Expressing and Aggregating Rich Event Descriptions

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Abstract. Publishing information about upcoming events such as concerts and discussion group meetings in a structured format allows the event information to be aggregated, filtered and delivered to potential participants. Making automatic personalized recommendations about events requires structured metadata such as machine-understandable locations and semantic descriptions about the topic and audience of the event. We present a survey of the state of current semantic representation formats for events, including iCalendar and its RDFa and microformat representations, and show that their support for expressing rich structured metadata is limited. We have also tested how well different tools support and understand the formats. Based on the surveys we have implemented a rich event information schema for a health-oriented activity portal and developed an aggregation and validation tool for gathering and processing event information.

1 Introduction

One common content type published on web sites is an upcoming event such as a concert, a discussion group meeting in a local cafeteria, or an aerobic lesson. Expressing event descriptions in a structured format such as iCalendar [1, 2] benefits both event publishers and potential attendants or end-users by reducing unnecessary work such as re-typing of event information. It may also allow positive network effects [3] when event descriptions can be shared more widely, aggregated into large repositories, and filtered and personalized for different users. To make events more findable by potential participants and to personalize them according to location, topic or audience, the events must be described using machine-understandable metadata. Such rich metadata allows events to be browsed using a faceted search user interface [4] and also automatically recommended to potential participants.

However, the original iCalendar data model is not sufficient for expressing all of the rich metadata required for faceted search, recommendation and personalization, and must be extended. To illustrate the issues involved, we will show in this paper how we have expressed the rich metadata of events in ACTIVITYFINLAND, a health-oriented web portal, using iCalendar-based formats. We also present an aggregation and validation system that ensures that event information reaches the portal and that event publishers follow the defined schema. In particular, we will look at the following issues:

1. How can current standards and formats for event metadata be leveraged and extended for representing rich event metadata, without sacrificing interoperability?

2. Which tools are available for working with the existing formats, and how well do they support rich event metadata?
3. How should rich event information be expressed so that unknown third parties are able extract a maximum of useful information?
4. How can rich event information be discovered, aggregated from web sources and validated before publishing them in the ACTIVITYFINLAND portal?

In order to answer these questions, we have surveyed the available standards for representing event information, tested a number of tools and libraries for their capabilities in processing rich event descriptions, designed and implemented a rich event metadata schema for the ACTIVITYFINLAND portal based on the knowledge gained from the surveys, and implemented an aggregation system for rich event metadata. The aggregation system has been published online, and it has an interactive mode which can be used for validating event descriptions.

2 Event Representation

The interoperability of calendar software has a relatively long history. In the late 1990's, the **iCalendar** specification (RFC 2445 [1], recently updated as RFC 5545 [2]) established a textual format for event descriptions which allows personal calendaring software to share event information. iCalendar files may also be published on web sites describing events, such as Upcoming[1], so that the events may be easily added to calendaring software by an interested user.

The iCalendar data model has been adopted as a starting point for other specifications. The iCalendar file format itself is a textual format which is not very suitable for web publishing and may be difficult to work with, so more modern means for expressing calendar data using XML or RDF have been proposed, including the iCalendar XML Representation [5].

In the Semantic Web world, the RDF calendar task force at W3C has created the **RDF Calendar** ontology [6], which is a direct transformation of the iCalendar data model into RDF. The Nepomuk project[2] has created its own calendar ontology **NCAL** [7], which also closely follows the iCalendar data model.

Event information is typically published on web pages, and the **RDFa** format allows any RDF-based metadata to be expressed in machine-processable form alongside the HTML code [8]. Thus, the above mentioned RDF-based vocabularies can be directly adopted for describing events on HTML pages using RDFa markup.

Microformats are another approach for expressing structured data on the web using only standard HTML code [9, 10]. The microformats community has produced the **hCalendar** specification[3], which is also based on the iCalendar data model. While RDFa is a generic mechanism for expressing any RDF triples, microformats are crafted for specific data types and thus encode both syntactic and semantic information. One benefit of the microformat approach is that the extra mark-up needed for expressing

[1] http://upcoming.yahoo.com
[2] http://nepomuk.semanticdesktop.org
[3] http://microformats.org/wiki/hcalendar

machine-readable metadata tends to be smaller than the equivalent RDFa markup. According to the semantic web index Sindice [11], the hCalendar microformat is at least an order of magnitude more popular[4] than RDF Calendar for expressing structured event information on the web sites and other sources known to Sindice.

2.1 Problems in Current Formats

While researching the current state of art in event formats, we found a number of problems with the formats and represenations. Many of these issues have been discussed on mailing lists, blogs, wikis and other web forums. We consider here only issues relevant to our use case of representing rich event metadata in the ACTIVITYFINLAND portal.

Structured Location Information In the iCalendar format, the *location* property of an event is defined as a literal field with no specified internal structure for sub-properties such as street address or country name. This lack of structure makes it difficult to aggregate event information in an international setting, filter events according to location, or display event locations on a map. Thus, structured location information is a necessity in ACTIVITYFINLAND.

The **vCard** format [12] is intended for expressing the kind of contact information shown on business cards. A common solution for representing structured event locations is to allow locations to be expressed using vCard. This approach has been adopted by the hCalendar microformat, which permits the use of the hCard microformat[5], based on vCard, in the *location* field of an event. The Yahoo SearchMonkey instructions for publishing event metadata[6] also suggest the use of locations expressed using hCard (when using microformats) or the vCard RDF vocabulary [13] (when using RDFa).

Extensibility Using vCard/hCard for representing locations is an example of extending event information using other vocabularies[7]. Similarly, it would be useful to be able to represent people and organizations referenced in event information using vCard or FOAF [14], and to express links to related blog posts, discussions etc. using the SIOC vocabulary [15]. However, the RDF Calendar ontology is not designed for this kind of extensibility. In contrast, the NCAL ontology is aligned with the other Nepomuk ontologies [7].

Event Categorization The iCalendar data model includes a *categories* field which can be used to describe an event using categories such as *appointment*, *education* and *meeting* [1, 2]. The usage is similar to tags, as there is no defined vocabulary of allowed category values. The RDF Calendar vocabulary accordingly defines the *categories* property

[4] A Sindice query on 9th March 2010 for the URI of vcal:VEvent returned 283000 hits with the source format limited to hCalendar, and 16000 hits when the hCalendar format was exluded.

[5] http://microformats.org/wiki/hcard

[6] http://developer.search.yahoo.com/help/objects/event

[7] However, this convention technically violates the current RDF Calendar ontology, which defines the *location* property as having a literal value, following the iCalendar specification.

as a string field [6]. In both representations, the field contains a comma-separated list of categories.

A representation format that uses a single comma-separated list of values makes it difficult to perform searches for events with specific tags using general purpose query languages such as SPARQL. The use of controlled vocabularies for describing event categories instead of textual tags would allow richer search facilities such as faceted search, and possibly better personalization through ontological background knowledge.

The microformat specifications address these issues by using a singular *category* field which may be repeated. The hCard specification and the current hCalendar 1.1 draft specification[8] also allow the use of the `rel-tag` design pattern[9] to represent categories with tags drawn from a *tag space*, which is a type of controlled vocabulary. However, the `rel-tag` definition of tag spaces is quite restrictive, and requires that the user-visible tag title is encoded in the last segment of the tag URL. This is not the case for many of the vocabularies used in our earlier portals such as HEALTHFINLAND, as numeric identifiers for concepts are typically used in large vocabularies such as Medical Subject Headings (MeSH)[10], where, e.g., `D012907` stands for *Smoking*.

Accessibility of hCalendar The hCalendar 1.0 specification defines a mechanism for expressing date and time values using the `abbr` HTML element and placing the value intended for machines in the `title` attribute. Unfortunately, this structure causes accessibility problems, in particular for people using screen reader software, which may read aloud the string intended for machines instead of the human-readable date. This issue forced BBC to remove hCalendar markup from its program schedule service[11]. The suggested solution developed by the microformat community is the `value-class` design pattern[12], but it has not yet been incorporated into the current hCalendar specification.

As accessibility is an important consideration in ACTIVITYFINLAND, we have further investigated the support for the `value-class` pattern. We limited ourselves to the *value-title* method of representing machine-readable data, which is independent of the human-readable date syntax used on the HTML page. However, the `value-title` syntax is quite heavy, requiring the use of an additional `span` element with empty content holding the machine-readable value in a *title* attribute.

Time Zones When date and time values are expressed on the web, it is important to indicate the timezone in which the value is valid. The current version of the RDF Calendar vocabulary expresses the timezone using RDF datatype notation [6]. However, this convention is problematic for several reasons, including the fact that it relies on a static database of timezone definitions[13] which has not been kept up to date. The prob-

[8] http://microformats.org/wiki/User:TobyInk/hcalendar-1.1
[9] http://microformats.org/wiki/rel-tag
[10] http://www.nlm.nih.gov/mesh/
[11] http://www.bbc.co.uk/blogs/radiolabs/2008/06/removing_microformats_from_bbc.shtml
[12] http://microformats.org/wiki/value-class-pattern
[13] http://www.w3.org/2002/12/cal/tzd/

lems with this approach are well documented in the NEPOMUK Calendar Ontology specification [7].

The issues can be sidestepped by including the timezone information in the datetime value. This approach has been taken by the microformat standards, which favor the W3CDTF [16] or RFC 3339 [17] profiles of the full ISO 8601 date and time format specification [18] and require that the timezone is specified for all time values. The same approach can also be used for event data expressed using the RDF Calendar ontology.

2.2 Tool Support

To better inform the development of an event schema and aggregator tool for ACTIVITY-FINLAND, we performed tests on some of the currently available tools for processing structured event information. In particular, we looked at parsing tools, conversion software and existing online event aggregation services.

The tests were performed using the most recent tool versions available on March 15th, 2010. For most software, an online version was used. Operator and Swignition had to be installed locally and were executed using an Ubuntu 9.10 system with Firefox 3.5.8 and Perl 5.10.0. In particular, we looked for the following features:

1. Support for RDFa syntax with RDF Calendar and vCard RDF vocabularies
2. Support for hCalendar and hCard microformats
3. Support for structured event locations using vCard/hCard
4. Support for the `value-title` construct of the `value-class` design pattern

The example files we used for testing have been published as part of our aggregator software, discussed below in Section 4. The results of the tests are summarized in Table 1. Of the eight tools we tested, only Swignition was able to successfully parse all the tested formats and specific features and convert the event metadata into RDF. Most RDFa-aware tools were able to handle any event metadata; however the Operator Firefox plugin and the Google Rich Snippets Testing Tool did not have specific support for the RDF Calendar format. All tools except for the RDFa-specific W3C Distiller were able to understand basic hCalendar data, but support for the accessibility-enhancing `value-title` construct and hCard structured locations was not available in all tools.

The online testing tools provided by Google and Yahoo! are particularily interesting as they show that general purpose search engines have started understanding structured metadata about events, providing new incentives for publishers to mark up their events in structured formats. The Yahoo! search engine has specific support for events and has a specialized display format for events in result listings. Google has also started displaying structured information about events in the search result listing[14].

Unfortunately, the two major search engines do not agree on the format of the structured metadata. Both support basic hCalendar data and can parse RDFa, but only the Yahoo! parser understands event data expressed using RDF Calendar and the vCard

[14] http://googlewebmastercentral.blogspot.com/2010/01/introducing-new-rich-snippets-format.html

RDF format. Instead of supporting RDF Calendar and vCard RDF, Google has created its own RDF vocabulary for events and organizations[15]. Google has full support of the hCalendar enhancements we tested, while Yahoo! cannot understand either the `value-title` construct or locations expressed using hCard[16].

[15] http://www.google.com/support/webmasters/bin/answer.py?hl=en&answer=164506

[16] The lack of support for hCard locations appears to be a bug in the Yahoo! parser, as their example code show the use of hCard for locations. We have reported this problem to Yahoo!.

Table 1. Tool support for different event data formats and features, as of 15th March 2010. ● indicates a supported feature, ○ an unsupported feature. Parentheses as in (●) indicate that the tool does not care about the specific RDFa content and will pass it through correctly.

Software	any23[a] (part of Sindice)	Operator[b] Firefox plugin	Optimus[c]	Swignition[d]	X2V[e]	W3C RDFa Distiller[f]	Google Rich Snippets[g]	Yahoo! Object Finder[h]
Version	online	0.9.5.1	online	0.1-alpha15	online	online	online	online
Purpose	convert	convert, export	convert, validate	convert	convert	convert, validate	validate	validate
Language	Java	XUL, JavaScript	XSLT	Perl	XSLT	Python	?	?
Output format	RDF	iCalendar	XML, JSON, RSS	RDF, others	iCalendar, vCard	RDF	HTML report	HTML report, RDF
RDFa	●	●	○	●	○	●	●	●
RDF Calendar	(●)	○	○	(●)	○	(●)	○	●
vCard RDF	(●)	○	○	(●)	○	(●)	○	●
vCard as location	(●)	○	○	(●)	○	(●)	○	●
hCalendar	●	●	●	●	●	○	●	●
value-title pattern	○	●	●	●	○	○	●	○
hCard as location	○	○	●	●	○	○	●	○

[a] http://any23.org

[b] https://addons.mozilla.org/en-US/firefox/addon/4106

[c] http://microformatique.com/optimus/

[d] http://buzzword.org.uk/swignition/

[e] http://suda.co.uk/projects/X2V/

[f] http://www.w3.org/2007/08/pyRdfa/

[g] http://www.google.com/webmasters/tools/richsnippets

[h] http://developer.search.yahoo.com/help/objectfinder

3 Event Metadata in ACTIVITYFINLAND

The ACTIVITYFINLAND portal[17] aims to get people away from their computers and involved in social activities, such as outdoor events, hobby groups and courses organized by non-profit associations. The main content of the portal consists of upcoming events, but it also showcases other activities of the participating organizations through blogs, videos and organization descriptions. It is developed as a sister project to the HEALTHFINLAND portal[18] [19], which focuses on health information.

In order to provide interesting, personalized events for its users, ACTIVITYFINLAND has been developed with a rich event metadata schema, which includes clear semantics for the description of event content and categorization, in order to provide topic-, audience- or interest-based recommendation and personalization. In addition to typical structured event information about time and place, events must also be categorized in several dimensions: event content or *subject* such as exercise, diabetes or sexuality; *event type* such as seminar, discussion group or excursion; participant *goals* such as losing weight or meeting new people; and target *audiences* such as families, students or children. The specific requirements for the event metadata were based on the portal user interface design which was created using a user-centered design process and in which many of the organizations producing event information participated.

In order to implement the metadata requirements in a machine-processable schema, we chose to represent as much metadata as possible using the iCalendar and vCard data models. Some of the descriptive metadata was expressed using Dublin Core Terms properties. For the rest, new properties were coined in an ACTIVITYFINLAND-specific namespace. The resulting metadata schema for events is shown in Table 2.

We decided to represent event locations using vCard, as it solves the issue of representing structured locations. We also chose to represent the publisher, organizer and creator of the event using FOAF, as this vocabulary is already used in both HEALTHFINLAND and ACTIVITYFINLAND for representing people and organizations. Event start and end times are represented using W3CDTF datetime values [16], which require the use of time zone specifiers, avoiding the time zone issues in RDF Calendar.

The categorization of events is described using concepts drawn from controlled vocabularies. The Health Promotion Ontology, which was originally developed in the HEALTHFINLAND project and consists of several source vocabularies including the Finnish General Upper Ontology (YSO)[19] and some parts of the MeSH thesaurus, is used for describing the subject matter of events. New, relatively small vocabularies have been developed for event types, participant goals and audiences. All vocabularies have been published using the ONKI Ontology Service [20]. We chose not to use the iCalendar *category* field, as it is too broadly defined and not intended for concepts drawn from a controlled vocabulary. However, we used the *subject* and *audience* properties of the Dublin Core Terms vocabulary and only had to coin new properties for event types and participant goals. The metadata schema is primarily intended to be expressed in either plain RDF or as RDFa metadata embedded on a web page describing the event.

[17] http://www.toimintasuomi.fi
[18] http://www.tervesuomi.fi
[19] http://www.seco.tkk.fi/ontologies/yso/

We also attempted to define an event information representation based on microformats, but this turned out to be difficult for several reasons. First, the microformats currently suffer from accessibility issues, although solutions are already emerging. Second, the categorization of events using controlled vocabularies is problematic from our point of view, since the `rel-tag` pattern is incompatible with the vocabularies we use. Third, there is no general purpose extension syntax (such as the X field name prefix used in iCalendar and many other Internet formats) for extending microformats that would be understood by all parsers. Thus, we have not yet created a specification for expressing all of the ACTIVITYFINLAND event information using microformats.

Table 2. ACTIVITYFINLAND event metadata. Mandatory fields set in **bold**. The Card. column shows the cardinality of fields using UML notation. For display purposes the schema has been flattened into one table; however, the location information is actually contained in a VCard.

Name	Identifier[a]	Card.	Property type	Value range
Title	**ical:summary**	1	Literal	Max 95 characters
Description	**ical:description**	1	Literal	Max 130 characters
Content	tosu:content	0..1	Rich text	XHTML 1.1 fragment
Start time	**ical:dtstart**	1	Datetime	W3CDTF (ISO 8601)
End time	**ical:dtend**	1	Datetime	W3CDTF (ISO 8601)
Available date	tosu:available	0..1	Datetime	W3CDTF (ISO 8601)
Expiration date	tosu:expires	0..1	Datetime	W3CDTF (ISO 8601)
Registration deadline	tosu:registrationDeadline	0..1	Datetime	W3CDTF (ISO 8601)
Venue name	**vcard:fn**	1	Literal	
Street address	vcard:street-address	0..1	Literal	
Municipality	**vcard:locality**	1	Literal	List of municipalities
Country	vcard:country-name	0..1	Literal	
Organizer	**ical:organizer**	1..*	Instance	foaf:Organization
Publisher	dct:publisher	0..*	Instance	foaf:Organization
Creator	dct:creator	0..*	Instance	foaf:Agent
Event type	**tosu:eventType**	1..*	Concept	Event type vocabulary
Subject	**dct:subject**	1..*	Concept	Health Promot. Ontology
Keyword	tosu:keyword	0..*	Literal	Non-empty string
Goal	tosu:goal	0..*	Concept	Goal vocabulary
Target audience	dct:audience	0..*	Concept	Audience vocabulary
Entry fee	tosu:fee	0..1	Literal	
Registration required	tosu:registrationRequired	0..1	Boolean	xsd:boolean
Image	tosu:image	0..1	URL	
URL address	ical:url	0..1	URL	
NoIndex	tosu:noindex	0..1	Boolean	xsd:boolean

[a] Namespaces:
```
ical:  http://www.w3.org/2002/12/cal/icaltzd#
vcard: http://www.w3.org/2006/vcard/ns#
dct:   http://purl.org/dc/terms/
tosu:  http://www.yso.fi/onto/toimintasuomi-schema/
xsd:   http://www.w3.org/2001/XMLSchema#
```

4 Event Aggregation and Validation Tool

The ACTIVITYFINLAND system uses a distributed event production model where the portal aggregates events from many content producers. In order to gather events from web sites and store them into the ACTIVITYFINLAND portal, we have implemented HARAVA, an aggregation and validation tool which collects event information from web sites and RDF feeds. It is configured by listing source URL's or URL patterns known to contain event information suitable for inclusion into ACTIVITYFINLAND.

HARAVA is based on a pipeline architecture (Figure 1), where each event description is 1) gathered by fetching or crawling source documents in HTML or RDF format; 2) syntactically transformed into RDF when necessary; 3) semantically enhanced with, e.g., literal values mapped to resources using the ONKI ontology service [20]; 4) validated using the ACTIVITYFINLAND event metadata schema; 5) filtered by date, skipping past events; and finally 6) stored in an RDF file suitable for importing into the ACTIVITYFINLAND content management system. After processing a source, HARAVA creates a report (Figure 2), i.e., a set of web pages detailing the problems encountered during processing. The report can be used by event publishers to check that their metadata follows the ACTIVITYFINLAND schema and to correct any mistakes or omissions.

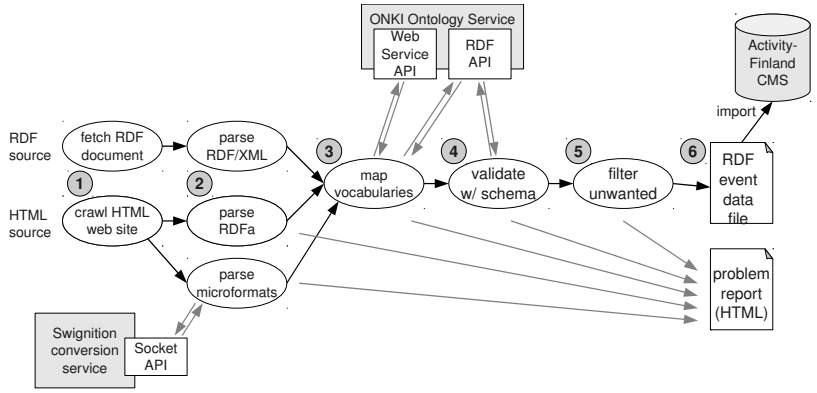

Fig. 1. HARAVA pipeline architecture. Dark arrows represent the flow of event information; grey arrows represent API calls and problem logging.

In addition to RDF and RDFa support, we have implemented basic support for microformats in HARAVA using the Swignition converter, which we chose in part on the basis of the tests described in Section 2.2. However, in order to be able to process the full ACTIVITYFINLAND metadata schema using microformats, we would have to modify Swignition to support our own extensions to the standard formats.

Normally HARAVA will be run in a batch mode so that it will collect all suitable events from several sources. The sources are processed in parallel, and each step in the pipeline is performed asynchronously using threads so that total runtime of the

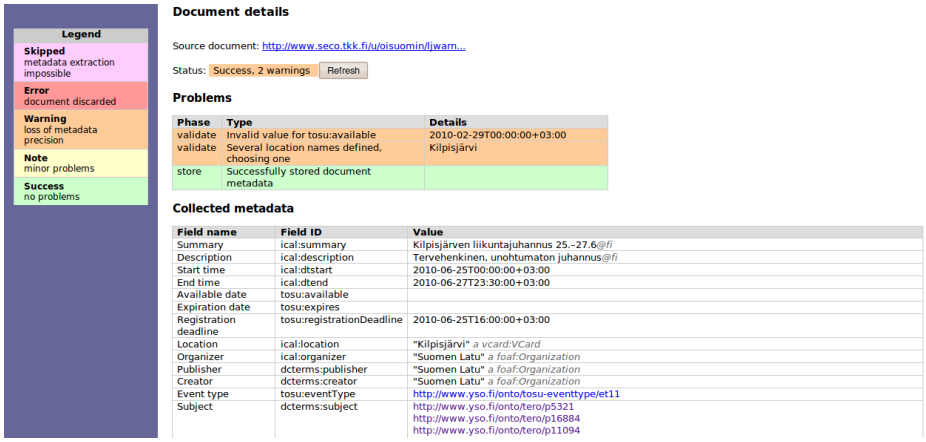

Fig. 2. Feedback report for event publishers, detailing the collected metadata and any problems encountered during processing and validation.

aggregator is minimally affected by network delays. However, HARAVA also contains an online validation tool, which can be used to check individual event descriptions for correctness. The validation tool is available at the HARAVA home page[20].

HARAVA has been implemented in Python, using the rdflib extension[21] for RDF processing and the pyRdfa RDFa parser used in the W3C RDFa Distiller. The implementation is based on our earlier aggregator tool used in the HEALTHFINLAND portal [19], which has been enhanced and further modularized to support both HEALTHFINLAND documents and ACTIVITYFINLAND events. The source code of HARAVA has been released under a MIT style open source license and published as a Google Code project[22].

5 Related Work and Discussion

Our aggregation tool has a similar purpose and architecture as MultiCrawler [21], which collects and indexes structured information from web sources. Similarly, Sindice [11] collects RDF and microformat data from the web and provides lookup facilities into the index. However, our tool is more oriented towards collecting specific formats from specific sources, and providing schema-specific validation.

Validating RDF data is typically performed by tools such as the W3C RDF Validator[23], which checks the syntax and structure of RDF data. There are also generic schema-aware validation tools such as the Validating RDF Parser[24]. The RDF:Alerts service [22] checks for many kind of problems and inconsistencies in published RDF

[20] http://www.seco.tkk.fi/tools/harava/
[21] http://rdflib.net
[22] http://code.google.com/p/harava/
[23] http://www.w3.org/RDF/Validator
[24] http://athena.ics.forth.gr:9090/RDF/VRP/

data. Our tool differs from these by having built-in knowledge of the schemas it supports, including rules that cannot be expressed using RDFS or OWL alone. It can also make corrections based on domain knowledge, such as automatically looking up unqualified keywords in a default vocabulary, or publisher-specific default values such as site-wide audiences.

The processing of structured event information appears not to have attracted much academic interest. However, there are many commercial systems that aggregate event information, including Upcoming and Eventful[25]. These typically require event information to be entered into the system using web forms or proprietary formats. We are not aware of any event aggregation systems, other than the web search engines mentioned above, which would use RDF or microformats for expressing event information.

Typically, event metadata is produced voluntarily in the hope of attracting more interest to events and their related web sites. In this setting any structured metadata is better than none and there is relatively little emphasis on the consistency and validity of metadata. However, we have demonstrated that the event information vocabularies can also be used in a setting where expressing rich semantic information, validating the metadata and providing feedback to event information producers is important.

Interoperability on a very basic level is relatively easy to accomplish, as shown, e.g., by the wide support for the hCalendar 1.0 microformat. However, extending the data model is problematic. The standards for expressing event information are still evolving and software implementers have to chase moving targets. In the microformat world, tool support lags behind the specification efforts, while in the RDF world there are several competing vocabularies with somewhat different goals.

The RDF Calendar standard has not been updated since 2005 and is relatively little used, except when microformat data is automatically converted to RDF by services such as Sindice. It is also not very well documented, its structure is somewhat awkward due to its direct iCalendar conversion approach, and it is not designed to be used together with other important Semantic Web vocabularies such as vCard, FOAF and SIOC. An update of the RDF Calendar specification, taking into account the evolving use cases for publishing event information on the Semantic Web, would be severely needed.

Our aggregation system HARAVA demonstrates practical means by which rich event descriptions may be collected from a distributed network of publishers, while providing feedback that allows the publishers to correct their mistakes in specifying event metadata. The reports it produces for the benefit of data integrity are fairly novel, at least in the Semantic Web world. By providing a validated output of rich structured event metadata, it allows a web portal to provide a rich, personalized user interface which makes interesting events easy to find for end users.

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[25] http://eventful.com

[26] http://www.seco.tkk.fi/projects/finnonto/

References

1. Dawson, F., Stenerson, D.: Internet calendaring and scheduling core object specification (iCalendar) (1998) IETF RFC 2445. http://www.ietf.org/rfc/rfc2445.txt.
2. Desruisseaux, B.: Internet calendaring and scheduling core object specification (iCalendar) (2009) IETF RFC 5545. http://www.ietf.org/rfc/rfc5545.txt.
3. Hendler, J., Golbeck, J.: Metcalfe's law, Web 2.0, and the Semantic Web. Journal of Web Semantics **6**(1) (2008) 14–20
4. Hearst, M., Elliott, A., English, J., Sinha, R., Swearingen, K., Lee, K.P.: Finding the flow in web site search. Communications of the ACM **45**(9) (2002) 42–49
5. Daboo, C., Douglass, M., Lees, S.: iCalendar XML representation (2009) IETF Internet Draft. http://ietfreport.isoc.org/idref/draft-daboo-et-al-icalendar-in-xml/.
6. Connolly, D., Miller, L.: RDF Calendar - an application of the Resource Description Framework to iCalendar data (2005) W3C Interest Group Note. http://www.w3.org/TR/rdfcal/.
7. Mylka, A., Sauermann, L., Sintek, M., van Elst, L.: NEPOMUK calendar ontology (2007) http://www.semanticdesktop.org/ontologies/ncal/.
8. Adida, B., Birbeck, M., McCarron, S., Pemberton, S.: RDFa in XHTML: Syntax and processing (2008) W3C Recommendation. http://www.w3.org/TR/rdfa-syntax/.
9. Khare, R.: Microformats: The next (small) thing on the Semantic Web? Internet Computing **10**(1) (2006) 68–75
10. Khare, R., Çelik, T.: Microformats: a pragmatic path to the semantic web. In: Proceedings of WWW 2006. (2006)
11. Tummarello, G., Delbru, R., Oren, E.: Sindice.com: Weaving the open linked data. In: Proceedings of the 6th International Semantic Web Conference (ISWC2007). (2007)
12. Dawson, F., Howes, T.: vCard MIME directory profile (1998) IETF RFC 2426. http://www.ietf.org/rfc/rfc2426.txt.
13. Halpin, H., Iannella, R., Suda, B., Walsh, N.: Representing vCard objects in RDF (2010) W3C Member Submission. http://www.w3.org/TR/vcard-rdf/.
14. Brickley, D., Miller, L.: FOAF vocabulary specification 0.97 (2010) http://xmlns.com/foaf/spec/.
15. Bojārs, U., Breslin, J.G.: SIOC core ontology specification (2010) http://rdfs.org/sioc/spec/.
16. Wolf, M., Wicksteed, C.: Date and time formats (1997) W3C Note. http://www.w3.org/TR/NOTE-datetime.
17. Klyne, G., Newman, C.: Date and time on the Internet: Timestamps (2002) IETF RFC 3339. http://www.ietf.org/rfc/rfc3339.txt.
18. ISO: ISO 8601:2004(E). Data elements and interchange formats — Information interchange — Representation of dates and times. International Organization for Standardization, Geneva, Switzerland (2004)
19. Suominen, O., Hyvönen, E., Viljanen, K., Hukka, E.: HealthFinland–a national semantic publishing network and portal for health information. Journal of Web Semantics **7**(4) (Dec 2009) 271–376
20. Viljanen, K., Tuominen, J., Hyvönen, E.: Ontology libraries for production use: The Finnish ontology library service ONKI. In: Proceedings of the 6th European Semantic Web Conference (ESWC 2009). (May 31 - June 4 2009) Springer-Verlag.
21. Harth, A., Umbrich, J., Decker, S.: Multicrawler: A pipelined architecture for crawling and indexing semantic web data. In: Proceedings of the 5th International Semantic Web Conference (ISWC2006. (2006)
22. Hogan, A., Harth, A., Passant, A., Decker, S., Polleres, A.: Weaving the pedantic web. In: Proceedings of the 3rd International Workshop on Linked Data on the Web (LDOW2010). (2010)