Speleothem - An Information System for Caves Based on Semantic Web Technologies

Nikolaos Fanourakis[1,2] and Panagiotis Papadakos[2]

[1] Computer Science Department - University of Crete, Greece
[2] Institute of Computer Science - FORTH-ICS, Greece
{fanourakis,papadako}@ics.forth.gr

Abstract. Humans have used caves throughout history for a wide variety of needs, showcasing the importance of caves in human evolution. Nowadays, speleological clubs organize expeditions around and under the globe in an effort to understand, study and record the still unexplored and complex network of caves that lies underneath. Unfortunately, a common vocabulary for recording information related to caves and caving activities does not exist and most speleologists use adhoc and even non-digital forms to store it. This demo showcases the `Speleothem` system, an open-source information system for the domain of caves that exploits semantic web technologies and is built on top of a proposed vocabulary for caves and caving activities. `Speleothem` is designed in collaboration with a Greek speleological club, where it is planned to become operational in the near future.

1 Introduction

Caves have been used by humans throughout history for a wide variety of needs and purposes, and are highly interlinked with human evolution and civilization. They have been considered sacred places, decorated with parietal cave paintings by the first human artists (e.g. caves of Lascaux[3] and Altamira), and appear frequently in mythological and folklore stories. During bad weather conditions or war times, caverns have provided shelter for humans and livestocks and have been used for storing and mining resources (e.g. dairy products, water, minerals). Caves narrate the history of earth, and due to their isolation and remoteness they preserve important facts of the human history and host alien and fragile closed ecosystems. As a result they are considered sensitive information islands for a lot of scientific and academic disciplines, including but not limited to geology, anthropology, archeology, paleontology, biology, hydrology, seismology and folkloristics, and as such they are protected by local and international legislations.

Currently, a lot of people are visiting horizontal caves for their beautiful decorations or historical importance, and vertical ones for athletic and exploration reasons. Unfortunately, public or restricted access to cave related information is limited to either general information offered by local or global touristic portals (e.g. tripadvisor) or hard to find scientific publications and books that use

---

[3] http://archeologie.culture.fr/lascaux/en

complex terminologies. In addition, a lot of precious, delicate and difficult to extract information from previous expeditions is stored by local cave clubs in adhoc digital or non-digital forms. Consequently, the preservation, retrieval, validation, integration, and dissemination of information about caves, and the related human activities and their impact on them, is a rather cumbersome task. Addressing the above issues will not only provide a useful entry point to such information, but can also raise the awareness of the public opinion about the importance, sensitivity and particularities of this unseen underworld.

In this demo we present the `Speleothem` system, an open-source[4] web based system for storing and retrieving information about caves and cave related activities. It is based on semantic web technologies and introduces the `speleothem` vocabulary, especially designed for modeling cave related information. A SPARQL endpoint and a REST API for easy access to the data are also provided. The `Speleothem` system is designed in collaboration with the Speleological Club of Crete[5] where it is planned to become operational in the near future. Our aim is to offer a reference caving information system, on top of a domain specific knowledge base that stores information that can be used and linked by other external resources, for the general public, speleologists, speleological clubs and organizations.

2   Related Work

Software for caving has been limited to cave surveying, where by using specific electronic devices (or not) the software can create 2D or 3D representation of a cave (e.g. [1] and survex[6]), recording of locations, entrances and other cave related information over a map[7], or for showcasing the importance and fragility of caves (iCavern app [3]). Currently important cave related information is stored locally in cave clubs using adhoc digital or non-digital forms and vocabularies. Unfortunately, well-known ontologies (e.g. DBpedia) model only general information about caves[8] and miss other important entities and information, while others are too restrictive (e.g. the ontology described in [4] for mining equipment). In this work we propose the `speleothem` vocabulary, especially designed for modeling information about caves and cave related activities, that is at the core of the demonstrated `Speleothem` system.

3   `speleothem` Vocabulary for Caves and Caving Activities

The current version of the proposed `speleothem` vocabulary consists of 50 classes, 25 object properties and 40 data properties. Using this vocabulary we can store

---

[4] `https://bitbucket.org/speleothem/speleothem`

[5] `http://caves-crete.gr/`

[6] `https://survex.com/`

[7] `https://github.com/apgeo/silexgis`, a relevant work based on a relational DB

[8] `http://dbpedia.org/ontology/Cave`

information about the physical properties of the cave, such as the type and the size of the cavern, its location and entrances[9], the map of the cave (either in textual representations that can be used by other software like therion, or as sketches/images), collections of images of the cave itself and the outside environment, information related to the contained rooms and the natural or human created speleothems that it contains, along with their images. Each cave can be associated with climate data, living organisms, folklore stories or historical data. Regarding the caving activities, the vocabulary uses the foaf[10] vocabulary to store user profiles and caving clubs, and associates the profiles with caving equipment, special abilities of cavers (e.g. rescue training) and access policies to information. Furthermore, the vocabulary is able to hold important data about cave expeditions. `sameAs` connections with classes of other ontologies like from DBpedia[11] are also provided. A screenshot of the vocabulary using the Web-VOWL tool[12] (a web application for the interactive visualization of ontologies) is shown in Fig. 1. The current version of the `speleothem` vocabulary is online[13] but is not considered stable yet. We expect to make further refinements based on feedback from the SPOK club (where it is planned to become operational), and publish it using the best practices and the five stars policy described in [2].
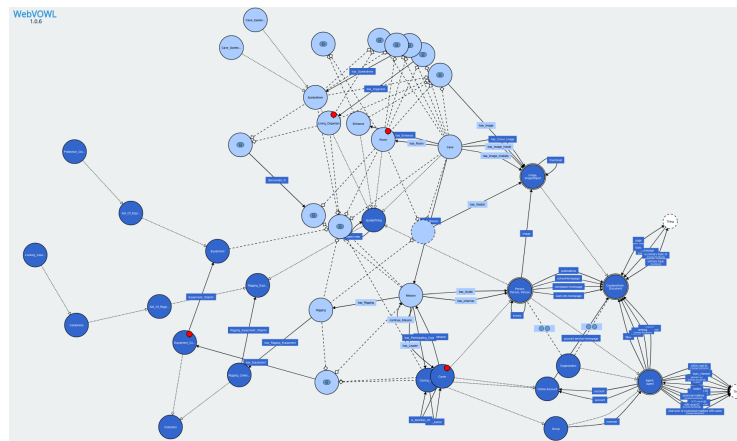
Fig. 1. The `speleothem` vocabulary as visualized by WebOWL

4   Architecture & Implementation

The architecture of the `Speleothem` system is given in Fig.2. The backend is implemented using Java technologies while the front-end is based on common web technologies and libraries (e.g. bootstrap, Google Maps API). The client
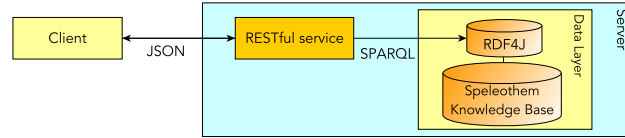
---

[9] `http://www.geonames.org`

[10] `http://xmlns.com/foaf/spec/`

[11] `http://wiki.dbpedia.org`

[12] `http://www.visualdataweb.de/webvowl/`

[13] `http://www.speleothem.org/vocabulary/alpha`

sends AJAX requests to a REST service[14] that is implemented using spark-Java[15], which exploits the SPARQL endpoint[16]. We use RDF4J[17] for storing and querying the `Speleothem` knowledge base.

Fig. 2. The `Speleothem` architecture

5 Demo Scenarios

In the current demonstration we plan to showcase the following scenarios for different user roles (i.e. unregistered, registered and administrator):

Tour of a Cave: Public data like physical properties and position, cave climate, biological and historical data, and images (Fig. 3 shows the search screen). Moreover, registered users have access to detailed cave and rigging maps, past expeditions, and any information about rooms and speleothems (check Fig. 4).

Expedition Overview: General information about a cave expedition, its aims, the participating cavers and clubs, previous related expeditions, a calendar and a report of the results, and possible revisions of cave data due to this mission.

Caving Club Overview: General club information, participated missions, members, general/rigging equipment and photos/sketches (check Fig. 5).

Caver Personal Information & Log book: User profiles of cavers, including caving clubs that they are members of, their personal equipment, important skills like knowledge of cave rescue and first aid techniques, participation in cave rescue exercises, and personal log book.

Cave Rescue: Organization and data logging during a cave rescue event.

References

1. Martin Budaj and Stacho Mudrák. Therion–digital cave maps therion–cartographie souterraine digitale. In *presented on the 4th European Speleological Congress. Banska Bystrica, Slovakia*, 2008.
2. Krzysztof Janowicz, Pascal Hitzler, Benjamin Adams, Dave Kolas, II Vardeman, et al. Five stars of linked data vocabulary use. *Semantic Web*, 5(3):173–176, 2014.
3. Sandra Dianne Joop. icaverns: Interpretation, there's an app for that! 2013.
4. Zhi Hai Liu, Qing Liang Zeng, Cheng Long Wang, and Yu Shan Li. Research of equipment selection and matching expert system in fully mechanized caving face based on ontology. In *Key Engineering Materials*, volume 419, pages 117–120. Trans Tech Publ, 2010.

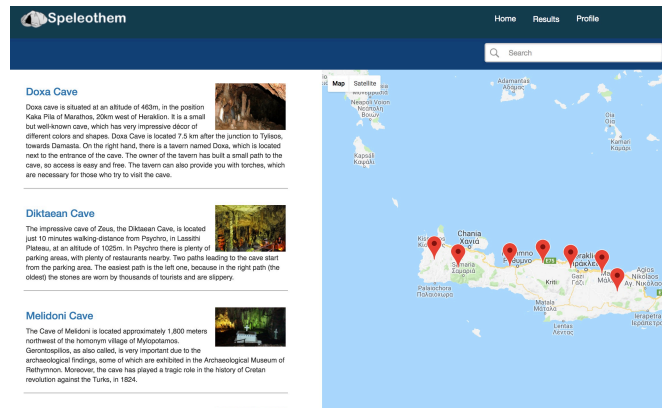[14] `http://www.speleothem.org/rest`

[15] `http://sparkjava.com/`

[16] `http://www.speleothem.org/sparql`

[17] `http://rdf4j.org/`

Fig. 3. Search Results Screen

Fig. 4. Cave Profile (Missions)

Fig. 5. Caving Club Profile