ADDING VALUE TO SPATIAL DATA INFRASTRUCTURES THROUGH VISUAL ANALYTICS SERVICES FOR GEOMARKETING

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ABSTRACT:

Spatial data infrastructures will shift from data catalogues to federated platforms for the development of low cost and low risk applications. The GEOeBIZ project will contribute to this development. This article introduces the project from a task-oriented perspective, i.e. two web portals for site assessment and planning of distribution areas. The tasks will be analysed and services for a visual analytics approach will be identified. Then issues of business models will be raised: small enterprises, commercial geodata, geomarketing software and even consulting services for such tasks are too expensive. The article will show how services for visual analysis and ebusiness can be combined and embedded into the portals that operate in a distributed spatial data infrastructure.

1. MOTIVATION

Small and medium enterprises (SMEs) have hesitated to use spatial data, due to high costs and missing competence in geographic information systems. Rightfully so. The use of such systems requires experts, and even dedicated geomarketing software may be a challenge if not used regularly. Furthermore, geographic data and geo-referenced market data are sold in large packages at substantial fees, and even periodical updates are costly.

The Internet, on the other hand, is a distribution channel that could improve this situation. And the EU resolution from November 2006 to establish a European spatial infrastructure (INSPIRE) is one more argument for using spatial data in new application fields. Soon, spatial data and spatially referenced data from public sources will become available in large quantities. However, the data will need further processing so that users obtain answers to the problems at their hand. With their service-oriented architectures, spatial data infrastructures (SDIs) can be extended to value-adding service chains from source data to task-specific solutions.

Today's SDIs still a lack of evaluated business models. The data are mostly provided for non-commercial use. First demand-oriented pricing models are based on the number of clicks, resp. service invocations, and possibly the amount of data transferred (Fornefeld and Oefinger 2005). This may be fine for the data providers, but as a single mouse click may entail diverse service invocations, how should a B2C model be aligned with the various B2B models behind?

Still, SDI's role will shift from data catalogues to federated platforms for the development of low cost and low risk applications. This article will present the GEOeBIZ project, which aims at contributing to this change. The article will focus on the applications, their geomarketing tasks and high end services for a visual analytics approach. As proofs of concept GEOeBIZ will develop and later operate web portals for two tasks in SMEs: site assessment and planning of distribution areas. The commercial geodata, geomarketing software and even consulting services for such tasks are too expensive for small enterprises, and they do not have the personnel to operate the software.

A web portal, designed to solve the concrete tasks, could be a fast, effective and cost efficient alternative. The portal should be easy to use by non-experts. It should recommend appropriate source data, take into account the users' own data and provide a secure and trusted environment. First commercial, geomarketing portals have gone online, for example Marion24 (www.marion24.at) and, more recently, Mapchart (www.mapchart.com). However, such portals are proprietary solutions and not backed up by a distributed SDI.

The application tasks for GEOeBIZ will be described in the next section. Portals, which offer solutions to these and other geomarketing tasks, shall be easy to compose from reusable components. Section 3 will identify elementary services for the required visual and analytic functionality and propose a structure for composite services. Pricing models have to be considered from the perspectives of data providers (B2B), users (B2C) and the portal operators in between. More generally, business models have to take into account issues of security, licensing and payment. The models have to be compatible and technically feasible. Section 4 sketches the approach taken in the GEOeBIZ project, including the envisaged distribution of services between the project partners. Task-analytic and ebusiness issues come together in the portals, which hold the application logic. Section 5 will show how user interactions are processed, licenses and accounts are managed, and service workflows are controlled. Section 6 gives an outlook of work to be done: implementation, test, standardization and deployment.

GEOeBIZ (www.geoebiz.de) involves two research institutions and four industrial partners from the geoinformation sector. The project (Jan. 2007 – June 2008) is supported by the German Ministry for Economics as part of its innovation and networking initiative innonet (www.vdivde-it.de/innonet/)

2. APPLICATION TASKS

With the Internet as distribution channel and substrate for services, the frontend will be web portals. A web portal should have a clear target group and offer solutions to specific but typical tasks of this group. For GEOeBIZ two portals are planned as proofs of concept. They shall demonstrate that

- there are geomarketing tasks for a commercially substantial target group,
- the tasks can be decomposed into units, preferably services, with a high potential for easy reuse,
- there are business models that are attractive for all involved parties and feasible organizationally and technically,
- the technical components for the business models can be decomposed into services with a high potential for re-use, these "ebusiness" services shall be standardized

2.1 Site assessment

One GEOeBIZ portal shall support the assessment of locations. Such assessments may be needed in companies from various branches and for different purposes: choosing among alternatives for new sites, comparison of the performance of a point of sale (PoS) with the market potential and competitors in its catchment area, or tuning a shop to its catchment area. A solution of this task may consist of three subtasks: Market analysis, penetration analysis, actual site assessment (Schüssler 2006).

Market analysis: For this kind of analysis the users need not upload any data. They will position the map to the area of their interest and choose data from a catalogue of socio-economic and socio-demographic geodata. The data will be shown at the level of road segments to support fine-grained micro-geographic analysis. In addition, locations of selected affine or competitive branches may be selected, and orthophotos may be inserted as background.

The methods for visual analysis should be selected carefully in order not to overburden the users. In GEOeBIZ we chose three methods, for analysing one, two and more numerical attributes. For one attribute, the user can choose a of classification method, adjust the borders of the classes and change the colour schema. The road segments in the map will be coloured accordingly. A dot plot complements the map. For two attributes, the dot plot is replaced by a cross-classification matrix with maximum 5*5 cells. The user can choose from several two-dimensional colouring schemas. For more attributes, the user can compute a score by differentiating cost and benefit criteria and assigning a weight to each. The methods were developed for CommonGIS (www.commonigs.com) and are described in (Andrienko and Andrienko, 2005).

Penetration analysis: For this subtask the user has to upload tables of locations with addresses and business figures. Different types of locations may be differentiated in one table, or be uploaded in different tables, e.g. shops, installations (mailboxes or machines), and customers with home service. For display on the map, the addresses will be geocoded. This can be done by interpolation in a road network, or through a gazetteer service that returns precise coordinates.
For the analysis, the locations may be coloured according to classifications as described before. As a difference, the numerical attributes now come from the user's tables rather than from the portal's catalogue. If the tables contain assignments, e.g. of customers to shops, these can be displayed by lines, e.g. from shops to their customers.

Site assessment: For this subtask the user uploads a table with the locations to be assessed. In case of only one or few locations, the address may be entered manually or directly indicated in the map. Now the users determine the radius of the catchment areas, either as driving distance or as driving time. A catchment area consists of all road segments that can be reached from the location through the road network and lie within the given radius. Colours distinguish different catchment areas. The user chooses the data that shall be aggregated within the catchment area. This can be data or computed scores from the road segments, or figures from the locations constructed during market or penetration analysis. The resulting numerical attributes are presented in a table per catchment area.

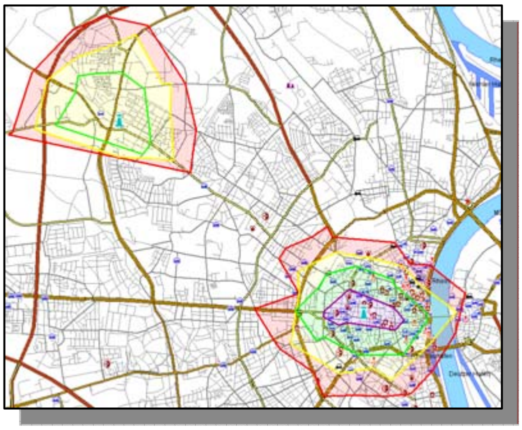

Figure 1. Map with three catchment areas for two sites

2.2 Planning distribution areas

The second web portal addresses regional delivery companies, e.g. for mail, journals and shopping newspapers. As an additional service, such companies may distribute promotional brochures for their customers. The customers, however, may expect consultancy for the best areas of such a marketing action. Their budget determines the numbers of households that may receive a brochure and, within this limit, the most attractive areas are sought for distribution. To be attractive an area should be close to the customers' PoS and have a high potential of the marketing action’s target group. The potential may be determined from different characteristics of the households in the delivery area. As delivery areas, postcode areas would be too coarse, while, for organizational reasons, the finest possible areas are the basic delivery districts. These basic delivery districts are specific to the delivery company and may be defined by address ranges or drawings on a paper map.

The solution of this task requires the user to input the basic delivery districts, select fine-grained socio-demographic data from the catalogue in the portal for aggregation to the basic delivery districts, define scores for the target group in the districts, upload the customers' PoS to compute distances to the basic districts, and balance distance versus score.

For the basic delivery districts a table with address ranges can be uploaded. They are converted into addresses by comparison with a direct marketing database. Matching direct marketing data are aggregated to the basic delivery districts. The polygon of such a district is computed from voronoi cells for the addresses restricted by buffers of the road segments. Once the basic delivery districts have been constructed, a score can be computed as described earlier. The PoS have to be uploaded and are processed like the locations in the other portal. The minimum distance between a basic delivery district and PoS is automatically computed and can be used for cross-classification with the score. The user can then select the most attractive districts by clicking in any display, i.e. map, the dot plot, cross-classification matrix, table. The number of households of the current selection is automatically summed up and displayed.

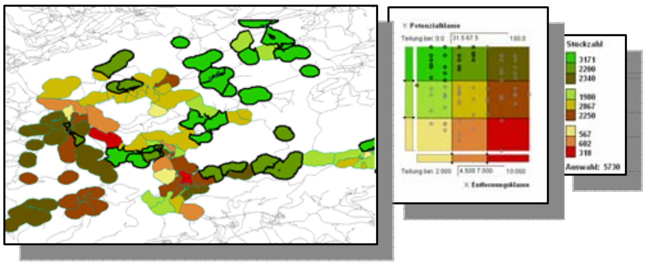

Figure 2. Selection of basic delivery districts using a cross-classification between distance and potential

3. VISUAL ANALYTICS SERVICES FOR GEOMARKETING

The research field of Visual Analytics (VA) aims at facilitating analytical reasoning by interactive visual interfaces. A first hurdle to overcome by defining visual analytic services for geomarketing is to close the gap between geodata services, as provided by SDIs and the powerful functionalities of present tools for VA and geomarketing. On the one hand, the user expects a high interaction with various presentation components that present different, but synchronized views of the data. On the other hand, SDIs mainly provide services for requesting and discovering spatial content, principally Web Mapping Services, Web Feature Services and Catalog Services. The requests to these services are static. That means, a call transforms stored data for filtering or portrayal, but does not keep the received parameters for the next request. The only exceptions are transactional requests for features (WFS-T), which impact the stored data for all further service users. In visual analysis the user really “interacts” with a method: an individual state must be kept to avoid repeating the whole processing at each minimal change.

A second problem is related to the complexity of the invoked operations. The processing may involve huge data volumes or may be too complex to be finished before a service consumer gets a timeout. In this case the client needs to be informed of the process results asynchronously to the request. The results can again be transformed by visualization operations, which are not inherent to the processing task and can vary according to user preferences or the design of the application. The visualization method should be selected according to the characteristics of the result: feature processing operations may produce one or more attributes for each feature (i.e. geographic object), while operations like aggregation produce a new feature type. The signature of the result type defines which visualisation method may be applied. Finally, the result may be requested in different formats: as image or vector data.

Thus, a visual analysis service has the following characteristics:

- It is a stateful processing service.
- It may perform a process or workflow.
- The workflow components (services) can be defined at each invocation.
- It can be modified by user interaction.
- It can be requested asynchronously for protracted operations.
- It allows the outputs of a same operation to be displays in different ways.

Many new service specifications and change requests for processing, messaging and the control of workflows have been developed in a user-driven way in the Open Geospatial Consortium’s (OGC) interoperability programme (http://www.opengeospatial.org/ogc/programs/ip). Particularly the OWS interoperability initiative testbed activity has a thread for geo-processing workflows (GPW) aimed at interconnecting geo-processes through publishing binding and finding mechanisms. This thread ties in with former phases, and participants of the present call for phase 5 are encouraged to contribute to concept maturation by using real-world scenarios and incorporating right access to resources. Most of the scenarios developed so far centre on handling sensor data and imagery.

A framework for a geomarketing scenario has not yet been proposed in any OCG working group. It should take into account that the services cannot be defined straightly, since the analysis and visualisation methods can vary according to the data and the specific user purposes. Moreover, geomarketing tasks will require a domain-specific semantic based on economic geography for strategical planning (SZABO 2006). For GEOeBIZ we will implement some of the concepts from OWS-4 and intend to apply for the OWS-5 call in order to submit our results on GPW for geomarketing tasks.

Following the postulated characteristics for VA services we propose a framework for the easy construction of geomarketing portals. Basic components for elementary analysis steps will be implemented as Web Processing Services (WPS). Although WPS are still under discussion at OGC, we chose it as an interface since it provides a status request for protracted computations. Furthermore, it specifies how to describe, store or reference inputs and outputs and thus facilitates service chaining and the development of reusable frameworks and clients (Schut and Whiteside, 2007). A well defined signature will describe each WPS according to the type of operation, the input data types and the result type. Such semantic definitions enable us to search for specific services by calling and interpreting the DescribeProcess operation and chain them to a workflow for an analysis task. The basic components of the framework will be called simple VA services. The logical representation of analysis tasks using workflow mechanisms will be called complex VA services. Their description descriptions should be based on a geomarketing ontology. In GEOeBIZ we will explore if complex service descriptions can be enhanced with semantic markups like OWL-S (http://www.daml.org/services/owl-s/1.1/). A complex VA service will have interaction interfaces, an event notification mechanism and a set of chained simple VA services controlled by a workflow engine. The final operational configuration can be set up during instantiation.

As simple VA services can be discovered and chained, different visualization services can be applied for the same task. Also different interaction interfaces can be registered in order to change task parameters and receive notifications of status changes. Finally, the framework will provide some client components that can communicate with services and can be used in different portal applications.

The next sections will categorize and summarize some simple VA services that will be developed on the GEOeBIZ project and demonstrate how they can be chained to complex VA services.

3.1 Simple VA services

These are described according to the input, the operation, the result type and possible interaction mechanism Two types of simple services can be distinguished: feature attribute processing services and feature type creation services.

Feature attribute processing services compute one or more attributes for each feature in a feature set.

Simple classification divides a set into graduated class intervals

- Input: Feature data source, target attribute (must be of type number), computation condition (this may by defined by an interval or a computation method and a number of resulting intervals)
- Result: 1 attribute with the interval number for each feature
- Possible interaction mechanisms: changing the class intervals, adding or removing class intervals, changing the attribute

2-dimensional classification: Like simple classification, but according to 2 attributes, divides a set into graduated class intervals matrix. The result are two attributes with the interval number for each feature and input attribute

Colouring/ ionization assigns a style to each feature, according to the method.

- Input: Feature data source, method, method parameters
- Possible methods for GEOeBIZ and their parameters are:
  - interval colouring: colour schema, number of intervals, attribute (numerical)
  - qualitative colouring: colour schema, attribute
  - 2-interval colouring: colour schema, x-axis-attribute, x-axis-intervals, y-axis-attribute, y-axis-interval
  - 1-attribute iconization: icon type, attribute (numerical), scalable icon property
  - 2-attributes iconization: icon type, first attribute (numerical), first scalable icon property, second attribute (numerical), second scalable icon property
  - qualitative iconization: icons schema, attribute number
- Result: 1 attribute with the feature style for each feature, or a Style Description Layer (SLD) document to be applied on the feature set
- Possible interaction mechanisms: changing the method parameters, changing the method

Filtering yields a Boolean classification of a feature (visible/not visible) according to a computation.

- Input: Feature data source, method, method parameters. With the method and method parametes a call for a selection service can be performed. According to the result set the features are classified. A selection service may be a WFS with Filter Encoding constraints.
- Result: 1 boolean attribute for each feature
- Possible interaction mechanisms: Changing the method parameters, changing the method

Scoring/ranking assigns a score or sorts the set elements into a ranking according to a computation method.

- Input: Feature data source, method, method parameters. For GEOeBIZ the score or ranking can be computed a linear weighted sum, given target numerical attributes and weight
- Result: 1 attribute for each feature
- Possible interaction mechanisms: Changing the method parameters

Feature join links two feature data sources together with a defined condition, (equivalent to left table join on databases).

- Input: Feature data sources, target attributes, linking condition
- Result: a set of attributes for the primary feature data source

Catchment area: Based on a street network the driving distance to a feature can be calculated. The outermost points of the street segments are linked together to a polygon.

- Input: A feature data source (source), the street network data source, method parameters (velocity, etc.) and the distance to be reached in time or length units. Optionally a second feature data source (target) can be given, to calculate the objects contained in the catchment area.
- result 1 attribute per feature. It can be either the catchment geometry as attribute from the source feature, or the reference of the source feature, which can be best reached for each target feature.

Feature type creation services create a new feature type mostly by processing one or more sets of features. The new feature type may have one or more features with or without geometries.

Aggregation method exist for geometrical for non-geometrical attributes

- Input: Feature data source, target attribute, computation condition (this may by defined by an interval or a computation method and a number of resulting intervals)
- Result: a feature with a set of attributes for each group

Parcelation divides a territory, containing point features. An example is the method voronoi computation, where each parcel has exactly one point feature.

- Input: The feature data source to be divided (source), the computation method and it parameters
- Result: a new feature geometry

Geometrical arithmeticcomprise computations based on one geometrical feature or the combination of two geometrical feature types by applying an arithmetical method like buffering, intersection, feature mapping (star).

- Input: Feature table (source), method, method parameters
- Result: A new geometry feature for each source feature

Geocoding: Based on textual location description a geometrical feature is selected and their attributes are returned.

- Input: feature attributes, target feature type (optional)
- Result: A new feature type with a set of attributes, (a geometrical and the correct descriptive attributes for each input)

3.2 Complex VA services

Complex services for visual analytics are mostly set up according to the schema in figure 3. When a client interface registers an action of the user (1), the interaction component sends a notification to the logic service managing the workflow (2). Depending on the previous computations the workflow control component either starts a new process or recomputes some process part. The workflow control may call one or more simple VA services (3) and process the responses (4). Upon termination of the workflow, a notification is sent to the event control (5) and the process results are sent via the calling interaction control service (6) to client (7). The event control service notifies all registered services about the changed event (8), so all client components displaying data that has been modified during the workflow, can be updated. Thus, different light display components at the client (like table, map or chart displays) seem to be linked together by actions executed by the server, allowing a better comprehension of the analysis results.

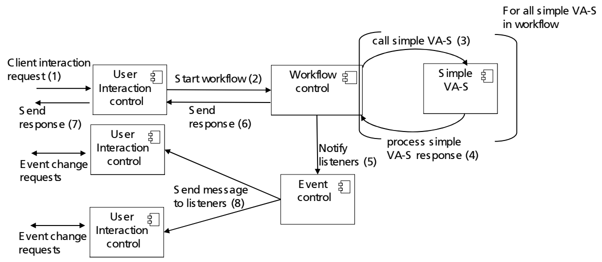

Figure 3. Structure of a complex service

4. BUSINESS MODELS

As soon as users may create or use personal data, they must be registered and authenticated, and access to the data must be authorized. Furthermore, if users need to pay for provided data, licenses must be issued, and they must be controlled while the data is accessed. Finally, the users must get personal accounts, which are updated as actions with costs are performed. Security (including registration and authentication), license management and payment are three major ebusiness functions in a commercial infrastructure.

Just like geomarketing functions, ebusiness functions can be packaged as services. And the more service interfaces are standardized, the better they can be reused in other contexts. Moreover, standardized services can be outsourced or operated by other parties, to be chained dynamically for solving a task invoked by a user from a portal. A trusted party operating ebusiness services has some advantages. The users may receive a single ID and password for all associated portals, and they could even receive a single invoice.

In GEOeBIZ, the operators of each portal will each host their own geodata and geomarketing services, but also provide them to the other portal, while the ebusiness services may be hosted by a third, trusted operator. Both portals may use geodata and geocoding services operated by German cartographic agencies.

The services are for commercial use. Therefore payment models have to be negotiated between the different parties. Nowadays, most geodata services are offered for non-commercial use. B2B and B2C payment models for geo web services have been proposed (Fornefeld and Oefinger 2005), but there has been no experience reported for value-adding service chains. It is suggested that models should be simple and combine a fixed (one-time or periodic) cost plus demand-dependent, possibly graded costs (per service invocation and maybe data transfer). And of course, users at a portal cannot know and should not pay for all services implicitly invoked with one mouse click.

This creates a problem for portal operators. For they have to figure out a price per click that covers, in average, all possible service chains. This is difficult without any experience in a new portal. Moreover, costs per mouse click discourage exploration, which is a key feature of our visual analytics approach to geomarketing in GEOeBIZ. It would be fairer if the users paid not for mouse clicks, but for tangible results. I.e. the demand-oriented price-component would account for print-outs or stored visualizations. In order to calculate the fixed and "result"-dependent pricing components, the GEOeBIZ partners clearly need usage data from first users of the portals. Until this data is available, external service providers will hopefully join the experiment and agree to more flexible licenses.

5. THE PORTALS

The portals have to meet the expectations of users, portal operators and service providers. Users need an intuitive, thin, browser-based client for small to medium-sized geomarketing tasks. They need to analyse market data and their own data at affordable costs without having to purchase a complete software or data product. The portal operator targets customers with recurring demands that can be served with light, customizable line-of-business-oriented applications. His own and external software shall be easy to integrate as reusable and exchangeable components with a calculable price model. The service providers can profit from promoting their products in different user-specific applications with business relations only to the portal operators.

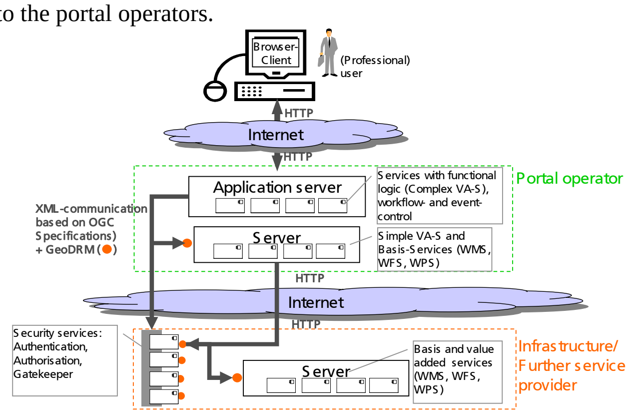

Figure 4: Structure of a portal

5.1 The structure

Figure 4 shows the portal structure from an operational point of view. The user can access the geomarketing application with a browser, after having registered to the portal and having received a user account. Next, the user will define a region of interests and order data licenses for this region from the portal's catalogue. The application server receives the orders via the user interaction control services and presets each service request with functions for the management of digital rights for spatial data (GeoDRM) using the information stored with the user account. The services invoked by the GeoDRM functions control security via web authentication and authorisation services (WAAS) and licences via web pricing and ordering services (WPOS). When the user analyses the data, the application server receives requests to geodata services like WMS, WFS and WPS and channels them through a gatekeeper. It encapsulates GeoDRM functions that check the requests and responses against the licences and charge the account, if needed. The GeoDRM services can be hosted by a trusted external service provider.

The application server holds the application logic and maintains the activity state of each user within the main application manager service and further complex VA services. It may call simple VA services within and outside the portal. To keep the application flexible and scalable all services will be requested using interoperable protocols according to OGC specifications.

5.2 Process chains

Let us illustrate the process for the penetration analysis task from section 2.1. After the user has logged in, the application server requests the authentication service with the user's identifying information and receives an identity token to be used for security control during the session. Penetration analysis is defined as a complex VA service that provides several visual components for the client. The data input component allows the user to upload tabular data with addresses for locations. This will trigger the geocoding service to acquire the point geometries for the addresses based on their geocoordinates. Before the geocoding is performed, the authorisation service will check that a licence for the geocoding service is associated with the user's identity token. Instead of geocoding addresses, the user may enter point objects on the map and supply some attribute data for each point. Both input components use transactional WFS requests to add data to a previously defined “location” layer. Once the location layer is added to the visible layers for the user, all the client display components are notified to be updated. Thus the user can see the new point symbols in the map, the new location data in the table, and a dotplot or scatterplot updated with the new data, although the client components are not linked directly but via the event control mechanism of the application server.

The location data can be combined with data from other visible layers, which may be provided by external infrastructure nodes. For instance, the map view can show orthophotos from the German federal surveying department via a WMS. At each repositioning of the map, the application server checks whether the requested section is covered by the license by intersecting the visible bounding box with the licensed region. Updating a layer will only affect the map view, not the table and or diagrams, which do not display any orthophotos.

The location layer can later be involved in further computations, e.g. of catchment areas during site assessment. The user may choose a target layer, for instance a point of interest (POI) layer. The results of the catchment area service will be managed by the penetration analysis workflow and added as new attributes to the location layer, polygons as geometrical attributes and the number of POI’s found on the catchment area as numerical attribute.

6. CONCLUSIONS

This article introduced the GEOeBIZ project with its objectives to move spatial data infrastructures from data catalogues to federated platforms for the development of low cost and low risk applications. Starting from requirements for site assessment and the planning of distribution areas, a framework for geomarketing portals and VA services were proposed. Simple VA services were identified and the structure of complex services was discussed.

After four months of requirements analysis and conceptual design, the project has now entered the first of four implementation phases. Beyond proving the mere feasibility of a service infrastructure for geomarketing, efficiency is an issue: will a thin client enable the kind of interaction with maps and other displays that we are accustomed to in desktop software? Will service chains work fast enough? Will the user interface be self-explanatory for users without any background in geographic information systems?

A glimpse on ebusiness aspects and payment models raised commercial issues: Can reasonable payment models be negotiated with external providers and governmental agencies? Will the costs be sufficiently low for the budget of small enterprises, but still give enough profit for all parties in the value chain? We a very curious to learn about the behaviour of the users and develop good business models for sustainable portals.

An analysis of typical geomarketing tasks (Freitag 2007) has shown that the services suggested indeed implement functions that occur in many geomarketing tasks and thus have a high potential for reuse. This encourages us to contribute to the standardization not only of ebusiness services (Wagner 2006) in the context of the OGC, but also of the geomarketing services.

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