

LEAPS: A Semantic Web and Linked data framework for the Algal Biomass Domain

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Abstract. In this paper we present, *LEAPS*, a Semantic Web and Linked data framework for searching and visualising datasets from the domain of Algal biomass. *LEAPS* provides tailored interfaces to explore algal biomass datasets via REST services and a SPARQL endpoint for stakeholders in the domain of algal biomass. The rich suite of datasets include data about potential algal biomass cultivation sites, sources of CO₂, the pipelines connecting the cultivation sites to the CO₂ sources and a subset of the biological taxonomy of algae derived from the world's largest online information source on algae.

1 Motivation

Recently the idea that algae biomass based biofuels could serve as an alternative to fossil fuels has been embraced by councils across the globe. Major companies, government bodies and dedicated non-profit organisations such as ABO (Algal Biomass Organisation)³ and EABA (European Algal Biomass Association)⁴ have been pushing the case for research into clean energy sources including algae biomass based biofuels.

It is quickly evident that because of extensive research being carried out, the domain itself is a very rich source of information. Most of the knowledge is however largely buried in various formats of images, spreadsheets, proprietary data sources and grey literature that are not readily machine accessible/interpretable. A critical limitation that has been identified is the lack of a knowledge level infrastructure that is equipped with the capabilities to provide semantic grounding to the datasets for algal biomass so that they can be interlinked, shared and reused within the biomass community.

Integrating algal biomass datasets to enable knowledge representation and reasoning requires a technology infrastructure based on formalised and shared vocabularies. In this paper, we present *LEAPS*⁵, a Semantic Web/Linked data framework for the representation and visualisation of knowledge in the domain

³ <http://www.algalbiomass.org/>

⁴ <http://www.eaba-association.eu/>

⁵ <http://www.semanticwebservices.org/enalgae>

of algal biomass. One of the main goals of *LEAPS* is to enable the stakeholders of the algal biomass domain to interactively explore, via linked data, potential algal sites and sources of their consumables across NUTS (Nomenclature of Units for Territorial Statistics)⁶ regions in North-Western Europe.

Some of the objectives of *LEAPS* are,

- motivate the use of Semantic Web technologies and LOD for the algal biomass domain.
- laying out a set of ontological requirements for knowledge representation that support the publication of algal biomass data.
- elaborating on how algal biomass datasets are transformed to their corresponding RDF model representation.
- interlinking the generated RDF datasets along spatial dimensions with other datasets on the Web of data.
- visualising the linked datasets via an end user LOD REST Web service.
- visualising the scientific classification of the algae species as large network graphs.

2 *LEAPS* Datasets

The transformation of the raw datasets to linked data takes place in two steps. The first part of the data processing and the potential calculation are performed in a GIS-based model which was developed for this purpose using ArcGIS⁷ 9.3.1. The second step of lifting the data from XML to RDF is carried out using a bespoke parser that exploits XPath⁸ to selectively query the XML datasets and generate linked data using the ontologies.

The transformation process yielded four datasets which were stored in distributed triple store repositories: Biomass production sites, CO₂ sources, pipelines and region potential. We stored the datasets in separate repositories to simulate the realistic scenario of these datasets being made available by distinct and dedicated dataset providers in the future. While a linked data representation of the NUTS regions data⁹, was already available there was no SPARQL endpoint or service to query the dataset for region names. We retrieved the dataset dump and curated it in our local triple store as a separate repository. The NUTS dataset was required to link the biomass production sites and the CO₂ sources to regions where they would be located and to the dataset about the region potential of biomass yields. The transformed datasets interlinked resources defining sites, CO₂ sources, pipelines, regions and NUTS data using link predicates defined in the ontology network.

Datasets about algae cultivation can become more meaningful and useful to the biomass community, if they are integrated with datasets about algal strains.

⁶ <http://bit.ly/I7y5st>

⁷ <http://www.esri.com/software/arcgis/index.html>

⁸ <http://www.w3.org/TR/xpath/>

⁹ <http://nuts.geovocab.org/>

This can help the plant operators in taking judicious decisions about which strain to cultivate at a specific geospatial location. Algaebase¹⁰ provides the largest online database of algae information. While Algaebase does not make RDF versions of the datasets directly available through its website, they can be programmatically retrieved via their LSIDs (Life Science Identifiers) from the LSID Web resolver¹¹ made available by Biodiversity Information Standards (TDWG)¹² working group.

We retrieved RDF metadata for 113061 species of algae¹³ and curated in our triple store. We then used the Semantic import plugin with Gephi to visualise the biological taxonomy of the algae species.

3 System Description

LEAPS provides an integrated view over multiple heterogeneous datasets of potential algal sites and sources of their consumables across NUTS regions in North-Western Europe. Figure 1 illustrates the conceptual architecture of *LEAPS*. The

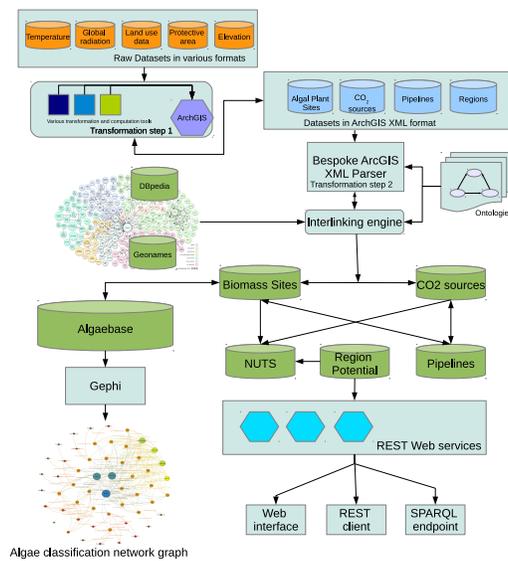


Fig. 1. Architecture of *LEAPS*

main components of the application are

¹⁰ <http://www.algaebase.org/about/>

¹¹ <http://lsid.tdwg.org/>

¹² <http://www.tdwg.org/>

¹³ The retrieval algorithm ran on an Ubuntu server for three days

- **Parsing modules:** As shown in Figure 1, the parsing modules are responsible for lifting the data from their original formats to RDF. The lifting process takes place in two stages to ensure uniformity in transformation.
- **Linking engine:** The linking engine along with the bespoke XML parser is responsible for producing the linked data representation of the datasets. The linking engine uses ontologies, dataset specific rules and heuristics to generate interlinking between the five datasets. From the LOD cloud, we currently provide outgoing links to DBpedia¹⁴ and Geonames¹⁵.
- **Triple store:** The linked datasets are stored in a triple store. We use OWLIM SE 5.0¹⁶.
- **Web services:** Several REST Web services have been implemented to provide access to the linked datasets.
- **Ontologies:** A suite of OWL ontologies for the algal biomass domain have been designed and made available.
- **Interfaces:** The Web interface provides an interactive way to explore various facets of sites, sources, pipelines, regions, ontologies and SPARQL endpoints. The map visualisation has been rendered using Google maps. Besides the SPARQL endpoint and the interactive Web interface, a REST client has been implemented for access to the datasets. Query results are available in RDF/XML, JSON, Turtle and XML formats.

4 Application access

*LEAPS*¹⁷ is available on the Web. The interface currently provides visualisation and navigation of the algae cultivation datasets in a way most intuitive for the phycologists. The application has been demonstrated to several stakeholders of the community at various algae-related workshops and congresses. They have found the navigation very useful and made suggestions for future dataset aggregation. At the time of this writing, data retrieval is relatively slow for some queries because of their federated nature, however optimisation work on the retrieval mechanism is in progress to enable faster retrieval of information.

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References

¹⁴ <http://dbpedia.org/About>

¹⁵ <http://sws.geonames.org/>

¹⁶ <http://www.ontotext.com/owlim/editions>

¹⁷ <http://www.semanticwebservices.org/enalgae>