Improvement of cartographic information for the WMS and WFS Web services

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Abstract—**The standard geographic web services WMS (web map service) and WFS (web feature service) comprise respectively two methods GetFeature and GetFeatureInfo that allow to obtain attributes associated to a geographic object represented on a map. Most certainly, the returned result brings semantics to the object but requires adaptation to the theme chosen by the user. Our paper proposes the conception and implementation of two interfaces the semi-automatic identification of additional attributes through semantic links in the schema of database, and the presentation of thematic enriched data to the final user.**

Keywords-geographical object; attribute; geographical Web service; lattice of concepts; link of relevance.

I. INTRODUCTION

The Geographic Information Systems (GIS) [1] have greatly evolved in the last few years with the growth of the Internet. They allow producing geographic information that is distributed in many places and under heterogeneous formats. To allow the dissemination and use of this information, the Open Geospatial Consortium (OGC) [2] proposes solutions for cartographic server's interoperability through standardized interfaces. This is mainly the case for Web Map Service (WMS) [3] and the Web Feature Service (WFS) [4]. The WMS allows produce maps composed by a set of geographical objects, whereas WFS allows access and manipulation of geographical data.

In this context, the consumption of WMS and WFS services, especially their respective methods GetFeatureInfo and GetFeature, has a double limitation. The first limit is that the information displayed to the customer is not automatically adapted to his context, taking into consideration the theme of research. The second is that the edited data are far from being sufficient, since these services bring from associated databases only elementary information of the geographical object.

Therefore, the proposed solution intends to implement two interfaces that are completely transparent to the final user and allows these Web services not only to enrich the cartographic information with additional data but also to adjust this supplement to the desired domain of research. The first interface, server-side database, aim to build a semantically rich data model, whereas the second, applications server side, is the use of this model to retrieve the relevant addition to display, besides basic information, in the final result.

In the second section, we present the state of the art of geographical Web services with their existing applications in the world of GIS. The third section discusses the proposed conceptual solution to improve the use of these services. In the last section, we outline the chosen technical platform and the two applications made for this purpose.

II. STATE OF THE ART

This section is devoted to the presentation of Webmapping at the outset. Then we will detail both WMS and WFS standards to locate their limitations and be able to approach the value of the solution to their improvement.

A. The Webmapping

The Webmapping [5] refers to anything related to Internet online mapping. Under this generic term, we find different types of applications ranging from simple map viewer to the dynamic and interactive mapping tool. For data processing, a tool for Webmapping functions can work with proprietary functions as the case of Google Maps [6] [7] to visualize the traffic (Figure 1).

It can also use standard geographical Web services of the OGC such example of microsoft BingMaps paying tool [8] [9].
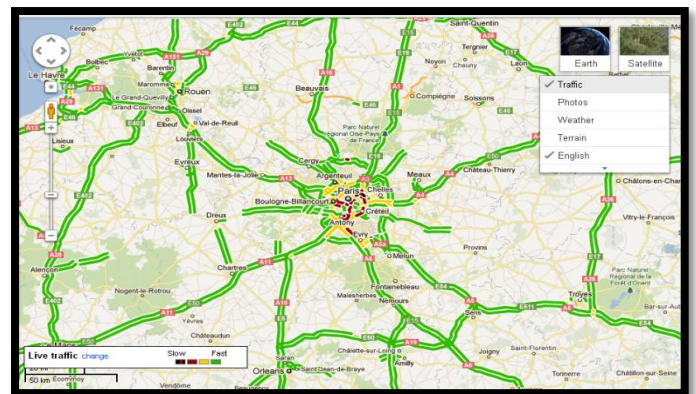

Figure 1. The traffic on Google Maps.

B. The WMS

The WMS [3] allows clients to obtain a map by a cartographic server using a standard URL. A WMS (Version 1.3.0) must respond to three queries (Figure 2): GetCapabilities allows the customer to get as an XML file the details of the services provided by the server, GetMap enables a cartographic representation of a layer available as

an image, and finally the GetFeatureInfo which allows to obtain the attribute information carried by the object (s) located where it has been clicked on the map.
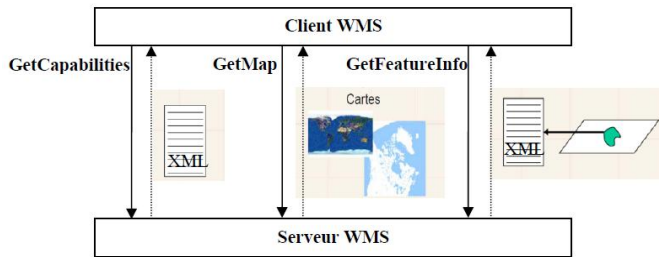

Figure 2. WMS operations.

C. The WFS

WFS [4] is a specification of the OGC services for data access. It allows, by means of a formatted URL, query map servers to manipulate geographic objects (points, lines, polygons) based on spatial constraints.

The WFS (Version 2.0.0) defines five operations, including three basic ones (Figure 3), to send requests to the server and obtain information: GetCapabilities allows to know the capabilities of the server (which operations are supported and which objects are included), DescribeFeatureType is used to return the structure of each entity which is likely be provided by the server. GetFeature can deliver objects (geometry and / or attributes) in GML, LockFeature allows to block objects in a transaction and then Transaction that allows to modify the object (create, update, delete). GetCapabilities, DescribeFeatureType and GetFeature are the three mandatory queries; A WFS with only these three queries can be considered as a read-only WFS. A request GetFeature will be made using a geographic region (BBOX) and a geographical reference system (SRS).
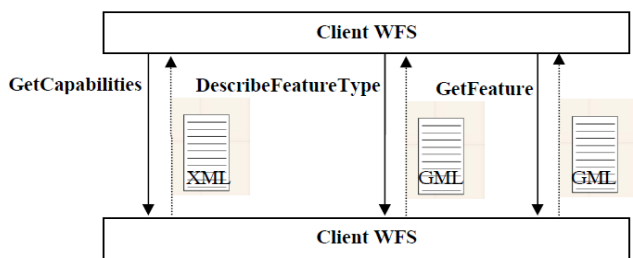

Figure 3. WFS basic operations.

D. Limitations

The operations GetFeatureInfo and GetFeature, belonging respectively to the WMS and WFS services, have some limitations. On one hand, they provide information associated with a geographical object, regardless of the type of interpretation desired by the user. On the other hand, they can not provide additional relevant attributes for the selected object. In the next section, we present the solution adopted to overcome these problems. It's consist to add an additional layer, above the standard geographical Web services, to improve and adapt the information requested by the final user. Similar process as views based on tables in the relational Database Management system.

III. CONCEPTUAL SOLUTION

In this section, we present the conceptual solution proposed to improve the use of geographical Web services. We introduce the basic concepts used in the new system, and then we present the conceptual solution materialized through a technical architecture and modeling according to the formalism XP [10].

A. Basic Concepts

1) The link of relevance

The concept of link of relevance (LR) presented in this section and proposed in [11] greatly extends the one of functional dependence to accommodate the semantics that may exist between attributes and between attributes[1] and methods[2]. The advantage of this concept lies in the fact that the information will be treated based on their semantics, and defined by the links of relevance and not just from their graphic representation.

Thus, an LR is considered as a link that allows from a data schema to obtain a set of relevant attributes with respect to the terms of the user. In this way, we will present three types of links of relevance; the first type is called LRintA-A and concerns the links between relevant attributes defined in the same class. The second type is called LRintA-M and concerns links of relevance defined between an attribute and a method of the same class[3]. The third type is called LRextA-A and concerns the links of relevance defined between attributes of different classes.

a) Link of relevance type LRintA-A

A link of relevance of type LRintA-A allows to link two attributes or two sets of attributes of the same class. This LR is defined by the following: the class affected by this LR, all the source attributes and target attributes. These two sets are disjoint and source attributes semantically determine target attributes.

b) Link of relevance type LRintA-M

A link of relevance of type LRintA-M can link an attribute or a set of attributes to the result of a method of the same class. This set of attributes designates the source that belongs to the initial schema associated with information provided by the operations GetFeatureInfo or GetFeature. The result of the method will also be provided to the user as an alphanumeric attribute named here the target attribute.

An LR type LRintA-M is defined by the following: the class affected by this LR, source the set of attributes, the method and the list of the method parameters used to generate the value of the target attribute.

c) Link of relevance type LRextA-A

A link of relevance type LRextA-A allows to link two attributes or two sets of attributes of different classes. The

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[1] The attributes of a class are alphanumeric or spatial. They represents the semantics and the geometry of a geographical object.

[2] A method, in our case is a function that returns a result as an attribute which will be part of the set of attributes provided by GetFeatureInfo and GetFeature operations.

[3] The class refers here to the class concept of UML modeling.

classes involved through these links of relevance may be related among other things, via the inheritance relationship, composition ... or be completely independent.

An LR type LRextA-A is defined by the following: the class affected by this LR (named source class), the set of source attributes belonging to the class source, the target class ,the set of target attributes belonging to the target class, the spatial query involving spatial objects semantically described by the source and target classes.

2) *The lattice of concepts*

The lattice of concepts (LC) [12] is a partially ordered structure forming a classification system for LR. In other words, it is a direct acyclic graph (DAG) whose nodes are, of a semantic point of view, the level of data interpretation required by the user. In this context, the term "theme" or node is used to denote the level of interpretation.

The instantiated lattice of concepts (ILC) is the application of LC to LR. The designer of the database will rely on this LC to associate a theme with one or more LR.

The operational lattice of concepts (OLC) is a subgraph resulting from the filtering operation of ILC based on the criterion of complexity [13] desired by the client.

The notion of complexity of access to information depends on the implementation of the database. Therefore, it is determined by the database administrator. It is evaluated according to the size of the resources allocated by the DBMS for processing each type of link of relevance.

B. *Proposed Solution*

The proposed solution consists in improving the Data Definition Language (DDL) used to model the LR and the establishments of a communication with the application that will help enrich the data from WMS and WFS services. Indeed, DDL will have as an input the basic conceptual schema and a LC, imported as a graph whose nodes present the desired level of interpretation (theme) and as an output the ILC. As for the communication, it provides sending the ILC to the application server via an intermediate layer of a cartographic server.

The other part of the solution concerns the part application. The interface to be implemented must be able to retrieve the ILC, and the complexity chosen by the client, the application will generate accordingly an OLC. The last feature is the ability to display information standards and enriched by themes based on the OLC and this by using Web services WMS and WFS.

1) *Data Modeling (Class Diagram)*

For the modeling phase we used the UML annotation [14] recommended by the XP formalism. To build this conceptual model, we have come to identify the list of candidate concepts, in this case the LC, ILC, OLC, the LR and the relationships within it. For a LC, it is a composition of a list of nodes and arcs. The ILC is a specialization of the LC, linking nodes with potential LR, while the OLC is a specialization of the ILC, by adding complexity required by the client.

As an LR can be an internal LR, an external LR or attribute-method type, we divided the LR into three classes. The class LR is assigned to an execution path, showing the various relationships within it. It is in association with the ILC, to tell each theme the associated LR. The class LR is also related to OLC to specify, this time, the complexity required by the user.

Figure 4 shows the class diagram resulting from the analysis phase of the business objects. In order to simplify the presentation, we do not mention methods associated with a class.
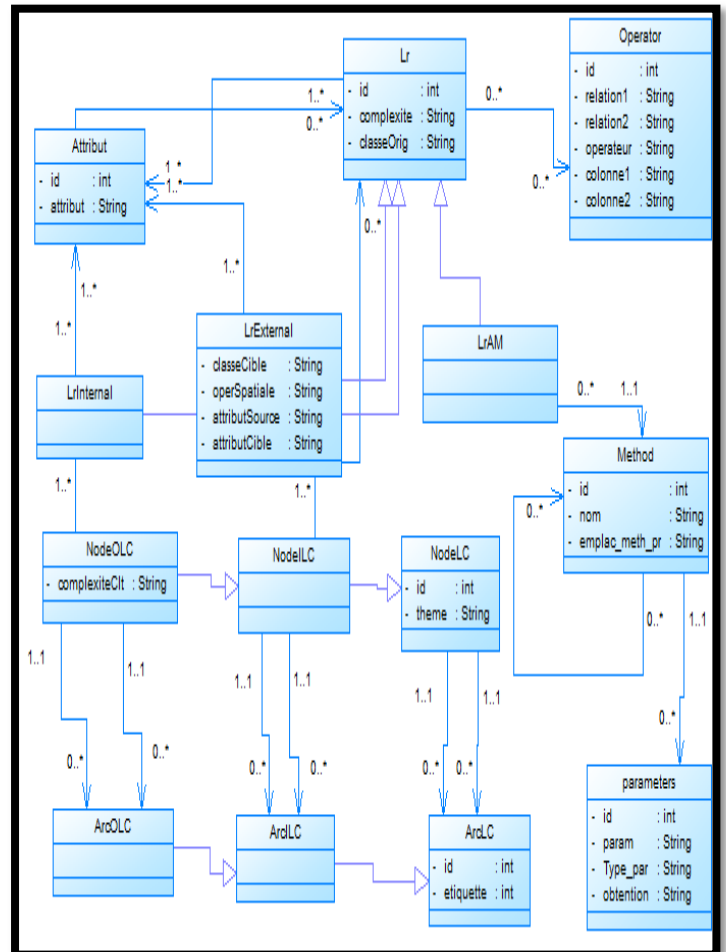

Figure 4. Class diagram "Construction of a data definition language".

2) *Schematic of the conceptual solution*

Server-side database (Figure 5), improving the DDL and the development of a communication interface with the application, will be held in the following steps:

- Import data from the LC,
- Import the conceptual business schema (classes containing the information to be displayed on the map),
- Development of LR,
- Typing of links by the couple (theme, complexity[4]),

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[4] The complexity is relative to the cost analysis of a query, not to the difficulty of expressing it. In this context, the values we have proposed to the final user include the exponential, quadratic, linear and algorithmic complexities.

- Generation of the new structure of ILC, combining the "LR" to "LC" ,
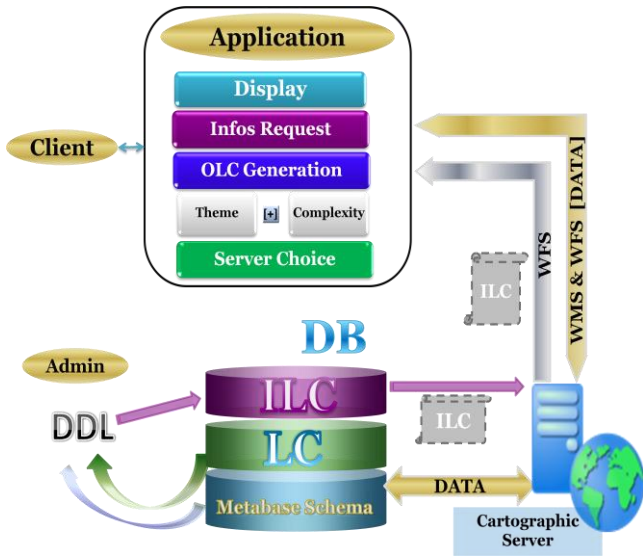- Communication and exchange of ILC with the application.

Figure 5. The conceptual solution.

Application server side (Figure 5), the interface to set up will allow the achievement of the following actions:

- On the application server side , the choice of a set of couples (Theme, complexity),
- Negotiating with database server :
  ✓ Designation of database Server,
  ✓ Recovery of "ILC",
- Generation of "OLC" according to the degree of complexity,
- Extraction of enriched attributes, based on the "OLC",
- Request information by generating queries via Web services WFS / WMS
- Displaying results to the customer.

IV. IMPLÉMENTATION

A. Architecture of the platform

The components of the platform are essentially open-source components. They comply with norms and open standards, enabling interoperability between systems (applications, services and clients).

1) Spatial Database Management System

A comparative study was made in advance of three spatial database management system; these are MySQL [15], Oracle [16] and PostgreSQL [17]. According to a study by LINAGORA and CamptoCamp [18] for the account of CNES [19] (Centre National d'Etudes Spatiales) in France, it appears that Oracle and PostgreSQL, in comparing the spatial cartridge, answer to all the spatial features unlike MySQL. In addition, Oracle is proprietary. The choice fell on PostgreSQL with its layer PostGIS [20] and PgRouting [21] for the exploitation and the graph covering.

2) The map servers

The study has focused on three servers, ArcIMS, [22] MapServer [23] and GeoServer [24].The first is a property

server, MapServer is heavy during installation and lacks finesse of the interface and maps. Hence the choice of Geoserver that supports many raster and vectorial formats, compatibility with a variety of development languages, connecting to multiple spatial databases and other features.

3) GIS desktop software

After installation, studying and testing of GIS: uDig [25], OpenJUMP [26] and Geotools [27], the choice fell on Geotools, since in OpenJUMP the reprogramming of the two plugins WMS and WFS was complicated and uDig does not allow thematic analysis or to perform spatial query. Easily integrated into the Eclipse Java platform, Geotools is the basis for the development of 16 GIS software including uDig. It is also the basis for development of Geoserver cartographic server and its modular architecture allows to easily incorporating additional functionality.

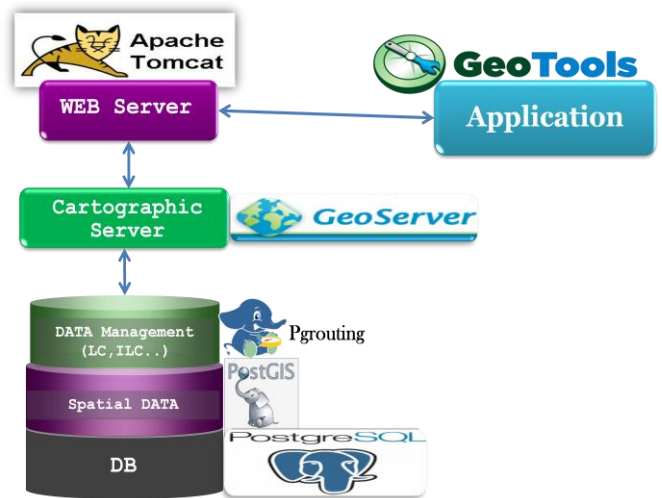Figure 6 summarizes the platform of the reached solution.

Figure 6. Architecture of the technical platform.

B. Presenting the application

1) Module "Generation of LR"

This module allows the designer to model LR. Depending on the link to model, the application displays a single class, two classes or a class and its methods. In the case of figure 7, this includes a model of an LR type LRintA-M. Source Attributes "A0" and "A5" of the class "Ville1" will be linked to the method "M6" of the same class. The generated LR will be associated with two themes "Social" and "Economic".
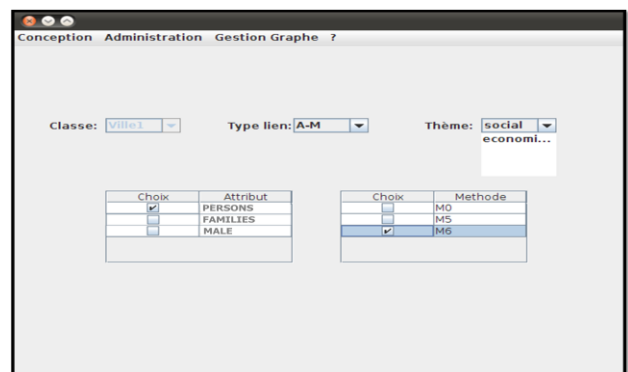

Figure 7. Screen of LR type A-M modeling.

2) Module "Additional information"

This module allows the administrator to enrich the LR by filling the complexity, the implementation plan of the link and eventually the location and method parameters. In figure 8, the administrator intervenes to enrich the LR No. 135 by the degree of complexity while showing the location of the method and its parameters.
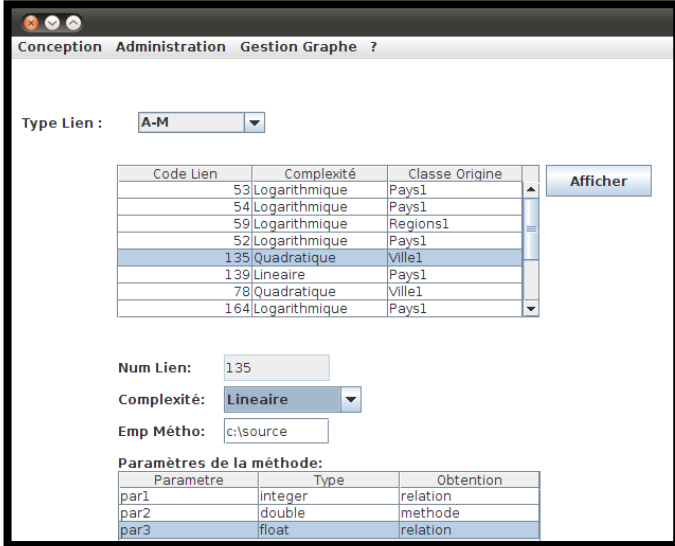

Figure 8. Screen of LRintA-M administration.

3) Module "Adaptation of the ILC"

This module aims to make the graph ILC compatible with the tool PgRouting. At the graph in figure 9, the theme "Politique" is related to the themes "Economique" and "Strategique". In turn, "Economique" is related to the "Social" and "Touristique." The arcs table contains, therefore, the pair of coordinates (x, y) of the starting node and the arrival node and the geometric shape of the linking arc. In this sense, the graph generated can be then covered through PgRouting and this, from any node.
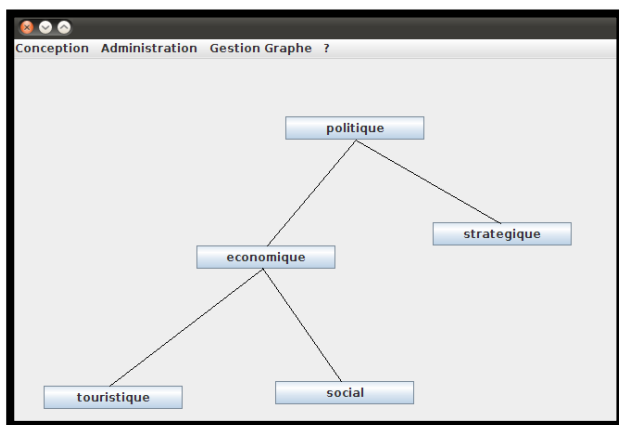

Figure 9. Screen of generation graph.

4) Module "Configuring the ILC as layers at the Geoserver"

In order for the remote application server to retrieve the graph ILC, through the WFS, the administrator must configure the server Geoserver map, as shown in figure 10, defining as data warehouse the database containing the LR and as a layer the structure defining the graph ILC.
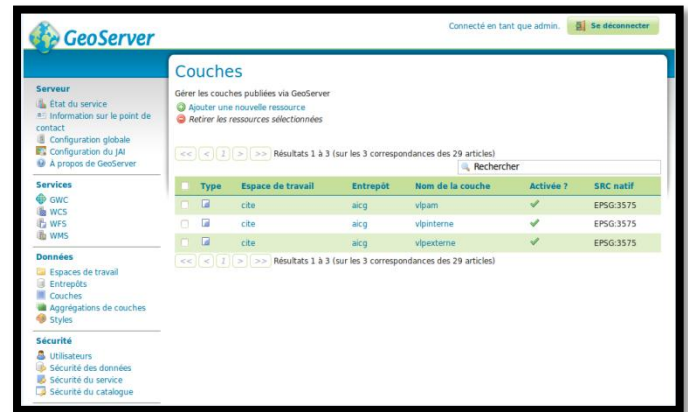

Figure 10.2 Integration of ILC at Geoserver.

5) Module "connection to cartographic server"

This module allows the client to log into the application to connect to a cartographic server (Figure 11) and recover the ILC.

Figure 11. Screen to connect to a map server.

6) Module of Information Request

To request enriched information, the customer must select the mode, the theme specifying whether this theme is with closure, that is to say the theme and sub themes in the graph. In addition, the customer must choose the map that he wants to work with (Figure 12).
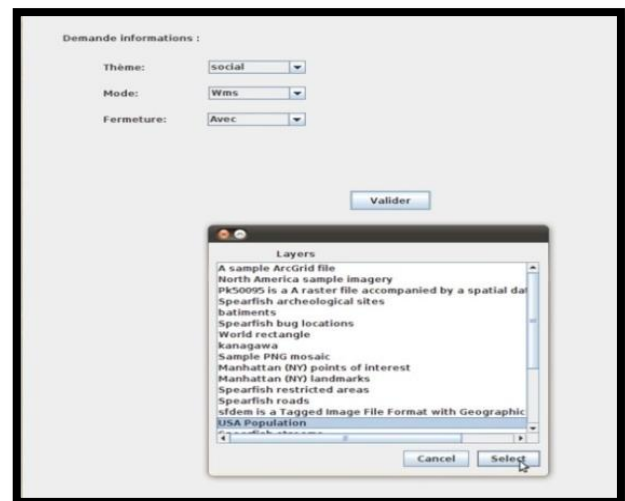

Figure 12. Screen of Information Request.

A query of type GetFeatureInfo of service WMS retrieves all information contained in the layer in all GIS software. While our application makes the sort of information and presents only those related to selected themes. In addition, it eliminates inappropriate data and returns the information enriched retrieved from other layers. In the example in figure 13, the request of the Washington area return back seven elements related to social and administrative theme instead of 22 non-filtered, so it has two additional information on the name of the parks in this area.
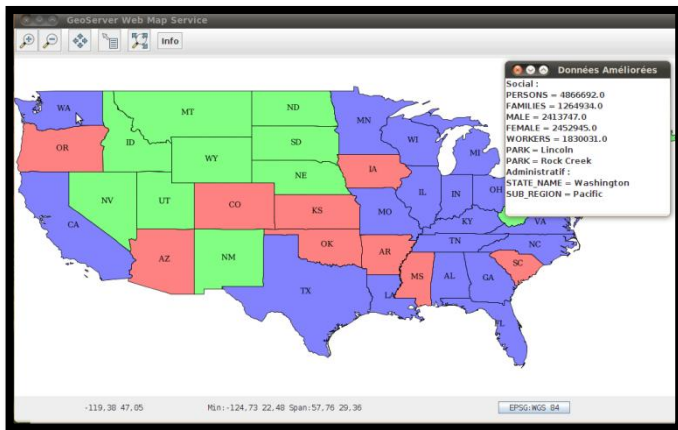

Figure 13. Information sorted and enriched.

V. CONCLUSION

The present Force was able to establish a technical solution to meet the functional limitations of Web services WMS and WFS. This is improving the display of attribute information and the adaptation of the informational content to the thematic context, using the concept of link of relevance (LR).

Database Server-side, we have developed a data description language allowing to model the LR. Application server level, and on the basis of the conceptual model repatriated from the remote database server, we have developed an application that enhances the display of geographic information.

In perspective, and to make this solution operational in GIS environment, we propose to conduct a metric study of performance of achieved applications. This study should focus particularly on the average response time of a given query and the dimensioning in terms of number of simultaneous accesses to the cartographic server.

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