

# Ontology based improvement of opening hours in e-governments

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**Abstract**—To inform citizens when they can use government services, governments publish the services’ opening hours on their website. When opening hours would be published in a machine interpretable manner, software agents would be able to answer queries about when it is possible to contact a certain service. We introduce an ontology for describing opening hours and use this ontology to create an input form. Furthermore, we explain a logic which can reply to queries for government services which are open or closed. The data is modeled according to this ontology. The principles discussed and applied in this paper are the first steps towards a design pattern for the governance of Open Government Data.

## I. INTRODUCTION

The question at what time a certain person or service can be contacted, consulted or visited, can only be answered by a smart device when the opening hours are published. Basic approaches to publish opening hours exist (see Section II), for example by creating a list of all time intervals within a standard week for when the service is *open*. Yet there is no standard way to handle exceptions on this week schedule, such as official holidays or sick leaves. This paper suggests a full solution to store, maintain, query and publish opening hours by introducing a concise ontology.

### A. Problem statement

When collecting data about opening hours, the data needs to be maintained by the authentic source<sup>1</sup> of the data. Their responsibilities need to be minimized. The latter can be achieved by **maximizing reuse**, as the more of the dataset is reused from other authentic sources, the fewer data this source is responsible for. These *authentic sources* need a User Interface (UI) through which they can maintain the data itself and link to other datasets maintained by other sources. In the case of opening hours, this may occur frequently. A group of *government services* for example share the same holidays and may open and close at the same time.

The core problem however was answering the question “when is a certain service open?” using smart devices. In order to solve the question, smart devices need to be equipped with the logic to **query** this data. This logic can become complicated when the data is not well structured, or straightforward when the data is well structured. Our proposed solution will have to

be a golden mean between the ease to maintain the data and the ease to query the data.

Finally, the data also needs to be **published**. When publishing opening hours in the Linked Open Data cloud, identifiers need to be created, in the form of URIs, in order for other sources to refer to and reuse these opening hours. This URI needs to be dereferenceable [1]. When a URI is requested, a consolidated (merging all the different layers into one) calendar needs to be returned.

### B. Proposed solution

In order to minimize the responsibilities for *authentic sources* and in order to maximize reuse, we introduce a high-level ontology (see Section III) which only links towards calendars with data about certain opening hours. By stacking different calendars, the consolidated opening hours calendar (see Section VI) can be calculated. A UI (see Section V) is created in order to manage the stacking and reuse of calendars within an e-government, and only when no other choice is left, a custom calendar can be defined.

The opening hours become machine-interpretable using this ontology and smart devices are able to understand whether a *government service* is available by reasoning over the calendars. Querying mechanisms (see Section IV) can thus be set up to query for services that are opened or closed within a certain timeframe.

## II. RELATED WORK

The current state of the art allows *authentic sources* to publish opening hours in free text fields on a website, or to publish the data using the Good Relations<sup>2</sup> or schema.org<sup>3</sup> vocabulary. Good Relations launched as an ontology for e-commerce. Later, schema.org integrated the good relations ontology and renamed it to schema.org. Using schema.org, you can give a *schema:openingHoursSpecification* property to any *schema:Place*. An *schema:OpeningHoursSpecification* has 5 properties to structure the opening hours:

- *schema:dayOfWeek*: a link towards an entity describing a day of the week,

<sup>1</sup>An authentic source is someone or a group of people in an organization, responsible for a certain part of a dataset.

<sup>2</sup><http://www.heppnetz.de/projects/goodrelations/>

<sup>3</sup><http://schema.org>

- *schema:opens* and *schema:closes*: the time of the day on which the place opens and closes,
- *schema:validFrom* and *schema:validThrough*: the start and end of the validity of this *schema:OpeningHoursSpecification*.

DBpedia, for instance for the triple in Listing 1, uses a free text field to store the data. This gives the freedom to the authentic source to describe the opening hours as they wish, but for the re-users it is not machine readable<sup>4</sup>, let alone its ability to be queried.

```
dbpedia:Kuwait_Zoo dbpprop:openingHours
"from 8 am until 12 pm and from 4 pm
until 8 pm and is closed on Sundays."@en .
```

Listing 1. A triple with opening hours stored in dbpedia

The way that Schema.org models opening hours is useful for data reusers: the data is easy to query once collected. For the data publishers however, there are some drawbacks of using Schema.org: when providing a form using this schema, the user will solely have the choice of filling out week schedules. Furthermore, parts of opening hours will not be able to be reused and it is particularly complex to add exceptions for for instance a sick leave. When multiple opening hours are provided for the same *government service*, there is no way to figure out which resource has priority over another. Summarizing, schema.org is limited as a datamodel. It should solely be used to specify the opening hours of local businesses on a website that needs to be indexed by search engines.

To represent time intervals in the Linked Open Data cloud, there are various approaches. Ian Davis created placetime.com, a URI namespace which uses the ISO8601 standard in the URI to represent time [6]. This is extended by the psi.enakting.org project [3], which introduces the identification of time intervals to publish statistics in the UK. The time ontology is another vocabulary “for expressing facts about topological relations among instants and intervals, together with information about durations, and about datetime information” [5].

A specification to model calendars is called RDFCal [2]. It is inspired by the iCal [4] format. This format has its own kind of serialization and it is, at the time of writing, adopted by popular calendar applications. ICal handles single events in a time interval, recurring events in a time interval, exceptions for these recurring events, and so on. It provides a broad spectrum of options to the user, while remaining machine readable and keeping its ability to be queried. The model of this specification has been transformed into RDF using the RDFCal ontology. This model strikes the golden mean between ease of use for reusers as for data publishers to publish the data. This paper will use the RDFCal ontology to describe opening hours.

### III. AN ONTOLOGY FOR OPENING HOURS

In Figure 1, we have created an ontology<sup>5</sup> for opening hours which allows to stack calendars. This way, *authentic sources* are not limited in any way.

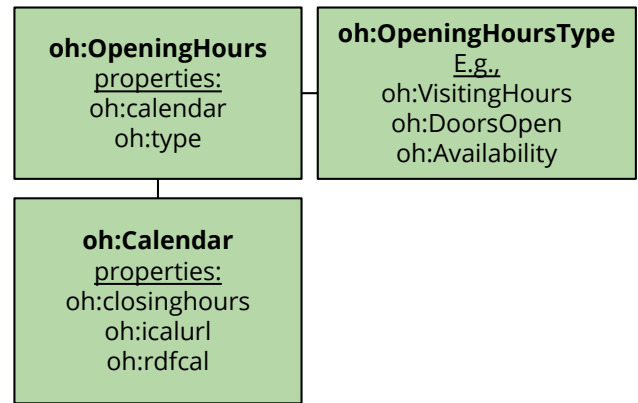


Fig. 1. Opening Hours ontology (oh)

The *oh:OpeningHours* are an *rdf:List* of calendars defined by the *oh:calendar* property. Each of the calendars get their priority through the list: the first has the highest priority, the last one the least.

The *oh:OpeningHours* contain a *oh:type* parameter, which contains a *oh:OpeningHoursType*. This type can be used to define whether the opening hours indicate that the service is open.

The *oh:Calendar* class is a definition of calendar. It contains three properties:

- *oh:closinghours* (false by default): if true, the calendar is used to indicate closing hours,
- *oh:rdfcal* (optional if *oh:icalurl* has been set): this is a link to a resource of a calendar described in RDFCal and
- *oh:icalurl* (optional if *oh:rdfcal* has been set): has a link to an ICal export of the calendar. When no *oh:rdfcal* url has been set, the data on this url can be transformed to RDFCal.

In the example in Listing 2, an example object is given *oh:openinghours* of the type *oh:DoorsOpen*. It has two calendars, from which the holidays calendar has the highest priority. The holidays calendar are closing hours, as indicated by the *oh:closinghours* property. There is an iCal url given, which can be, when adding to a store, mapped to the RDFCal ontology. The identifier of the second calendar, *layer2*, is also the identifier for the RDFCal. This calendar are opening hours, as when no *oh:closinghours* parameter is set, it defaults to false.

```
@prefix rdf:
<http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix xsd:
<http://www.w3.org/2001/XMLSchema#> .
@prefix oh: <http://semweb.mmlab.be/ns/oh#> .
@base <http://example.org/ns/> .

<entity1> oh:openinghours <entity1/open> ;
    oh:type oh:DoorsOpen .

<entity1/open> a oh:OpeningHours ;
    oh:calendar (
        <http://foo.bar/holidays> <layer2>
    ) .
```

<sup>4</sup>Natural language processing is out of the scope of this paper.

<sup>5</sup>The base uri of of this ontology is <http://semweb.mmlab.be/ns/oh>

```

<http://foo.bar/holidays> a oh:Calendar ;
  oh:closinghours "true"^^xsd:boolean ;
  oh:icalurl "http://foo.bar/holidays/ics" .

<layer2> a oh:Calendar ;
  oh:rdfcal <layer2> .

```

Listing 2. Example usage of the oh ontology describing opening hours with two calendars published at <http://example.org/ns/entity1/open>

#### IV. QUERYING OPENING HOURS

In Figure 2 we show how a query for opening hours is parsed through a SPARQL proxy before returning the results. These queries contain a filter to match two timestamps to opening hours descriptions and rules. After the query is being received by the proxy (1), the proxy transforms the query (2) to a CONSTRUCT call to configured SPARQL endpoints (3) that contain opening hours without the filter. The resulting temporary result graphs which contains all businesses that have to filtered according to availability openinghours is loaded in to the SPARQL MODEL (4). An example of an openinghours calendar is given in Listing 3. The full query with a filter is sent to a SPARQL MODEL (5) which refines the results. Finally the results are being sent under the form of open and closed businesses with a URI to their opening hours (6).

```

@prefix rdf:
<http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix ical:
<http://www.w3.org/2002/12/cal/ical#>.
_:calendar a ical:Vcalendar;
  ical:Vcomponent _:event1,
                 _:event2;

_:event1 a ical:Vevent;
  ical:dtend
    "2003-01-01T23:00:00"^^ical:dateTime;
  ical:dtstart
    "2003-01-01T11:00:00"^^ical:dateTime;
  ical:rrule _:rule1.
_:event2 a ical:Vevent;
  ical:dtend
    "2003-01-01T23:00:00"^^ical:dateTime;
  ical:dtstart
    "2003-01-01T16:30:00"^^ical:dateTime;
  ical:rrule _:rule2.
_:rule1 ical:byday "WE,TH,FR,SA,SU";
  ical:freq "WEEKLY".
_:rule2 ical:byday "TU";
  ical:freq "WEEKLY".

```

Listing 3. Example opening hours in RDF describing: "Open Wednesday to Sunday from 11AM to 11 PM and Tuesdays from 4PM to 11PM. Closed on Mondays."

The SPARQL Model is being buffered in memory for the duration of the query. The custom filter transforms all RDF opening hours of matching *government services* to a *calendar* object. The calendar object supports time based filtering of events. Each event matching the time based filter can be returned and the *government services* that are open can be extracted.

#### V. A FORM FOR OPENING HOURS

To ease the registration and publication of opening hours, we have developed a proof of concept for an *OpeningHours*

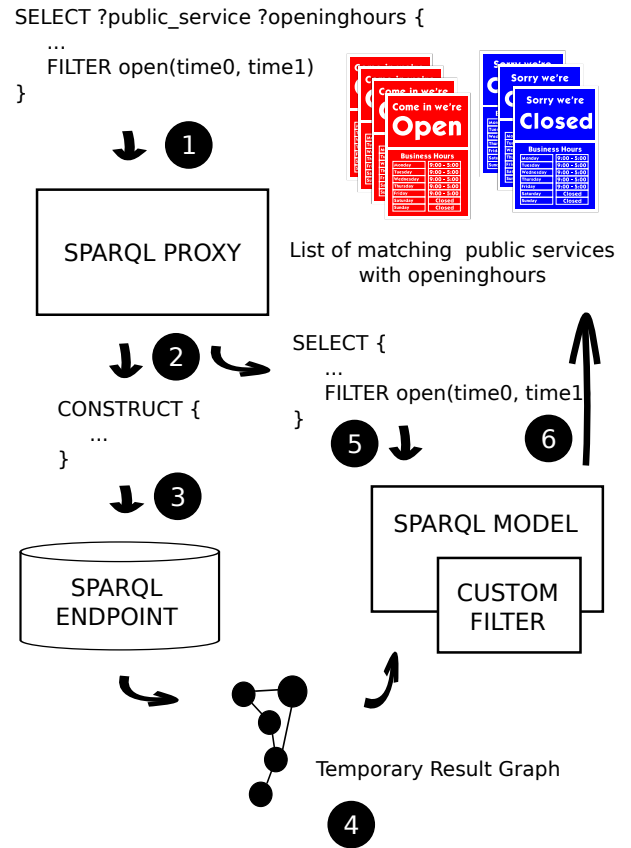


Fig. 2. Querying for Opening Hours

form that supports the creation and reuse of iCal calendars. The first part of the form (shown in Figure 3), can be used to create a new `oh:Calendar` and provides a clear set of fields to express the `OpeningHoursType`, recurrence, timeRange and validRange of a calendar. Each new calendar will be pushed to the `oh:OpeningHours` list of calendars and the priority of calendars can be changed using the priority setting at the end of the form. The first calendar in the list has the highest priority. Exceptions to a particular calendar, as special opening and closing days which deviate from the regular `OpeningHours`, can be defined in an additional calendar. Giving it a higher priority than other calendars will make sure exceptions are always to be handled before other calendars.

To minimize user input and to maximize reuse of calendars, the form allows uploading, and linking to, existing iCal calendars. Both internal iCal (.ics) files and publically available iCal exports of an existing calendar (e.g., Belgian public holidays<sup>6</sup>) can be added to the `oh:OpeningHours` list of calendars. To process/parse the existing calendars we use jQuery and the `ijp iCalendar javascript parser`<sup>7</sup>. In its current state, our form handles single events, recurring events, exceptions for these recurring events, and reuse of existing calendars.

<sup>6</sup><http://sites.google.com/site/dpetest/Home/belgian-holidays.ics> - an iCal file with the Belgian public holidays

<sup>7</sup><https://code.google.com/p/ijp/> - a javascript parser for iCal

Form Demonstrator

>> Add new Calendar

id:

TypeHours:  Recurrence:

TimeRange:  ValidRange:

>> Add existing iCal Calendar

(URL of existing OpeningHours calendar)

>> Change priority of Calendar(s)

- Closing Days Flemish Organisations
- Normal VistingHours

Fig. 3. OpeningHours form for the creation and reuse of iCal calendars.

## VI. CONSOLIDATED CALENDARS

In various linked data sources, we are now able to also include a URI towards the opening hours of a certain *government service*. This URI has to be dereferenceable [7]. The webservice we are creating in order to dereference the URI supports content negotiation between *text/turtle*, *text/calendar* and *text/html*. The representations returns a consolidated calendar: all layers in the system are combined and only one calendar is returned which can be used in a calendar application. The URI itself is the global identifier of the opening hours of a particular *government service*. There is a representation in RDF (in the turtle serialization), there is a representation in the iCal format and there is a visualization of the calendar to be found in a *text/html* representation.

## VII. FUTURE WORK AND EVALUATION

In Flanders, a region in the country of Belgium, there is an Open Standard for Local Governments (OSLO)<sup>8</sup>, which specifies a vocabulary for contact data. It is an extension of the Core Public Service Vocabulary (CPSV), which is specified by the Interoperability Solutions for European Public Administrations (ISA) programme which has to raise interoperability amongst government services in Europe. The second generation OSLO vocabulary, OSLO 2.0, will contain thesauri for functions, roles, and services within the Flemish government, but more importantly, models opening hours as part of the vocabulary: when can this role, function or service be contacted?

In order to evaluate our model, first implementations of the OSLO 2.0 specification with the *oh* ontology are going to be tested. The usability is going to be analyzed within participating pilot cities in Flanders, to query, maintain and reuse the data.

## VIII. CONCLUSIONS

This paper described a concise ontology as a solution for problems with the current state of the art when publishing and querying opening hours. We suggested a User Interface (UI)

which can be integrated in Content Management Systems (CMS) or Enterprise Resource Planning (ERP) software. This UI supports the use of the ontology and reuses the iCal specification for calendars to describe when a service is open or closed. In order to maximize reuse, the ontology is built in such a way that it can stack different calendars. For example, a calendar of the public holidays can be shared amongst the entire government. With extra logic, smart devices are able to query the published opening hours. A SPARQL proxy was implemented to merge the layers at the level of the SPARQL endpoint. The URIs used to identify different calendars are made dereferenceable. When GET-ting the URIs identifying the calendar, a consolidated calendar is returned.

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## REFERENCES

- [1] P. Colpaert, R. Verborgh, and E. Mannens. Painless URI dereferencing using The DataTank. In *Poster and Demo Proceedings of the 11th Extended Semantic Web Conference*, May 2014.
- [2] D. Connolly and L. Miller. RDF Calendar: An Application of the Resource Description Framework to iCalendar Data. *W3C Interest Group Note*, 29, 2005.
- [3] G. Correndo, M. Salvadores, I. Millard, and N. Shadbolt. Linked timelines: Time representation and management in linked data. In *First International Workshop on Consuming Linked Data (COLLD 2010)*, Shanghai, China, 2010.
- [4] F. Dawson and D. Stenerson. Internet calendaring and scheduling core object specification (icalendar). 1998.
- [5] J. R. Hobbs and F. Pan. Time ontology in OWL. *W3C working draft*, 27, 2006.
- [6] International Organization for Standardization. *Data Elements and Interchange Formats: Information Interchange: Representation of Dates and Times*. International Organization for Standardization, 1988.
- [7] K. R. Page, D. C. De Roure, K. Martinez, J. D. Sadler, and O. Y. Kit. Linked sensor data: RESTfully serving RDF and GML. 2009.

<sup>8</sup><http://purl.org/oslo>