Semantic Interoperability for Enhancing Sharing and Learning through E-Government Knowledge-Intensive Portal Services

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ABSTRACT

E-Government emerges from the web sites that offer static information, documents and forms for employees and citizens to more advanced types of transactions, enquiries, and process automations to many types of stakeholders. Increasingly, different layers of government services are being consolidated into a knowledge portal providing on time and online services to the public. Such a knowledge portal not only provides a platform for integrating applications and information from all government sources, but also provides a platform for knowledge sharing and learning to the public with the objective to improve the efficiency and the quality of E-Government processes and services. However, due to the heterogeneity of applications and information across different levels of government agencies, a significant amount of work is usually needed to re-configure such applications and services into a new platform despite the progress made in service-oriented architectures. Semantics and in particular meta-knowledge about the nature and types of application services are often lacking. Semantic interoperability needs to be established for effective knowledge sharing and learning in E-Government. In this paper, we discuss how knowledge intensive portals can be used for enhancing sharing and learning in E-Government. We will also discuss the current state-of-the-art of how the Semantic Web and Web 2.0 technologies can be applied in providing interoperability to leverage knowledge sharing and learning activities in effective and efficient ways, to the public[1].

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[1] *This research was carried out at The Hong Kong Polytechnic University, Hong Kong*

Keywords: Knowledge Sharing and Learning, E-Government, Semantic Web, Web 2.0, Ontology

1. INTRODUCTION

With the advent of the Internet, E-Government has developed immensely since the end of the 90s. Most countries all over the world are implementing E-Government services to facilitate a range of services to citizens, public sectors and other authorities. E-Government provides a convenient way for citizens to access and obtain the information they desire, without having manually to locate and filter out the content that is not needed (Wagner *et al.*, 2006). Hence, E-Government encompasses the largest volume of web documents over the Internet as shown in Table 1 and the volume of web documents has indeed grown within 3 years from 2005 to 2008. The rapid increase of E-Government web documents over the Internet has been partly due to the government of China; its documents have increased from 2.6 million to 184 million, following China in the proliferation of web documents is the Thailand government and the New Zealand government with increases of 2702% and 1055% of increments respectively. With such a massive build-up of codified assets, the problem of "information overlook" can no doubt easily occur, leading to valuable information being ignored and missed by the citizens (Misra, 2006).

Table 1. Page count of selected E-Government sites available through Google on June 2005 vs. May 2008

Country	Government domain	Number of web pages		% Increment number of web pages	Website link
		June 2005 [1]	May 2008		
USA	.gov	368,000,000	855,000,000	132%	http://www.usa.gov/
Canada	.gc.ca	12,100,000	22,400,000	85%	http://www.canada.gc.ca/
UK	.gov.uk	9,280,000	62,200,000	570%	http://www.direct.gov.uk/
Australia	.gov.au	7,200,000	37,300,000	418%	http://www.gov.au/
China	.gov.cn	2,630,000	184,000,000	6896%	http://www.gov.cn/
New Zealand	.gov.nz*	1,290,000	14,900,000	1055%	http://newzealand.govt.nz/
South Africa	.gov.za	816,000	1,810,000	122%	http://www.gov.za/
Hong Kong	.gov.hk	887,000	4,430,000	399%	http://www.gov.hk/
Thailand	.gov.th*	728,000	20,400,000	2702%	http://www.thaigov.go.th/
Slovenia	.gov.si	388,000	1,080,000	178%	http://www.gov.si/

Remark: * indicated the government domain has changed (May, 2008).
.gov.nz changed to **.govt.nz** and **.gov.th** changed to **.go.th**

One approach to solve this problem is to develop a *one-stop knowledge-intensive government portal service* to unify all government agency websites, and to allow access to all government agencies' webpage services and information. Such a knowledge portal enables the public to access the Government's knowledge sharing and learning activities. Knowledge sharing and

learning are important activities in E-Government which enhance and improve the efficiency and quality of E-Government processes and services and also improve interaction and the relationship between the public and government. Despite the recent uptake in the adoption of service-oriented architectures (SOA) (Niemann, 2008; Nagarajan *et al.*, 2006; Bloomberg, 2003) among enterprise applications, much of the needed contextual knowledge about the provided application, which is crucial for providing concise and personalized knowledge, is still lacking. The core focus of SOA has been, up to now, on issues concerned with business and IT alignments.

Semantic interoperability in E-Government remains a crucial issue in E-Government due to the heterogeneity problem which has arisen in applications and knowledge repositories in different levels of agencies in government. Hence, knowledge sharing and learning activities have failed to take place in government processes and services. A potential solution can be the use of Semantic Web and Web 2.0 technologies for effective knowledge sharing and learning in an E-Government environment.

In Section 2 of this paper, we discuss the evolution, (including interoperability), of E-Government towards knowledge sharing and learning through knowledge-intensive portal services. The semantic interoperability issues of E-Government are discussed in Section 3. Meanwhile, the use of Semantic Web and Web 2.0 technologies to support knowledge sharing and learning in E-Government are discussed in Section 4 and 5, respectively. The challenges and issues in adopting Semantic Web and Web 2.0 technologies are presented in Section 6. The final section provides our conclusions.

2. E-GOVERNMENT EVOLUTION AND INTEROPERABILITY

2.1 Evolution of E-Government

E-Government is the use of ICT to unify the services of government agencies into a portal which we refer to as, ideally speaking, a *one-stop knowledge-intensive government portal service* to improve the efficiency, convenience and accessibility of services to the public. The impact of E-Government services and processes is increasingly important to the public as is evidenced by the increasing number of visitors to E-Government portals for accessing services. For example, the Malaysian Government (Steven, 2008) reported that there has been a threefold increase in the number of visitors in these two years and it had recorded 6.5 million visitors as at May 15 2008 and 9.9 million visitors as at 04 Jun 2008.

E-Government is being deployed not only to provide citizen services such as driving license renewal, business registration, electronic income tax returns, form downloading etc., but also as a knowledge repository for information searching to leverage knowledge sharing and learning activities. A survey by Estabrook *et al.* (2007) revealed nearly four out of five American Internet users have visited government websites to seek information or assistance for problem solving and decision-making. They usually visit local, state or federal government websites for information and a total of 71% has done this in the last 12 months compared to 66% in the past year.

Knowledge-intensive portal services not only offer customization or personalization functions, static content and electronic transactions, but they are able to collect and disseminate information and knowledge to the public. Such a portal can automatically connect the public to

the right government agency, to answers and information through FAQs. It then rates information content based on collective preferences. Various efforts on developing such portals have been reported in (Paralic, 2003; Sidoroff & Hyvnon, 2005; Klischewski, 2003; Fraser *et al.*, 2003; Daddieco, 2004; Wimmer, 2006; Overeem *et al.*, 2006; Gugliotta *et al.*, 2005).

According to United Nations E-Government Survey (2008), E-Government has gone through five phases. In the first phase, information on government operations and services was published in a static way. In the next phase, more information on public policy and governance was provided with links to archived information. Moving to the third phase, an interactive portal to deliver online services to enhance the convenience of citizens is evident. Interactions between public and government are established and online transactions are provided in the forth phase. In the fifth phase, which no E-Government has achieved so far, integration between E-Government and back office infrastructure is established to enable involvement of the public in government decision-making, in particular, through e-participation. Interoperable services and applications are integrated in E-Government at this phase.

2.2 Interoperability in E-Government

The aim of E-Government is to develop a *one-stop knowledge-intensive government portal service* to enable the public to access all services at different levels of agencies where the users need have no knowledge or direct interaction with the government agencies. Therefore, services need to be interoperable in order to allow for data and information to be exchanged and processed seamlessly within or across government agencies. However, in E-Government development and implementation, there are challenges ahead and the following questions were raised in (Ojo & Janowski, 2005):

- How can systems from different agencies exchange information and messages meaningfully?
- How can information be integrated from various agencies, while guaranteeing semantic accuracy?
- How can government intranets capture and use the knowledge about the government itself (e.g. services, resources, etc.)?
- How can government services be dynamically configured based on the specifications of citizens, the private sector and public authorities?

Commonly, government organizations have a very distributed structure; whereas different agencies are organized in different levels (e.g. federal vs. state vs. local) and provide different services to the citizens. The operation of each of these agencies is supported by proprietary legacy systems. Due to the diversified level of government organizations, various issues related to technological heterogeneity, Organisational heterogeneity and information heterogeneity have arisen. Therefore, Organisational, semantic and technical interoperability as shown in Table 2 and illustrated in Figure 1 need to be established in order to resolve the heterogeneity problems in E-Government deployment (Brusa1 *et al.*, 2007).

Table 2. Heterogeneity and Interoperability in E-Government

Heterogeneity	**Interoperability**
Organisational heterogeneity arises when the elements have different features that must be	*Organisational interoperability* refers to defining business goals, modeling business

taken into consideration to solve problems in the State, such as processes, decisions, guidelines, criteria, work actors, among others.	processes and bringing about the collaboration of administrations that wish to exchange information and may have different internal structures and processes.
Information heterogeneity arises from structural heterogeneity and semantic heterogeneity. Structural heterogeneity occurs when data are kept in different data structures; meanwhile semantic heterogeneity occurs when different data have the same meaning or when unique data refers to two different concepts.	*Semantic interoperability* concerns ensuring that the exact meaning of the exchanged information is understandable by any other application within or between administrations, either locally or across countries and with the enterprise sector.
Technological heterogeneity arises when there is technical diversity, such as different methodologies, platforms, protocols, equipments and work environments, among others.	*Technical interoperability* refers to the technical issues of linking computer systems and services, defining standard protocols and data formats.

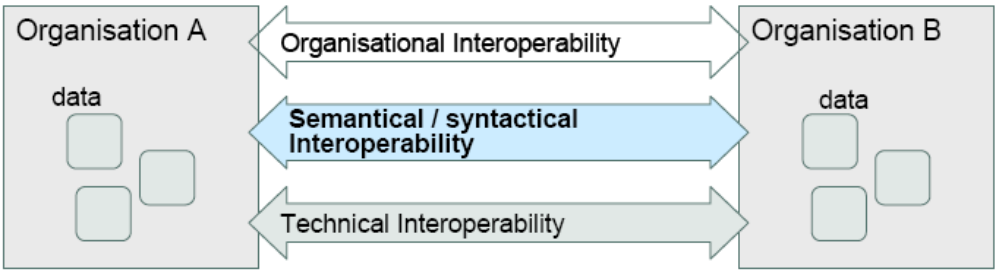

*Figure 1. Interoperability layers (*Reichling*, 2009)*

3. SEMANTIC INTEROPERABILITY

Interoperability is the ability to make information from one system semantically and syntactically accessible to another system. According to (Tripathi *et al.*, 2007), "semantic interoperability is concerned with ensuring that the precise meaning of exchanged information is understandable by any other application that was not initially developed for the current purpose. Semantic interoperability enables distributed systems to combine received information with other information resources and to process it in a meaningful manner. Semantic interoperability is therefore a prerequisite for the front-end multilingual delivery of services to the user".

As depicted in Table 2, semantic interoperability is used to resolve information heterogeneity which resulted from structural heterogeneity and semantic heterogeneity. Examples of semantic heterogeneity are *synonymy*, *polysemy*, *acronym*, and *abbreviation*. These terms are further explained below:

- Synonymy refers to two different words with similar meaning, e.g. *reservation* and *booking* are synonymous.
- Polysemy are words which take on different meanings in different contexts, e.g. in a *military* context, *hardware* means military weaponry while in an *information technology* context,

hardware refers to electrical components making up a computer system.

- Acronym is a word formed from the initial letters of a multi-word name. For example, the acronym for *grade point average* is *GPA*.
- Abbreviation is a shortened form of a word or phrase. For example, *technical* is abbreviated as *tech*.

Semantic interoperability needs to be achieved in order to integrate heterogeneous, distributed information and applications of different agencies so as to provide a comprehensive E-Government service as well as a knowledge sharing and learning platform for citizens. Abecker et al. (2006) emphasize the importance of such an environment and succinctly summarize it as a "combination of information and process integration facilitating a variety of objects with specific semantics which seems to be quite natural: the E-Government domain can provide an ideal test bed for existing semantic web research, and semantic web technologies can be an ideal platform to achieve the vision of a knowledge-based, user-centric, distributed and networked E-Government."

4. SEMANTIC WEB TECHNOLOGIES

The Semantic Web technologies allow for publishing information to the public. They gather information through usable forms, react online to specific requests from the public, manage the online exchange of items of high-value and integrate services (Paralic et al., 2003) for E-Government. In addition, the Semantic Web provides an effective and transparent E-Government. The web pages are defined with semantic meanings and metadata to enhance machine understanding and interpretation during information exchange as well as facilitate the integration of applications and information from many different sources (Klischewski, 23).

The Semantic Web aims to alleviate integration and interoperability problems of heterogeneous knowledge repositories across a network. The Semantic Web provides a common framework for developing an infrastructure to allow efficacious knowledge sharing and learning through the Semantic Web layer stack as depicted in Figure 2 (Arroya *et al.*, 2004), whereas the lowest three layers (Unicode, URI, namespace and XML) act as a basis for defining semantics for a range of web resources. The RDF (Resource Description Framework) layer can be viewed as the first layer of the Semantic Web that provides metadata to web resources. Additional meta-information for annotating semantics to web resources is provided by the ontology layer and above.

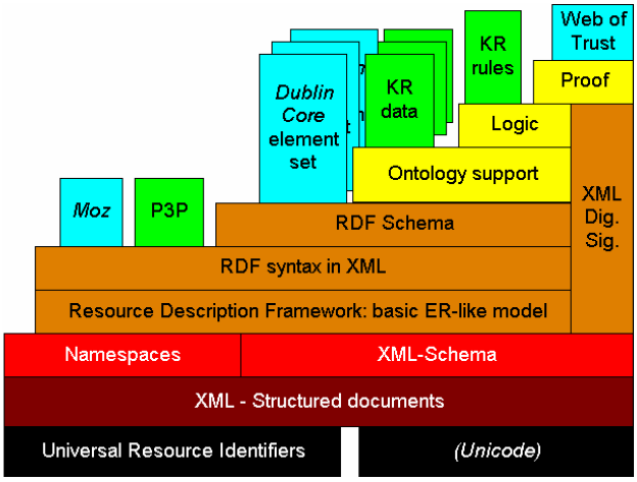

Figure 2. Semantic Web stack (Arroya et al., 2004)

According to Gruber (1993), an ontology is an "explicit specification of a conceptualization". Ontology is used to give explicit meaning to stored information, making it easier for machines to automatically process and integrate information. Commonly, semantic interoperability is achieved through the implementation of existing ontologies into a E-Government knowledge portal. In such portals, different ontologies have been developed in order to resolve the issue of semantic interoperability among various government agencies and departments. Through the use of these ontologies, integration of otherwise heterogeneous information and applications from various agencies into an E-Government portal has been made possible. For instance, (Fraser *et al.*, 2003) developed the SmartGov E-Government ontology to provide the public authority with a knowledge-based core repository for government transaction services; Daddieco (2004) has developed an ontology for the subject domain of export controls in the US government for effective knowledge retrieval and sharing. Wimmer (2006) has developed an ontology for a knowledge map (semantic net) to support search and navigation via the net to enhance learning about government.

Ontology has also been used in conjunction with Semantic Web Services for enhancing semantic interoperability to E-Government services as illustrated in the work by Overeem *et al.* (2006) and Gugliotta *et al.*, (2005). However, the use of ontology in defining knowledge services for E-Government services is still immature, and this topic of research will be quite a challenge for the E-Government movement as appropriate knowledge services from diversified types of services provided by different levels of government agencies need to be defined.

5. WEB 2.0 TECHNOLOGIES

5.1 Leveraging Web 2.0 in E-Government

In the world of Web 2.0, problems of interoperability are essentially issues about the quality of service. The public want to discover, access, organize, utilize whatever is available at the E-Government portal to help generate the results they desire, with minimal effort. This solution entails semantics in the user interface on the development of E-Government services (*Semantic Interoperability Community of Practice (SICoP)*, 2006). Semantic interoperability is needed in

order to provide the much needed semantics (i.e. meaning and context) to Web 2.0 services in the E-Government portal. Through semantic interoperability, "in-context" meaning among users can be better harnessed and shared leading to a richer user experience and a more user-friendly operating environment.

The Web 2.0 technologies provide a new infrastructure for government to interact with the public. Web 2.0 technologies such as blogs, wikis, content syndication, content tagging services, podcasting and multimedia sharing services (Anderson, 2007) are dramatically improving the knowledge sharing and learning capability of the public through (collective and collaborative) e-participation in government decision-making. Web 2.0 technologies increase the public awareness of the government processes and also provide a greater two-way communication between the government and the public.

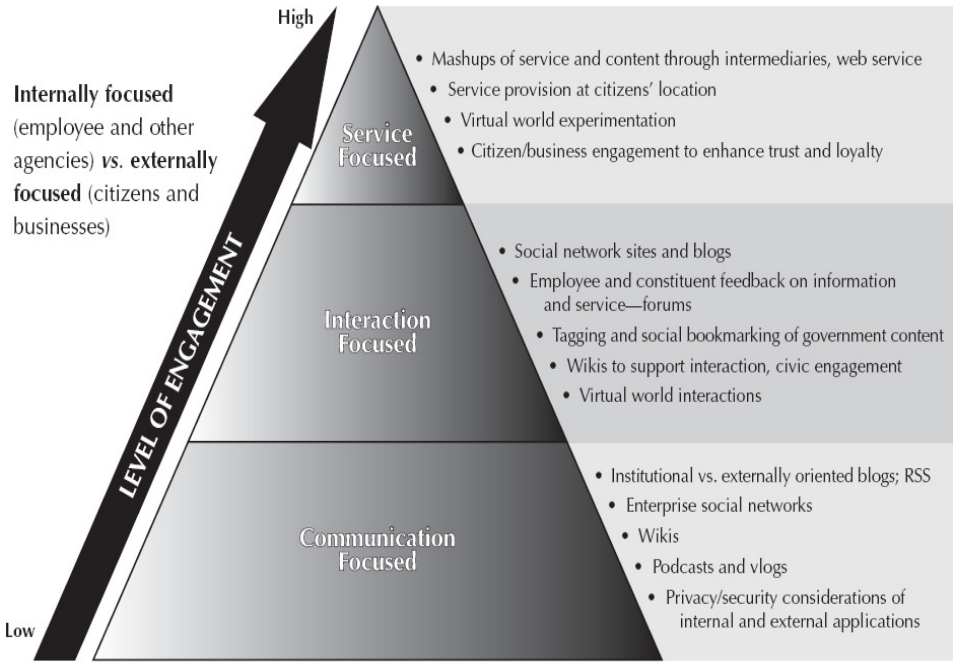

Figure 3. A framework for leveraging Web 2.0 in E-Government (Chang & Kannan, 2008)

The role of the Web 2.0 technologies in E-Government can be categorized into three distinct levels of use, which are: communication-focused, interaction-focused and services-focused as shown in Figure 2 (Chang & Kannan, 2008).

- *Communication-focused uses*: Government disseminates information that is relevant to citizens in a broad manner through blogs, RSS, wikis, enterprise social networks and podcasts and vlogs. In this way citizens have easy access to the information and gain more awareness of the content than they did previously.
- *Interaction-focused uses*: Government interacts with employees, other agencies and citizens to get their feedback on service design, new ideas, policies, plans, services and other government issues. Mash-ups of content and application are created to benefit citizens. Web 2.0 technologies such as online community chat, blogs, social tagging, social networking, wiki are commonly leveraged in an E-Government portal.
- *Services-focused uses*: Government allows intermediaries to mash-up content and applications of government organizations to provide items of value to citizens. For example, banks can

combine their customers' information with government information to help their customers file taxes and make the process more efficient for citizens. Virtual world experimentation to get feedback from citizens on service designs is another example of a useful application.

5.2 Web 2.0 Applications in E-Government

As can be seen from the E-Government portals shown in Table 3, news, email, RSS feeds, mobile, blogs and chats are the media used by the government to stay connected with the public. These are particularly useful for disseminating up-to-date information on government services and activities. As shown in Table 3, Web 2.0 services are not yet widely adopted in E-Government. The most common Web 2.0 service used in the E-Governments to channel update information to public is RSS feeds. RSS (Really Simple Syndication) feeds allow the public to obtain up-to-date information automatically from RSS-enabled E-Government portals without having to constantly go and visit the sites.

Table 3. Media used for knowledge sharing and learning in E-Government

Country	News	Email	RSS	Mobile	Blog	Chat
USA	x	x	x	x	x	x
Canada	x	x	x	x		
UK	x			x		
Australia	x	x	x			
China	x	x				
New Zealand	x	x	x			
South Africa	x	x				
Hong Kong	x		x	x		
Thailand	x					
Slovenia	x	x				

In Table 4, other Web 2.0 technologies that can positively contribute to the way the public can leverage their knowledge sharing and learning activities as well as participate in E-Government decision-making are listed.

Leveraging Web 2.0 technologies into Semantic Web E-Government knowledge-intensive portal services can be an effective way for knowledge and information exchange and can enhance the learning process through collaborative effort as demonstrated in Wagner et al.'s (2006) work. They have developed Semantic Webs for E-Government using the Wiki technology, namely the semantic Wiki web. Through such portals, knowledge sharing can be more successful and knowledge learning can be fostered in more effective and collaborative way.

Table 4. Web 2.0 technologies, descriptions and E-Government websites

Application	**Descriptions**	**Examples of E-Government websites with such features (if available)**

Blogs	A Blog is a simple webpage consisting of information, opinion or links, called posts which are arranged chronologically with the most recent first. Blog facilitates critical feedback from the public by letting them express their opinion on topics by adding comments.	http://www.egovni.com/ http://blog.usa.gov/roller/ http://www.pueblo.gsa.gov/ http://www.openmass.org/
Wikis	The best known Wiki is Wikipedia, the world's largest online encyclopedia, it allow users to read and edit the information in the wiki web document. It can be referred to as a collaborative tool for the community. Wiki can store plain texts with a limited degree of formatting support.	http://www.govitwiki.com/ http://utahegov.wikispaces.com/ http://oim.modernisering.dk/StartSide
Podcasts	Postcasts are audio or video recordings of talks, interviews etc. that play on wide range of handheld MP3 devices. These content are usually tagged for easy and automatic download into consumer devices for replay.	http://utahsciencecenter.org/uscprograms.php http://www.polity.org.za/
Mashups	Mashups are web services that pull together data from different sources to create a new service. Increasingly, business users are empowered to produce their own mashups without support from IT staff.	http://www.dhs.alabama.gov/ http://rru.worldbank.org/businessplanet/
Social bookmarking	Social bookmarking allows users to create lists of bookmarks which can be tagged with keywords. A bookmark can belong in more than one category.	http://www.ico.gov.uk/ http://www.usa.gov/
Social networking	Social networking builds links with relevant social networks through interaction and by posting tailored information.	http://twitter.com/egovrc

6. CHALLENGES AND ISSUES

Designing a Semantic Web for E-Government poses several challenges. Firstly, there is the difficulty of extracting knowledge and information from documents and people and identifying the semantic relationships between these knowledge objects in order to design ontologies for E-Government. Secondly, integration often is a bottleneck and poses severe difficulties due to the highly heterogeneous structure of diversified applications across different levels of government. Thirdly, there is also the shortage of expertise and resources to verify the content and the semantic links in indexed web documents. Lastly, rapid change of web documents and their

semantic relationships compromise the review efforts mentioned above.

In the world of Web 2.0, one key challenge for E-Government is how to select and implement the right Web 2.0 technologies to positively enhance and leverage knowledge sharing and learning capabilities for improving government services and processes, and also to increase participation from the public for better government decision-making. There is also the common challenge of Knowledge Management (KM) which is to entice people to use these services and share their knowledge in a sustained way.

More complications exist. With the use of social bookmarking in tagging, folksonomy has emerged from the practice and this has resulted in inconsistent and ambiguous terms that prevent knowledge sharing and learning activities from taking place efficiently. Resolving the ambiguity and inconsistent meanings of the tags poses another challenge for E-Government. Current research on integrating taxonomy and folksonomy tags is nevertheless being carried out by the authors (Kiu & Tsui, 2009).

Without proper control and coordination, E-Government might have difficulty in maintaining the fast growing repository of knowledge through the widely used Web 2.0 services.

7. CONCLUSION

The E-Government knowledge-intensive portal services extend knowledge management by enabling different groups of users (civil servants and citizens alike) to organize and share information from heterogeneous applications of government agencies. Such a portal is highly advantageous to the public because it offers great opportunities for quality service delivery and interaction in an easy and convenient way, and can deliver a range of government information and services.

Deployment of E-Government knowledge-intensive portal services with a combination of the Semantic Web and Web 2.0 technologies can ensure semantic interoperability to integrate heterogeneous applications and information from different levels of government agencies in order to share knowledge and enable learning to take place efficaciously. Such an accomplishment can improve public participation in government decision-making. In addition, an appropriately devised knowledge service enables governments to provide appropriate and efficient services to the public through the E-Government knowledge portals. However, significant challenges still need to be overcome before the above aim can be achieved.

ACKNOWLEDGMENT

The authors gratefully acknowledge the support of The Hong Kong Polytechnic University (under grant account 1-45-37-0542) for carrying out this piece of research.

REFERENCES

Abecker, A., Sheth, A., Mentzas, G., & Stojanovic, L. (2006). The Semantic Web meets eGovernment. *2006 AAAI Spring Symposium* Series, Stanford University, California, USA,

Retrieved 28 August, 2008, from http://www.aaai.org/Press/Reports/Symposia/Sprin g/ss0606.php

Anderson, P. (2007). What is Web 2.0? Ideas, technologies and implications for education, *JISC Technology and Standards Watch*.

Arroyo, S., Ding, Y., Lara R., Stollberg M., & Fensel, D. (2004). Semantic Web Languages - Strengths and Weakness. *International Conference in Applied computing (IADIS04)*, Lisbon, Portugal.

Bloomberg, J.(2003). The role of the service-oriented architect, *The Rational Edge*, Rational Software. Retrieved August 28, 2008, from http://www.therationaledge.com/conte nt/may_03/ PDF/bloomber g.pdf

Brusa1, G., Caliusco, M. L., & Chiotti, O. (2007). Enabling Knowledge Sharing within E-Government Back-Office Through Ontological Engineering. *Journal of Theoretical and Applied Electronic Commerce Research*, 2(1), 33 – 48.

Chang, A. & Kannan, P.K., (2008). Leveraging Web 2.0 in Government, *E-Government/ Technology Series*, IBM Center for The Business of Government.

Daddieco, R. J. (2004). *Retrieving knowledge in E-Government: the prospects of ontology for regulatory domain record keeping systems*, In Wimmer.

Di, A. M. (2007). What Does Web 2.0 Mean to Government?. *Gartner Publication* ID Number: G00146261.

Estabrook, L., Witt, E., & Rainie, L. (2007). Information searches that solve problems - How people use the Internet, libraries, and government agencies when they need help. *Pew Internet & American Life Project*.

Fraser, J., Adams, N., Macintosh, A., McKay-Hubbard, A., Lobo, T.P., Pardo, P.F., Martínez R.C., & Vallecillo, C.S. (2003). Knowledge Management Applied to E-Government Service: The Use of an Ontology", in: Wimmer, M. (ed.), *Knowledge Management in E-Government*, Proceedings KMGov 2003, Springer Lecture Notes #2645, 116-126.

Gruber, T.R. (1993). A Translation Approach to portable Ontology Specifications, Knowledge Acquisition, Vol. 5, pp. 199-220, 1993.

Gugliotta, A., Cabral, L., Domingue, J. & Roberto, V. (2005). A semantic web service-based architecture for the interoperability of E-Government services. *In proceedings of International Workshop on Web Information Systems Modeling (WISM 2005)*, Sydney, Australia.

Kiu, C. C., & Tsui, E. (2009). Taxonomy - Folksonomy Integration for Knowledge Navigation through Unsupervised Data Mining Techniques. *Knowledge Management Research & Practice (KMRP)(inPress).*

Klischewski, R. (2003). Semantic Web for E-Government. In R. Traunmuller (Ed). *Proceedings EGOV 2003*, Springer Lecture Notes No. 2739.

Misra, D.C. (2006). *E-Government: The State of Art Today-2*. A Presentation at the Official Launching of the Government-to-Government System and CIO Workshop, Ebene Cyber Tower, Rose Hill, Mauritius.

Nagarajan, M., Verma, K., Sheth, A. P., Miller, J., & Lathem, J. (2006) Semantic Interoperability of Web Services - Challenges and Experiences. *IEEE International Conference on Web Services (ICWS 2006)*.

Niemann, B. (2008). Getting to SOA and Semantic Interoperability for DoD Architectures. *6th Annual DoD Architectures Conference*. Retrieved August 28, 2008, from http://semant icommunity.wik.is/@api/deki/files/569/=BNiemannIDGA03032008.ppt?revision=2

Ojo, A. & Janowski, T. (2005). *Ontology, Semantic Web and Electronic Government*. Retrieved 1 August, 2008, from http://www.emacao.gov.mo/documents/14/13/seminar1 3.pdf

Overeem, A., Witters, J., & Peristeras, T. (2006). *Semantic Interoperability in pan-European eGovernment services*. Retrieved July 6, 2008, from http://www.semantic-gov.org/ind ex.php?Name=UpDownload&req=getit&cid=2&lid=246

Paralic, J., Sabol, T., & Mach, M. (2003). Knowledge Enhanced E-Government Portal, *Knowledge Management in Electronic Government*, Springer Berlin / Heidelberg.

Reichling, K. (2009). Semantic interoperability for public administrations in Europe – challenges and solutions, iDABC European eGovernment Services. Retrieved 1 July, 2009, from https://www.posccaesar.org/svn/pub/SemanticDays/2009/Session_1_Klaus_Reichling.pdf

Semantic Interoperability Community of Practice (SICoP). Semantic Wave 2006, 2006. Retrieved 1 August, 2008, from http://web-services.gov/SICOPsemwave2006v1.0.doc

Sidoroff T., & Hyvonen, E. (2005). Semantic E-Government portals - a case study. *In Proceedings of the ISWC-2005 Workshop Semantic Web Case Studies and Best Practices for eBusiness (SWCASE05)*.

Steven, P. (2008). Govt portal wins global award. *The Star Online*, Retrieved May 21, 2008, from http://thestar.com.my /news/story.asp?file=/2008/5/21/nation/200805211819&sec=na tion

Tripathi, R., Gupta M. P., & Bhattacharya, J. (2007). Selected Aspects of Interoperability in One-stop Government Portal of India, *5th International Conference on E-Government*, Hyderabad, India.

United Nations E-Government Survey 2008 - From E-Government to Connected Governance, United Nations, New York, 2008.

Wagner, C., Cheung, K.S.K., Ip, R.K.F., & Böttcher S. (2006). Building Semantic Webs for E-Government with Wiki technology. *Electronic Government*, 3(1), 36–55.

Wimmer, M. A. (2006). Implementing a knowledge portal for egovernment based on semantic modelling: The E-Government intelligent portal (eip.at). *In Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06)*.