Semantic Interoperability in Electronic Marketplaces: A Business Model for NSDI

Sumit Sen Christoph Brox Werner Kuhn

Institute for Geoinformatics, Robert Koch Str. 26-28,
48149 Münster, Germany
{sumitsen, broxc, kuhn}@uni-muenster.de

Abstract

The high market potential of geographic information is currently not exploited. Impediments are non-appropriate GI products, outdated business models, and lacking access of potential customers to the GI market. We suggest electronic marketplaces as an essential element of NSDIs' business models in order to support overcoming these impediments. We validated the feasibility of marketplace implementation in terms of business processes, economical, and technical feasibility. A prosperous GI market is a market of information services, adding human, technical, organizational and institutional services to the raw products data and software. Semantic interoperability of services is one of the core issues of service chaining, and emerging standards of ontology based web-service descriptions target its implementation. We suggest the use of ontologies as a step towards semantic description of GI services.

1. Introduction

Given the central role of space in political and economic decisions, geographic information should have a high market potential. Geographic information is used in many different application fields, e.g., navigation, logistics, marketing, regional and ecological planning (Keenan 2004). However, market growth does not seem to achieve its potential (CommonGIS 1999), (Nebert 2000). A recent market study estimates that the GI market potential in Germany is about 8 Billion €; however, currently 1.2 Billion € are exploited (Fornefeld, Oefinger et al. 2003). (Frank 1999) estimates that GI could improve efficiency of economy by 15 %.

The mission of NSDIs is to improve the GI market. This mission represents a substantial, long term research challenge addressing key societal and economic needs:

- Addressing some of the biggest problems in society, such as communicable diseases, malnutrition, water supply, climate change, and migration, requires geospatial information integrated across scales as well as disciplinary, cultural, and technological differences.
- Geographic information is a potentially valuable resource for economy. From the NSDIs point of view, two sides of the same elephant are crucial: NSDIs are often driven by governmental surveying agencies. Their core interest is to market and sell their core products: data. In order to achieve this goal, NSDIs have to create a market for data.

Geographic data alone are not products being successful on the market. Section 2 identifies the current obstacles and needs of the GI market. Section 3 suggests electronic marketplaces as core elements of NSDIs addressing these needs. Section 4 validates the feasibility of the implementation of an electronic marketplace. Section 3 describes the importance of services in regard to GI Data and outlines the major issues in automated discovery of services, mainly in the context of interoperability. Section 4 gives an overview of current work on use of ontologies to specify conceptual models and some of the open research issues. Finally, we present a summary and an outlook on further work (section 7).

2. Needs of the GI Market

We observe three major obstacles of the current GI market:

a. Products often do not match customers' needs.

b. Monolithic business models impede the efficient provision of products.

c. Potential customers have no appropriate access to GI products.

2.1. Products often do not match customer needs

For too long, geographic data and GIS were considered as usable products per se. However, they do not fulfill the user requirements, because mostly they are not ready-to-use. This problem became apparent observing many GI projects of our institute and its partners, companies and authorities: The implementation of a GI solution mostly required a GI project, where most of the costs resulted from working hours of the personnel. Their human services consisted for example in GI consulting, and integration of geographic data and GI software into a non-GI system. Available products of the GI market were apparently not ready-to-use. Mostly, demanded GI products a complex, composed by several intermediate products (Brox and Kuhn 2004). In a case study of a typical business client requesting a typical GI product, more than 90 % of the costs went into human services. Less than 10 % of the total costs were data and software (Brox and Kuhn 2004).

2.2. Monolithic business models impede the efficient provision of products

The technological step forward in GI is interoperability. The Open Geospatial Consortium promotes the combination of technical GI services versus the ancient model of monolithic GIS. Innovative and interoperable components are developed, e.g., in the BRIDGE-IT project (www.bridge-it.info).

Technological evolution forces economical evolution as well; interoperability has to be transferred from technology to business. Mostly, the GI market's business models are still monolithic. There are many examples for companies that cover all tasks of a geospatial value chain: produce data, adjust data, produce software, adjust applications to users' needs, integrate systems, consult users, and train users (Brox and Kuhn 2004).

Monolithic business models affect impediments for the GI market. Many GI products consist of various intermediate products. Typically, a company has a core competence in provision of one or some intermediate products, but not covering all intermediate products such as different as GI consulting, software development, and training. Consequently, the end product delivered by one company will lack quality and/or will have too a high price. In addition, potential customers will not sufficiently be able to compare different providers by quality and price. The customer is dependent on monopolistic providers in an in-transparent market.

The provision of complex GI products requires a networked cooperation of the entire geospatial value chains of producers, service providers, integrators, service enablers, and end-users (Niedzwiadek 1999). This requires new forms of business models, tools for its establishment, and cooperation of business partners within the value chains.

2.3. Potential customers have no appropriate access to GI products

On the one hand, various potential applications of GI affect a high market potential. On the other hand, this leads to an almost unlimited number of profiles of potential GI products and providers. Consequently, geographic information is a heterogeneous, fragmented market (Brox, Kuhn et al. 2004).

Usually, potential customers have little knowledge about the needed GI products. In this case, a potential customer has two options:

- Rely on and engage a general contractor, or
- Use existing internet resources.

Both options impede the GI market. A general contractor might suggest non-optimal GI products due to a lack of knowledge about all aspects of a complex GI product, or links to specific software vendors and data providers might lead to the usage of a less appropriate software or data. A lack of competition might lead to high prices. Existing internet resources mostly do not offer information for non-GI-specialists – often not even for GI-specialists – in order to get a sufficient overview of GI products and prices.

3. Electronic Marketplaces in NSDIs

Running electronic marketplaces within NSDIs require

- an organizational framework,
- and a catalogue of offered services.

3.1. Organizational framework

Geographic information is still a young market. We do not consider that it already achieved the critical mass for establishing a GI marketplace as a private company with a sufficient return of investment. Reverse, we see a GI marketplace as a non-profit organization, which targets the improvement of the GI market.

We consider the GI marketplace as an independent, neutral organization, which is open to cooperation of various players and competitors, GI providers as well as customers from financial services industry.

Spatial Data Infrastructure (SDI) initiatives match this profile by its self-definition (Nebert 2000); they are appropriate entrepreneurs in public-private partnerships.

For example in Germany, SDI initiatives as InGeoForum (www.ingeoforum.de) and CeGi (www.cegi.de) target the improvement of the GI market, and have initiated internet-based platforms (www.ingeoic.de and www.terramapserver.de). These organizations execute valuable contributions by addressing marketing GI in politics, legal issues, connecting GI providers, and technological standardization. They also provide GI services, however we see the following impediments for addressing financial service providers as potential clients. The SDIs are

- mainly regional
- addressing all branches, and providing few offers to special branches, e.g., financial service providers
- focusing on data instead of adding additional GI services.

Although existing SDIs in Germany and other countries still need to improve business models for an increasing GI market, the organizational infrastructure for GI marketplace implementation already exists.

Marketplaces have to be open for new providers and new products, i.e. services. Especially within the GI market connected value chains for the generation of information services are missing. It will be crucial to integrate a critical mass of providers within the marketplaces for geographic information. Therefore, the impediments for new providers to enter the GI market and to participate with the marketplaces have to be kept as low as possible (Merz 1999), furthermore, the integration of new providers and new products has to be actively facilitated.

An open market corresponds with the need for standards, e.g., technical agreements, and rules, e.g., legal regulations about offering products within marketplaces. Too little standards and rules will not allow for a successful co-operation of providers and providers or providers and customers. A too high degree of standards and rules will increase the costs and the organizational efforts for the business within a GI marketplace and could prevent the integration of new, innovative companies and products (Merz 1999).

3.2. Services

Conformant to the needs of the GI market is the general trend of non-GI marketplaces to extend their services to fulfillment services, logistic services, Enterprise Resource Planning (ERP) Systems – CRM (Customer Relationship Management), consulting, content, newsletter, marketing, public relations, and addressing international clients (Spiller and Wichmann 2000).

We identified services needed for buyers and sellers of GI marketplaces in the following categories:

- Firstly, the market has to support *matching buyers and sellers.* Main components are determining product offerings, search, and price discovery (Bakos 1998). The focus of this category is on information.
- A particular requirement of the GI market is to *support co-operation within the geospatial value chain*. For this, a GI marketplace should provide mechanisms and services for the connection various providers to geospatial value chains and their co-operation.
- Marketplaces offer, in addition to the services of shop solutions or portals, the *facilitation of transactions.* A GI marketplace facilitates B2B transactions between buyers and sellers of geographically referenced products. B2C transactions might be included for special reasons, e.g., marketing initiatives.
- *Marketing* within a GI marketplace covers two aspects. Firstly, a GI marketplace provides services for the marketing of the products offered by the companies and organizations. Sec-

ondly, we think it crucial to initiate marketing initiatives for the GI market and the GI marketplace. This includes an extended awareness of customers to the potential use of geographic information and an extended co-operation of business partners within the GI marketplaces.

- The GI market consists of a great variety of players, is fragmented, and lacks standards and tools for cooperation. To improve the use of geographic information, the co-operation of business networks, and transparency of the market, GI marketplaces need to *provide an institutional, organizational, and technical infrastructure*.
- The *provision of additional services* extends the marketing of products by future-oriented initiatives. For example, the significance of international co-operation increases; the bigger non-geospatial marketplaces in Germany employ 25 % of its personnel abroad, smaller marketplaces employ at least some staff in a foreign country (Spiller and Wichmann 2000).

4. Feasibility of Marketplace Implementation

The validation of feasibility has four aspects:

- Execution of services in business processes
- Economical feasibility
- Technical feasibility
- Research needs.

4.1. Business processes

In principle, all services listed in section 3.2 have to be implemented in concrete business processes. In this paper, we will focus on a single core business process: A customer buys a GI product. In a specific scenario we will design a business process for buying a product. Afterwards, we will validate this business process addresses the current impediments of the GI market discussed in section **Fehler! Verweisquelle konnte nicht gefunden werden.**.

4.1.1. Scenario

The overall scenario is a bank, which targets the evaluation of the locations of its branches. The evaluation targets a priority list of existent and planned localities by the comparison of costs and market potential. The final goal is to decide about improvements of branches, shifting or closing of existing localities, and opening new ones. The evaluation is based on enterprise and demographic data, and it shall be supported by geographic information. The bank repeats the evaluation every year. Therefore, the bank needs a tool and working processes for an in-house execution. The generation of the desired end product includes different tasks, e.g., finding business partners, define requirements for needed data sets and GI software, integrate data and software into the bank's business system, and training of employees on the new system.

Within the scenario, we focus on buying data and a data integration service (see figure 1): The business process starts with the request of a bank manager for a product offer. The bank manager fills in his request in an electronic form provided by the GI marketplace. The GI marketplace addresses the request to three GI consulters, which – according to the GI Marketplaces' database could potentially do the job. In addition, the GI marketplace evaluates by customer's request potential data providers and data integrators. This information the GI marketplace transmits with addressing the customer's request to the GI consulter.

Two of the addressed GI consulters internally decide not to process the request, one decides to do. The GI consulter checks potential data providers by viewing their data and relevant metadata information. After deciding for a suitable data set, the GI consulter addresses the customer's request for data integration to two data integrators. One of them sends back an offer for the integration service. The GI consulter evaluates all information and sends an offer for the required end product to the bank manager via the GI marketplace. Based on the product offer, the bank manager orders the required GI product at the GI marketplace. The GI marketplace passes the confirmation to the GI consulter. The GI consulters orders and pays the required data, and confirms the data integration service. The data integrator performs data integration. Data provider and data integrator are paid via the GI consulter.

Figure 1 shows different types of services. We classify them into three groups: technical GI services, human GI services, and organizational services. The latter are notification services of the players of the scenario in order to inform the business partners about the fulfillment of a request, e.g., by email.

It is important to realize that the business model for the GI Market place is depended on Technical feasibility of the processes and once this is established the economic feasibility of offering services between Consulters, Data providers and Data Integrators is to be established. While GI markets still exist today the high cost of human services often leads to impediments for its growth. The human intervention is sought due to the need for semantic interpretation of the components of GI and thus highlights the necessity to address semantics in order to provide value addition to the present system.

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We consider services as technical GI services if automated processing is state-of-the-art on the GI market, mainly when OGC specifications are available or planned, e.g., Web Mapping Services, Web Feature Services, and Catalogue Services. We discuss the evolution and significance of such services in the following section.

On the other hand, human GI services are provided by human beings, e.g., processing a request for an offer for integrating a data set. However, differentiation becomes weaker in other cases. For example, nowadays a common business process of the GI market is thinking about data integrator who could potentially do the required job or looking for one in the internet. Our paper targets the automation of this process by matching specified requests for services with specified offers. Thus, we classify some GI services, e.g., "address", as human services because it is the state-of-the-art, although a successful implementation would turn them to technical GI services.

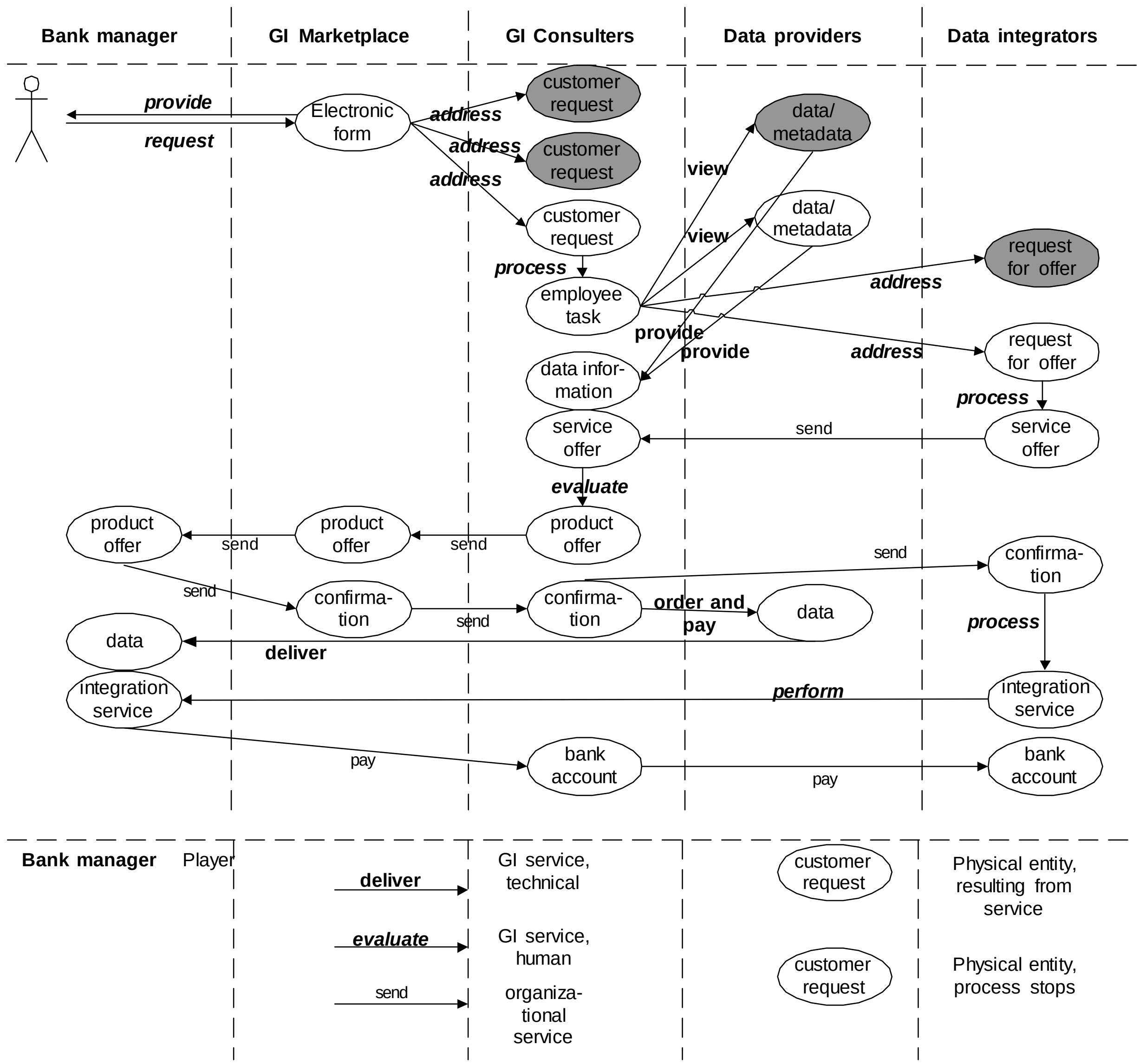

Figure 1 : Business process for GI product provision

4.1.2. Validation

In the above described business process, the GI marketplace serves as an interface for workflows between the business partners. The design allows the execution of transaction- and collaboration-oriented features, which address the three major impediments of the current GI market showed in section 2:

- The business process provides different types of services. Technical services, e.g., access to metadata catalogue are added to the raw product “geographic data”. The GI providers offer human services via the GI marketplace, e.g., data integration. The GI marketplace provides organizational services, e.g., the provision of an electronic form to fill in the customer’s request. In the background, not explicitly shown in the figure, the GI market-place has provided institutional services, e.g., establishing a group of potential providers, and standards for data offering and contract models. Thus, in the end the customer gets an *information service* as a ready-to-use end-product.

- The business process addresses *business networks*. First, the GI marketplace addresses many providers, and second, it addresses specialized providers of the geospatial value-chains. Thus, it helps overcoming the monolithic business model of “one hand serves all”.
- The potential customer gets an easy *access* to GI products, product information, and providers. Thus, his transaction costs for buying a product are comparably low, and by a competing market of GI providers the quality of the required end-product probably is higher while the price is lower.

Although we highlighted a single scenario, we think that this typical business process can be generalized. A potential GI customer has access to various types of GI providers and services, thus addressing the key impediments of the current GI market.

4.2. Economical feasibility

In a case study, we estimated the economical feasibility if the realization of a GI marketplace for the financial services industry in Germany (Brox, Kuhn et al. 2004). We suggest a two-year project phase before starting the operation mode. For preparation phase, prototype implementation, testing, evaluation, and preparation of operation mode, public funding is required. For the operation mode, we foresee two means for cost recovery: Member fees of GI providers and a percentage of the turn-over mediated by the GI marketplaces.

The risk for the pilot phase is low, once acquired public funding for this phase. In the operation mode, there is a need of a high number of customers/partners and annual turn-over. We estimate the risk for acquiring 100-200 GI providers willing to pay for the GI marketplace services as high. On the other hand, current big GI projects easily have a turn-over of 500.000 $. Therefore, a high GI marketplace turn-over can be achieved with a relatively low number of users. We estimate the overall risk of the GI marketplace realization as medium – high (Brox, Kuhn et al. 2004).

The risk has to be weighed against the potential benefit. The realization of the GI marketplace can implement new business models in the GI market, mostly common in general economy. This is a step forward in integrating GI in business processes of the free market. The GI marketplace realization is a chance to significantly increase the sale of GI products. We see the realization of a GI marketplace for financial service providers as a pilot initiative. It will enable the establishment of further marketplaces for other potential branches with lower costs. This will provide an additional impact on the GI market.

4.3. Technical feasibility

Regular business processes of marketplaces can also be implemented in a GI marketplace. Business process description languages for internet-based service chaining are available, e.g., BPEL4WS, WSFL.

In general economy, we observe the increasing use of semantic enabling languages, and ontologies. They are used for knowledge and content management, e.g., the INKASS project (Abecker, Apostolou et al. 2003) targets the trade of knowledge on electronic marketplaces by using ontologies for the description of existing knowledge in the Web and, the more advanced step, adding services for enabling business processes.

In the GI world, we can observe a similar evolution. The need for semantics was firstly addressed to geographical objects in data sets. Then, the need for semantic enabling description of services became the next challenge (Kuhn 2002). Mostly, ontologies are used to describe and enable technical service chaining; OWL-S (formerly DAML-S) is an appropriate tool for implementation (Janowicz and Riedemann 2003).

However, usable products of the GI market consist of technical services AND human services, e.g., GI consulting, integrating geographic data to bank-internal data, and adapting GI software to business software as SAP. The ongoing challenge is to add human services into business processes in order to make GI economically more successful. (Brox and Janowicz 2004) validated that OWL-S is capable by its concepts to fulfil the requirements of implementing human and technical services in internet-based service chains. The following section describes services in detail and we explain the technical aspects of integration of services using ontologies in the section thereafter.

5. Data, Services, Service Chaining, and Interoperability

Components of spatial data infrastructures constitute data sources drawn from semantically heterogeneous domains such as cadastral survey, geology, transportation and hydrology to name a few. It has been argued that GI data transfers across domains can result in information loss (Kuhn 1997) and operations that can be defined on the data entities are essentially inseparable from the data itself. This leads to a justification for the participation of GI services in the SDI rather than data alone. Obviously one may constitute the web feature services (WFS) as a type of service by itself and it is truly so but perhaps the complete meaning of GI Services lies in the geo-processing services like “finding buffer regions”, “finding nearest” besides others can be provided as a part of the infrastructure.

Services invariably use data themselves and can be available inside its system. Such self contained systems can be found to be monolithic and less flexible in terms of the purpose to which they can cater. This is reflected in the efforts of the web services community which now focuses on building smaller and more basic services that can be couple to each other to achieve more complex tasks. Service chaining and composite services built from simple services are therefore seen as a more promising way that users would be able to obtain information for their customized objectives.

Services are described using accepted standards and protocols. The syntactic problems of integration can thus be tackled as it is done in any information integration task across domains. However the semantic heterogeneity still persists and needs to be resolved. Such problems are classified (Probst and Lutz 2004) as

1. Naming heterogeneity
2. Datatype heterogeneity
3. Conceptual heterogeneity

Catalogues that maintain metadata about the services (and are typical constituents in an SDI) are not very helpful in recording the semantics of the services or publishing them. Hence the focus shifts to ontologies and conceptual models about these services that can be published on the web.

So why should services be preferred over data products. Some of the argument is already presented in the previous section. Just to summarize this is mainly to provide easier access, provide more –ready-to-use products, allow interfacing between multiple services and thus provide flexible, networked business nodes.

5.1. Value addition through interoperability

Let us discuss the significant fact that since human services account for major cost and effort component in the usage of GI products (consider services as the product offered), it would be significant to include automation as a core component of service discovery and matchmaking.

So what is the value addition proposition and why is it important to have interoperability. Let us assume that there are two services offered in the market place- one offers the road network data and the other offers route finding service. It is obvious that by integrating these two services customers can get a *information service* as ready to use product mentioned earlier. There are four scenarios possible in this regard.

1. *Total Interoperability is assured*
2. *Syntactic interoperability is assured*
3. *Only semantic interoperability is assured*
4. *No Interoperability is assured*

The level of human services involved gets higher as we go down the list. It also increases the chance of incorrect results, the cost of which cannot be realistically estimated. Thus the value add proposition would have to be on the lines of going up the order in the list and hence provide increased savings and larger customer base for the vendors. The consumers would look forward to higher reliability and freedom to choose. This is shown in the figure 2 below.

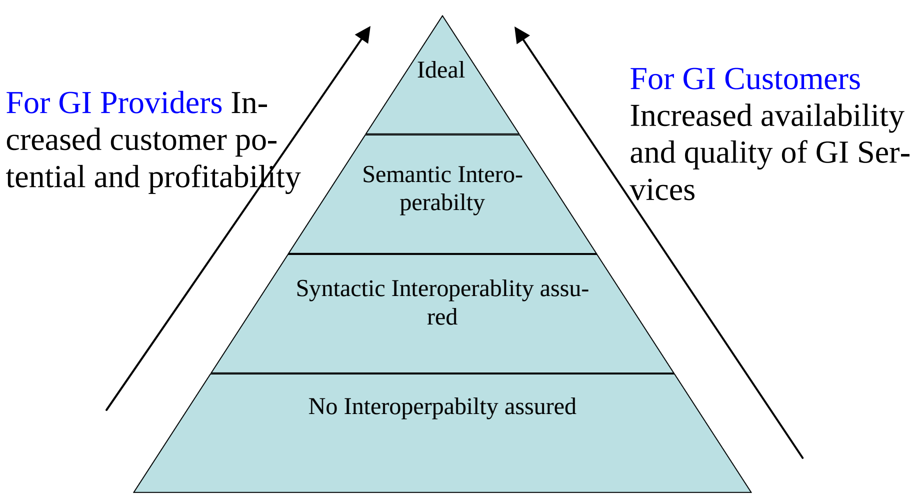

Figure 2 Value of Interoperability

Lastly, one has to look at the investment required for such a proposition is in the form of implementation of standards for resolving syntactic problems and knowledge based systems for semantic problems. Investments in standards and implementation of standards are required for syntactic case. Use of Ontologies or other conceptual modeling tools and investments in such efforts is the investment for the later case. We discuss these in our next section.

6. Integration of services using ontologies

Conceptualizations that are behind the objects and artifacts that constitute the system are domain dependent. These conceptualizations that are expressed as ontologies usually specify objects and their relation to other objects. A glimpse of such conceptualizations can be had while reading documents that record the purpose and requirements of systems in natural language texts.

There are several definitions of ontologies that can be referenced but in the context of the semantic web are specifications of concepts and knowledge about these concepts.

Current efforts in extraction and specification of ontologies include use of Description Logics (DL) and DL based tools for specifying and inferencing. Thus in typical ontologies, concepts are related to each other using taxonomic relations that may include patronymic (is-a) and meronymic (Part-of) relations. These are however argued to have certain restrictions currently and need to be extended for adequate reasoning for processes. Nevertheless such logic systems make it possible to implement simple knowledge based systems which is indeed valuable.

6.1. Creation of Ontologies

There are many ways that help to identify conceptualization of objects. The method based on text analysis has been shown to be useful (Kuhn 2000) to extract concepts and their behavior based on lexical differences. It is worth noting that it not only identifies objects based on their attributes but also on their behavioral properties. The main points of this methodology are:

1. Ontologies need to be extracted from textual descriptions that are usually analyzed for system design and communication.
2. In this endeavor spatial verb classes and transformations thereof, would help to identify actions and activities
3. Behavior is combinations of such actions and activities. Therefore by grouping and categorizing objects on the basis of Behavior, users can identify the object concepts.
4. Behavior is also not independent of the state and events of the objects. Thus identification of object concepts in different event and states is also recommended.
5. Attributes of object concepts could also be recognized at the end. These are attached to the object on the basis of how the behaviors of the objects influence their values.

While extraction methodology is one significant choice, it is also possible to choose the ontology specification language. Due to the W3C standardization efforts and collaboration of interested groups, the OWL specification language (McGuinness and Hermelen, 2004) is now used widely (at least in conjunction with others). There are also many tools that can be employed to created or edit OWL. A wind observation ontology specification is shown using two different tools in Figure 3.

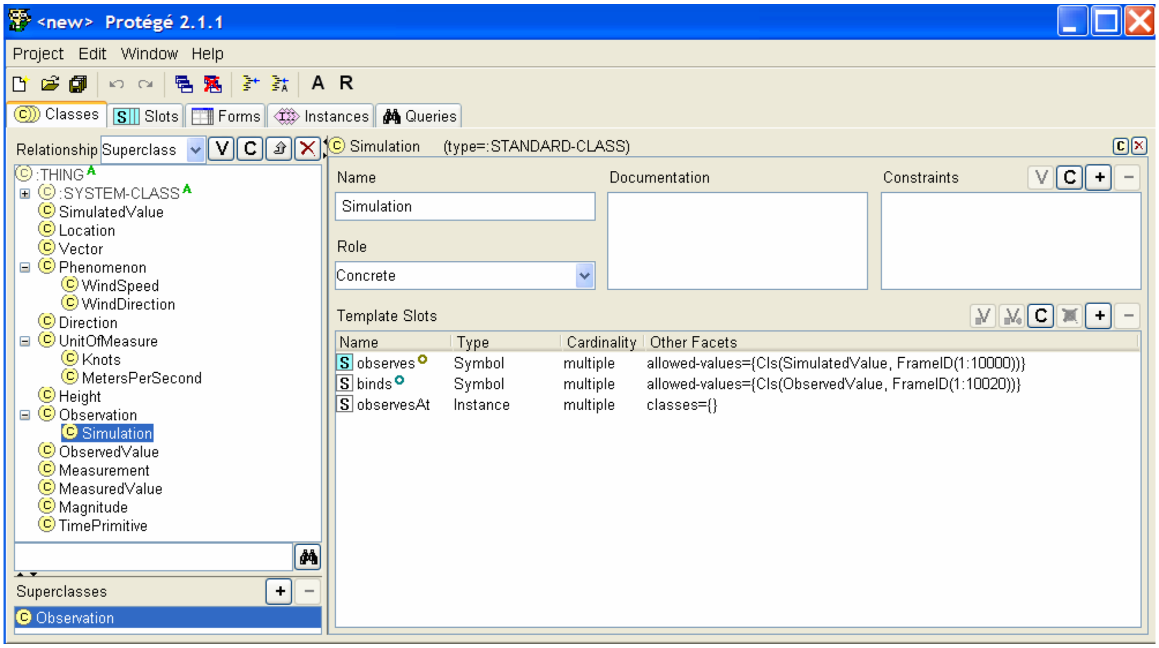

Figure 3 Editing a WindObservation Ontology

6.2. Matchmaking: Does inferencing work?

Finally when one is able to express the ontologies in a standard way (we do not debate whether it is the best way) the focus now shifts to whether one could now attempt the matchmaking. Could the inference engines now decide whether one concept is equivalent of another? Is it possible to chain services on the basis of such specifications, at least semi-automatically?

The Semantics based Service Discovery Assistant (SeDA) prototype tool attempts to do so. This tool uses OWL descriptions of domain and application ontologies to suggest services registered in a UDDI registry that uses the same concepts. Fig 4 displays the tool showing the concept hierarchy generated by SeDA.

This is perhaps only a semi-automatic method of service discovery based on semantics. The next step of automation is perhaps attempted by the Semantic web services arm involved in Web ontology language for services (OWL-S). OWL-S supplies Web service providers with a core set of markup language constructs for describing the properties and capabilities of their Web services in unambiguous, computer-intepretable form. OWL-S markup of Web services will facilitate the automation of Web service tasks including automated Web service discovery, execution, interoperation, composition and execution monitoring. The OWL-S is aimed at automatic service chaining and although DL based logic system enables matchmaking there are still expectations of greater capabilities of semantics based searches (Koehler & Shrivastava, 2003) .

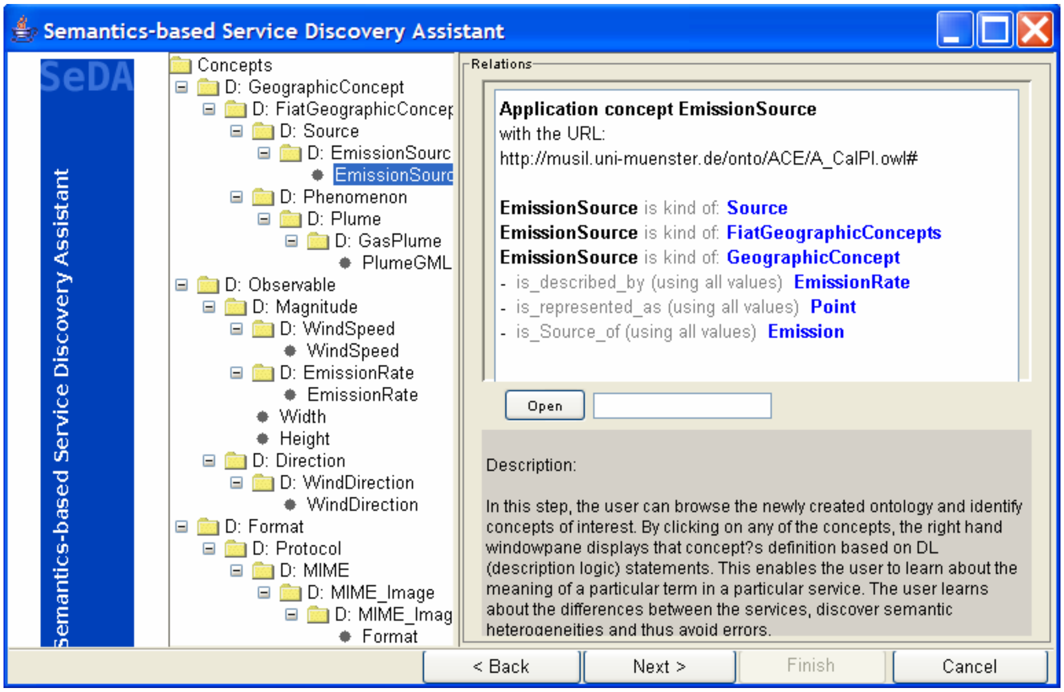

Figure 4 SeDA tool for semantics based service discovery

6.3. NSDI business models enabled by Semantic interoperability

Under this topic one has to discuss the main advantages for the NSDI by enabling semantic interoperability to a large extent. Some of the points that have already been discussed are that of the possibility to produce value addition to the offerings by automatic or semi-automatic service discovery using semantics. The other important points are as follows.

- Expanding offerings of the existing data and services by making more usable end products. It follows from the fact that the same GI data and services can have different uses in different domains and different applications in each domain. This means by providing semantic translation of information non-conventional users can be targeted. This is perhaps one of the stated goals of the NSDI.
- Outdated monolithic business models can be replaced with co-operative business networks that trade on products based on market rules of supply and demand which provides competitive pricing and value for money to GI consumers. Such GI consumers and also GI providers would be winners in this model.

The research needs as identified in the four feasibility aspects for GI markets would also have to contribute in order to ensure that there is increased possibility of offering semantically interoperable platforms for web based services.

6.4. Research Challenges in Semantics for GI services

We have pointed out that research needs are a critical aspect of the overall feasibility of marketplace implementations. While there are overall research needs, some of the research needs in regard to semantic interoperation of services are as below.

- Current ontology engineering methods only provide techniques to specify concepts and sub concepts using concept trees along with their properties and sub properties. The relationships between such tree elements is purely based on “is-a” and “part-of” relations. This leads to a probably less expressive specification. The reasoner for the logic system would be able to check for consistency of the specification on descriptive logic reasoning for equivalence, transitive closure, inverse consistency and subsumption.
- Spatial ontologies have the challenge of specifying complex spatio temporal relations between objects which seem to have common basic roots in cognitive linguistics (image schemas) and still have different language and cultural contexts. Additionally, the processes and data in GI systems are closely linked to each other (like methods are usually attached to class definitions) and hence the semantics of the data are mostly embedded in the semantics of the service itself. Hence it is important to identify objects based on their behavior rather than only on attribute relations only.
- Spatial domain knowledge is important to the design of information systems with spatial objects but there seems to be a lack of such knowledge in the form spatial domain ontologies. Formal specifications of conceptual models of geospatial entities in different domains need to be available as a first step to semantic interoperability.

7. Summary and Future Work

We have discussed that GI market places as elements of the NSDI and semantic interoperability as a requirement for such a model. It shows how it is economically significant to address the problem of semantics and how its absence can lead to lower economic feasibility.

NSDIs have a crucial interest in expanding the GI market. The implementation of electronic marketplaces as core elements of the NSDIs’ business model addresses three major needs of the GI market:

- Provision of information services vs. data
- Business networks vs. monolithic business models
- Access of potential GI customers to products, product information, and providers.

We have validated the feasibility of the marketplace implementation. The exemplary business process addresses the needs above. From the economical perspective, the implementation of an electronic marketplace requires public funding in the starting phase. The risk for the operation mode is medium to high, which has to be weighed against the potential of significantly improving the GI market and its volume. From the technical perspective, business process description languages for internet-based service chaining are available, e.g., BPEL4WS, WSFL. Service chaining requires a semantic enabling description language. By its concepts, OWL-S is capable to fulfill the tasks.

It has also been shown how services as GI products have unique advantages and how investment in interoperability is justified. Semantic heterogeneity has been argued as impediment to such interoperability and current approaches using semantic based semi-automatic and automatic service discovery has been discussed.

Further work primarily targets the realization of a GI marketplace within an NSDI. An ongoing research challenge is semantic interoperability. Web services present a unique opportunity to provide GI as information services with significant benefits to both customers and providers. Interoperability between such services is therefore of direct interest to both. Current knowledge based tools and techniques using ontologies do provide ways and means to semantically match data. However there still remain some challenges towards ideally interoperable services which are being currently explored.

8. Acknowledgements

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