CARTOGRAPHIC INTEGRATION ON MOBILE DEVICES
FROM SEVERAL PROVIDERS' LBS BY MEANS OF MAP SYMBOL ONTOLOGY

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KEY WORDS: GIS, LBS, Cartography, Ontology, OWL, CartOWL, Web Services, OWS

ABSTRACT:

With the increasing number of geographical data and distributed geospatial applications with heterogeneous databases, many problems may arise while integrating the details of user's response from many service providers into a unified visual portal on mobile device (i.e. Street View map). Through a conventional point of view, the use of many Location Based Services (LBS) providers will imply several maps, one for each; whereas a cartographic integration will generate a unique map whose components will come from those various LBS providers. For this purpose, spatial domain ontology-driven approach of map symbols will be presented and some selection rules will be given especially based on user's preferences and graphical semiology. To avoid duplicate outputs of homologous objects, issued from many providers, different issues of data/metadata integrations will be studied by using (1) geometric reasoning (based on Euclidian distance), (2) semantic reasoning (based on a feature ontology), (3) place name reasoning (based on a gazetteer or Levenshtein distance), within the framework of belief theory and (4) symbol integration (through the map symbol ontology). This article will present the fusion techniques and the development of a platform named MPLoM (Multi-Providers LBS on Mobile) which is able to support its mobile navigators with personalized preferences and location based services either in push or pull mode. We conclude this paper by advocating the creation of new web services based on multiple providers.

1. INTRODUCTION

The use of ontology is common for many domains such as semantic web, database interoperability, e-commerce, artificial intelligence and geographical information systems. It deals with issues concerning what entities exist and how such entities can be grouped, related within a hierarchy and subdivided according to similarities and differences. From a computing point of view, ontologies are tools or solutions used to represent a corpus of information specific to a certain domain in order to be able to share, queries, extract and update information among many providers through Internet. However, the vocabulary used in ontologies is always textual; concepts and relations are identified and labelled by words. But some concepts include a visual aspect especially in the cartographic domain. For example, in a cartographic legend, a point of interest symbol is identified as a concept with its icon and/or abbreviation, colour, texture, font style, orientation and number. The overall concerns of our research are to integrate different Location Based Services (LBS) visual ontologies towards a unique map conflation.

In the general context of geographical databases' interoperability, our concerns in this article are to study the feasibility of location based services' (LBS) integration, proposed by several providers, and their limitations especially in terms of precision for location and cartographic conflation in order to avoid duplicated results on the mobile screen.

Let us take, as a simple example, the application that finds the nearest restaurant in your area with the navigation instructions to get there. First of all, one might encounter the answer of an Italian restaurant listed by two different providers, not exactly located at the same place (50 meters of difference) due to the inaccurate precision from GPS (Global Positioning System) and different positioning references that require geocoding conversion functions. The same Italian restaurant is named "Carlo's Pizzeria" in the first one and "Da Carlo Trattoria" in the second one, visualized by different cartographic symbols. The goal is simply to be able to consider them as the same object. [Fig. 1]
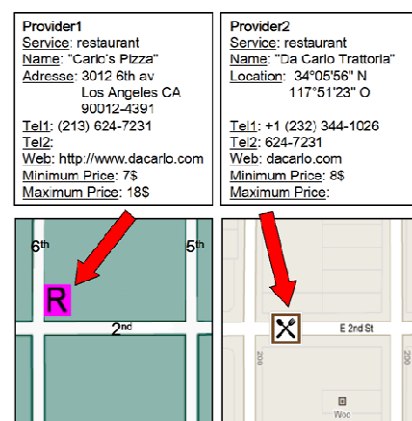

Figure.1 Example of same LBS object from two different providers (Candidates for integration)

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15 m	A, (1,2,3)	B, (1,2,3)	C, (1,2)	D, (1,2,3)
12 m	A, (1,2,3)	B, (1,2,3)	C, ( )	D, (1)
9 m	A, (1)	B, (1,2,3)	C, ( )	D, (1)
6 m	A, (1)	B, (1,2,3)	C, ( )	D, (1)
3 m	A, (1)	B, (2)	C, ( )	D, ( )

Figure.2 Example for the choice of Threshold
(Stricher technique)

Many approaches may be used to solve all the conflicts and ensure the integration of homologous objects, overlaid on a unique base map.

To achieve this, Section 2 presents the location integration by listing the problems of geographic, place names and semantic details' conflicts for the same object and the implemented solutions via our MPLoM platform. Section 3 details the cartographic integration also known as map conflation, by extending the web ontology language OWL [Horridge, 2004] via CartOWL and by developing a new building/matching application for visual ontologies. In Section 4, we will advocate new geographical web services for a fully interoperable LBS system without any human intervention. Section 5 describes the MPLoM platform. Section 6 demonstrates our building/matching application. Finally, conclusions and future work are elaborated in Section 7.

2. LOCATION INTEGRATION VIA MPLOM PLATFORM

We can distinguish three types of integration related to the location of objects: geographic, place names and semantic details.
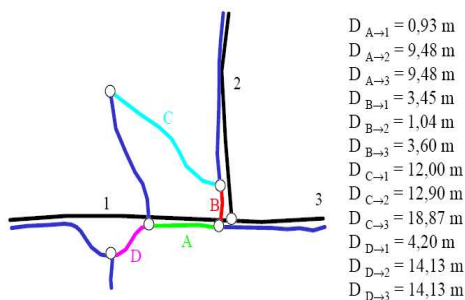
2.1 Geographic Integration

It consists of matching the geographical components by their position and representation form. Same services could be retrieved as points (0D) from the first provider or line (1D) / polyline (2D) / volume (3D) from the second one. At another level, differences in location due to GPS tracking device precision and conflicts in positioning rules / geo coding conversion functions would interfere against a smooth integration (e.g. postal address v/s longitude and latitude).

In our MPLoM framework, to decide if two objects are the same, we choose a threshold of five meters between the candidates. For the integration of two punctual objects, the Euclidian distance dE is used [Devogele, 1997 – Mustiere, 2003]. To integrate two linear objects, three types of distances could be used (average distance, Hausdorff distance, and Frechet distance) [Wikipedia].
So as far as the distance between object 1 and object 2 is less than a threshold of 5 m, we can suggest that these objects are homologous. However, the choice of the threshold is very important. A large threshold (9 m distance) can lead to many doubtful candidates for integration and a small one (3 m) can discard many solutions.
To reach a good compromise, Stricher technique is used by eliminating with successive thresholds, the doubtful points. For this reason, the threshold of 5 meters was adopted.

$D_{A\to1} = 0,93$ m
$D_{A\to2} = 9,48$ m
$D_{A\to3} = 9,48$ m
$D_{B\to1} = 3,45$ m
$D_{B\to2} = 1,04$ m
$D_{B\to3} = 3,60$ m
$D_{C\to1} = 12,00$ m
$D_{C\to2} = 12,90$ m
$D_{C\to3} = 18,87$ m
$D_{D\to1} = 4,20$ m
$D_{D\to2} = 14,13$ m
$D_{D\to3} = 14,13$ m

2.2 Place Name Integration

As per the use case scenario described in the introduction, the same restaurant could be saved as "Carlo's Pizzeria" in the first GDB and "Da Carlo' Trattoria" in the second one, even though they represent the same restaurant. Place names' differences are mainly related to GDB lack of "real time" updates for their data/metadata. This may cause duplication thus uncertain representation of the geographical information on the mobile screen.
For the place names' integration, the fusion technique uses the Levenshtein distance dL [Davala] to compare the place name (String of characters) of two objects from two different providers. This distance will increase if the number of differences between characters increases as well thus increasing the probability of heterogeneity. Gazetteers could be used as well for large scale of place names dictionary such as Alexandra library.

2.3 Semantic Integration

Details about the same restaurant could be different from one provider to another as described in Fig.1. This is due to lack of updates and common agreements on the rules for saving email addresses, websites URL, etc. This may cause duplication of unnecessary or inaccurate data/metadata on the mobile screen.
To avoid this, a matching table had been used in our framework MPLoM and a semantic ontology-driven approach had been implemented via Protégé [Horridge,2004]. For example, if a navigator wants to know what restaurants can offer "Hamburger", the platform should list all the restaurants of type American or Fast food.
However, we can assume that location integration ambiguities had been partially solved by the above solutions. The final decision for homologous objects depends on the output result of the belief function with Dempster operator [Olteanu, 2008, DEvogele,1997]. Geographic, place names and semantic details reasoning are assigned, each one of them, a certain weight to reflect the degree of correct homogeneity of the candidates for integration. Dempster operator will combine the three different weights (the first mass m for the geographic decision, the second mass for the place names decision and the third mass for the semantic details decision). The order among the three decisions' types is not obligatory. As far as the final result which is the sum of the three weights is high, the probability to consider both objects homologous will be higher. [Olteanu, 2008]

3. CARTOGRAPHIC SYMBOLS INTEGRATION VIA CARTOWL

Through a conventional point of view, the use of many LBS providers will imply several maps, one for each, with its specific legend (visual attributes: icon, colour, texture, etc.), whereas a cartographic integration will generate a unique base-map whose components will come from various LBS providers.

Fig.3 shows how different legends are used by three different providers to represent the same service. Which cartographic symbol should be prioritized for the same integrated service?

This can cause lot of ambiguity based on symbol's selection, user's profile, geographical zone, graphical semiology constraints, background map used, generalization and adaptation of maps on the device (limitations in memory, resources and display), etc. For example, Metro is symbolized by letter M in a country or S (Subway) or T (Tube) in others. This means that the same service could have different shapes or spatial attributes from one provider to another.

Figure.3 Different Visual aspects collection from the three legends

Building a graph of visual concepts instead of textual ones could be a good suggestion for GIS or any other visual application where the extraction and fusion of objects is based on their visual aspects and not the semantic ones.
Nowadays, all the software tools like Protégé can extract concepts from textual corpus only. What if we have visual aspects (i.e. icons) to describe geographic locations that need to be extracted and imported as XML files? The current XML Schema file or ontology standards (RDF/RDFS, OWL), do not support visual tags like icon.jpg. Symbology Encoding [OGC] in OGC (Open Geospatial Consortium) had included only the icon image and not the other attributes via XML schema code.

To overcome this limitation and to improve the extraction time, the complexity of alignment and the difficulty in the validation process, we propose another building/matching application and an extension of the de facto standard OWL, named CartOWL, for the treatment of visual aspects.

In order to facilitate the automatic build of local ontologies and their integration towards domain reference ontology, we propose CartOWL (Cartographic OWL) as an extension to the Web Ontology Language OWL [Horridge, 2004].
Building visual ontologies would become easier by generating the corresponding CartOWL file through our application.

The full prototype would be able to parse the CartOWL output files and align them towards one reference knowledge base (domain ontology) so that we can ensure map conflation result on a mobile device.

The cartographic symbols of the spatial ontologies are detailed below:

─An icon, described by its URL, e.g., http://www.example.net/TouristInfoCenter.png
─ A colour, described by its RGB model value, e.g., #FF8000
─A texture, described by its URL, e.g., http://www.example.org/ParkTexture.png
─ An abbreviation, e.g., "info"
─ A number, e.g., "A 30"
─ A font, described by its name, e.g., "Times"

As OWL can handle only textual concepts, it needs to be revised in order to describe visual aspects as well. In the <Class> tag, the human readable textual representation of the concerned class is done with the <Label> tag. One appropriate way seems to extend this <Label> tag with new attributes or to add a new <Symbol> tag that includes two parameters:

─ The symbol type: the parameter value may be "iconURL" or "colour" or "texture" or "abbreviation" or "number" or "font".

─ The symbol value: the parameter value may be one of the following string values: the icon URL, the RGB colour, the texture URL, the abbreviation's text, the presence of a number indicated by the boolean values "yes" or "no", or the font name.

Below is an example. We define the class "Tourist Information Center" and its three attached symbols: an icon, a colour and an abbreviation. The first part of the example shows the DTD definition of the new <symbol> tag.

```
<!DOCTYPE rdf:RDF [
<!ELEMENT cartowl:Symbol EMPTY >
<!ATTLIST        cartowl:Symbol        cartowl:symbolType
(iconURL|color|texture|abbreviation|number|font)#REQUIRED
cartowl:symbolValue CDATA  #REQUIRED
xmlns:cartowl CDATA  #FIXED
"http://www.example.net/CartOWL.owl# ... >
]>
<rdf:RDF ... ..
xmlns:cartowl="http://www.example.net/CartOWL.owl#" >
...
<owl:Class rdf:ID="Tourist Information Center">
<cartowl:Symbol                  cartowl:symbolType="iconURL"
cartowl:symbolValue="http://www.example.net/TouristInfoCen
ter.png" />
<cartowl:Symbol                    cartowl:symbolType="color"
cartowl:symbolValue="FF8000" />
<cartowl:Symbol            cartowl:symbolType="abbreviation"
cartowl:symbolValue="info" />

</owl:Class>
```

Once the local ontologies corresponding to each LBS provider's cartographic visual concepts are generated, then should start the matching step. To ensure ontology matching, relations such as equivalence and inclusion have to be previously set at the level of the domain ontology. The CartOWL ontology reasoner would then take the statements encoded (asserted) in this reference ontology as input and derive (infer) new statements from them. Not many details are given in this paper about this integration key element, since it is still under development.

This step would allow us to keep and/or to get only the visual concepts aligned with the reference ontology, which we will use when showing to the mobile user the results of his search.

Different other elements should be taken into consideration in order to achieve a coherent and complete visual integration:

─ The profile of the user (culture, age, map preferences, etc.)
─ The geographical zone and the graphical semiology rules

We should note that some subjectivity could interfere in case of conflicts due to linguistic and cultural differences while drawing the relations via the matching application. This is the drawback of all ontology matching.

4. GEOGRAPHICAL WEB SERVICES FOR MULTIPLE PROVIDERS

A remaining critical problem should be solved which is related to security issues. In real mode, the administrator doesn't have full access to the GDB tables to retrieve the requested data. Web services are then developed by many providers and used as secure, simple, fast and economical solutions. The client could access automatically any server regardless of the technology used (interoperability) and without any human intervention via HTTP and the service oriented architecture.

Due to the fact that we are able to provide interoperable solutions at all GDB levels, what about proposing interoperable geographical web services that can work easily via W3C web services standards and SOAP protocol from one side and OGC web services standards (WMS, WFS, WCS, etc.) and RESTful protocol for light-profile devices from the other side?

OGC had prepared a recommendation for ensuring interoperability in geo web services and it is called OWS (OGC Web Services), by adopting W3C standardization in SOAP, UDDI and WSDL. The "Get Capabilities" function in OWS can improve interoperability, but it's not sufficient to allow semantic interoperability. [OGC]

Let us start by this scenario: Suppose a user of the system likes to know the current temperature for the City of Munich. However, the temperature sensor for the location Munich must be accessible. It might exist different registered services that provide different temperature kinds (e.g. current temperature, average temperature, etc.) or return the temperature in different units of measure (e.g. Celsius or Fahrenheit) for just one location, an area or for multiple locations.

One of the solutions would be via service orchestrations, where input means location is Munich and the output is temperature in Celsius for example. Some suggestions on this case study were listed below:

.The implication of REST instead of SOAP for LBS mobile applications due to its simplicity. [Kurtagik, 2009]

•The semantic description of geo web services by using extensible location ontology based on OWL-S and RDFS for the taxonomy schema. [Lemmens, 2004]

•The development of knowledge domain base and the adequacy of a reasoner to perform matchmaking between the descriptions of a required service and advertised services and by including some matching rules based on the concepts and their relationships. [Lemmens , 2006]

•Intelligent orchestration of geo web services via Web Services Orchestration Engine (WSOE). [Matheus, 2004] Each service is described by the semantics of the input and output data and the restrictions on the input and output data using concepts of the domain knowledge base.

•The integration of International Spatial Data Infrastructures (SDI) to assist in discovering, visualizing, evaluating and accessing geo-data. [Najar, 2004]

•The development of chaining composite geo web services that can be implemented using Web Service Flow Language WSFL (an IBM initiative based on WSDL) or XLANG of Microsoft, to develop flow and global models [Jonwicsz, 2007]. It describes how geo web services have to interact with each other and their matching rules so that a simple scenario such as finding a place of interest is realized by combining geocoding web service and proximity web service.

•The development of a content syndication where the members agree to use the common schema for metadata retrieval purpose.

From the above suggestions, we can build a composite geo web service which can combine the role of WFS through unified cGML and WMS/WIS through unified CartOWL files. In that case the user will just call the URL of our proprietary web service. This service will contact via Knowledge base all the other chaining web services to get the appropriate response (i.e. geocoding web service and restaurant-finder service and calculatedistance service for the nearest restaurants and time).

We can propose as well a Multi Web Feature Service that will contact many providers and get their cGML files for processing in the mediator database

5. ARCHITECTURE AND FUNCTIONALITIES OF MPLOM

The platform MPLoM is developed to test the feasibility of the location and map symbols integrations into a unique visual portal on mobile devices.

Phase 1 covers the location integration from two providers offering pull services based on user's request (i.e. hotel and restaurant finders) and push service (weather forecast) while phase 2 covers the cartographic integration especially with other suggestions related to web application and geo web services standards for multi providers.

The pull services (restaurant and hotel) are visualized on a 2D background Google map downloaded via API key and the components are overlaid as Google markers(R for restaurants and H for hotels). The access to the providers was done directly via java servlets to the concerned tables.
However, push service (weather forecast) is delivered as textual output to the user interface via web service WSDL SOAP connection.
Both providers are created in Postgresql with the PostGIS feature for spatial usage.

The User interface is presented on a S60 Nokia emulator with LBS middleware; the platform is coded in JAVA and XQuery [W3C] is used to parse cGML files (compact geographic Markup Language), and to integrate the details of the objects into a unified cGML file before visualizing the results on the screen.
cGML is an extension of GML used for mobile devices that can minimize up to 60% of storage capacity due to its compressed

tags (i.e. GML tag=(Coordinates) v/s cGML tag= (cds)). [DeVita, 2003]

A mediator database, which is controlled by the administrator, is used to store the user's preferences, and the unified cGML file output that should contain all the unified details of the objects from both providers.

Two scenarios, describing Restaurant/Hotel finders and Weather Forecast services, were developed with some of the corresponding screenshots. The user should start by entering his preferences and logged in via a User Textual Interface.

5.1 Scenario 1: Restaurant-Finder Pull LBS service

Figure. 1 Restaurants Markers overlaid on a 2D map and List of Details

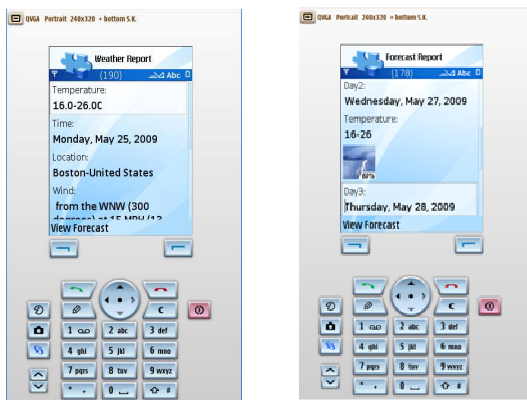### Scenario 2: Weather Forecast Push LBS web service

Figure. 2 Web services integration as textual output

6.   BUILDING/MATCHING APPLICATION

Having collected and identified the visual aspects of the concepts belonging to each one of the three different cartographic organizations Ordnance Survey, Rand McNally and IGN as described in section 3, we need to build three different visual ontologies in order to gather and semantically represent these concepts.
This is the role of the application we had implemented, as shown in Fig 6. By inserting manually semantic and visual attributes of the touristic concepts, we can edit, personalize and visualize the ontology we are building.

Improvements should be done as well on the proposed building/matching application and the CartOWL extension to support especially the alignment of the visual spatial ontologies from many LBS providers into unique domain ontology thus a unique map. In that case, map conflation will be solved via this application. The matching scenario between all local visual ontologies of the LBS providers towards a reference domain visual ontology is currently under development. Further details will be demonstrated in future reports.
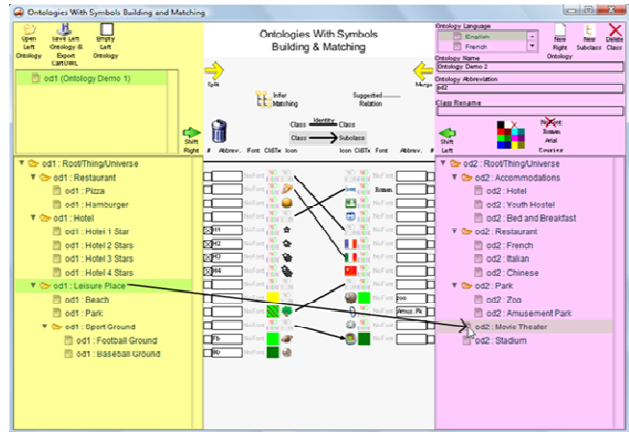

Figure.6 Building/Matching Application

7.   CONCLUSIONS AND FUTURE WORK

We had illustrated many issues and suggestions in this paper to achieve a fully interoperable LBS system without any human intervention. From the 1)geographic, place names and semantic details integration to the 2) map conflation concept then 3)geographical web services development and finally the 4) implementation of two different applications which are :MPLoM and building/matching application; We can find how Geographical Information Systems and especially their Databases Interoperability and LBS Integration were considered very important to elaborate.

Phase 2 is currently running to ensure the implementation of a catalog in the mediator database to list all the metadata about the providers and their services so we can pre filter, based on user's request, before accessing the database. Geo Web Services for multiple providers and/or APIs should be developed to ensure access to the LBS services worldwide without any human intervention and thus respecting as well the security privileges for the GDBs. Furthermore, the cartographic map symbols integration should be tested via our application in order to match all spatial providers' ontologies through an LBS domain one and to present all the components on a unique map with the help of CartOWL.

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