SEMANTIC DATA INTEGRATION APPROACHES FOR E-GOVERNANCE

Dr. Mohammed T. Al-Sudairy[1] and T. G. K Vasista[2]
[1]College of Business Administration, King Saud University, Riyadh, KSA
mas@ksu.edu.sa
[2]King Saud University, Riyadh, KSA
gtatapudi@ksu.edu.sa

ABSTRACT

Increased generation of data in the e-governance R&D process is required to generate the expected services in terms of enhanced e-services productivity and pipelines. The inability of existing integration strategies to organise and apply the available knowledge to the range of real scientific, business and governance issues is impacting on not only productivity but also transparency of information in crucial safety and regulatory applications. This requires focusing on normative models of e-governance that typically can assert horizontal (inter-agency) and vertical (inter-governmental) integration of data flows to represent the most sophisticated form of e-government delivering greatest payoff for both governments and users. The new range of semantic technologies based on ontology enable proper integration of knowledge in a way that is reusable by several applications across governance business from discovery to ministry affairs. The objective of this paper is to provide an insight on the necessary and sufficient knowledge base to deal with data integration using semantic web technologies applicable for e-governance based on exploratory research using literature survey. It assumes that reader has the capability of understanding some basic knowledge on E-governance, Relational Database Management, Ontology, and Service Oriented Architecture and Semantic Web Technology.

KEYWORDS

Data Integration, E-Government, Ontologies, Semantic Web, Semantic Data Integration.

1. INTRODUCTION

Perhaps the most important need of the hour is to integrate the isolated application developed for different departments across geographies. It means the provision of a single face to the end user, who should not be bothered with too many hassles when performing government activities and to achieve the final outcome of the individual objective.

Government as a virtual enterprise will get an opportunity to work in collaborative manner to deliver government services. Correspondingly E-Governance devolution areas include planning, business process re-engineering, change management, enterprise architecture, networks, portals, back-office, e-services etc. [1].

1.1. Objective, Methodology, Purpose and Scope

The objective of this paper is to present the exploratory research in the semantic data integration and its applicability to the e-governance context based on the literature survey. It discusses the significance, potential challenges in various data integration approaches to lead the reader towards potential approaches for providing semantic data integration for the purpose of providing the reader an insight and introductory knowledge into this interdisciplinary field. The scope of this paper is limited to present only the broad approaches of semantic data integration. However it gives the reader an immense opportunity for exploring and conducting further research on the selected topic of interest either from their core domains of technology (such as web technologies, data mining and ontology), management (e-commerce and e-business) and public administration (public policy and organisational development) etc. vertically or can

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continue performing more in depth in an interdisciplinary manner (knowledge management, e-service quality) horizontally to work on information system strategies from enterprise perspective.

1.2. E-Government vs. E-Governance

A perspective on the difference between e-Government and e-Governance can be inferred from the literature [2], [3], [4] findings especially from the terminology based understanding of government and governance is, that E-Governance deals with the planning, policy and proposal part, while E-Government is the concerns of actual implementation and execution after getting assent from formal government authorities.

1.3. Literature Survey on the Significance of Semantic Data Integration in E-Gov.

It is cited that E-Governance has the potential to improve service delivery; it could stimulate integration in the design of services explicitly as in [5].

It is cited that the earlier works on semantic data integration are done in fields such as semantic annotation of geodata; Semantic integration of geographic ontologies; measuring semantic similarity, in passing [6].

It is cited that OntoGov Project is developed as a semantic platform for composition, configuration and evolution of e-Gov service; SmartGov as a knowledge-based platform for assisting online transaction on public sector employee, in passing [7]. A study was proposed in the use of ontology versioning approach to preserve the compatibility serialization between ontologies and related data on e-Government service management, in passing [7].

It is cited that web Services and Service Oriented Architecture (SOA) are gaining momentum as an effective framework for enabling application integration not only with in organizations but also across organizational boundaries, explicitly as in [8]. Web Services are the most appropriate means for building e-Government applications on the internet, mentioned explicitly as in [9]. They provide higher-level abstractions for organizing applications for large-scale, open environments [10] and are addressing issues such as collaborative process management [8] while providing safety and convenience.

It is cited that the Federal Enterprise Architecture [12], which was established by US Government's Office Management in which Data Reference Model is one of the five models that illustrated the business focused data standardization aspect for the purpose of cross-agency information exchanges, in passing [11] as shown in the figure 1.

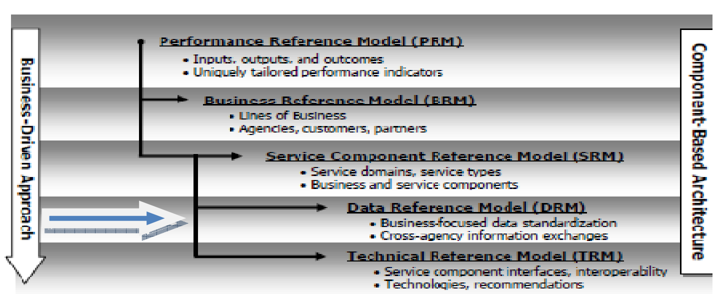

Figure 1. Federal Enterprise Architecture (FEA) Reference Models [11]

The problems on the semantic data level may be caused by an absence of unified data models directly applicable to specific administrative entities [13], despite the availability of general metadata standards available in the form of **Data Reference Model** as shown in the figure 1 [11].

This inability of existing integration strategies to organize and apply the available knowledge to the range of real scientific and business issues is impacting on not only productivity but also transparency of information on crucial safety and regulatory applications. The new range of semantic technologies based on ontology enables the proper integration of knowledge in a way that is reusable by several applications across the governance or businesses from discovery to corporate affairs. So the key to the next generation e-government related web applications will be cooperative services and incorporation of an overall understanding based on semantics [14, 15], [16], [17].

It is cited that the importance of the semantically enabled interoperability of the government service was emphasized many times as a key challenge, explicitly in [18] and crucial progress factor in the field of e-government, in [19].

The ability to manage solutions at higher semantic level enable administrators who are not proficient in programming to customize solutions in order to address specific needs of different levels of governments that include semantic government data integration too especially for the purpose of designing better public policy, public administration and public management.

2. PROBLEMS AND CHALLENGES WITH CURRENT WORK FLOW SOLUTIONS

On the information level, the modeling of workflow sequences of provided services and maintenance and their corresponding presentation towards the citizens is often a difficult task for public administration employees. Finally, however it is often an expensive and time-consuming process to employ advanced solutions supporting the semantic interoperability which usually requires changing significantly if not changing completely, an existing infrastructure on the public administration. On the other hand the existing solutions in public policy, public administration are mostly back-office oriented integrated solutions that require special knowledge on process modeling and maintenance of complex systems related to semantic capabilities, which is rather difficult to setup [18].

So our presentation on semantic data integration has been treated as a solution approach to it and the subject matter given in sections 3 to 6 represents such effort.

3. DATA INTEGRATION

Data Integration is a becoming a persistent challenge faced in applications that need to query across multiple autonomous and heterogeneous data sources. Data integration is crucial in large enterprises that own a multitude of data sources for producing data sets that can develop and enhance cooperation among government agencies across World Wide Web [20].

The goal of data integration system is to provide uniform access to a set of heterogonous data sources and to free the user from the knowledge about how data are structured at the sources and how they are to be reconciled in order to answer queries. Data integration is mostly achieved using one of the three approaches: Application Integration (mediation), database federation and data warehousing [21].

It is cited that Data Integration is the problem of combining data residing at different sources and providing the user with a unified view of these data [23], [24], in passing [22].

3.1. Problems in Data Integration

The different protocols, procedures and formats across different types of government (local, state and central) may cause a great hindrances to generate frequency based mandated report as a part of normative procedure to the government policy. Existing tools for managing these data are neither integrated nor do they provide any sort of data analysis capability to allow public systems managers to make decisions. This kind of data integration complexity creates fundamental challenges to developing policies based on robust information stream which are responsive to a wide range of stakeholder interests especially in a scenario where government promotes development schemes and projects under public-private partnerships. Such setting of a problem represents the kind of challenge to be addressed by sophisticated e-government systems.

3.2. Problem in Data Integration with DWH

It is argued that though Data Integration using a **D**ata **W**are**H**ouse (DWH) approach is a mature solution, the biggest drawback is the requirement of large scale integration of source data. Building and maintaining such large scale integrated DWH is difficult and expensive. Once built, may become inflexible to changes in the questions that can be asked. This is largely because they require a copy to be made of data from all the underlying data sources in a synchronized **E**xtraction, **T**ransformation and **L**oading (ETL) process. If the data is not properly extracted and kept in the DWH, Queries cannot be executed conveniently and hence this places a large upfront design burden on the warehouse schema and the ETL process [25] (p.5).

4. Ontology and Semantic Data

Ontologies provide a highly dynamic and flexible map of the information contained in the data sources within a domain. Because ontology enable true semantic integration across the data sources that they represent, it is possible not only to draw wider conclusions from the data but also to look at the data from several distinct perspectives relevant to the specific job being undertaken. The generation of Ontologies is an important activity to enable semantic data integration. Efficiency in data integration can be achieved by Ontologies [26]. Thus risk associated with the continual redevelopment of project-specific integration strategies can be reduced. The formation of Ontology becomes a corporate asset rather than another new super-silo for data, because it can represent an atlas of all the knowledge of an organization that is embedded in the enterprise database, licensed data sources and personal observation of its scientists. The formation of ontology helps a range of applications that delivers the right information at the right time to make better informed decisions throughout the lifecycle of discovery, development of various applications such as marketing, sales, public policy etc., in passing [27]. Thus a range of semantic technologies based on ontologies enable the proper integration of knowledge in a way that is reusable by several applications across governance or business from discovery to corporate affairs, explicitly as in [26].

5. Semantic Data Management

It is elucidated that Web Ontology Language (OWL) can be used more as an abstract modeling layer on the top of XML data sources described by an XML schema. OWL can be used for mapping heterogeneous data sources to a common global schema in order to establish the semantic relationship. The consistency of such mappings can be done using the inference mechanisms of OWL, explicitly as in [28].

It is elucidated that Semantic Data Management typically includes Resource Description Framework (RDF), RDF Schema (RDFS) and OWL standards. These semantic database features enable (i) storing, loading and DML access to RDF/OWL data and ontologies, (ii) inference using OWL and RDFS semantics and user defined rule (iii) querying of RDF/OWL data and ontologies using SPARQL-like graph patterns embedded in SQL, (iv) ontology assisted querying of enterprise (relational) data. The Semantic Data Store enables application developers to benefit from an open, scalable, secure, integrated, efficient platform for RDF and OWL based application, explicitly as in [29].

For example Oracle product delivers an advanced semantic data management capability as a part of Oracle Database 11g Enterprise Edition with Oracle Spatial 11g as its option. It has a native support for RDF/RDFS/OWL standards [29].

It is further elucidated that some organizations are using semantic approaches to create an information model based on ontology where data schema is considered from a particular choice of enterprise domain. These individual application database schemas are mapped to standard information model in order to make the meaning of the concepts in different application specific data schema explicit and relate them to each other. The information architecture resulted provides a unified view of the data sources in the organization. The application users can begin to query these enterprise semantic metadata models which comprise RDF data or ontologies. Standard ontologies provide reconciliation on queries that need access to heterogeneous data sources and application-specific schema. The results and queries have the power to address unique problems facing enterprise and Web based systems such as (i) data integration across heterogeneous, expanding set of corporate/public data sources (ii) tracking provenance information and (iii) modeling probabilistic data and schema. The figure 2 shows how Oracle 11g can provide enterprise integration work flow using semantic technologies, explicitly as in [29].

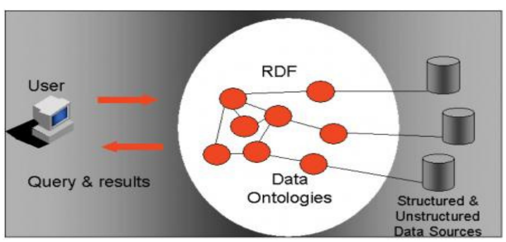

Figure 2. Enterprise Integration Workflow (Source: Oracle [29])

The Semantic Database features in Oracle Spatial are directly integrated with leading semantic technology tool vendors. Oracle Database can serve as an interoperable knowledge base, since Oracle's RDF and OWL data type is compliant with Open W3C standards. Semantic data can be shared more easily within organisaitons and across enterprise, so that increased return on knowledge bases while reducing cost can be realized [29].

6. RELATIONAL DATABASE AND SEMANTIC WEB

The research finding [30] details mentioned that Internet accessible databases are contained data up to 500 times more data than the static web and roughly 70% of the web sites are backed by relational databases [29]. The quantity of data suggests that the success of the Semantic Web depends on developing methods for making relational database accessible to the Semantic Web. The first workshop hosted by W3C on RDF access to Relational Database had produced a working group to work on standardizing a language for mapping relational data and relational database schemas into RDF and OWL in the year 2009. This is because the need to map relational data to RDF is increasing for the purpose of publishing linked data for the specific and individual needs using common standard data model with a standard query language called SPARQL. Usually this linked data is the data from relational databases [30].

6.1. Approaches to Implementing RDB2RDF

It is cited and elucidated two approaches of implementing RDB2RDF. They are:
1) **Physically converting relational data to RDF using ETL** (Extract-Transform-Load) technique and storing it in triple store [31]

A '**triplestore'** is a purpose-built database for the storage and retrieval of Resource Description Framework (RDF) metadata. Unlike relational database, a '**triplestore'** is optimized for the storage and retrieval of many short statements called triples in the form of subject-predicate-object [32] [33]. While one advantage with this approach is achieving data integration, the disadvantage could be keeping a separate copy of relational data. In this approach a mapping between the relational data and RDF can allow on-the-fly SPARQL on the top of relational database. In other words, a SPARQL query gets translated to SQL which then gets executed on the relational database. This means the relational data is published on the web as RDF and linked data through a SPARQL endpoint. It seems it is simply like querying relational database using SPARQL, but are we really integrating semantically here? [31]

2) Probably the second approach may give a near solution. The second approach deals with **enabling SPARQL queries** over different SPARQL endpoints with which at least some level of data integration can be achieved. An illustrated and comprehensive understanding on this approach can be obtained, [34] and [35] in passing [31]. However efforts are put to elucidate on SPARQL in the form of a code snippet presented in the section 6.2.

3) **Jena Model vs. SPARQL**: The third approach is called Jena Model approach. SPARQL is a data oriented query language. It has the capability of only querying the information held in the models. It does not have inference capability. But Jena model is 'smart'. In that it provides the impression that certain triples exist by creating them on-demand, including OWL reasoning [36]. In Jena, ontology is treated as a special type of RDF model [37]. Jena is a framework for building Semantic Web applications. It provides a programmatic environment for RDF, RDFS and OWL, SPARQL and includes a rule-based inference engine. Both ontology schemas and its populated instances are stored in theKAON2ontology repository, an infrastructure for managing OWL-DL ontologies [38]. The reasoning is obtained because of the vocabulary relationship expressed in the form of a parent-child relationship and also based on transitive dependency relationship. SPARQL does not do anything other than taking the description of what application wants in the form of a query and returns the information in the form of set of bindings or an RDF graph. RDF documents are written in XML and the XML used in RDF is called RDF/XML. By using XML, RDF information can be exchanged between different computers, operating systems and application languages. The next section briefly elucidates an example of SPARQL in the E-Gov.

6.2. SPARQL in E-Gov.

Examples and tutorials [36] can give better understanding on E-Gov. related to SPARQL. Suppose if the government would like to allocate the budget to the Ministry of Transportation for the purpose of repairing the existing roads in the country UK, for this purpose the government can fire a SPARQL against the Transport data set (the government data belonging to different ministries are usually available as different data sets). So if the question is: How many roads of each classification are there in UK? The corresponding SPARQL query in this case would look like:

```
PREFIX skos: <http://www.w3.org/2004/02/skos/core#>
PREFIX roads: <http://transport.data.gov.uk/0/ontology/roads#>
SELECT ?cat_name (COUNT(DISTINCT ?thing) AS ?roads)
WHERE {
   ?thing a roads:Road ; roads:category ?cat .
   ?cat skos:prefLabel ?cat_name
}
GROUP BY ?cat_name
```

Output

cat_name	roads
Unclassified Road	5698
B Road	1299
C Road	2342
A Road	1742
Motorway	55

Output is shown in the box where as the expected result is shown in Appendix.

6.3. Existing RDB2RDF Tools

The brief list and short description of RDB2RDF tools, explicitly as given in [31] are as follows:

1) **Asio Semantic Bridge for Relational Databases***:* "Asios' SBRD enables integration of relational databases to the Semantic Web by allowing SPARQL queries over the relational database. Initially OWL ontology is generated from the database schema which can then be mapped to defined domain OWL ontology.

2) **D2RQ: D2RQ consists of a mapping language** between relational database schema and RDFS/OWL ontologies. The D2RQ platform creates an RDF view of the relational database, which can be accessed through Jena, Sesame and the SPARQL query language. Additionally, using D2R Server, the relational database can be accessed via the Web through the SPARQL protocol and as Linked Data. The first release of DBpedia in 2007 was done using D2R Server.

3) **Metatomix Semantic Platform***:* Metatomix's Semantic Platform allows mapping a relational database with ontology and outputting the relational data as RDF. The mapping is done through a graphical eclipse plug-in. Other structured sources can map to the same ontology allowing data integration under the same ontology.

4) **RDBtoOnto:** RDBtoOnto is an automatic tool that generates a populated ontology in RDFS/OWL from a relational database, acting as a ETL tool. This automated tool also provides a user interface that allows specific configurations.

5) **SquirrelRDF***:* SquirrelRDF is a tool that allows to relational databases to be queried using SPARQL. This tool takes a simplistic approach by not performing any complex model mapping like D2RQ

6) **Triplify***:* Triplify is a lightweight plug-in that exposes relational database data as RDF and Linked Data on the Web. There is no SPARQL support. The desired data to be exposed is defined in a series of SQL queries. Triplify is written only in PHP but has been adapted to several popular web applications (Wordpress, Joomla, osCommerce, etc).

7) **ODEMapster***:* ODEMapster is a plug-in for the NeOn toolkit, which provides a GUI to manage mappings between the relational database and RDFS/OWL ontologies. The mappings are expressed in the R2O language.

8) **Oracle Database 11g***:* Oracle Database 11g supports RDF, RDFS and OWL data management as a native triple store. It is also integrates relational database with other RDF data and is able to combine SQL queries of relational data with RDF graphs and ontologies stored together. It also provides support to Jena.

9) **Ultrawrap***:* Ultrawrap is an automatic tool that automatically exposes relational databases as RDF and allows them to be queried using SPARQL. OWL ontology is generated and then it can be mapped to domain OWL ontology through a GUI. This tool makes maximal re-use of existing commercial SQL infrastructure by letting the SQL optimizer do the SPARQL query execution. This tool will be released in summer 2010.

10) **Virtuoso's RDF View***:* Virtuoso RDF Views maps relational data into RDF and allows SPARQL queries to be executed over the relational database and at the same time with a local RDF store, enabling integration of relational and RDF data."

7. Conclusions

Data integration and systems inter-operation though challenging but are necessary tasks for government agencies and monitoring councils that need to identify various sources and give public access to such information. For example Governments are trying to adopt 'quango' model [39] for the purpose of the growth of rural economy with entrepreneurship development. But the allegations and corruption related scams on ministers in India [40] (this kind of situation might be true with other developing countries also especially with countries whose Corruption Perception Index value is low) are putting the policy makers into a conflict situation and hence are in turmoil whether to reinforce the privatization and liberalization policy with 'quango' model. Since the process involves the participation of high number of companies, projects and human resources as well, the government obviously seeks to have a 360^{o} feedback process to establish the evaluation of the partners to participate in 'quango' model [41] for the purpose of improving the partner selection process. These challenges of informed decisions on policy issues underscored the need to rationalize various sources, sets and levels of data that are available to policy makers in various domains. EgeoIT's RDi-Advise kind of tools [38] that are developed for R & D intermediation information management using semantic technologies can be considered as a pilot study tool for the selection of 'quango' model partnership evaluation too.

The insight in the form of brining the review of the literature on e-governance and underlying data integration and semantic capability provision thus established a linkage between advanced levels of e-government and underlying data integration for users external to government, stakeholders and policy makers [42].

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Authors

Dr. Al-Sudairy is currently working as an Associate Professor in College of Business Administration for MIS Department and the Dean of Skills Development of King Saud University at Riyadh, KSA. He obtained Two Masters one in Economic and another in Business MIS from USA and a Doctorate on EDI and E-Business from University of Leicester, UK. His interested areas include IT, E-Business, E-Commerce, Information Systems Strategy and ERP. He has publications in reputed journals and conferences.

Mr. TGK Vasista is currently working as Researcher at King Saud University, Riyadh, KSA. He obtained a Master's from University of Roorkee (Now called IIT-Roorkee) and a PG Diploma in E-Governance from University of Mysore, India. He has former experiences in the field of IT as a programmer analyst in USA and as a senior lecturer in academic field in the area of Systems and IT, E-Business and E-Governance. He has few publications in journals and conferences in E-Business and E-Governance.

APPENDIX


```
<?xml version="1.0"?>
<sparql xmlns="http://www.w3.org/2005/sparql-results#">
  <head>
    <variable name="cat_name"/>
    <variable name="roads"/>
  </head>
  <results>
    <result>
      <binding name="cat_name">
        <literal>Unclassified Road</literal>
      </binding>
      <binding name="roads">
        <literal
datatype="http://www.w3.org/2001/XMLSchema#integer">5698</literal>
      </binding>
    </result>
    <result>
      <binding name="cat_name">
        <literal>B Road</literal>
      </binding>
      <binding name="roads">
        <literal
datatype="http://www.w3.org/2001/XMLSchema#integer">1299</literal>
      </binding>
    </result>
    <result>
      <binding name="cat_name">
        <literal>C Road</literal>
      </binding>
      <binding name="roads">
        <literal
datatype="http://www.w3.org/2001/XMLSchema#integer">2342</literal>
      </binding>
    </result>
    <result>
      <binding name="cat_name">
        <literal>A Road</literal>
      </binding>
      <binding name="roads">
        <literal
datatype="http://www.w3.org/2001/XMLSchema#integer">1742</literal>
      </binding>
    </result>
    <result>
      <binding name="cat_name">
        <literal>Motorway</literal>
      </binding>
      <binding name="roads">
        <literal
datatype="http://www.w3.org/2001/XMLSchema#integer">55</literal>
      </binding>
    </result>
  </results>
</sparql>
```