1. Purpose of the Application

Sextant has been used in the domains of Earth Observation and Environment by presenting its browsing and visualization capabilities using a number of link geospatial datasets and other geospatial data sources publicly available on the Web. In particular, we showed how Sextant can be used by an expert in Earth Observation (EO) as a tool to serve the two use-cases of the TELEIOS project, namely, rapid mapping and knowledge discovery from satellite images. While the feedback received from the two user partners of the project, the German Aerospace Center (DLR) and the National Observatory of Athens (NOA) was encouraging in terms of the offered functionality, it was discouraging in terms of usability. Briefly, Sextant was considered hard to be operated by users not familiar with semantic web technologies, while it missed a handful of features needed by EO experts, such as visualization of statistical data, support of certain raster and vector formats, editing capabilities, and a mobile counterpart version.

In this report we present the web-based and mobile version of Sextant that tries to remedy the shortcomings of the original version of Sextant and focus on creating a user-friendly application enhanced with features, which exist in the matured Geographic Information Systems, allowing both experts and non-experts to explore and visualize linked geospatial data. This new release is focused on introducing semantic web technologies to non-expert users and assist them on using the features provided, in an intuitive way. This is achieved by hiding from the user all the interaction with the SPARQL endpoints and providing a friendly interface for creating thematic maps, searching and visualizing existing maps, exploring the contents of SPARQL endpoints and allow for search over the GEOSS Portal to discover Earth Observation datasets.
2. Architecture
Sextant is a web-based and mobile ready application for exploring, interacting and visualizing time-evolving linked geospatial data. What we wanted to achieve is develop an application that is flexible, portable and interoperable with other GIS tools. Sextant is build using a client-server architecture model as depicted in Figure 1.

![Architecture of Sextant](image)

2.1. Client
We used Bootstrap framework\(^1\) to implement a responsive single code base user interface (UI), that is used in both the web application and the mobile application. For map rendering we decided to use OpenLayers 2.13\(^2\) JavaScript Mapping Library, that enables us to run the application in a local environment and supports a great variety of GIS file formats. To handle the evolution of geospatial data through time, we use Timemap JavaScript library\(^3\), that integrates the SIMILE Timeline widget\(^4\)

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2. [http://openlayers.org/two/](http://openlayers.org/two/)
3. [https://code.google.com/p/timemap/](https://code.google.com/p/timemap/)
with OpenLayers, to allow visualization of KML files enriched with temporal information. A lot of effort was put in designing a user-friendly and flexible environment for the end-user, that is developed using HTML 5, CSS and JavaScript technologies.

### 2.2. Server

The server is build in Java 7 and is composed of the endpoint connector, the ontology manager, the map registry and the KML translator. The communication between the clients and the server is implemented using Jersey RESTful Web Services framework⁵.

The endpoint connector is responsible for the communication between Sextant and various SPARQL endpoints that are publicly accessible on the web through a URI and are compliant with the specification documents of SPARQL 1.1 protocol and the SPARQL query results XML format.

As we described above, each map created with Sextant is represented using the map ontology. The ontology manager is the component responsible for maintaining the description of a map, and communicates with the map registry to store or retrieve the RDF description of a map.

The map registry is responsible for storing the RDF description of maps according to the map ontology. In Sextant we use Strabon Endpoints to act as map registries in order to offer search capabilities on spatial and temporal attributes.

Finally, the KML translator is used to translate the results of GeoSPARQL and stSPARQL queries from SPARQL query results XML format to the KML file format.

To achieve interoperability with other well-known GIS tools, Sextant is based on the OGC standards listed below:

- OpenGIS Simple Features Access (OGC-SFA) standard that defines Well-Known Text (WKT) format for representing geometries.

- Geography Markup Language (GML) for expressing geographical features.

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⁵ [https://jersey.java.net/](https://jersey.java.net/)
• The KML file format that was designed by Google and became an OGC standard in 2008, which is an XML notation for expressing geographic annotation and visualization on web-based and mobile two-dimensional maps or three-dimensional Earth browsers.

• The query language GeoSPARQL for representing and querying RDF data with geospatial information.

3. Sextant

Linked geospatial data are receiving growing attention as researchers and practitioners are using the matured semantic web technologies to publish and structure web data. New data are constantly produced, but also changes in form of updates occur over the existing data sets and the temporal dimension has started to play a crucial role. While the list of geospatial and temporal data made available as linked data is growing, the need of managing and using this information to address broad environmental or social needs across geographic scales has emerged. Applications for exploiting this abundance of geospatial information have started to emerge, that focus on browsing and exploring linked geospatial datasets and combine them with other heterogeneous geospatial data to create thematic maps that are useful for analyzing or assessing an event or situation.

In this report we present a mobile platform for exploring and interacting with linked geospatial and temporal data, producing statistical charts, as well as creating, sharing and searching for thematic maps that combine geospatial information from different sources. Many new features were added and new functionality has been introduced in an attempt to create a user-friendly application that would allow both domain experts and non-experts to take advantage of semantic web technologies, and convince them to adopt these technologies by presenting the benefits of the linked open geospatial Web through the use of Sextant.

The features of this release are the following:
1. Create thematic maps and share them with other users.
2. Support for KML, GML vector formats and GeoTIFF images.
3. User added points and polygons along with their metadata such as title, creator, description and more.
4. Feature Coloring. Using this addition, users can give different colors to each placemark of a KML file according to the value of a specified feature. Using this feature we can create color maps that are used to understand the layer's data in a quick look of the map.

5. Search for Maps. The map ontology was enhanced with a list of metadata such as title, creator, geographic extent, theme and more, that the user can use to search for maps.

6. Create layers by querying SPARQL endpoints.

7. Predefined Queries. This feature gives access to various predefined queries that the user can select from a list, only by providing the URL of an endpoint. Each predefined query is presented with a description in plain text that anyone can understand without the need of knowing SPARQL.

8. Statistical Charts. Using RDF Data Cube Vocabulary we have introduced a technique for enhancing and existing ontology and allow users to create charts in an intuitive way. Using this feature, users can create charts without the need of writing SPARQL queries, just by using the friendly interface of Sextant to select the dimensions they want to fix and the measures they need to visualize.

9. Explore the ontology of SPARQL endpoints and describe its contents.

10. Search for EO datasets in GEOSS Portal.

3.1. Layout and User Interface
The following chapters describe the layout and application flow of Sextant. The visualizations are used as indicators. Therefore, these may slightly differ from the resulting implementation.
### 3.1.1. Screen Layout

The screen layout is divided into three parts:

- **The top action bar** contains the application functions. It displays all actions as icons when the screen resolution is wide enough. Otherwise, these actions are provided as menu entries accessible by the virtual or hardware menu key.

- **The main content view** provides a map base layer where the contents of thematic maps are visualized into layers, and a timeline to view the evolution of layers through time.

- **The side panel** provides several function buttons over the layers, the map information and the explore function.

![Figure 2 - Sextant screen layout](image)

The layout adapts itself to any screen resolution, for both smartphones and tablets. It is therefore usable on any mobile device running Android 4.0 and up. The application will stretch and/or fill the application content where needed to make use of the whole screen and provide an optimal visualization.
The different action bar entries provide the following functionalities:

**Figure 3 - Sextant menu bar**

An additional tab is provided for the Android client to allow the connection to a server:

**Figure 4 - Connect to server tab**
3.1.2. Save map

In Figure 5 we present how to save a map in Sextant. The user has to provide the map information to populate the map metadata, and the endpoint where the map will be saved. Then choose to create new map or overwrite an existing one and select the layers that will be saved in this map by clicking the respective checkboxes.

*Figure 5 - Save a map in Sextant*
3.1.3. Load map
In Figure 6 we present how to load a map in Sextant. Each map has a unique identifier, and by providing that and the SPARQL endpoint where it is saved, we can load the map in the application.

![Figure 6 - Load a map in Sextant](image)
3.1.4. Search for maps
To search for maps, the user can provide keywords in the search parameters fields as depicted in Figure 7 and draw an extent that the map’s bounding box must intersect. Then we select the endpoint where the search will take place.

Figure 7 - Search for maps in Sextant
The results of the search are a list of maps with their respective metadata and a checkbox that the user can choose to visualize the selected map. In Figure 8 we present a result set with three maps.

**Figure 8 - Results from map search**
### 3.1.5. Layers in Sextant

Each layer we create in Sextant is connected to the respective record in the Layer panel. Each record consists of a checkbox to show/hide the layer, the name of the layer and a set of buttons to interact with the layer:

![Figure 9 - Layer buttons](image)

- **Zoom function** that zooms the map to the extent of the layer.
- **An information button** that shows to the user all the information regarding this layer.
- **Query edit and update function** that shows the query that resulted in the creation of this layer and the user can edit the query and update the current layer. This function is available only for layers that are created by querying a SPARQL endpoint.
- **Global styling function** that provides an interface to chromatically edit vector layers.
- **Feature styling function** that provides an interface for changing the color of each placemark in a KML file according to the value of a selected feature.
- **Move the layer on top of every other layer on the map.**
- **Delete button** to erase the layer from the map.
3.1.6. The userInfo layer
Each map has one special layer that allows to add Points of Interest (POIs) and Areas of Interest (AOIs) on the map. In Figure 10 we present the forms to add these features on the map.

![Figure 10 - Add POIs and AOIs to map](image-url)
3.1.7. Create layers
There are four forms the user can use to create a layer according to its type (KML, GML, GeoTIFF, query). In Figure 11 we show these forms.

Figure 11 - Create layers in Sextant
3.1.8. Predefined queries
To assist non-expert users on visualizing the content of a SPARQL endpoint, we provide the predefined queries. These queries are written by an expert and presented in plain text through Sextant interface for users to select and visualize their results. In Figure 12 we demonstrate how to access these queries and create a layer out of the results.

![Figure 12- Predefined queries](image-url)
3.1.9. Statistical Charts

Users can use Sextant to visualize statistical charts out of the information in a SPARQL endpoint. In Figure 13 we demonstrate how to create such a chart step-by-step, using the interface of the application.

Figure 13 - Create statistical charts in Sextant
In each step, users provide information about the chart they want to create. First they need to provide the URI of the SPARQL endpoint that holds the data. Then they select which dimension they want to visualize and the instance of the specified dimension. In the last step they select the measures they want to visualize and the type of the chart. The result of this process is the chart in Figure 14.

Figure 14 - Statistical chart example
3.1.10. Explore and Describe ontologies

Using the Explore panel, we can connect to a SPARQL endpoint and view the classes available in the dataset along with their properties. In Figure 15 we show an example of this functionality, using the SPARQL endpoint that holds the datasets for LEO. The classes are represented following the hierarchy of the ontology. By clicking the plus button we retrieve all the properties of the selected class along with the range of each property. All the URIs in the explore panel are resolvable and by clicking them we get a describe modal, as presented in Figure 16, that shows all the triples in the dataset where the URI appears in the place of subject, predicate or object. The URIs in the describe modal are also resolvable and in this manner we can explore the data of the endpoint.

![Figure 15 - Explore panel](image)
<table>
<thead>
<tr>
<th>Subject</th>
<th>Predicate</th>
<th>Object</th>
</tr>
</thead>
</table>

**Figure 16 - Describe modal**
3.1.11. Search for datasets
Established in 2005, GEO\(^6\) is a voluntary partnership of governments and organizations that envisions “a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.” GEO Member governments include 96 nations and the European Commission, and 87 Participating Organizations comprised of international bodies with a mandate in Earth observations. Together, the GEO community is creating a Global Earth Observation System of Systems (GEOSS) that will link Earth observation resources worldwide across multiple Societal Benefit Areas - agriculture, biodiversity, climate, disasters, ecosystems, energy, health, water and weather - and make those resources available for better informed decision-making.

In an attempt to link Earth Observation (EO) resources, the GEO Discovery and Access Broker\(^7\) (DAB) was created by ESSI lab\(^8\). DAB is a middleware component which is in charge of interconnecting the heterogeneous and distributed capacities contributing to GEOSS and became part of the GEOSS Common Infrastructure (GCI) since November 2011. The DAB provides three main functionalities:

- Discovery of resources from brokered sources
- Semantics-enriched discovery
- Access of resources

DAB is used in GEOSS Portal\(^9\) to provide an entry point to EO data from all over the world.

To support EO data discovery, exploration and visualization, we added the DAB component in Sextant. Users can use the modal depicted in Figure 17, where you can provide key words, a general theme, the valid time of the data and draw an extent for the area of interest, to search for EO data that meet the given criteria.

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\(^7\) [http://api.eurogeoss-broker.eu/docs/index.html](http://api.eurogeoss-broker.eu/docs/index.html)

\(^8\) [http://www.uos-firenze.essi-lab.eu](http://www.uos-firenze.essi-lab.eu)

\(^9\) [http://www.geoportal.org/web/guest/geo_home_stp](http://www.geoportal.org/web/guest/geo_home_stp)
Figure 17 - Search for datasets in GEOSS Portal
The results are presented using the reports DAB provides, that follow the ISO 19115\textsuperscript{10} specification, which suggests formats for visualizing the results' metadata, such as KML, KML, WMS, GeoTIFF and more. In Figure 18 we demonstrate the results of a search query for water themed EO data in the area of Europe.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{search_result.png}
\caption{Search results for datasets in GEOSS Portal}
\end{figure}

\textsuperscript{10}\url{http://api.eurogeoss-broker.eu/docs/classes/Report.html}