



Data, Information and Process Integration
with Semantic Web Services

DIP

Data, Information and Process Integration with Semantic Web Services

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Deliverable

WP 9: Case Study eGovernment
D9.12
SWS Enhanced GIS prototype (IRSIII) v2.0

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EXECUTIVE SUMMARY

This deliverable describes the second version of the SWS enhanced GIS prototype, extending the work introduced in deliverable D9.11: SWS Enhanced GIS prototype (IRSIII) v1.0.

This prototype contributes to the following golden bullet of DIP: *Real Use Case Implementation of SWS in the e-Government sector*. It represents a SWS-based Emergency Management Application (EMA) and has been developed to fulfil Essex County Council's (ECC) needs to access geospatial data for emergency management and to share it with other partners (e.g.: police, ambulance services, meteorological office, other public organizations, etc) during an emergency situation.

The improvements in the second prototype mainly involve the following two of the application's architectural layers:

- **Ontologies:** user-oriented ontologies (now named *aggregation ontologies*) have been improved to better describe concepts associated with the visualization of geospatial objects in the user interface; moreover, a new ontology (named *context ontology*) has been developed to introduce and represent the context of emergency situations within the application.
- **User Interface:** the previous user interface has been integrated with ontology browsing and authoring facilities. This benefits the openness of the application, since expert users can more easily become aware of existing semantic descriptions and provide new ones in order to introduce new services (i.e. new data sources and processes). Moreover, the current version of the user interface adopts the DIP APIs for interfacing to IRS-III [1] – the specific WSMO implementation which is the basis of this prototype; as a result, the same interface has been reused in the WSMX implementation of the GIS prototype, deliverable D9.13: *SWS Enhanced GIS prototype (WSMX) v 1.0*.

The deliverable is intended to be read by DIP technical partners to inform them of the way in which the tools/technology has been used to create a use case scenario. In addition, it will be of interest to the end-user community and other data suppliers (e.g.: Essex County Council and other public authorities' emergency planners, police, Essex Fire & Rescue Service, ambulance service, highways and transport, meteorological office, Ordnance Survey, BAA safety services, Essex Rover Rescue).

The deliverable follows the document structure used in deliverable D9.11, but mainly focuses on the improved aspects.

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Abstract (for dissemination)	WP9 is an e-government use case. This document provides the description of the second version of the GIS emergency prototype implemented in the WSMO compliant Internet Reasoning Server (IRSIII).
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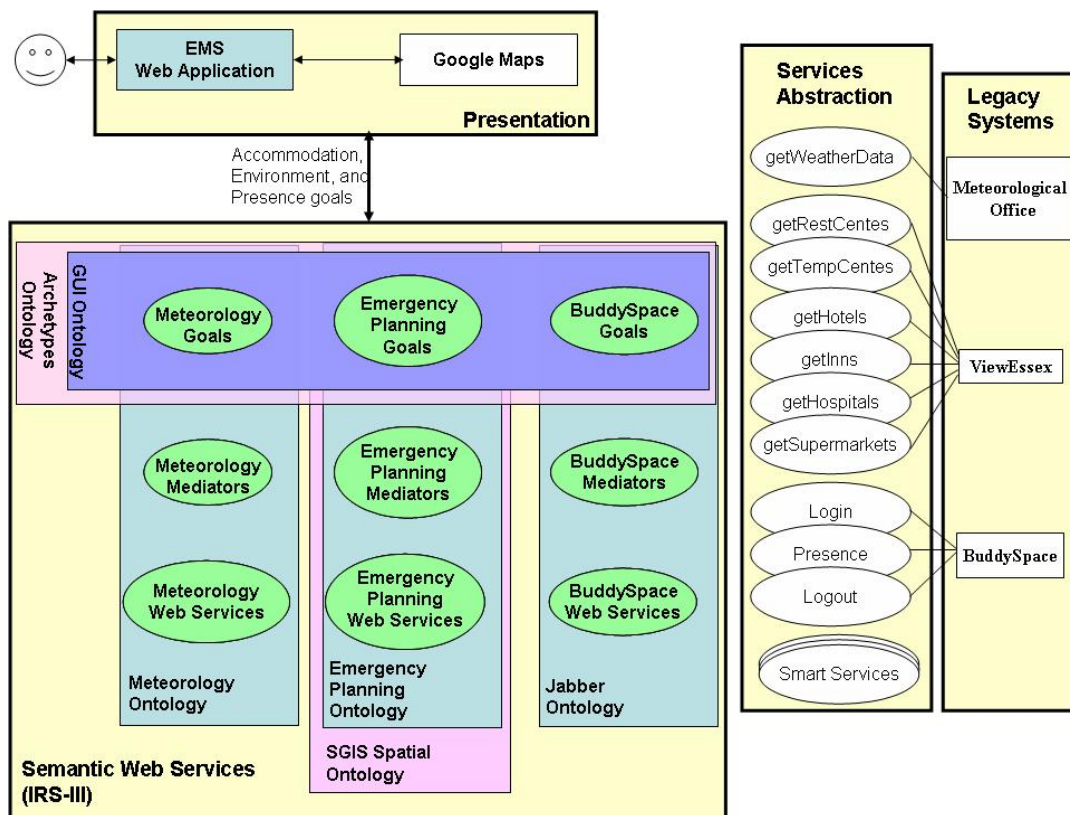
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ACRONYMS/GLOSSARY**BAA** British Airports Authority**ECC** Essex County Council**EMA** Emergency Management Application**EO** Emergency Officer**GIS** Geographical Information Services**IRSIII** Internet Reasoning Server 3**OU** Open University**SRD** Spatially Related Data**SWS** Semantic Web Service**WgM** Web Service-Goal mediator**WP9** Work Package 9**WS** Web Service**WSMO** Web Service Modelling Ontology

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1 INTRODUCTION

In an emergency situation, relevant information is needed to assist planning and decision making. Such information elements range from demographic data, weather forecasts and sensor data, available transportation means to the presence of helpful agents (people), land use and include statistics or values, etc. Moreover, the emergency management process is dynamic as it involves various defined sequential and alternative - on the basis of the specific situation - steps, described in standard procedures with which the Emergency Officer (EO) should always comply. Different agencies own different relevant data and emergency related knowledge, which needs to be shared with the other partners during an emergency.

Exchanging this information by interacting on a personal/phone/fax basis is slow and error prone. Using traditional Geographical Information Systems (GIS) to handle specifically Spatial-Related Data (SRD) is not always satisfactory, since data sources are not always suitably exposed to other organizations and might have different semantics. Our aim is to overcome such communication barriers and achieve complete interoperability during an emergency situation.

The proposed Emergency Management Application (EMA) is a decision support system based on Semantic Web Services (SWS) technology, which assists the EO in the tasks of retrieving, processing, displaying, and interacting with relevant information, more quickly and accurately. As a result, the involved agencies will be able to extend their knowledge about the emergency situation they are dealing with by making use of different functionalities based on data held by other agencies which otherwise might not be accessible to them or slow to obtain.

2 ARCHITECTURE

Figure 1 depicts the multi-layered architecture of the proposed EMA.

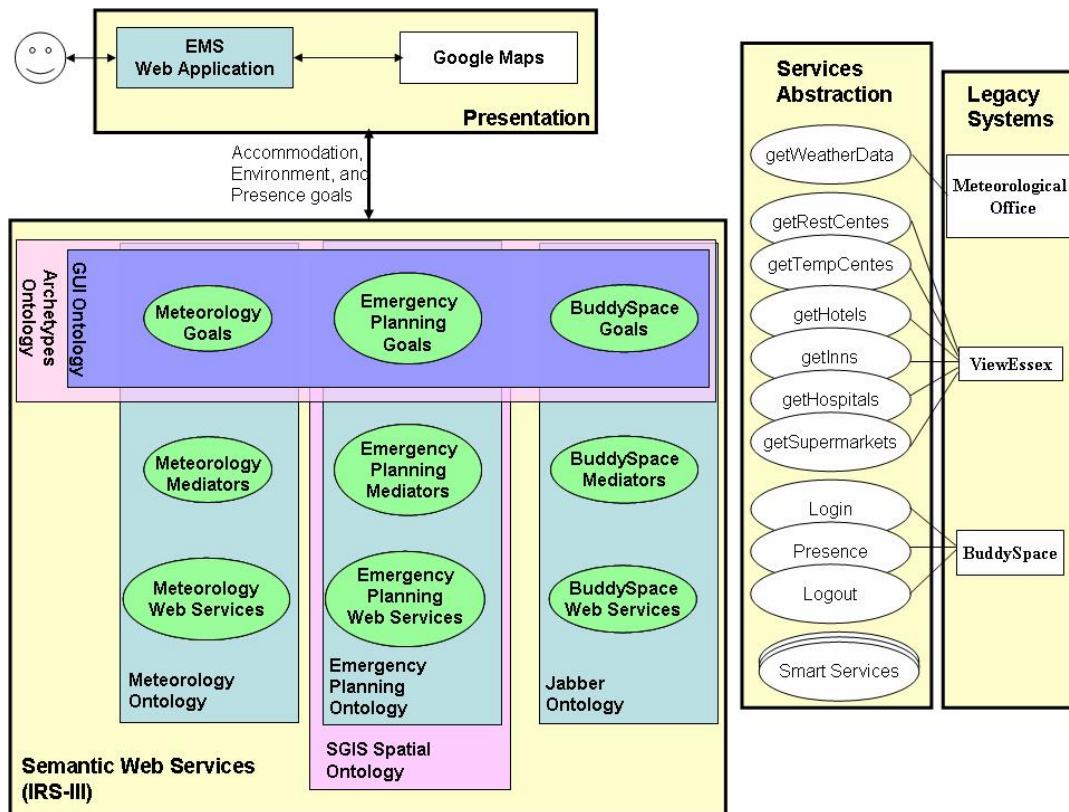


Figure 1 - The general architecture of the EMA.

The application is composed of the following four layers:

- *Legacy System layer:* consists of existing data sources and IT systems provided by each of the involved governmental parties.
- *Service Abstraction layer:* exposes the functionalities of the legacy systems as Web Services (WS), abstracting from the hardware and software platforms of the legacy systems. Whenever a new service is available at this layer, it will be semantically described and properly linked to existing semantic descriptions.
- *Semantic Web Service layer:* given a goal request this layer, implemented in IRS-III [1], will (i) discover a candidate set of Web services, (ii) select the most appropriate, (iii) mediate any mismatches at the data, ontological or business process level, and (iv) invoke the selected Web services whilst adhering to any data, control flow and Web service invocation requirements. To achieve this, IRS-III makes use of a set of WSMO descriptions [2], which comprise goals, mediators, and Web Services, supported by relevant domain ontologies. This layer provides flexibility and scalability for the application. By modifying the semantic descriptions, the developer can add new functionalities to the application (e.g. new EO goals that can be invoked by the user interface) or update existing ones.
- *Presentation layer:* is a Web application accessible through a standard Web browser. The goals defined within the Semantic Web Service layer are reflected in the structure of the interface and can be invoked either through the IRS-III API or as an HTTP request. Goal requests are filled with data provided by the user and then sent to the Semantic Web Service layer.

The second version of the prototype has improved the Semantic Web Service and Presentation layers and did not integrate new data sources and services. For this reason, the following sections detail only the modified layers. For a description of the other two layers please refer to D9.10 and D9.11.

2.1 Ontologies for the Semantic Web Service layer

The following ontologies reflecting the client and provider domains were developed to support WSMO descriptions:

- *Meteorology, Emergency Planning and Jabber Domain Ontology*: These ontologies represent the concepts used to describe the services attached to the data sources, such as snow and rain for Met Office, hospitals and supermarkets for ECC Emergency Planning, session and presences for Jabber. If a new source and the Web services exposing its data and functionalities are integrated, the developer could introduce a new domain ontology or reuse an existing one. The services, which are composed of the involved data types as well as its interface, have to be described in such an ontology.

To get the information provided by Web Services up to the semantic level, we introduce *lifting operations* that allow passing data type instances from a syntactic level (XML) to the ontological level (class instances) specified in the domain ontology definitions. These functions – implemented in LISP - automatically extract data from SOAP messages and create the counterpart class instances. The mapping information between data types and ontological classes is defined at design time by developers.

- *GUI Ontology*: part of the user layer, this ontology is composed of GUI and user-oriented concepts. It allows lowering from the semantic level results to the particular interface which is used (e.g. stating that Google Maps API is used, defining ‘elegant’ names for ontology elements, etc.). Note that although the choice of the resulting syntactic format depends on the chosen lowering process, concepts from the GUI ontology are used in order to achieve this transformation in a suitable way.
- *Archetypes Ontology*: part of the user layer, this is a minimal ontological commitment ontology aiming to provide a cognitively meaningful insight into the nature of a specialized object; for example, by conveying the cognitive (“naïve”) feeling that for example a hospital, as a “container” of people and provider of “shelter” can be assimilated to the more universal concept of “house”, which we consider to be an archetypal concept, i.e. based on image schemata and therefore supposed to convey meaning immediately. It is moreover assumed that any client, whilst maybe lacking the specific representation for a specific basic level concept, knows its archetypal representation.
- *Spatial Ontology*: a part of the mediation layer, it describes GIS concepts of location, such as coordinates, points, polygonal areas, and fields. It also allows describing spatial objects as entities with a set of attributes, and a location.

The purpose of the GUI, Archetypes and Spatial ontologies is the aggregation of different data sources on, respectively, representation, cognitive and spatial level. Therefore we can group them as *aggregation ontologies*. They allow different data sources to be handled and presented in a similar way. Inversely to the lifting operations,

lowering operations transform instances of aggregation ontologies into syntactic documents to be used by the server and client applications.

- *Context Ontology*: the context ontology allows describing context n-tuples which represent a particular situation. In the emergency planning application, context n-tuples have up to four components, the use case, the user role, the location, and the type of object. Contexts are linked with goals, i.e. if this type of user accesses this type of object around this particular location, these particular goals will be presented. Contexts also help to inform goals, e.g. if a goal provides information about petrol stations in an area, the location part of the context is used to define this area, and input from the user is therefore not needed. Each time an object is displayed by a user at a particular location, a function of the context ontology provides the goals which need to be displayed and what inputs are implicit.

2.2 WSMO descriptions for the Semantic Web Service Layer

For illustration purposes, a small portion of the SWS descriptions are shown in Figure 2. The example details the main goal “*Locate suitable shelters for evacuated people*”. For a more detailed description of WSMO descriptions please refer to D9.10.

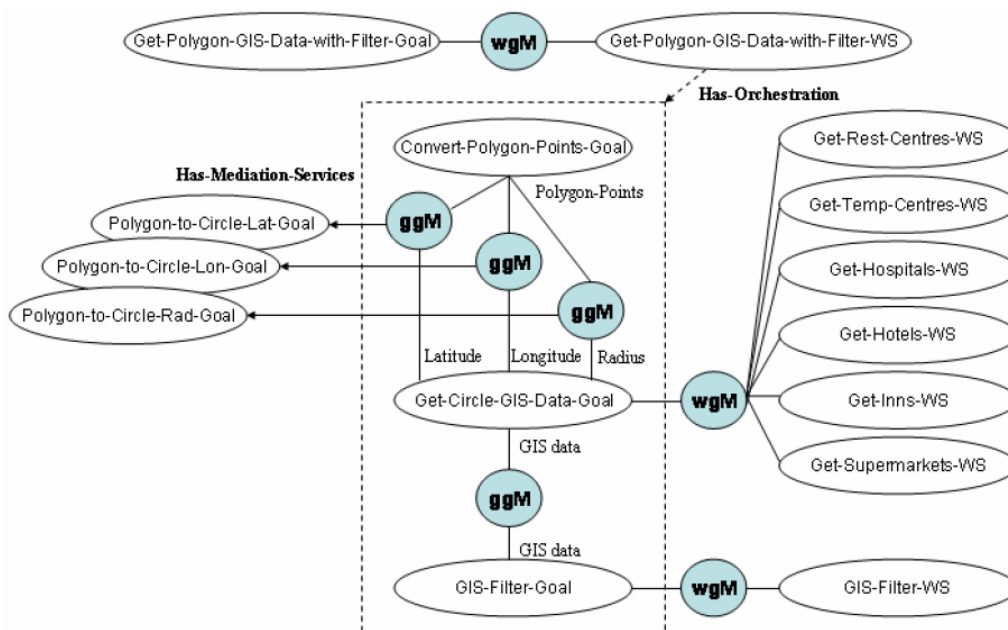


Figure 2 - A portion of WSMO descriptions for the EMA.

Get-Polygon-GIS-data-with-Filter-Goal represents a request for available shelters within a delimited area. The user specifies the requirements as a target area, a sequence of at least three points (a polygon), and a shelter type (e.g. hospitals, inns, hotels). As mentioned above, the set of ECC Emergency Planning Web services each return potential shelters of a specific type with a circular query area. The obtained results need to be filtered in order to return only shelters correlated to emergency-specific requirements (for example a snowstorm). The process, automated in our application, is usually performed by the EO manually.

From a SWS point of view the problems to be solved by this particular portion of the SWS layer included: (i) *discovering* the appropriate ECC Emergency Planning Web service; (ii) *mediating* the difference in area representations (polygon vs. circular) between the goal and Web services; (iii) *composing* the retrieve and filter data operations. Below we outline how the WSMO [2] representations in Figure 2 address these problems.

- *Web service discovery*: each SWS description of ECC Emergency Planning service defines, in its capability, the specific class of shelter that the service provides. Each definition is linked to the *Get-Circle-GIS-Data-Goal* by means of a unique WG-mediator (depicted as wgM). The inputs of the goal specify the class of shelter, and the circular query area. At invocation, IRS-III discovers through the WG-mediator all associated Web services, and selects one on the basis of the specific class of shelter described in the Web service capability.
- *Area mediation and orchestration*: the *Get-Polygon-GIS-data-with-Filter-Goal* is associated with a unique Web service that orchestrates, by simply invoking three sub-goals in sequence. The first gets the list of polygon points from the input; the second is *Get-Circle-GIS-Data-Goal* described above; finally, the third invokes the smart service that filters the list of GIS data. The first two sub-goals are linked by means of three GG-mediators (depicted as ggM) that return the centre, as a latitude and longitude, and radius of the smallest circle which circumscribes the given polygon. To accomplish this, we created three mediation services invoked through: *Polygon-to-Circle-Lat-Goal*, *Polygon-to-Circle-Lon-Goal*, and *Polygon-to-Circle-Rad-Goal* (the related WG-mediator and Web service ovals were omitted to avoid cluttering the diagram). The results of the mediation services and the class of shelter required are provided as inputs to the second sub-goal. A unique GG-mediator connects the output of the second to the input of the third sub-goal. In this instance no mediation service is necessary.

It is important to note that if new Web Services – for instance providing data from further GIS are available, new Web Service descriptions will be simply introduced, and linked to the *Get-Circle-GIS-Goal* by the proper mediators (even reusing the existing ones, if semantic mismatches do not exist), without affecting the existing structure. In the same way, new GIS filter services (e.g. more efficient ones) may be introduced. The effective workflow – i.e. which services are invoked – is known at run-time only.

3 PRESENTATION LAYER

The presentation layer has been entirely re-factored since the previous version (see **Error! Reference source not found.**). Indeed, the use of disparate web technologies (JavaScript to implement AJAX, HTML + JavaScript for the user interface) made the prototype dependent of the browser at runtime (cross browser functionality was difficult to achieve) as well as at development time (JavaScript debugging could only occur on the host browser). Moreover, given the absence of strong typing in JavaScript, the addition of new functionalities was becoming problematic as the size of the presentation layer was increasing. GWT, the Google Web Toolkit¹, allows eliminating these concerns by providing a pure Java development environment; the front end is written in the Java programming language, and the GWT compiler converts Java classes to

¹ <http://code.google.com/webtoolkit/>

browser-compliant JavaScript and HTML. A screencast of the interaction as well as a live version are available online².

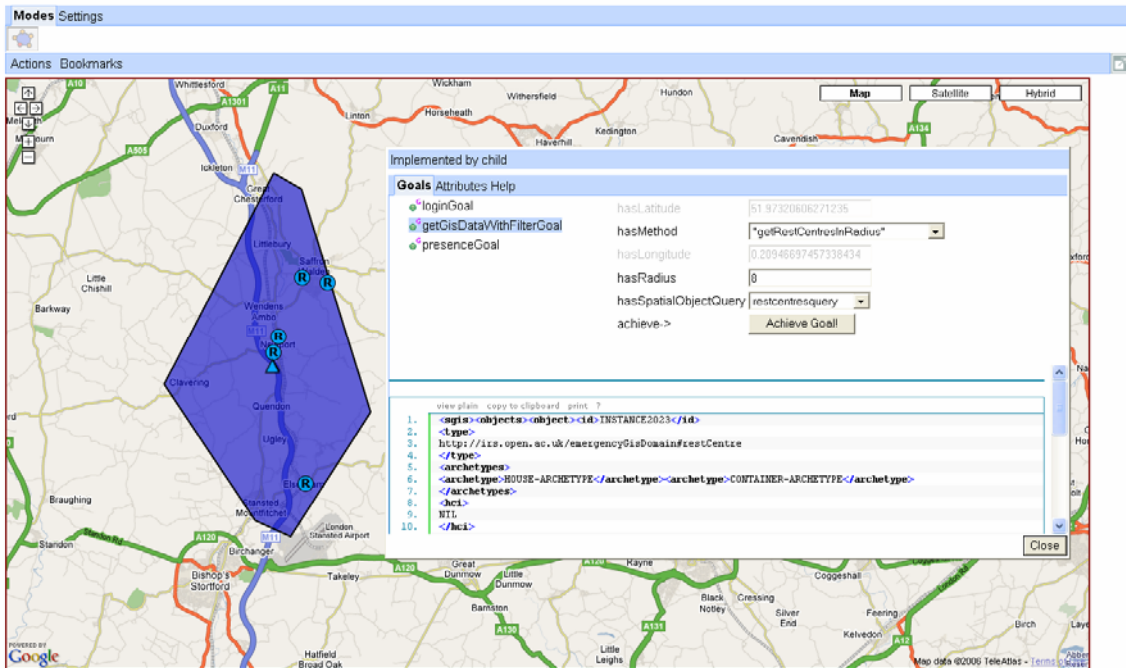


Figure 3 - The “new look” of the prototype’s interface.

Functionalities in version 2 of the prototype are comparable to version 1; i.e. it allows the user to define areas that can be associated to a given type of emergency from the emergency ontology. Each emergency type presents goals that can be invoked in order to retrieve contextually relevant emergency related elements. However, the version 2 of the prototype takes advantage of the functionalities of Google Maps 2, which includes maps for almost all Europe, and with which version 1 of the prototype was incompatible.

Also the integration with IRS and the underlying ontologies is much tighter. As an example, when a goal is selected for an object, the user interface for this goal is directly extracted from the goal definition, and instances are fetched whenever an input role is not of a basic type (Figure 4). In a similar way, the interface allows the user to browse the ontology in order to associate an emergency type to a new area, i.e. polygon (Figure 5)

² <http://irs-test.open.ac.uk/sgis-dev/>

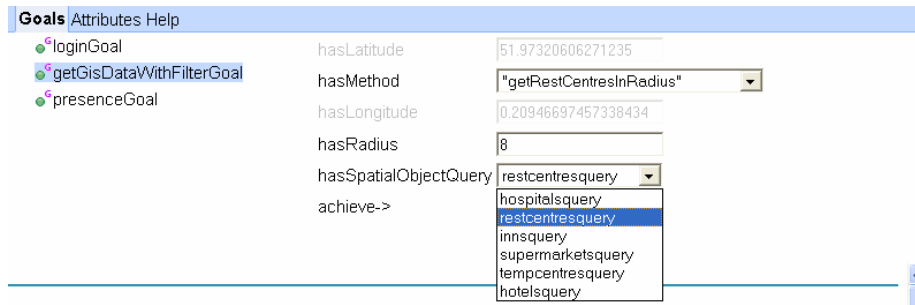


Figure 4 - Direct link from goals to ontologies.

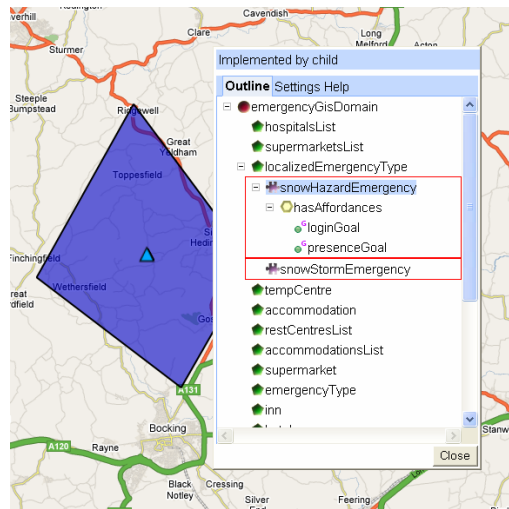


Figure 5 - Ontology browsing for new area type attribution.

However, naïve end-users (e.g. EO) may raise some concerns about the reduced user-friendliness induced by the usage of ontology names. This issue is about to be solved by adding to the GUI ontology a mapping between ontology types and their user names. We believe that this technique, coupled with GWT's support for internationalisation, will allow us to obtain a multiple user interface: distinct user modes will be available in order to meet the requirements of different classes of user.

4 INTEGRATING NEW DATA SOURCES

The integration of new data sources is relatively simple although not totally trivial. These are the steps involved in the process of adding a new data source, as well as the ability to automate them:

1. *Ontological description of service*: the service, composed of the data types involved as well as its interface has to be described in a low level ontology (i.e. containing concepts that directly maps to input and output of involved services only). This step can be automated in many cases.
2. *Lifting definition*: the lifting operation allow the passage of data types instances from a syntactic level (xml) defined in the data schema to an ontological one (ocml) specified in the ontology definition. We found that this process can be automated every time the previous one can be.

3. *Mapping to aggregation ontologies*: this process links concepts defined at Step1 to concepts of existing aggregation ontologies; the process can be fully automated by default, and customizable as needed.
4. *Goal description*: a new goal has to be defined which represents the newly integrated web service.
5. *Mediator description*: the goal has to be linked to the WS with a mediator, which is often a trivial operation.
6. *Lowering definition*: the lowering operation transforms instances of aggregation ontologies into syntactic documents to be used by the server and client applications.

5 USERS' FEEDBACK

Before developing the current version of the prototype, the application has been shown to ECC emergency planners and other emergency stakeholders. The purpose of the meeting was to validate with them what we've done and get some feedback in order to create a realistic and useful second version of the prototype. The discussion principally involved the following main aspects:

1. *Functionalities*; all of the stakeholders judged the functionalities provided by the prototype useful for the accomplishment of some of their tasks in emergency situations. In particular, they have found very helpful retrieving as much as possible emergency relevant information in a few clicks, since at the moment they have to separately query several systems to obtain the same information. They suggested improvements of the prototype regarding forecast functionalities – e.g. evolution of emergency situations such as snow storms – and multi-queries of affected areas and surroundings - i.e. drawing several polygons and invoking services asynchronously - to identify, for instance, safe areas where moving affected people. Finally, an interesting aspect was how the application can deal with emergencies that affect two adjoining councils; it seems that currently systems do not interoperate between boundaries.
2. *User Interface*; the user interface resulted easy to use and, thus, positively accepted. Some remarks regarded the used terminology: for instance rest centres terminology in local authorities is often different to emergency services; the user interface should be able to show the proper terminology according to the class of user.
3. *New data sources integration*; several proposals regarded the integration of new data sources. In particular, stakeholders suggested us to focus more on sources such as traffic data and cameras, weather forecast (flooding situations), real-time data, chemical incidents census data, hotels availability, and avoid sensible and police-related data (e.g. regarding terrorist attack and hijacking) that are difficult - realistically impossible - to obtain and require high levels of security.
4. *Security*; this is one of the priorities required by stakeholders. In particular, they expect that the application logs every action performed by the users – and eventually the obtained data - in order to have a proof of taken decision. This follows a precise requirement of the existing emergency procedures. Further remarks regarded the possibility of introducing a user authentication (to obtain personalized service also) and how to deal with sensible data (citizen's privacy).

On the basis of obtained feedback, we decided to focus on points 1 and 3 for the second prototype. In particular, we realized the multi-query functionality and developed a general purpose platform to ease the integration of new data sources. The result of the latter improvement has not visible benefits in this prototype, but will benefit the next one since where several new data sources will be integrated. The user interface and security aspects are under discussion for the third prototype too.

6 CONCLUSIONS

V2.0 of the prototype adopts WSMO and IRS-III to (i) provide an infrastructure, in which new services can be added, discovered and composed continually; (ii) allow the automatic invocation, composition, mediation, and execution of complex services.

Although the procedure of integrating data sources may seem tedious, and can actually only be performed by a knowledge expert, it presents many advantages compared to standard based approaches as the one demonstrated in the OWS-3 Initiative³:

- *Framework openness*: standards are helpful but not necessary. For example, in the case of integrating sensor data, the use of standards – e.g. SensorML⁴ – helps the reuse of service ontologies and lifting procedures since they can be applied to any service using a similar schema. However, following our integration procedure, any other schema can be integrated with the same results. In this way, all of existing sensor data systems - standard compliant or not – can be considered.
- *High level services support*: since services are described as SWS, they inherit all benefits of the underlying SWS execution platform and are updated as more features are added to the platform (e.g. trust based invocation). In other solutions support for composition and discovery is imbedded in syntactic standards themselves, which implies specific parsing features and adding ad hoc reasoning capabilities to standard software applications, which is time consuming and error prone. Moreover, SWS introduce a minimalist approach in the description of a domain, by modelling the concepts used by Web Services only, and allowing on-the-fly creation of instances when Web Services are invoked (lifting).
- *Support of the Emergency Handling Process*: the conceptual distinction between goal and web services - introduced by WSMO – allows developers to easily design business processes known a priori (e.g. emergency procedure) in terms of composition of goals, and shift at run-time the (automatic) identification of the most suitable service. Moreover, the use of context to link goals and situations greatly enhances the decision process. Indeed, actions are oriented depending on the use case, the object, user role and location. With the help of explanations of the utility of each goal in each context, the Emergency Officer's task is greatly simplified. A future development of the context ontology will include feedback from goal invocation history, and allow workflow definitions, i.e. this goal only appears after these two have been invoked. Note that all goals are also accessible independently of any context which allows non directed queries to occur, if needed.

³ <http://www.opengeospatial.org/initiatives/?iid=162>

⁴ <http://vast.nsstc.uah.edu/SensorML/>

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