Dendro: collaborative research data management built on linked open data

João Rocha da Silva
João Aguiar Castro
Faculdade de Engenharia da Universidade do Porto/INESC TEC, Portugal,
{joaorosilva,joaoaguiarcastro}@gmail.com
Cristina Ribeiro and João Correia Lopes
DEI—Faculdade de Engenharia da Universidade do Porto/INESC TEC, Portugal
{mcr,jlopes}@fe.up.pt

Abstract. Research datasets in the so-called "long-tail of science" are easily lost after their primary use. Support for preservation, if available, is hard to fit in the research agenda. Our previous work has provided evidence that dataset creators are motivated to spend time on data description, especially if this also facilitates data exchange within a group or a project. This activity should take place early in the data generation process, when it can be regarded as an actual part of data creation. We present the first prototype of the Dendro platform, designed to help researchers use concepts from domain-specific ontologies to collaboratively describe and share datasets within their groups. Unlike existing solutions, ontologies are used at the core of the data storage and querying layer, enabling users to establish meaningful domain-specific links between data, for any domain. The platform is currently being tested with research groups from the University of Porto.

1 Introduction

Research data is diverse and requires specific knowledge to be interpreted, driving user communities to create metadata recommendations. Metadata for datasets, as for any other kind of resource, requires a tradeoff between a comprehensive description and control of the production cost [8]. This is more drastic in the "long-tail of science" as institutions often lack financial resources for data curation [4]. As metadata schemas grow to encompass the needs of different groups, their descriptors may become unnecessary or irrelevant to others, even in similar domains, and lead to an overall lack of interoperability [1,2]. This motivated some research groups to adapt and combine sets of descriptors from several metadata schemas in order to suit the needs of their applications, creating *Application Profiles* [3] to describe research datasets.

We focus on data description in the early stages of research, much like ADMIRAL [5], and propose that researchers choose their own set of metadata descriptors from existing ontologies. Dendro, our platform, innovates by integrating research datasets in the Semantic Web and allowing users to describe them using concepts captured in ontologies. We combine this dynamic approach with the advantages of a triple-based data model proposed in the same context [6]. To simplify the workflow, we do not attempt to represent the contents of files as sets of RDF triples (as done in VoID[1] for example) instead focusing on describing and relating the files and folders themselves.

Dendro is designed to support researchers in their daily data management activities. With a generic data model that allows on-demand metadata descriptor selection by the user, it is completely built on both generic and domain-specific ontologies. OpenLink Virtuoso and SPARQL are at the core of its data layer, enabling metadata descriptions to be exposed on the Web and queried through Virtuoso's SPARQL endpoint.

2 Enabling collaboration and interoperability

Dendro was designed from the start as an user-friendly interface layer for users without data management knowledge. Users build a knowledge base using ontologies *in the background*, allowing them to focus on choosing the *properties* with the right semantics for their descriptions without being concerned with design and implementation issues that arise from ontology use. Given its collaborative nature, the solution can be classified as a semantic wiki built on a triple store. It differs from other semantic wikis like Semantic Mediawiki, for example, that stores amalgamated sets of triples as "pages" in its relational database. According to the documentation[2], Semantic Mediawiki an use a triple store to provide a SPARQL endpoint, but the synchronization between the relational database and the triple store uses dedicated business logic—a trait shared by other linked open data compatible systems.

Based on our own past developments in Semantic Mediawiki [7], we concluded that its interface is not designed to allow users to combine descriptors from several ontologies when describing a page[3]. Dendro, on the other hand, makes it easier to describe any kind of resource using combinations of descriptors not specified *a priori*. The ontology-based data model enables data management personnel without coding skills to contribute by building and loading additional ontologies into *their* Dendro, which can then be shared on the web to document the descriptions and reused by others in the Dendro instances that they manage.

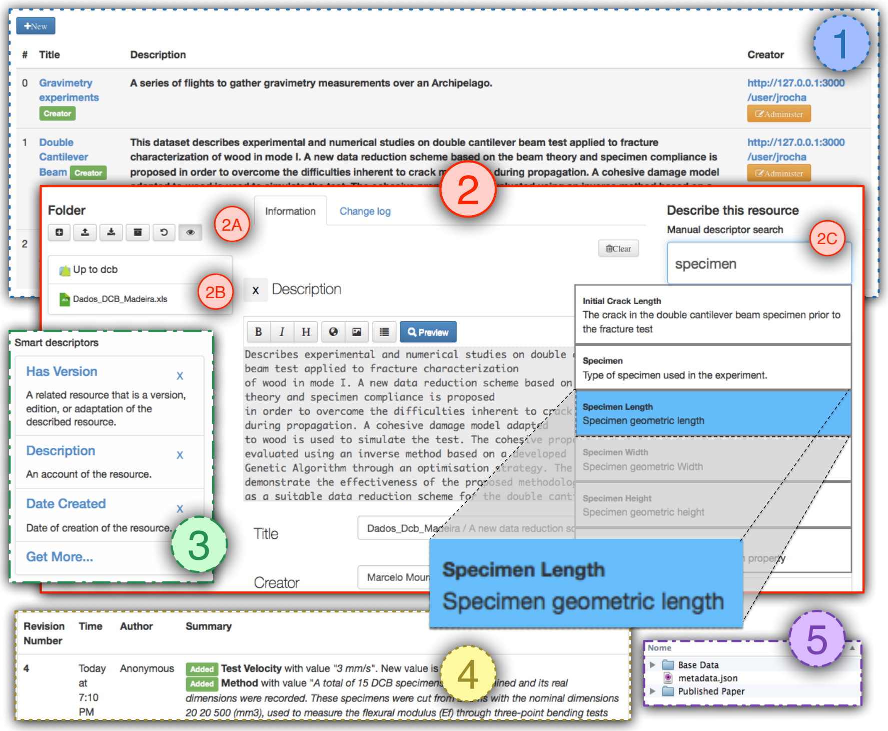
3 A walkthrough of the solution

In this section we will provide an overview of the main features provided by Dendro in its current form. We demonstrate the usage of Dendro in the daily

[1] `http://www.w3.org/TR/void/`

[2] `http://semantic-mediawiki.org/wiki/Help:Using_SPARQL_and_RDF_stores`

[3] A *description template* must be specified *a priori* for each type of description page.



#	Title	Description	Creator
0	Gravimetry experiments Creator	A series of flights to gather gravimetry measurements over an Archipelago.	http://127.0.0.1:3000/user/jrocha Administer
1	Double Cantilever Beam Creator	This dataset describes experimental and numerical studies on double cantilever beam test applied to fracture characterization of wood in mode I. A new data reduction scheme based on the beam theory and specimen compliance is proposed in order to overcome the difficulties inherent to crack m during propagation. A cohesive damage model	http://127.0.0.1:3000/user/jrocha Administer
2			

Describes experimental and numerical studies on double
beam test applied to fracture characterization
of wood in mode I. A new data reduction scheme based on
theory and specimen compliance is proposed
in order to overcome the difficulties inherent to crack
during propagation. A cohesive damage model adapted
to wood is used to simulate the test. The cohesive prope
evaluated using an inverse method based on a developed
Genetic Algorithm through an optimisation strategy. The
demonstrate the effectiveness of the proposed methodolog
as a suitable data reduction scheme for the double cant

Title: Dados_Dcb_Madeira / A new data reduction sc

Creator: Marcelo Mour

Describe this resource

Manual descriptor search: specimen

Initial Crack Length
The crack in the double cantilever beam specimen prior to the fracture test

Specimen
Type of specimen used in the experiment.

Specimen Length
Specimen geometric length

Specimen Width
Specimen geometric Width

Specimen Height
Specimen geometric height

Smart descriptors

Has Version
A related resource that is a version, edition, or adaptation of the described resource.

Description
An account of the resource.

Date Created
Date of creation of the resource.

Get More...

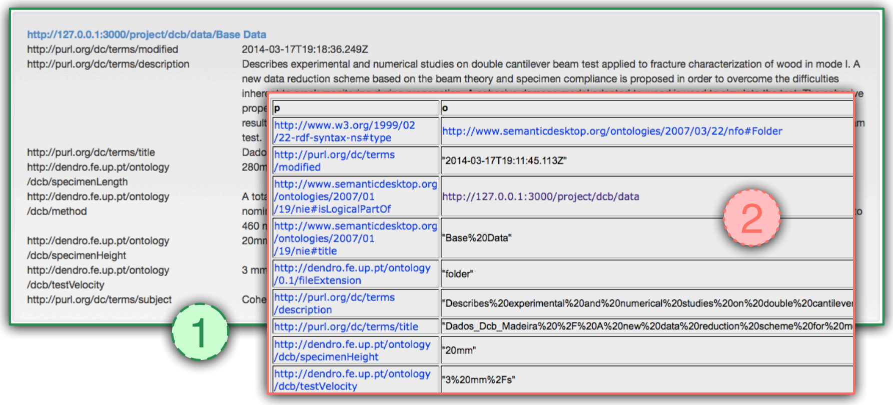
Revision Number	Time	Author	Summary
4	Today at 7:10 PM	Anonymous	Added **Test Velocity** with value "*3 mm/s*". New value is Added **Method** with value "*A total of 15 DCB specimens ... ined and its real dimensions were recorded. These specimens were cut from ... s with the nominal dimensions 20 20 500 (mm3), used to measure the flexural modulus (Ef) through three-point bending tests*

Fig. 1. Using Dendro to describe a mechanical engineering dataset

research data management activities within research groups from two very distinct domains—fracture mechanics experiments (mechanical engineering) and pollutant analysis (analytical chemistry)[4].

Figure 1 is a composite of screenshots showing how Dendro can be used to describe a dataset from the mechanical engineering domain. Area **1** shows the *project list* that allows users to see the projects that they have created in the system (i.e. there is an instance of `dcterms:creator` in the graph, with the project as its subject and the user as its object). Area **2** shows the main description interface. Note the list of options available to the user (area **2A**, from left to right: create folder, upload file(s), download folder, backup folder, restore folder, and show/hide deleted files). The file list **2B** shows the contents of the current folder and allows the user to navigate in the system. The *autocomplete* box **2C** is used to retrieve descriptors from the ontologies currently loaded in the Dendro instance, based on the values of their `rdfs:label` and `rdfs:comment` annotation properties—upon selection, the descriptor is added to the description

[4] Video demonstrations for Dendro are available; short version (4 min): `http://goo.gl/ug4FTh`. Long version (40 min): `http://goo.gl/SvdXhd`.



http://127.0.0.1:3000/project/dcb/data/Base Data

http://purl.org/dc/terms/modified	2014-03-17T19:18:36.249Z
http://purl.org/dc/terms/description	Describes experimental and numerical studies on double cantilever beam test applied to fracture characterization of wood in mode I. A new data reduction scheme based on the beam theory and specimen compliance is proposed in order to overcome the difficulties inhere prope result test.
http://purl.org/dc/terms/title	Dado
http://dendro.fe.up.pt/ontology/dcb/specimenLength	280m
http://dendro.fe.up.pt/ontology/dcb/method	A tota nomi 460 r
http://dendro.fe.up.pt/ontology/dcb/specimenHeight	20mm
http://dendro.fe.up.pt/ontology/dcb/testVelocity	3 mm
http://purl.org/dc/terms/subject	Cohe

p	o
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	http://www.semanticdesktop.org/ontologies/2007/03/22/nfo#Folder
http://purl.org/dc/terms/modified	"2014-03-17T19:11:45.113Z"
http://www.semanticdesktop.org/ontologies/2007/01/19/nie#isLogicalPartOf	http://127.0.0.1:3000/project/dcb/data
http://www.semanticdesktop.org/ontologies/2007/01/19/nie#title	"Base%20Data"
http://dendro.fe.up.pt/ontology/0.1/fileExtension	"folder"
http://purl.org/dc/terms/description	"Describes%20experimental%20and%20numerical%20studies%20on%20double%20cantilever
http://purl.org/dc/terms/title	"Dados_Dcb_Madeira%20%2F%20A%20new%20data%20reduction%20scheme%20for%20m
http://dendro.fe.up.pt/ontology/dcb/specimenHeight	"20mm"
http://dendro.fe.up.pt/ontology/dcb/testVelocity	"3%20mm%2Fs"

Fig. 2. A free-text search and SPARQL query over Dendro's graph

area to be filled in. All descriptors originate from ontologies available on the web. Upon loading an ontology into Dendro, its properties become available in the search box, provided they have their own `rdfs:label` and `rdfs:comment` annotation properties.

The system also provides a set of *smart* descriptors **3**, usually presented below **2C**, which can be seen as shortcuts for fast selection of most recently used descriptors. Upon first use, the system will simply recommend the most used descriptors in the system. When the user selects a descriptor, the system will give preference to descriptors from the same ontology. When the user selects another descriptor from a different ontology, the recommendation is broadened to the descriptors from the now two *active* ontologies. All changes to descriptor values are versioned, as can be seen in area **4**. Finally, the system supports recursive backup and restore of directory structures (including metadata) through `ZIP` files. Area **5** shows the contents of a complete backup of the current project—note the `metadata.json` file at the root, which contains all the metadata for all resources in the project's directory tree.

Figure 2 shows the resource described in Figure 1 among the results of a full-text search for the term "fracture mechanics" over the Dendro system (**1**). The search is powered by an ElasticSearch index that indexes every resource in the graph by its literals and that is continuously updated. Area **2** shows a partial view of the results of a SPARQL query used to retrieve the metadata for the same resource—SPARQL queries such as this are used internally by Dendro to retrieve and modify data in the underlying OpenLink Virtuoso graph database.

4 Conclusions and future work

Dendro is a research data management platform designed to provide researchers with a collaborative environment for storing and describing their datasets. Ontologies are used as sources for properties, picked by researchers to describe their research data.

Dendro differs from other research data management platforms in its “all semantic web” approach. By employing a triple-based data model and OpenLink Virtuoso, each resource can have an arbitrary set of descriptors. As they interact with the system, Dendro users are actually building a Linked Open Data graph of interconnected research-related resources, while data access is performed internally via SPARQL all accross the platform.

Dendro development is informed by the requirements of a panel of researchers from the University of Porto, and preliminary tests have shown a good match between their data management needs and the services of the platform. We regard it as an effective practical application of semantic web technologies, as well as a catalyst for the creation of domain-specific lightweight ontologies.

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