014);
- with the attribute `type` set to “application/rdf+xml” for adding plain RDF/XML content (Gandon and Schreiber, 2014).

An example of use of `script` for Turtle and JSON-LD statements is introduced in the following excerpt:

```
<script type="text/turtle">
    @prefix pro: <http://purl.org/spar/pro/> .
    @prefix foaf: <http://xmlns.com/foaf/0.1/> .
```

[64] https://www.mathjax.org/

```
    @prefix sd: <https://w3id.org/scholarlydata/person/> .
    sd:silvio-peroni a foaf:Person ;
        foaf:givenName "Silvio" ;
        foaf:familyName "Peroni" ;
        foaf:homepage <http://www.essepuntato.it> ;
        pro:holdsRoleInTime [
            a pro:RoleInTime ;
            pro:withRole pro:author ;
            pro:relatesToDocument <>
        ] .
</script>

<script type="application/ld+json">
    {
        "@context":
            {
                "nick": "http://xmlns.com/foaf/0.1/nick",
                "sd": "https://w3id.org/scholarlydata/person/"
            },
        "@id": "sd:silvio-peroni",
        "nick": ["S.", "essepuntato"]
    }
</script>
```

It is worth noticing that, excepting three properties from schema.org[65] for defining author's metadata (see Section 2 of the RASH documentation[66] for additional details), RASH does not constrain any particular vocabulary for introducing RDF statements. For instance, in this document (in particular, in its RASH version[67]) we mainly use CiTO (Peroni and Shotton, 20122012) and other SPAR Ontologies (Peroni, 2014) for creating citation statement about the paper itself, but alternative and/or complementary vocabularies are freely usable as well.

THE RASH FRAMEWORK

One of the issues we had to face, and in general anyone has to face when proposing a new markup language, was to provide tools for writing papers in RASH. It is undeniable that:

- not all the potential authors are able (or willing) to write scholarly articles in HTML, even considering those people within the Web community;
- not all the potential authors are able (or willing) to add additional semantic annotations, even considering the Semantic Web community.

The authorial activity of writing an article by using RASH, but also any other new Web-first format, *must* be supported by appropriate interfaces to reach a broad adoption.

One possible solution could have been to implement a native HTML authoring environment, so as authors do not have to deal with the new language directly. Apart from the technical difficulties in creating such environment and in making it acceptable/accepted by the final users, there is another issue: all co-authors are required to stick to the same tool. We believe that a more liberal approach, that allows each author to keep using her/his preferred tools, even off-line, is more practical.

This is the idea behind the RASH Framework[68]: a set of specifications and writing/conversion/extraction tools for writing articles in *RASH*. In this section we give a brief description of all the tools we have developed in the framework. All the software components are distributed under an ISC License[69], while the other components are distributed under a Creative Commons Attribution 4.0 International License[70]. A summary of the whole framework is introduced in Fig. 1.

Validating RASH documents

RASH has been developed as a RelaxNG grammar (Clark and Makoto, 2001), i.e., a well-known schema language for XML documents. All the markup items it defines are fully compatible with the HTML5 specifications (Hickson et al., 2014).

[65] `http://schema.org`

[66] `https://rawgit.com/essepuntato/rash/master/documentation/index.html#metadata`

[67] `https://rawgit.com/essepuntato/rash/master/papers/rash-peerj2016.html`

[68] The full project is available at `https://github.com/essepuntato/rash/`. Please use the hashtag `#rashfwk` for referring to any of the items defined in the RASH Framework via Twitter or other social platforms.

[69] `http://opensource.org/licenses/ISC`

[70] `http://creativecommons.org/licenses/by/4.0/`

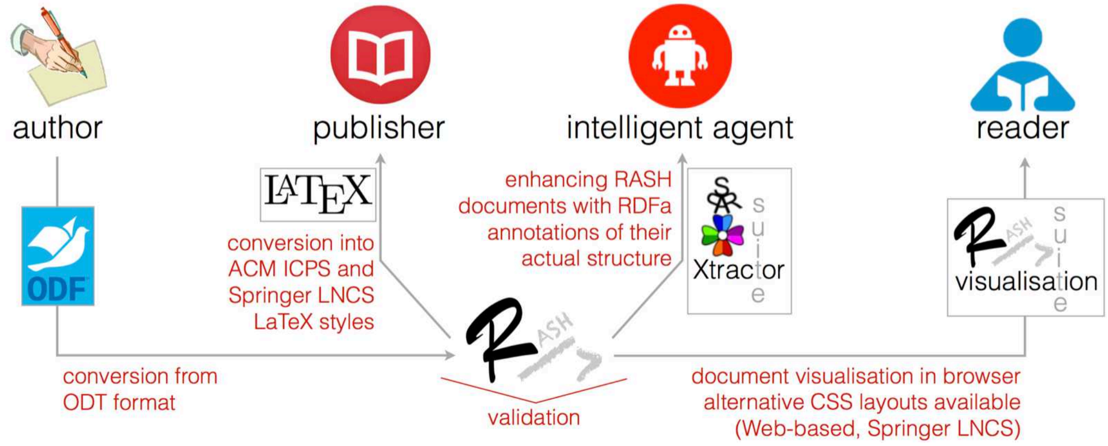

Figure 1. The RASH Framework and its main components.

In order to check whether a document is compliant with RASH, we have developed a script to enable RASH users to check their documents simultaneously both against the specific requirements in the RASH RelaxNG grammar and also against the full set of HTML checks that the W3C Nu HTML Checker[71] (a.k.a., HTML5 validator) does for all HTML documents (by checking all requirements given in the HTML specification). This ensures that RASH users get alerted to more potential mistakes in their documents so that they can easily fix them. Among other things above just using the RASH grammar only, this script adds relatively sophisticated checking of the datatype microsyntaxes of attribute values.

Visualising RASH documents

The whole visualisation of this document (as any other RASH document) is rendered by the browser in the current form by means of appropriate CSS3[72] stylesheets (Atkins J et al., 2015) and Javascript scripts developed for this purpose.

We are actually using some external libraries, i.e., Bootstrap[73] and JQuery[74], in order to guarantee the current clear visualisation and for adding additional tools to the user. For instance, the footbar with statistics about the paper (i.e., number of words, figures, tables and formulas) and a menu to change the actual layout of the page[75], the automatic reordering of footnotes and references, the visualisation of the metadata of the paper, etc.

Note that these kinds of automatic rendering of paper items, such as references to a bibliographic entry or a figure, reduce the cognitive effort of an author when writing a RASH paper. For instance, a piece of text referencing a table, e.g. “as shown in Table 2” is created without caring about the particular text to specify for that reference (“Table 2” in the example), since RASH prescribes to specify just an empty link to the object one wants to refer to, as shown in the following excerpt:

```
<p>... as shown in <a href="#table_patterns"></a> ...</p>
```

For these objects, the Javascript scripts developed will take care about deciding what is the more suitable text to put there according to the type of the item referenced.

Converting RASH into LaTeX styles

We have spent some effort in preparing XSLT 2.0 documents (Kay, 2007) for converting RASH documents into different LaTeX styles, such as ACM ICPS[77] and Springer LNCS[78], among the others. This is, actually, one of the crucial step to guarantee the use of RASH within international events and to be able to publish RASH documents in the official LaTeX format as required by the organisation committee

[71] http://validator.w3.org/nu/
[72] http://www.w3.org/Style/CSS/specs.en.html
[73] http://getbootstrap.com/
[74] http://jquery.com/
[75] The layouts currently available are Web-based and Springer’s Lecture Note in Computer Science[76].
[77] http://www.acm.org/sigs/publications/proceedings-templates
[78] http://www.springer.com/computer/lncs?SGWID=0-164-6-793341-0

of such events. Obviously the full adoption of RASH, of any other Web-first format, would make these stylesheets not necessary but, currently, they are fundamental for the adoption of the overall approach.

Producing RASH from ODT

In addition, we have already developed another XSLT 2.0 document to perform conversions from OpenOffice documents into RASH documents, which allows us to write a paper through the OpenOffice editor and then converting the related ODT file into RASH automatically.

The RASH documentation provides a detailed description of how to use OpenOffice for writing scientific documents that can be easily converted in the RASH format. The standard OpenOffice features (e.g. styles, document properties, etc.), elements (e.g. lists, pictures, captions, footnotes, hyperlinks, etc.) and facilities (e.g. mathematical editor, cross-reference editor, etc.) can be used to produce fully compliant RASH documents. A web-based service (for converting documents online) and a Java application (that can be downloaded and used offline on the local machine) have been developed to facilitate the conversion process of OpenOffice documents to the RASH format.

In the past few years, as sort of alpha-testing, we have used these conversion approaches with many internal projects in the Digital and Semantic Publishing Laboratory of the Department of Computer Science and Engineering at the University of Bologna. Moreover, also our co-authors and collaborators from different disciplines (e.g. business and management, humanities, medicine, etc.) have successfully used this approach for producing their documents, giving us a chanche to have fruitful feedbacks, comments and suggestions. In particular, we have been able to convert several ODT files of the main part of the research papers, project proposals and deliverables, documentation, and two Ph.D. thesis we wrote in our group into RASH, with a discrete success.

ROCS

We created an online conversion tool called *ROCS* (*RASH Online Conversion Service*)[79] (Di Iorio et al., 2016) for supporting authors in writing RASH documents and preparing submissions to be easily processed by current journals, workshops and conferences. ROCS integrates the tools introduced in the previous sections.

The abstract architecture of the tool is shown in Fig. 2. ROCS allows converting an ODT document, written according to specific guidelines, into RASH and, then, into LaTeX according to either the Springer LNCS or the ACM IPCS layouts. Such ODT guidelines[80] are very simple and use only the basic features available in OpenOffice Writer, without using any external tool or plug-in.

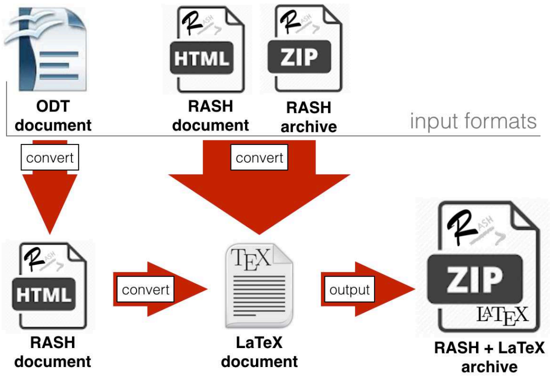

Figure 2. The architecture of ROCS.

ROCS allows users to upload three kinds of file, i.e., an ODT document, a HTML file compliant with RASH, and a ZIP archive which contains an HTML file compliant with RASH and related files (i.e., CSSs, javascript files, fonts, images). It returns a ZIP archive containing the original document plus all its converted versions, i.e., RASH, if an ODT file was given, and the LaTeX file.

The main advantage of having the paper both in RASH and in LaTeX is that it is very easy for RASH to be adopted by workshops, conferences or journals. Since, the program committee, the reviews and

[79] http://dasplab.cs.unibo.it/rocs
[80] https://rawgit.com/essepuntato/rash/master/documentation/rash-in-odt.odt

the editors will also have access to a LaTeX or a PDF version of the paper, the RASH file is an addition that does not preclude any current workflows. Of course, the hope is that the inherent advantages of an HTML-based format such as RASH will eventually persuade stakeholders to adopt the HTML version whenever it will be possible, keeping the alternatives as fallback options.

Enriching RASH documents with structural semantics

A recent development of the RASH Framework has concerned the automatic enrichment of RASH documents with RDFa annotations defining the actual structure of such documents in terms of the FRBR-aligned Bibliographic Ontology (FaBIO)[81] and the Document Component Ontology (DoCO)[82] (Constantin et al., 2016). More in detail, we developed a Java application called *SPAR Xtractor suite*[83]. SPAR Xtractor is designed as a one-click tool able to add structural semantics to a RASH document automatically. In fact, SPAR Xtractor takes a RASH document as input and returns a new RASH document where all its markup elements have been annotated with their actual structural semantics by means of RDFa. Namely, the tool associates a set of FaBIO or DoCO types with specific HTML elements. The set of HTML elements and their associations with FaBIO or DoCO types can be customised according to specific needs of expressivity. The default association provided by the current release of SPAR Xtractor is the following:

- the root `html` element is mapped to an individual of the class `fabio:Expression`[84]. The class `fabio:Expression` identifies the specific intellectual or artistic form that a work takes each time it is realised;
- the `body` element is mapped to an individual of the class `doco:BodyMatter`[85]. The class `doco:BodyMatter` represents the specific intellectual or artistic form that a work takes each time it is realised;
- `p` elements are represented as individuals of the class `doco:Paragraph`[86], i.e. self-contained units of discourse that deal with a particular point or idea;
- `figure` elements containing the element `img` within a paragraph are represented as individuals of the class `doco:FigureBox`[87], which is a space within a document that contains a figure and its caption;
- `section` elements are mapped to individuals of the class `doco:Section`[88], which represents logical division of the text. As sections can be organised according to a variable level of nested sub-sections. Accordingly, SPAR Xtractor reflects this structural behaviour by representing the containment relation by means of the object property `po:contains`[89][90]. For example, a certain `section` element with a nested `section` element produces two individuals of the class `doco:Section` (e.g. `:section_outer a doco:Section` and `:div_inner a section:Section`) related by the property `po:contains` (e.g. `div_outer po:contains :div_inner`).

In addition to these semantic annotations, which come from the actual structure of a document, the tool is also able to automatically detect sententes and represent them as individuals of the class `doco:Sentence`[91]. A `doco:Sentence` denotes an expression in natural language forming a single grammatical unit. For the sentence detection task SPAR Xtractor relies on the sentence detection module of the Apache OpenNLP project[92], which provides a machine learning based toolkit for the processing

[81] http://purl.org/spar/fabio
[82] http://purl.org/spar/doco
[83] The source code and binaries of SPAR Xtractor are available at https://github.com/essepuntato/rash/tree/master/sources/spar-xtractor and https://github.com/essepuntato/rash/tree/master/tools/spar-xtractor, respectively.

[84] http://purl.org/spar/fabio/Expression
[85] http://purl.org/spar/doco/BodyMatter
[86] http://purl.org/spar/doco/Paragraph
[87] http://purl.org/spar/doco/FigureBox
[88] http://purl.org/spar/doco/Section
[89] http://www.essepuntato.it/2008/12/pattern#contains
[90] The prefix po: stands for the namespace http://www.essepuntato.it/2008/12/pattern#.
[91] http://purl.org/spar/doco/Sentence
[92] https://opennlp.apache.org/

of natural language text. By default, SPAR Xtractor is released to support english only. However, it is possible to extend it with new languages by adding their corresponding models for Apache OpenNLP, most of which are available with open licence[93].

We remark that the object property `po:contains` is used for representing any kind of containment relation among the structural components that SPAR Xtractor deals with. Hence, the usage of such a property is not limited to the individuals of the class `doco:Section` only. In fact, the property `po:contains` can be used, for example, for expressing the containment relation between a `doco:BodyMatter` and a `doco:Section` or between a `doco:Section` and a `doco:Sentence`. For example, let us consider the following code snippets that provides a sample HTML document.

```
<html>
  ...
  <body>
    ...
    <section><h1>A section</h1>
      ...
      <p>This is a sentence. This is another sentence of this paragraph.</p>
      ...
      <section><h1>A sub-section</h1> ... </section>
      ...
    </section>
    ...
  </body>
</html>
```

The HTML document in the snippet above is enriched by SPAR Xtractor resulting in the document reported in the snippet below.

```
<html
  resource="expression"
  typeof="http://purl.org/spar/fabio/Expression">
  ...
  <body resource="body"
    typeof="http://purl.org/spar/doco/BodyMatter"
    property="http://www.essepuntato.it/2008/12/pattern#contains">
    ...
    <section resource="section_outer"
      typeof="http://purl.org/spar/doco/Section"
      property="http://www.essepuntato.it/2008/12/pattern#contains">
      <h1 resource="section_outer/title"
        typeof="http://purl.org/spar/doco/SectionTitle" >
        <span property="http://purl.org/spar/c4o/hasContent">
          A section
        </span>
      </h1>
      ...
      <p resource="section_outer/paragraph-1"
        typeof="http://purl.org/spar/doco/Paragraph"
        property="http://www.essepuntato.it/2008/12/pattern#contains" >
        <span property="http://www.essepuntato.it/2008/12/pattern#contains"
          resource="section_outer/paragraph-1/sentence-1"
          typeof="http://purl.org/spar/doco/Sentence">
          <span property="http://purl.org/spar/c4o/hasContent">
            This is a sentence.
          </span>
        </span>
        <span property="http://www.essepuntato.it/2008/12/pattern#contains"
          resource="section_outer/paragraph-1/sentence-2"
          typeof="http://purl.org/spar/doco/Sentence">
          <span property="http://purl.org/spar/c4o/hasContent">
            This is another sentence of this paragraph.
          </span>>
        </span>>
      </p>
      ...
      <section resource="section_inner"
        typeof="http://purl.org/spar/doco/Section"
        property="http://www.essepuntato.it/2008/12/pattern#contains">
        <h1 resource="section_inner/title"
          typeof="http://purl.org/spar/doco/SectionTitle" ">
              <span property="http://purl.org/spar/c4o/hasContent">
                A sub-section
              </span>
            </h1>
        ...
```

[93] Some models are already available under the terms of the Apache Licence at `http://opennlp.sourceforge.net/models-1.5/`.

```
      </section>
      ...
    </section>
    ...
  </body>
</html>
```

RASH AND SAVE-SD: AN EVALUATION

The true validation for RASH as a format for research papers rests on its **use by a good number of authors and workshops** and its **integration in the publishing process**. For this reason, RASH was first released in conjunction with the Semantics, Analytics, Visualisation: Enhancing Scholarly Data (SAVE-SD 2015) workshop[94], co-located with WWW 2015. It was subsequently adopted by a number of workshops and conferences[95]. In this section, we will present an evaluation of RASH based on the analysis of questionnaires completed by authors and reviewers of SAVE-SD 2015 and SAVE-SD 2016[96] workshops and a study on RDF annotations in the relevant papers.

The users were asked to fill a survey which included a section about their background, a SUS questionnaire and six open questions about their experience with RASH. We will first introduce the two workshops and then discuss and compare the evaluation results. Finally, we will present an analysis of the most frequent vocabularies and entities in RASH papers. The completed questionnaires and the outcomes of the analysis are available at (Osborne and Peroni, 2016).

It is worth anticipating that in 2015 there were no converters in the RASH framework, and ROCS was introduced immediately before SAVE-SD 2016. Thus, in both years authors wrote RASH papers with plain text-editors or XML editors, apart from one author that used ROCS in 2016. In general, the authors appreciated RASH and the tools in the RASH framework, even if the editing environment and the converters are still limited.

SAVE-SD 2015 and 2016

SAVE-SD 2015 was organized by some of the authors of this paper with the aim of bringing together publishers, companies and researchers in order to bridge the gap between the theoretical/academic and practical/industrial aspects in regards to scholarly data. It was thus an inherent multifaceted workshop which drew researchers from a number of heterogeneous fields, such as Document and Knowledge Engineering, Semantic Web, Natural Language Processing, Scholarly Communication, Bibliometrics and Human-Computer Interaction. Since many of the interested researchers were keen to experiment with novel technologies regarding semantic publishing it was a natural choice for the debut of RASH. For this reason, SAVE-SD 2015 allowed authors to submit papers using either RASH or PDF, explicitly encouraging authors to try the new format. To this end, the organisers introduced a special award for the best submission in RASH, according to the quality of the markups, the number of RDF statements defined in RDFa, and the number of RDF links to LOD datasets. The possibility of submitting in RASH was also advertised on social media (e.g., Twitter[97], Facebook[98]) and during various international events (e.g., DL 2014[99], EKAW 2014[100], FORCE 2015[101]).

The initiative had a substantial success: the workshop received 6 out of 23 submissions in RASH and after the review process an additional author chose to prepare the camera ready paper in RASH. Out of these 7 final submissions, 3 were research papers, 1 was a position paper, and 3 posters/demo. These papers were submitted by 16 authors from Switzerland, Italy, Germany, Netherlands, United Kingdom, Ireland, and USA.

At the time of the workshop submission deadline, there were no public tools available for converting other formats into RASH. However, the authors were able to self-learn it by simply referring to the documentation page, confirming that computer scientists have no particular problem in handling it directly. The conversion of the RASH submissions into the ACM format requested by Sheridan publisher

[94] http://cs.unibo.it/save-sd/2015/index.html
[95] https://github.com/essepuntato/rash/#rash-papers-accepted-in-scholarly-venues
[96] http://cs.unibo.it/save-sd/2016/index.html
[97] https://twitter.com/savesdworkshop
[98] https://www.facebook.com/savesdworkshop
[99] http://www.city.ac.uk/digital-libraries-2014
[100] http://www.ida.liu.se/conferences/EKAW14/home.html
[101] https://www.force11.org/meetings/force2015

(responsible for the publications of all WWW proceedings) was handled by the organisers through a semi-automatic process. In particular, they used the XLST files introduced in Section and had to fix only a few layout misalignments.

Six authors and four reviewers involved in SAVE-SD 2015 participated to our evaluation.

SAVE-SD 2016 was the second edition of the workshop and had the same characteristics and goals of the predecessor. In order to give authors full freedom, the organizer decided to accept not only RASH, but any kind of HTML-based format. Since it was not possible to handle the conversion of any possible HTML-based format to the publisher layout, the authors of alternative formats were asked to prepare a PDF of the camera ready version according to the publisher needs.

SAVE-SD 2016 received 6 out of 16 submissions in RASH from 14 authors from Italy, Sweden, Greece, Germany, Belgium, and United States. In total, 5 out of the 14 accepted papers were in RASH, including 2 full papers, 2 demos and 1 position papers. Even if no author chose to submit in other HTML-based formats, this possibility will be kept open in future editions. Differently from the previous edition, the proceedings were published as a dedicated LNCS volume. The conversions of RASH papers to the PDF documents in Springer LNCS layout was automatically handled by ROCS.

As in the previous edition, we evaluated RASH by conducting the same study (with the same exact questions). Seven authors of RASH papers and three reviewers participated to the survey.

User background

It is useful to first assess the background of RASH pioneer users in term of their knowledge of relevant technologies and software. For this reason, the first section of the survey included a number of statements about the user expertize (e.g., ”I have extensive experience in writing academic papers with LaTeX ”) and allowed five response options, from ”Strongly Agree” to ”Strongly Disagree”. Table 3 shows the percentage of users who claimed to be familiar with a range of technologies (by selecting ”Agree” or ”Strongly Agree”).

Table 3. User background for SAVE-SD 2015, SAVE-SD 2016, and average values.

Year	MS Word	OO Writer	LaTeX	HTML	XML	RelaxNG	SW	RDFa	Turtle	JSON-LD
2015	33%	33%	83%	83%	100%	67%	83%	100%	100%	50%
2016	57%	0%	71%	71%	71%	29%	57%	57%	57%	43%
AVR	40%	13%	67%	67%	73%	40%	60%	67%	77%	40%

In 2015, the authors were mainly from the Semantic Web community and therefore familiar with technologies such as RDFa and Turtle. Most of them knew how to correctly annotate a HTML file and understood the advantages of including semantic relationships in the paper. They also commonly used LaTeX rather than Microsoft Word or OpenOffice Writer. This suggests that they were acquainted with WYSIWYG editors and had experience with complex formats. A qualitative analysis of the survey answers confirms this intuition; for example an author remarked: “I am used to writing papers in LaTeX so I do not want to bother with formatting and in that sense RASH is similar”.

In 2016 the situation changed and only 57% of the users were familiar with semantic technologies. In addition, even if most of them knew how to use LaTex, the majority of them had experience also with Microsoft Word. It seems thus that RASH started to interest also less technical users with a different research backgrounds.

User survey

We assessed strengths and weaknesses of RASH by means of six open questions. We summarize here the answers of both authors and reviewers for the 2015 and 2016 edition. The reviewers answered only questions 2, 3, 4 and 5. Note that the questions were exactly the same in both editions and none of the participants filled both the surveys.

SAVE-SD 2015 Survey

- *[Q1] Why did you choose the RASH format for your paper?*
  Four authors answered that the main reason was to try it out, mostly because they “supported the idea of publishing academic papers as HTML” and were convinced that “PDF should be replaced”.

Two of them added that they were motivated by the possibility of adding semantic annotations to their papers.

- *[Q2] How effectively did RASH support you in writing/reviewing the paper?*
  The majority of the authors suggested that some tasks, such as setting up the bibliography, were still cumbersome. They added that the development of tools that could solve these issues and hide the technical details to the common users would be very important for a broader adoption. The reviewers remarked that their experience was very similar to reviewing a paper in PDF format and did not present any particular challenge (e.g., "did not have many features that would distinguish it from a PDF", "it met all of my needs and was easy to use").
- *[Q3] What were the most useful features of RASH to help you writing/reviewing the paper?*
  The authors listed a number of functionalities including the multiple graphical layouts (2 authors), the support of RDFa annotations (2) and the built-in validation (1). The ability to display the paper according to different layouts was also praised by reviewers.
- *[Q4] What were the main weaknesses that RASH exhibited in supporting the writing/reviewing of the paper?*
  Most authors suggested that the handling of bibliography, figures and captions should be improved. Half of them also pointed out that the manual insertion of semantic annotations was cumbersome and a large amount of RDFa "introduces a bit of confusion in the paper". An author observed that using the word count as limit in the RASH venues rather than the number of pages introduces the issue of possibly exceeding the editor limits. Most reviewers did not report any problem in using RASH for assessing a paper. However, one of them noted that it still lacked a menu for easily navigating the different sections, as PDF files instead support.
- *[Q5] Can you think of any additional features to be included in RASH that would have helped you to write/review the paper?*
  The majority of authors suggested that the aforementioned limitations were mainly due to the use of a HTML editor and it will be imperative to develop a WYSIWYG editor or a tool to convert from ODT to RASH. A user also suggested developing a tool for graphically showing the semantic annotations, as "what is linked to what, in order to check the correctness of assertions" and a reviewer advised to implement a way to easily access to the different sections of the document.
- *[Q6] Would you use RASH regularly for writing your academic papers?*
  Five out of six authors answered they would like to keep using RASH. Most of them however added that this would also depend on the creation of a better editor and a solid array of tools for managing technical details and converting standard formats for writing research paper to and from RASH.

SAVE-SD 2016 Survey

- *[Q1] Why did you choose the RASH format for your paper?*
  As with the 2015 results, the majority of the authors (4) claimed that they adopted it for trying a new format, three authors because they were motivated by the workshop and three because they actively support the ideas behind RASH.
- *[Q2] How effectively did RASH support you in writing/reviewing the paper?*
  Five users wrote the papers directly in RASH and only one used Open Office and then converted it with ROCS. In the first group, one user was positive, one neutral, and three suggested the need for a WYSIWYG editor, since "writing in html is not so effective" and "not everyone [of the co-authors] knew how to validate against the schema". In particular, it was suggested the need for a Microsoft Word converter, since the ODT produced by Microsoft Word could not be processed by ROCS. As in 2015, the reviewers did not find many differences with respect to PDF papers. One of them claimed to actually prefer RASH since it "makes better use of the page space".
- *[Q3] What were the most useful features of RASH to help you writing/reviewing the paper?*
  The authors mentioned a variety of different features including the formatting semantics ("no worries about section and layout"), the bibliographic reference management and the ability to display the paper according to different layouts. A reviewer also praised the ability of converting RASH to PDF.
- *[Q4] What were the main weaknesses that RASH exhibited in supporting the writing/reviewing of the paper?*
  Differently with 2015, the authors had no particular problem with the handling of bibliography,

figures and captions. However, most of authors (5) pointed to the fact that with the current version they still had to write HTML, which is usually not straightforward. Three of them suggested solving the problem by introducing a WYSIWYG editor, while two of them suggested creating new converters to translate LaTeX and Microsoft Word into RASH. One user also flagged that the visualization of RASH document can change in different browsers. The reviewers, as in 2015, did not report any particular problem in using RASH.

- *[Q5] Can you think of any additional features to be included in RASH that would have helped you to write/review the paper?*
  Consistently with the aforementioned weaknesses and the 2015 results the users called for the creation of a WYSIWYG editor (3) and a way to convert from LaTex and Microsoft Words (3). In addition, a user suggested a tool for automatically generating a bibliography, similar to BibTeX.
- *[Q6] Would you use RASH regularly for writing your academic papers?*
  Three authors asserted that they would be happy to keep using RASH even in the current version, two of them that they were ready to use it again, depending on its development, and only one was negative about it.

RASH usability

We also performed a quantitative analysis of the usability of RASH, using the System Usability Scale (SUS) questionnaire (Brooke, 1996). The scores are acceptable, though not very high, especially if we consider that all authors but one edited RASH files directly with text/XML editors. Users perceived even a ’vanilla RASH’ as acceptable, though they need more sophisticated converters as remarked in the open questions of the survey.

RASH yielded a mean score of 62.7±11.9, slightly lower than the average SUS score (68). However, SUS scores varied dramatically according to the person background. Fig. 3 shows the results of different categories of expertize[102] in HTML, LateX and and Semantic Web Technologies (SWT), which appear correlated with the average SUS scores (respectively r = 0.78, 0.97, 0.99). Authors with a strong expertize in LaTeX and SWT yielded significantly better SUS scores, while authors with HTML expertize yielded only slightly better scores. For this reason, authors from 2015, who as previously discussed had a higher expertize in these categories obtained an average SUS score of 69.6±11.9, while the authors from 2016 yielded 57.1±9.7. However, the difference is not statistically significant because the two samples are small and the test power low.

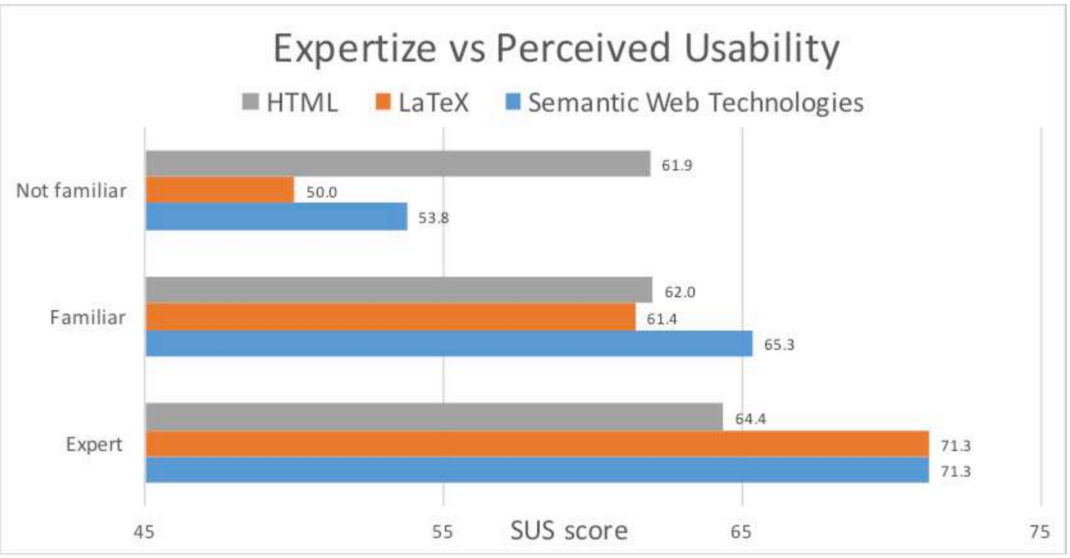

Figure 3. User expertize in HTML, LaTeX and Semantic Web Technologies versus average SUS score.

These results further confirm that most users with limited expertize in non-WYSIWYG editors and semantic technologies find unfeasible to write HTML directly, even in a simplified form.

[102] The authors who answered ”Strongly Angree” to the background questions where classified as ”Experts”, the ones who answered ”Agree” as ”Familiars”, and all the others as ”Not familiar”.

Analysis of RDF annotations in RASH documents

To complete the previous analysis, we also studied the nature of the semantic annotations in RASH papers. We focused on a sample of 1751 annotations obtained from 11 papers published in SAVE-SD 2015 and 2016. The number of statements in a single paper was found to range from 24 to 903, yielding a median value of 46 (25th percentile 34, 75th percentile 175). We extracted all the RDF statements by running the W3C RDFa 1.1 Distiller service[103] on each article. We then considered only the statements that used http-based entities as predicates, or their objects if used for typing resources. The data are organised in several CSV files and have been obtained by running a Python script we developed for gathering the data used in this evaluation.

The first goal of the study was to determine the prevalent vocabularies and how much they were used in the average paper. The left panel of Fig. 4 shows the common vocabularies. Schema.org and PRISM are actually enforced by RASH: the first is used for standard metadata such as emails, affiliations and organization names and the second for keywords. In addition, a quantity of XHTML statements was automatically extracted when processing DPUB-ARIA roles (Garrish et al., 2016). Thus we will not consider such vocabularies in the rest of the evaluation. The other common vocabularies are Dublin Core, which appear in 82% of the papers, FOAF (27%) and the SPAR ontologies (Peroni, 2014), such as FABIO (36%) and CITO (27%) (Peroni and Shotton, 20122012). The right panel of Fig. 4 illustrates the average number of statement for each of these vocabularies. Dublin Core characterizes the highest number of annotation (9.4), followed by FOAF (7.4) and FABIO (6.4).

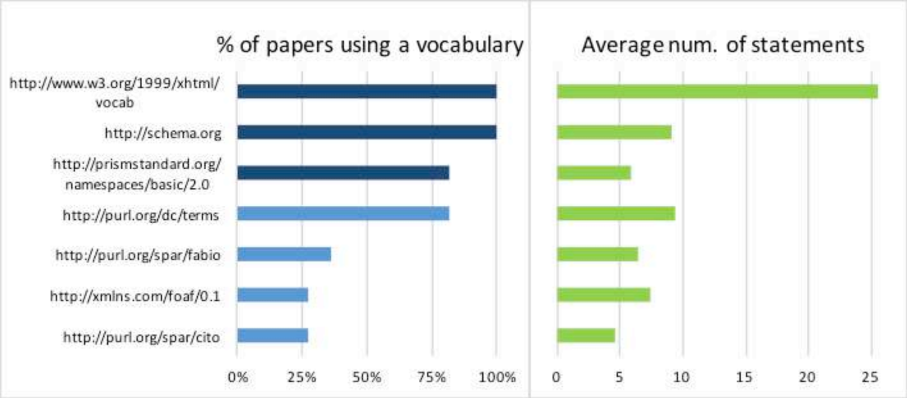

Figure 4. Percentage of papers and average number of statements using a vocabulary

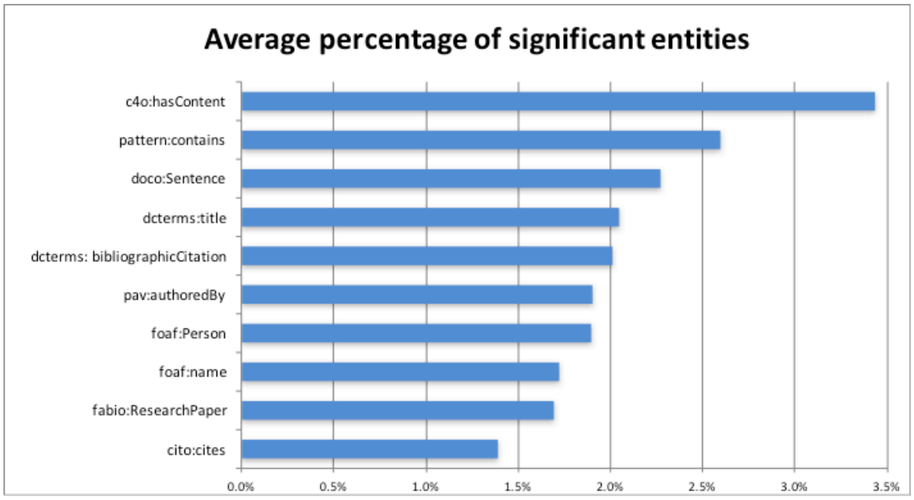

Figure 5. Average percentage of vocabulary entities in a RASH paper (excluding the mandatory ones).

[103] https://www.w3.org/2012/pyRdfa/

We also performed a more fine-grained analysis considering the amount of entities of these vocabularies within the various RDF statements. The goal was to understand the percentage of contribution that the various entities provide (on average) to the statements of the document analysed. As expected, the entities that contribute to about 60% of the statements are either those that are obliged by RASH (`prism:keyword` 6.9%, `schema:affiliation` 5.7%, `schema:name` 5.3%, and `schema:email` 4.7%) or those automatically extracted by processing the DPUB roles included, mandatorily, in the documents (`xhtml:role` 38%). Excluding these, the following top ten entities, shown in Fig. 5, cover about 20% of the statements.

Among these entities, we have three classes describing three diverse but interlinked kinds of objects, i.e. people (`foaf:Person`) authoring a research work (`fabio:ResearchPaper`) and the sentences (`doco:Sentence`) therein contained. The other seven entities are three object properties – two of them (`pav:authoredBy` and `pattern:contains`) provide the links between the three aforementioned classes, while the other, i.e., `cito:cites`, describes citation links between papers – and four data properties – used for providing additional metadata about the entities (`dcterms:title`, `dcterms:bibliographicCitation`, `foaf:name`) and for describing bunches of textual content of the sentences (`c4o:hasContent`).

Discussion

The evaluation study confirmed that RASH can already be adopted in workshops, conferences and journals and can be quickly learnt by researchers who are familiar with HTML. However, it also highlighted some issues in the adoption of HTML formats, especially by less technical savvy users.

The 2016 survey showed that RASH is currently being tried also by users unfamiliar with semantic web technology. While the expansion of the user base represents a positive development, it also yields a number of challenges. The mass of authors accustomed to WYSIWYG editors such as Microsoft Word or OpenOffice Writer, tend to have difficulties with HTML editors. In addition, since research papers are often written by multiple authors, it is usually simpler to use the most well-known solutions. For these reasons, we need to offer the authors who cannot or do not want to change their workflow the tools for converting their favourite format to RASH and annotate the resulting paper. While ODT was a first step in this direction, it is imperative to be also able to process DOCX and LaTeX. A second important issue is that authors who are not expert in semantic technologies can find hard to correctly annotate their papers. Hence, we also need to develop simple tools for helping authors in this phase. The introduction of these solutions will be critical for motivating users to adopt HTML-based approaches and for creating a robust framework that could be used by expert and common users alike.

As far it concerns the analisys of RDF annotations in RASH documents, the outcomes highlighted that the users spontaneously decided to adopt few well-known standard vocabularies, rather than using a multiplicity of different solutions. The most used vocabularies other than Schema.org and PRISM, which are enforced by default in RASH, are Dublin Core, FOAF, and the SPAR ontologies. However, the outcomes of our evaluation generally show a quite low number of statements specified by the authors. This behaviour could derive from the lack of appropriate support for the annotation of RASH papers with RDF data. In addition, this low number seems not to be related to the research community the authors work in. For instance, several of the papers written by Semantic Web experts do not include any RDF statement in addition to those annotations that are enforced by RASH.

CONCLUSIONS

In this paper we have introduced *RASH*, a markup language defined as a subset of HTML for writing scientific articles, and the *RASH Framework*, a set of specifications and tools for writing articles in RASH. In particular, we have discussed the rationale behind the development of RASH, and we have presented the language and the validation/visualisation/conversion/extraction tools developed so far.

The goal of the paper was also to investigate the applicability and the potentialities of RASH, though the evaluation of its adoption in two editions of the SAVE-SD workshop. To the best of our knowledge, this is the first empirical evaluation on the adoption of HTML-based languages for writing scientific papers. The experiments proved that RASH can be successfully used for workshops and conferences, with a good acceptance by the authors and a smooth integration in the existing publishing process.

As immediate future developments, we plan to develop tools for automating the process of semantic enrichment of RASH documents. For instance, we are currently working on the automatic identification of section rhetorics and citation functions so as to describe them according to two SPAR Ontologies (Peroni, 2014), i.e. the Document Component Ontology (DoCO)[104] and the Citation Typing Ontology (CiTO)[105] respectively. We also are developing a Web tool for validating RASH document so as to spot possible syntactic errors easily.

We also intend to further develop the RASH framework. Firstly, we are working on more sophisticated authoring tools and converters. For instance, we are currently developing additional XSLT documents in order to convert DOCX documents into RASH and to convert RASH documents into several different LaTeX formats for scholarly communications – such as IEEE conference proceedings, ACM journals, IOS Press journals and PeerJ – as well as into EPUB for easing its (offline) portability in mobile devices.

We are also studying the possibility of integrating AsciiMath[106] as additional language for writing formulas and correctly translating it in other standard formats (e.g. MathML and LaTeX) so as to handle it during the conversion process available in ROCS. In addition, we are experimenting techniques for automatically generating accessible graphs from data contained in a referenced CSV file.

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[110] http://www.oerc.ox.ac.uk/people/jun-zhao
[111] http://www.oerc.ox.ac.uk/people/alejandra
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