

# KnowledgeScapes: linking Knowledge to Spatial Features

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## 1. Introduction

This paper presents a method that links spatial features in a spatial dataset to concepts expressed in an ontology in a browsable *KnowledgeScape*. The link between spatial data at the feature level and formally defined knowledge provides much scope for enhancing our discovery and use of spatial data and new opportunities for creatively composing spatial data with other kinds of information at that feature level.

The methodology presented brings together a number of existing tools in the creation of a linked dual-paned browser, one pane presenting the ontology browser and the other the spatial data. The technologies used in support of this methodology include *PostGIS*, the *ArcGIS Flex API*, *Triplify*, and the *OpenLink Virtuoso* server. Combined they provide a useful first prototype and the basis for much future development.

## 2. Context

With the advent of the Semantic Web (Berners-Lee et al. 2001), formal means of defining our knowledge about the world are more widely available, and our ability to enhance the discovery and use of data and information is increasing. In the context of GIScience, new methods are being developed to associate a panoply of resources with a spatial dataset to improve its discovery and use (Stock et al. 2009, Brodaric et al. 2008).

While GIS is a powerful and increasingly ubiquitous tool, at a basic level the way we model Geographic Information (GI) limits data or service discovery, harmonisation and use (Reitsma et al. 2009). A simple yet valuable extension, given recent developments in the Semantic Web community, is the addition of the link from information to knowledge defining the nature of that information, which goes beyond the present link from data to information. Such a link allows for the expression of the meaning of our data and information.

This paper presents research on the implementation of one method that connects spatial data at the feature level to knowledge about that feature, which we term a *KnowledgeScape*. This builds on previous work that presents the theoretical foundations of implementing such feature level semantics and an earlier implementation (Batcheller and Reitsma 2010). The link between data and knowledge allows us to browse and select concepts which then highlight relevant spatial features. Ultimately this could also support reasoning with spatial data at the feature level and the dissolution of datasets and their recombination from features based on knowledge about those features. In what follows, Section 3 provides a review of related research in visualisation, while Section 4 describes the approach taken.

### 3. Visualisation Background

Within GIScience, there has been much work in the field of spatialisation of information (Skupin and Fabrikant 2007), some of the concepts of which naturally apply to visualising ontologies, particularly those methods developed for data without geographic coordinate references where there is an explicit link between data items. Work by Tricot and Roche (2006) applies some of these ideas in the visualisation of knowledge that is guided by the semantic structure of the information space, where cartographic principles are used to aid the visualisation of knowledge.

Yet the purpose of this paper is not only to visualise geographic knowledge, but to support the link between the knowledge expressed in an ontology and the geographic features represented in a spatial dataset. The work of Dadzie et al. (2009) in creating XMediaBox is an example of linking ontological knowledge about concepts and relationships in a domain with associated resources such as images and documents. Similarly within GIScience, work has been undertaken to associate spatial datasets with affiliated resources, such as the COMPASS project and ConceptVISTA (Stock et al. 2009, Gahegan et al. 2009).

Beyond linking spatial datasets and associated resources to ontologies, Métral et al. (2007) conceptually describe how one might provide a visual link (i.e. an arrow) from spatial features presented in a 3D map view to other resources such as plans and associated planning documents in aid of enhancing the visualisation of linked resources. More recently, Auer et al. (2009a) have utilised Triplify (Auer et al. 2009b) to map the geospatial data provided by OpenStreetMap to an ontology. Called LinkedGeoData, the online application developed by Auer et al. (2009a) allows the user to browse the spatial data via an indented list of classes and properties.

The work of this paper is a tightening of this co-ordination (Roberts 2005), that is, the linking together of forms of interaction between the ontology and the spatial data at the feature level. It also provides an alternative visualisation interface for browsing spatial data through associated knowledge.

### 4. Approach

The method that has been implemented allows a user to browse the ontology, such that when a concept is selected in the knowledge viewer, spatial data that relates to that concept is selected and highlighted in the spatial data viewer. The implementation builds on existing technology, bringing together a number of tools, namely Triplify<sup>1</sup>, PostGIS<sup>2</sup>, ESRI ArcGIS API for Flex<sup>3</sup>, and OpenLink Virtuoso server<sup>4</sup>. The canonical example used for testing the technology is that of the University of Canterbury's campus buildings and associated departments and colleges, housed within these buildings, which forms the organisational structure of the University.

The knowledge viewer relies on multiple data and transformation layers that are represented in Figure 1. A PostgreSQL database server with PostGIS spatial extensions stores and serves the spatial data that are converted to triples by Triplify. Triplify (Auer et al. 2009b) is a PHP script that converts the results of database SQL queries into RDF, JSON and Linked Data. The results of these queries can then be accessed at particular URLs that map to IDs found in database tables. Since the RDF serialisation used by triplify is *n3*, we query the results through triplr, which converts *n3* triples to

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<sup>1</sup> <http://triplify.org/>

<sup>2</sup> <http://postgis.refrains.net/>

<sup>3</sup> <http://resources.esri.com/arcgisserver/apis/flex/>

<sup>4</sup> <http://virtuoso.openlinksw.com/dataspace/dav/wiki/Main/>

the XML serialisation used by the client. And OpenLink Virtuoso server is used as a triple store for the ontologies describing the spatial data, which includes basic reasoning mechanisms for *rdfs:subClassOf*, *rdfs:subPropertyOf* and *owl:sameAs*<sup>5</sup>, and which is queried using SPARQL. For browsing the spatial data, an interface using ESRI's ArcGIS API for Flex has been built<sup>6</sup>.

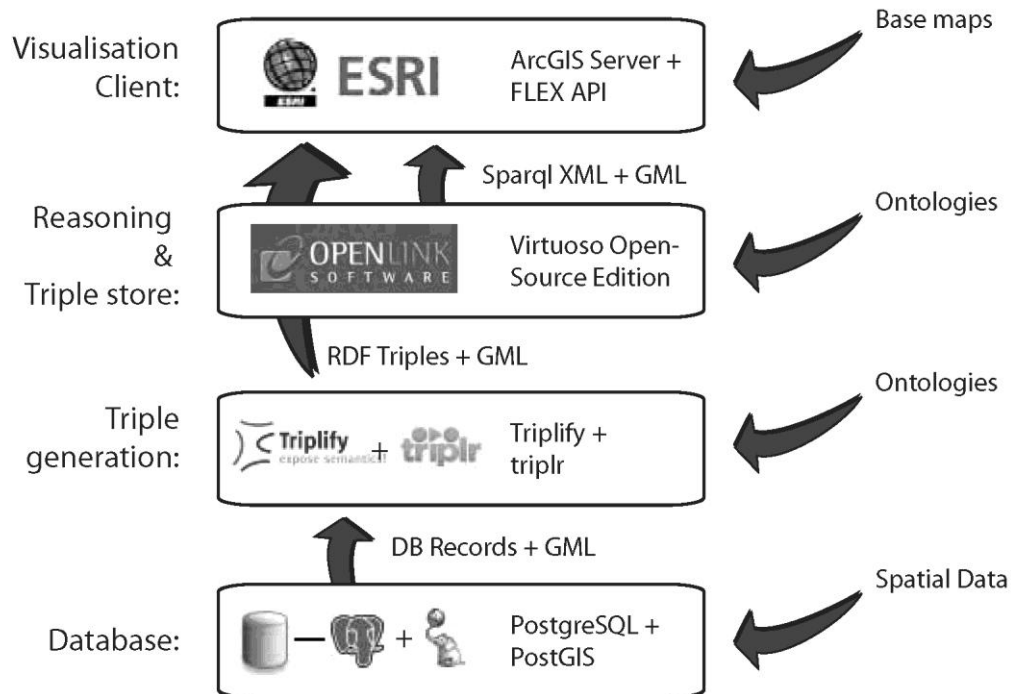


Figure 1. Architecture of knowledge viewer.

A simple spatial dataset of building footprints of the University of Canterbury was created. The shapefile was generated from a CAD file used by the University to manage its resources, and then imported into PostGIS using the *shp2pgsql* data loader function. Within the attribute table of this dataset is a unique identifier and the name of each building. Complementing the spatial dataset, ontologies were developed that define the facilities, institutional structure, and qualifications of the University, as well as a small sample of courses and academics. The *facilities* ontology defines classes relating to *Buildings*, types of buildings and parts of buildings. The *institutions* ontology describes the administrative structure of the university, such as *Colleges*, *Schools* and *Departments* and their relationships. The *courses* ontology lists the qualifications awarded by the University of Canterbury, which is linked to a set of *Courses* taught at the University that form a contributing part to the qualification as well as being linked to a set of people who teach those courses. And finally, a background dataset containing 0.75m colour ortho-photography was accessed from a local government web service<sup>7</sup> and used as a base layer for the spatial data viewer presented in Figure 2.

<sup>5</sup> <http://docs.openlinksw.com/virtuoso/rdfsparqlrule.html>

<sup>6</sup> <http://resources.esri.com/arcgisserver/apis/flex/>

<sup>7</sup> <http://arcgis.ecan.govt.nz/ArcGIS/rest/services/ImageryBasedata/MapServer>

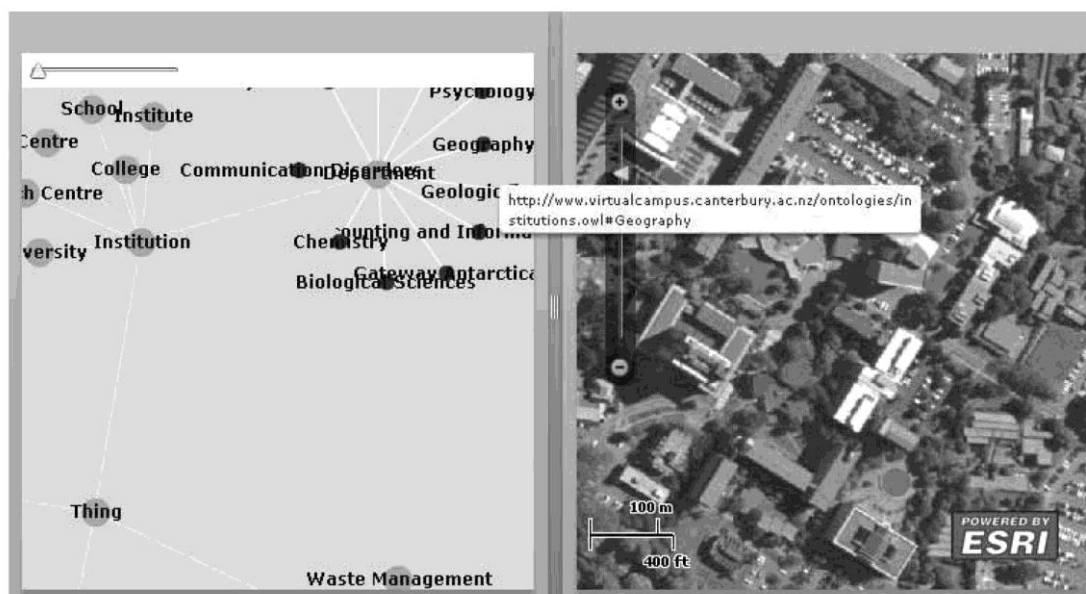


Figure 2. KnowledgeScape browser with the Geography building selected.

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