ENHANCED BI SYSTEMS WITH ON-DEMAND DATA BASED ON SEMANTIC-ENABLED ENTERPRISE SOA

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Recommended Citation

Mahmoud, Tariq; Marx Gómez, Jorge; Rezgui, Abdelkerim; Peters, Dirk; and Solsbach, Andreas, "ENHANCED BI SYSTEMS WITH ON-DEMAND DATA BASED ON SEMANTIC-ENABLED ENTERPRISE SOA" (2012). ECIS 2012 Proceedings. Paper 184.  
http://aisel.aisnet.org/ecis2012/184

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Abstract

Since the 1990s, companies have been investing into IT infrastructure initiatives such as Enterprise Resource Planning (ERP) systems, Supply Chain Management (SCM) systems, and Customer Relationship Management (CRM) systems in order to increase efficiency, effectiveness, and internal process integration, among other goals.

The current value of Business Intelligence (BI) for companies could be summarized by two main achievements: improvement of management of processes and improvement of operational processes.

This paper will identify current requirements of BI and present a linkage to service-oriented architectures including added-values. Semantic-enabled Enterprise Service-Oriented Architecture (SESOA) is an enterprise solution that links businesses to external systems based on Web Services and SOA concept. It represents a lightweight web application that annotates Web Services that are coming from different service providers with semantics so that the indexing and discovery of these services can be more comprehensive.

BI applications can be considered as service consumers in SESOA and can discover, select and invoke the services supplied by the external systems (service providers). In this way, SESOA forms the bridge between SOA and BI concepts to deliver in real time the “on-demand” data as services and this opens the BI market to include SMEs as main resources of these services.

Keywords: Business Intelligence, Web Services, SESOA, Semantic Service Repository.
1 Introduction

Luhn (1958) has defined BI as “business is a collection of activities carried on for whatever purpose, be it science, technology, commerce, industry, law, government, defence, et cetera” with “the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal” (Luhn, 1958). BI is able to integrate the information of all business processes to support company goals and decisions. The definition of Luhn is seen as birth of BI.

Since the 1990s, companies have been investing into IT infrastructure initiatives such as Enterprise Resource Planning (ERP) systems, Supply Chain Management (SCM) systems, and Customer Relationship Management (CRM) systems in order to increase efficiency, effectiveness, and internal process integration, among other goals. The companies’ IT landscape has to be integrated into any system which aims to support reporting and decision support such as BI systems.

The definition of BI by Dresner, worker of Gartner Inc., in 1989 opens BI to a broader public. He introduces BI in the way as a collective term. The definition was updated seven years later: “Data Analysis, reporting, and query tools can help business users wade through a sea of data to synthesize valuable information from it – today these tools collectively fall into a category called Business Intelligence” (Anandarajan et al., 2004).

The current value of BI for companies could be summarized by two main achievements: (1) improvement of management of processes and (2) improvement of operational processes. BI systems are not only an extension of a data warehouse which transfers data from an operative system using online transaction processing towards a decision support and reporting system via online analytical processing. The idea of BI is an overall concept aiming to support three main fields: technology, users and expert knowledge (Marx Gómez et al., 2009).

Service-oriented Architecture (SOA) to enrich BI or vigilant information systems (VIS), focussing on sensing and responding capabilities (Houghton et al., 2004), proposes to support company requirements. SOA concept offers standard protocols that allow interoperating in the IT-infrastructure without barriers as traditional BI-architectures (client/server architectures) which have to be overcome. Another benefit is the orientation of SOA to the Internet and technologies supporting the distribution of information through the web, which is more and more a demand of stakeholder.

The SOA approach to enrich BI could be in a following research step combined with the main ideas of VIS stated in Houghton et al. (2004) which identifies “building blocks” for sending and responding. The building blocks could be defined as Web Services and would allow adopting the current ideas and approaches to new technologies and market conditions. The Web Services could be used as black box to handle any kind of information necessary for decision support and be used to generate the OODA loop as discussed in Hougthon et al. (2004). The orientation towards solutions accessible from a diverse user group that leverage existing IT-infrastructures to a new level of scalability and services could be solved by an SOA approach. Managers are demanding reports, which can be easily customized to the users’ requirements and can be distributed via the Internet to stakeholders. Using SOA Web Services accessible from everywhere will allow consolidating IT skills and erasing redundancies by using a Web Services Description Language (WSDL)1 and one solution instead of locally IT infrastructures that have to be supported by IT personnel.

The paper proposes a new approach that enriches the traditional BI applications with semantic-annotated Web Services to enhance the decision-making process. The structure of this paper is as

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1 “Web Services Description Language (WSDL) 1.1”: http://www.w3.org/TR/2001/NOTE-wsdl-20010315 [retrieved: 20.03.2012]
follows: after the short introduction written in this section, section two gives the main background information about BI and how it relates with SOA concept. In section three, the reference architecture of semantic-enabled enterprise SOA with its main characteristics are explicated. The main contributions of this paper are described in section four that shows how semantic-annotated Web Services repository can be used as additional data source. The paper then concludes in section five with a brief summary regarding the main content of this contribution and gives an outlook to the future directions.

2 Background Information

2.1 Business Intelligence

Currently BI activities could be divided into two parts: developing of a BI strategy and implementing of BI. The development of a BI strategy should be a first step to create a BI roadmap and a BI strategy, which will be followed by a BI implementation in the current IT landscape. Referring to Gansor, Totok and Stock (2010) a holistic model to develop a BI strategy is suggested.

The basis of the model is the company strategy that will be used in five phases (definition, analysis, benchmarking, conception, and measurements) to develop a BI strategy. All phases are divided into subject-matter knowledge, technique and organisation, which have to be defined, analysed and benchmarked to create concepts that will be consolidated into a BI roadmap (consisting of measurements). Maturity models in the benchmarking phase are oriented towards maturity models from software engineering that are focusing on quality.

Reasons for a BI strategy are to overcome the problems of an grown IT landscape which is oftentimes not integrated and not focused on the company strategy due to that system are supporting only small parts (sections) of a company without sharing functionality with other sections. The measurements are centralised using a BI strategy and will support subject-matter knowledge, technique and organisation and not only a part of it.

To implement successful BI projects, companies need to go through several phases: selecting reliable data, preparing and transforming selected data, modelling, analysing, data-mining, and finally interpreting, visualizing and evaluating eventually discovered knowledge (Fayyad et al., 1996). From this perspective, Inmon (1996) proposed to use a single common data model for all useful data regardless of its sources. He pointed out that multidimensional databases or data warehouses are, from a conceptual point of view, the solution that we needed. They are business-oriented databases, made to support huge amount of data, and data stored in these databases can be easily analysed and interpreted according to indicators (facts) distributed along axes (dimensions).

Conventional BI applications are mostly based on client/server architectures. The data warehouse architecture, which is the basis for several BI realisations, consists of seven layers (Liebhart, 2010): operational systems, data transformation (extraction, loading and transformation (ETL)), enterprise data warehouse (DWH), replication and propagation, data marts, discovery and mining, and information access.

In general, BI can be defined as the analytical process, which transforms (internal) company data and (external) market data into decision- and action-oriented knowledge of competencies, activities, positions and aims of the examined internal or external fields of operations (stakeholders and processes) (Grothe and Gentsch, 2000). From a more technical point of view, BI can be seen as a set of techniques and/or applications, which have a decision-supporting character and lead to a better understanding of the mechanisms of the relevant functional chains (Gluchowski et al., 2007). Relying on the previous explanation, the main goal of BI is to support decision-makers with information about the historical, actual, and future situation (forecast).
The advent of the Web has launched a new challenge to the BI process. The quantity of data available and easily accessible is increasing exponentially. Data volumes are growing, and corporations are demanding ever-more sophisticated BI and analytics to deal with that data. In addition to its big amount available, data is becoming more and more complex and heterogeneous and its integration from different sources requires more than a transformation of data into a single representation. The data sources are not necessarily all structured in the form of databases, but can be a corpus of documents e.g. or come from the Web with recurring refresh. With this type of data, ETL processes cannot be held traditionally. The data warehouse facilitates complex data analyses without placing a burden on the operational source systems that run the day-to-day business. In order to catch up with data changes in the operational sources, the data warehouse is refreshed in a periodic manner (usually on a daily, weekly, or even monthly basis). It is proven that ETL process is a big resources consumer. It lowers the performance of the source system that cannot support many selects of data on the running time. Based on that, data warehouse refreshment is typically scheduled for off-peak hours where both, the operational sources and the data warehouse experience low load conditions, e.g. at night-time (Jörg and Dessloch, 2010). However, if enterprises want to be more competitive on today’s global economy, they are forced to satisfy the customer’s constantly changing needs. Additionally, the speed and dynamic nature of business often negates the time required for long term planning and time consuming implementations in order to stay on top. Because of this, organisations must implement solutions that can be deployed quickly and in a cost-effective manner (Zicker, 1998).

2.2 Service-Oriented Architecture

This section illustrates the main service-orientation concept. The OASIS SOA Reference Model group defines SOA as follows: “SOA is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with and use capabilities to produce desired effects consistent with measurable preconditions and expectations” (MacKenzie et al., 2006, p. 29). Several technologies are used to realise SOA but Web Services are accorded the most common ones. A Web Service as defined by the W3C consortium is “a software system designed to support interoperable machine to machine interaction over a network” (Booth et al., 2004). In concept, there are three main components in SOA namely:

- **Service Provider**: It creates a Web Service and possibly publishes its interface and access information to the service registry.
- **Service Registry**: is responsible for making the access information of both Web Service interface and implementation available to any potential service requester, and categorizing the results in taxonomies. The Universal Description Discovery and Integration (UDDI)\(^2\), defines a way to publish and discover information about Web Services.
- **Service Consumer**: The service consumer (Web Service client) locates entries in the service registry using various find operations and then binds to the service provider in order to invoke one of its Web Services.

These three components constitute the traditional SOA concept (Mahmoud and Marx Gómez, 2008). While several schools suggest that SOA could be a very efficient alternative to traditional ETL approaches, others pointed out that ETL is a very mature process that has shown a high level of effectiveness as the basis for creating successful BI projects. Our point of view reaches the second reflection with some precautions. We consider that we should keep the existing BI IT infrastructure

\(^2\) It is also known as service broker.

and try to integrate a SOA-based component that can provide us with the real-time information needed for a faster decision-making process.

The only issue is that a Web Service could give us anything and everything. Of course we will have the information we needed, but meanwhile, there will be a plenty of noisy information stored within the BI system. Given the circumstances, most would agree that integrating all information conveyed by Web Services without first cleansing or filtering would be a very bad idea. Because if we do not feed our analytical tools with right information, we won’t be able to discover trustful and accurate knowledge and to go further, this could be very dangerous if it gives us wrong or biased overview of the business we are analysing. Besides, this can lead to a huge expansion of the data warehouse in terms of size. This abundance of information makes it crucial that we set some rules to identify whether the information we are using to help effective decision-making process is reliable or not.

Therefore, the proposed approach can generate a lot of benefits to enterprises who have to challenge fast changing market conditions and a rising competitive pressure. It can provide BI systems with up-to-the-second information in a semantic-driven manner.

3 Semantic-enabled Enterprise SOA

In the beginning it is essential to give a brief overview of SOA before introducing our concept. The 2000s decade came to strengthen the concept of information system integration by being relied on the service orientation paradigm. SOA is one recent architectural and design discipline in the IT application architecture. SOA been based typically on Web Services, aligns the business along with the technology by providing powerful integration of applications and data. Instead of being connected to several disparate applications, Web Services-enabled SOA solutions provide connectivity between these heterogeneous applications by avoiding central point of integration, which was often a bottleneck in the prior architectural designs (Mahmoud, 2009).

By adopting Web Service-enabled SOA solutions, the vision of software integration has been carried out by exposing businesses’ functionalities using Web Service technology. Existing SOA-based solutions are just reducing the number of the point-to-point adapters by designing each interface following the Web Service Description Language (WSDL) specifications. However, what these solutions really lack is the semantic documentation of these interfaces. This is besides several defects related to these solutions like lack of interoperability, massive unstructured data and increasing number of various systems waiting to be linked (Hu et al., 2008).

After the big evolution of the Semantic Web (Berners-Lee et al., 2001), the semantic documentation of the Web Service interfaces has been defined. This allows the Web to understand and satisfy the requests of service consumers to use the Web content. However, the emerging semantic approaches are considered as complex solutions. This is because these solutions are founded on expressive formalisms that are trying to provide semantics first. Moreover, they are accorded inaccurate in terms of applying semantics to the Web content in a standardized way because of the vague representation of their evolving ontologies. Based on the aforementioned brief discussion, we propose a semantic-enabled SOA solution based on lightweight semantic annotation of Web Services. This annotation is mainly done by assigning Resource Description Framework (RDF)4 vocabularies to services relations.

The proposed solution is called Semantic-enabled Enterprise Service-Oriented Architecture (SESOA). It is an enterprise solution that links businesses to external systems based on business process and Web Service-enabled SOA concepts. It represents a lightweight Web framework that annotates the Web Services coming from different service providers with semantics so that the indexing and discovery of

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these services can be more comprehensive. Examples of service providers can be those who provide services to measure energy efficiency or carbon footprints. These providers publish their services in a common registry called SESOA semantic service repository. SESOA can be considered as an enhanced SOA concept in which the consumer system (service consumer) can discover its repository and invoke the provider’s services. The Web Services are published in this repository and they are semantically annotated as mentioned before using RDF triples. These triples are subject-predicate-object statements that link the services in groups called assemblages. The assemblages for example are the subjects, the relation is member of, and the objects are the services. Doing so, any service can be queried based on the group to which it belongs using any RDF query language like SPARQL Protocol and RDF Query Language (SPARQL)\(^5\). Last but not least, SESOA framework offers also the traditional discovery provided using former techniques like the Universal Description Discovery and Integration (UDDI) standard.

The following paragraph explains the SESOA architecture, its components and main interactions between these components. The research process that has been followed to design SESOA is derived from the design science research methodology by (Peffers et al., 2008). In SESOA, all the business functionalities are realized using Web Services that can be invoked by service consumers. Moreover, the main characteristics of this framework are as follows:

- It is a process-oriented framework where business processes are managed, implemented and executed using the Web Services supplied by various service vendors;
- SESOA validates Web Services following predefined businesses’ criteria, evaluates them and annotates their relations with semantics;
- It is a lightweight semantic-enabled SOA solution;
- It groups Web Services based on the business domains to which they belong;
- It provides semantic annotations to the Web Services relations using RDF vocabularies;
- It supports service reuse because the adoption of SOA concept.

\(^5\) "W3C Semantic Web Activity News - SPARQL is a Recommendation": http://www.w3.org/blog/SW/2008/01/15/sparql_is_a_recommendation/ [retrieved 20.03.2012]

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Figure 1. Semantic-enabled Enterprise SOA Reference Architecture
Figure 1 illustrates SESOA architecture. Consumer system, provider system and Web Service directory are the typical ingredients of the main SOA concept. The main and centric component in this framework is the processing system. It is workflow-based system from which all the business processes can be initiated in form of workflows with connection to the other SESOA components.

As mentioned above, the Web Services are grouped based on the domain to which they belong. The service groups are called assemblages in this architecture. These assemblages are placed in the assemblage unit within the semantic Web Service-based system component. This latter is responsible of managing the assemblages (create, update, and delete). Each assemblage is having its id, category, domain and members. All Web Services are registered as members in one or more assemblages. The relations between the services and the assemblages are annotated semantically using RDF statements. These semantic annotated relations are made available in the semantic service repository. All the RDF statements, the business and user management data are stored in the SESOA database system. Listing 1 shows an example of RDF statement between an assemblage and one of its services.

Listing 1: Assemblage - Service RDF-annotated Relation

```xml
<?xml version="1.0"?>
<rdf:RDF xmlns:assemblage="http://asbl.wi-ol.de/sesoa"
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:sesoa="http://asbl.wi-ol.de/sesoa/"

<rdf:Description rdf:about="http://asbl.wi-ol.de/sesoa/assemblage/EnergyEfficieny">
   <sesoa:hasMember rdf:resource="http://asbl.wi-ol.de/sesoa/services/MeasureEnergyConsumption"/>
</rdf:Description>
</rdf:RDF>
```

Based on that the BI system can use a SPARQL engine to query the above listing based either on the subject, the predicate, or the object to call the service and get the data from the external systems to use it for generating reports.

The validation system has four subsystems namely: ranking unit, annotation provider unit, announcement unit, and service test unit. The ranking unit subsystem is evaluating the services supplies by the provider system in form of machine-to-machine evaluation (services response time and availability are the adopted criteria). The annotation provider unit is having the responsibility of semantically annotating the relations between the services and the assemblages using RDF statements besides storing these relations in the SESOA database system. The announcement unit is advertising for new service functionalities where the service provider system may implement. Finally, the service test unit subsystem is providing set of tests exposed as Web Services like primitive data types tests (integer, string, decimal, etc.).

The main interactions between the SESOA components are explained as follows: consumer system starts to run one of the activities within the processing system via the system’s front end. The processing system is forwarding this request to the assemblage unit within the semantic Web Service-based system to check whether there is a corresponding service or not. The semantic Web Service-based system discovers the semantic service repository to see in which assemblage the service(s) are located. Upon finding corresponding service(s), it will respond back to the consumer system via the processing system. Direct binding will be made then between the consumer system and the service(s). The services that are supplied by the provider system validated and ranked using the validation system. Services validation is more on a data type level to assure that all services use the same data types. As for the SESOA database system, it is responsible of managing:

1. The semantic service-assemblage relations where they are stored as statements composed of entities (subject-predicate-object expressions);
2. The assemblages and service properties;
3. The system’s user profiles (user management) and
4. The data of the implemented business processes.
SESOA can be applied to a bunch of business domains like Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), Sales Leads, Environmental Information Management Systems, BI, etc. In the next section, the main link between SESOA and BI is going to be introduced with highlights to the enhanced BI architecture by adopting one of the main SESOA components that is the semantic service repository.

The SESOA implementation is done as a Web application that can be used to build on top of it several business cases. Table 1 shows an example of a fictional energy consumption measurement using SESOA prototype. It calls the responsible service and returned the measurement number, the date, and the status of this measurement. Status can be either over limit, below limit or normal. This status is essential for the BI system to generate the energy consumption reports.

<table>
<thead>
<tr>
<th>Measurement number</th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>12/20/2011 3:42:56 PM</td>
<td>Normal</td>
</tr>
<tr>
<td>5</td>
<td>12/14/2011 4:17:14 PM</td>
<td>Normal</td>
</tr>
<tr>
<td>4</td>
<td>12/14/2011 4:15:06 PM</td>
<td>Over Limit</td>
</tr>
<tr>
<td>3</td>
<td>12/14/2011 4:09:11 PM</td>
<td>Normal</td>
</tr>
</tbody>
</table>

*Table 1. Energy Consumption Measurement Example*

There are several lightweight frameworks similar to WSMO-Lite proposed by (Vitvar et al., 2008). They all share the idea of augmenting the existing service specifications with semantic descriptions following the bottom-up modelling approach. They also cover the other grounding approaches namely: the WSDL-based services and RESTful-based services using their lightweight service ontologies. Comparing these efforts with our proposed architecture we can conclude that they are extending the existing service descriptions with semantics but they are not annotating the relations among services. This is exactly where SESOA differs from those efforts.

### 4 BI enhanced by SESOA

#### 4.1 Realisation

BI applications can be considered as consumer systems in SESOA (refer to Figure 2) and can discover, select and invoke different services supplied by the external systems (service providers). The BI architecture can be enhanced using SESOA semantic service repository as depicted in Figure 2.

By doing so, the main potential data processing can be done using available Web Services published in the SESOA semantic service repository. The Web Service consumer system can then discover this repository in form of services requests to find services that fulfil these requests. In the semantic service repository, the services can be located using their end points that indicates the main information together with the Service Level Agreement (SLA) that helps the consumer in deciding which service(s) will fulfil his/her request to later have a direct binding with the service provider that supplies them.

Moreover, the Web Services published in the semantic service repository are annotated with semantics so that the proper data can be retrieved at the right time to the right user. This semantic annotation is applied to the relations between the services and the groups (assemblages) to which they belong. Using SPARQL as an RDF query language, the BI application can query the repository RDF statements that link the assemblages with their services to find the proper service based on the domain to which it belongs (business domain). Eventually, this will enhance the decision support process by providing another level of service classification (the semantic allocation of services) besides the conventional service discovery techniques.
The data in BI systems are not only stored but they must be collected, administered, filtered, analysed and controlled (Rezgui and Naana, 2010). This whole chain of data management invokes a high cost of ownership in terms of hardware (disk sizes, network, etc.), software and human resources. For many companies (especially for start-ups and medium-sized business), these costs represent a real challenge. With the introduction of BI-enhanced SESOA system, SMEs can use data from multiple external sources without the limitation of using just their in-house data.

One of the projects to which this concept is applied is the IT-for-Green project. This project belongs to the corporate environmental management information systems (CEMIS) domain. IT-for-Green: environment, energy and resource management with next generation CEMIS project that aims at generating an open source software module, which is able to handle current stakeholder demands and is flexible and adaptable for future demands of stakeholders. The underlying idea is to develop web-based software situated in a service-oriented architecture, able to handle the generation process of structured reports and supporting the required processes in the software (Rapp et al., 2011). This project represents a perfect place for the realisation of the concept presented in this paper. It links analysing and reporting of environmental information via Web Services.

Our concept is employed in this project to administer the environmental sustainability reporting using the functionalities of BI to analyse and generate environmental performance indicators to be reported in sustainability reports. Such reports are based on the social, economic and ecologic aspects. The calculation of these indicators is based mainly on these aspects and is done with the help of Web Services that are registered within the SESOA semantic service repository. All the external resources can collaborate with their Web Services and register them within the semantic service repository to let

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6 More information about IT-for-Green project can be found at http://www.it-for-green.eu
the others use it in a collaborative manner. Examples of such services are: energy efficiency measurement, carbon footprint measurement, eco balancing creation services. The ‘on-demand’ data are provided by external systems and it is semantically annotated and published in this repository so that it can be retrieved whenever it is needed. In this way, the realisation of the IT-for-Green project with the help of SESOA forms the bridge between SOA and BI concepts, as shown in Figure 2, to deliver in real time the ‘on-demand’ data as Web Services and this will open the BI market to include SMEs as main resources for these services.

Semantic service-enabled BI infrastructure will lead both SOA and BI concepts to a new era.

4.2 Outcomes

The main outcomes from merging the BI concept with SESOA framework can be concluded as follows:

- Open the BI-market for SMEs;
- BI-related Web Service validation and evaluation;
- Semantic annotation of BI-related Web Service relations;
- Export ad-hoc reports in form of BI-related Web Services.

In this work, Web Services are not just supplied by the internal company that hosts the BI solution rather they can be provided by a wider set of services providers. This will open the BI-market for SMEs that was for long time dominated by huge BI software vendors, like SAP®, Microsoft®, IBM®, Oracle®, etc. All of the enterprises (regardless of their size) can supply their services to the SESOA semantic service repository that the BI application uses to process BI functionalities. In this way, we extend the traditional BI concept to utilise external data that were not accessible before.

By combining SESOA and BI concepts, one of the generic advantages that can be harvested from SESOA concept is to validate and evaluate Web Services. Putting this in BI concept, BI-related Web Service validation and evaluation can be achieved. On the one hand, the validation is applied as a set of validation tests exposed in form of Web Services and applied on the services operations and messages where data types, such as integer or string, can be validated following specific criteria. To make it more clear, the string data type, for example, can be split into alpha, numeric, alphanumeric and non-alphabetic sub-data types. Based on the usage of Web Service operation, a validation test can be applied on one of the sub-data types or the generic data type. In this way, the verification of the external data imported to the BI application can be guaranteed. On the other hand, service evaluation represents secure service rating protocol based on machine-to-machine evaluation protocol. This protocol enables automatic ranking of Web Services based on two criteria, namely: service availability and response time. Service evaluation helps the BI managers to decide which external services can be utilized based on their reputation.

As mentioned before in this paper, SESOA semantic service repository groups the Web Services into WS-assemblages. It is up to the business to decide how many assemblages are sufficient to group the BI-related Web Services. Therefore, BI enhanced by SESOA supports the Semantic annotation of BI-related Web Service relations. This annotation is based on RDF statements in which the subject is BI WS-assemble(s), the object is the actual Web Service(s), and the predicate is the relationship (e.g. hasMember, isMemberOf, etc.).

Finally and as a part of the future directions of our work, the proposed work supports the export ad-hoc reports in form of BI-related Web Services. This is done by automatic generation of reporting services based on the ad-hoc reports that come from the BI applications. Mechanisms or algorithms to achieve this report automatic generation need to be defined. These services can be grouped in BI reporting WS-assemblages to be called either internally by the business managers or externally by other businesses based on the rights and privileges assigned to those reports.
5 Conclusion and Future Directions

Starting from a brief description of the different understandings of the term ‘Business Intelligence’, this contribution firstly gives a short motivation about the relevance of the combination of BI as a set of different tools and techniques and SOA coming with its specific characteristics. Followed by an introduction to the two main fields of BI activities, namely developing a BI strategy and the implementation of BI in general, we suggest semantic-enabled enterprise SOA as a possible, efficient alternative to the traditional ETL approaches as part of the BI implementation.

Due to the changing needs of BI applications in the last decade, we propose the integration of these SESOA components on the basis of the existing BI IT-infrastructure in order to provide more efficient real-time data for the decision-making process. The semantic-enabled enterprise SOA solution is based on a lightweight semantic annotation of Web Services and can be applied to different business domains as well as to BI solutions. Therefore it links businesses based on business processes and Web Service-enabled SOA concepts. In this way, BI applications can profit by the SESOA approach through performing the main data processing by available Web Services, which are published in the SESOA semantic service repository.

In summary, the proper data can be retrieved instantly and in accordance to specific needs of different users without considering any performance, validity or architectural issues. SESOA is forming the bridge between SOA and BI concepts to deliver the ‘on-demand’ data as services in real time. This will open the BI market for SMEs that can provide BI-related services and play a role in a market that was closed before, because of the huge BI software vendors’ domination.

In future, the concept suggested approach of “enhanced BI systems with on-demand data based on semantic-enabled enterprise SOA” has to be converted into a concrete architectural design. Possible future directions of this on-going research can be the automatic generation of reporting services based on ad-hoc reports that can be excluded from the existing BI applications. Another direction can be the utilisation of more sophisticated ontology languages like Web Ontology Language (OWL) to annotate the service relations. Optionally, semantic conceptual frameworks for Web Services can serve as data sources for the BI decision-making support.

On this basis, different technologies can be examined and a planned prototypical implementation can be conducted. Therefore a specific scenario can be applied coming from existing partners from the industry for example. This offers the possibility to evaluate the approach in the context of a real case and also underline the benefits SMEs can gain from our approach.

Acknowledgement

This work is part of the project IT-for-Green (Next Generation CEMIS for Environmental, Energy and Resource Management). The IT-for-Green project is funded by the European regional development fund (grant number W/A III 80119242). The authors thank for the support.

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