Chapter 3

SEMANTIC TECHNOLOGY FOR E-GOVERNMENT

Ralph Hodgson[1] and Dean Allemang[2]
[1]*TopQuadrant, Inc., rhodgson@topquadrant.com*

[2]*TopQuadrant, Inc., dallemang@topquadrant.com*

1. INTRODUCTION

In the last five years a number of significant developments have occurred that motivate the use of Semantic Technology in e-Government. In 2001, the US President announced 24 e-Government initiatives (US President's E-Government Initiatives, 2001).

In 2004 the Federal Enterprise Architecture (FEA) was first published (Federal Enterprise Architecture, 2004). It is well-known that Semantic technology is an enabler for federation, mediation, aggregation and inferencing over information from diverse sources. Why then, not advocate its use for helping solve interoperability, integration, capability reuse, accountability and policy governance in agencies, across agencies and even across governments?

With this vision, TopQuadrant set out in 2002 to bring Semantic Technology to the attention of the emerging technology work-groups of the US Government at their "*Open Collaboration*" Workshop meetings in Washington DC (Collaborative Expedition Workshops). What followed is a success story of growing awareness and advocacy of semantic technology in e-Government.

In this paper we gave an account of one of the pilot projects that happened within the, now-called, Semantic Interoperability

Community of Practice (SICoP, 2005). This group, under the leadership of Brand Niemann, was established for the purpose of achieving "semantic interoperability" and "semantic data integration" in the government sector, seeking, through pilots, to demonstrate the power of semantic technology (Niemann, B., 2005). The SICoP group is also producing in a series of White Papers[1] (SICoP Module I, 2005).

We will describe the "*eGOV FEA-Based Capabilities and Partnering Advisor*", referred to in-short as the "*Capabilities Advisor*", some reference will be made to the Federal Enterprise Architecture Reference Model Ontology (FEA-RMO). First, as necessary background, the FEA Reference Model (FEA-RM) is briefly described.

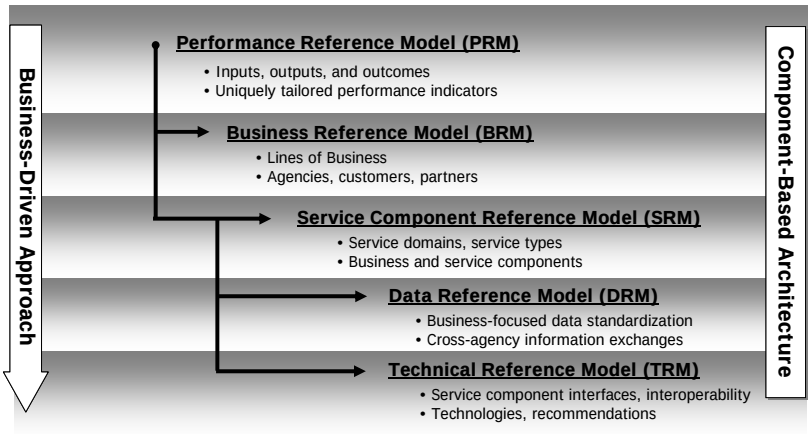
2. THE FEDERAL ENTERPRISE ARCHITECTURE REFERENCE MODEL (FEA-RM)

In response to the US President's identification of e-government as a key component of his management agenda, the US Federal Enterprise Architecture Program Management Office has proposed five reference models for the architecture of e-government. These reference models were conceived by researching and assembling current practices of the various government agencies. The goals of the reference models include:

- Elimination of investments in redundant IT capabilities, business processes, or other capital assets
- Saving time and money by leveraging reusable business processes, data, and IT-components across agencies
- Providing a simpler way for agencies to determine whether IT investments they are considering are not duplicative with other agencies' efforts
- Identification of common business functions across agencies
- Providing means to agencies to evolve FEA business reference model in response to their changing situation and needs

[1] As an indication of worldwide interest, it is of interest to note that one module of the series has been translated into Japanese (SICoP Module 1, Japanese, 2005).

The FEA models are illustrated in Figure 1, from the FEA Program Management Office Web-Site (Federal Enterprise Architecture, 2004). The FEA was established by US Government's Office of Management



Budget (OMB), with support from the Federal CIO Council

Figure 1: The 5 Federal Enterprise Architecture (FEA) Models

The FEA has five models:

1. Performance Reference Model (PRM),
2. Business Reference Model (BRM),
3. Service Component Reference Model (SRM),
4. Technology Reference Model (TRM) and
5. Data Reference Model (DRM).

Each of these is, at its core, a taxonomic structure of Enterprise Architecture constructs as indicated in the figure above. Like other reference models, this is not enterprise architecture itself, but a model to guide enterprise architects in government agencies as they create their own, agency-specific, enterprise architectures. Like other reference models, it provides design guidance, and allows for latitude for specific agencies to tailor and/or map to their specific Enterprise Architectures.

The first full version of the FEA Reference Model (FEA RM) was released in 2004. The work reported in this paper made use of the first four models. At the time of our work, the DRM was under revision.

3. THE FEDERAL ENTERPRISE ARCHITECTURE REFERENCE MODEL ONTOLOGY (FEA-RMO)

Reference models are typically written in natural language, and are presented as some form of human-readable document. The reference models of the FEA are no exception. This form of presentation has the advantage that the reference models can be read by anyone who can read PDF files; but it has the disadvantage that the process of reusing the reference model ("alignment") can only be verified by an interpretation process whereby an enterprise architect (or whoever has the job of making the alignment) determines what the reference architecture means, and argues for the particular alignment of their architecture to the model. This is a highly ambiguous and subjective task, and is prone to errors and even misuse.

A formal representation of a reference model addresses this problem by providing an unambiguous (or at least, less ambiguous) representation of the reference model, and allows for the definition of objective criteria for whether an architecture is actually conformant.

By representing the reference models in a semantic-rich language like RDF/S and OWL, much of the interpretation and enforcement of the reference model can be automated. Consider, for example, a "*Service Architecture Advisor*", which would check proposed service implementations for compliance to the reference architecture. Such an advisor could make recommendations about how the architecture could achieve greater compliance with the reference architecture or with other services that are already available. As a second example, in fact the subject of this paper, consider a "*Capabilities Advisor*" that uses the reference model to advise on capabilities that are available or are being built to support particular services and lines-of-business. By having an ontology of the FEA, a system can "*make connections*" between requirements and capabilities and give advise based on inferences.

Figure 2 illustrates how ontological relationships can answer questions about aspects of an Enterprise. An executive, manager or employee can discover how the activities of the business support business goals, how capabilities support those activities, and what systems enable the capabilities.

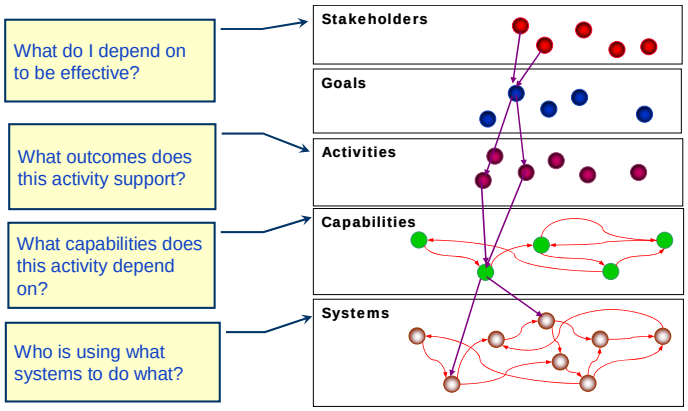


Figure 2: Some questions that can be answered by a Semantic Model of an Enterprise

An ontology-based system can answer questions such as:

- Who is using what business systems to do what?
- Who is using what technologies and products to do what?
- What systems and business processes will be affected if we upgrade a software package?
- What technologies are supporting a given business process?
- Where components are being re-used or could be re-used?
- How is our agency architecture aligned with the FEA?

An example of inferencing over properties is shown in Figure 3. Using RDF/OWL transitive and sub-properties enables new information to be inferred.

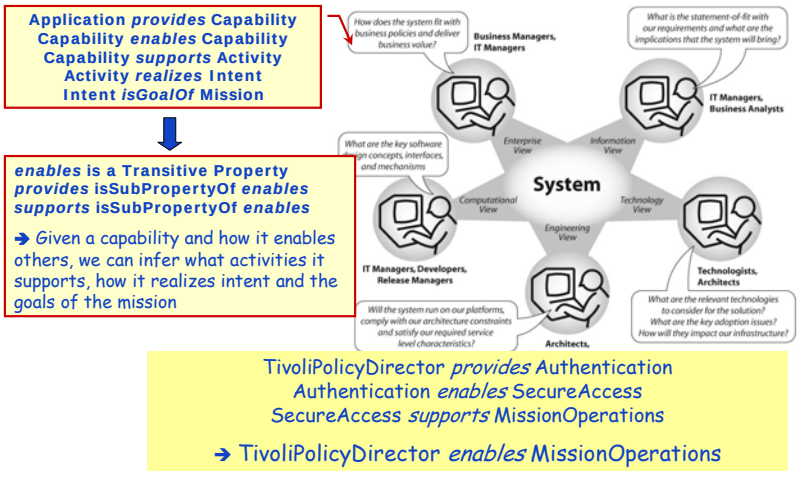


Figure 3: An example of Inferencing in an Enterprise Architecture

These, and other motivations, led to the development of the FEA Reference Model Ontologies, FEA-RMO, in 2004. FEA-RMO is open source and available at the General Services Administration (GSA)'s OSERA web-site (FEA-RMO, 2005).

FEA-RMO is a number of ontologies built using the W3C standard Web Ontology Language OWL. The FEA Reference Model Ontology architecture mirrors that of the FEA RM itself, that is, the Performance Reference Model (PRM) organizes the overall architecture, making reference to the other models as needed. The Business Reference Model (BRM) draws upon the Service Reference Model (SRM), the Data Reference Model (DRM) and the Technical Reference Model (TRM). In representing these models a recurring design pattern which we named the "*Class-instance Mirror Pattern*" was found to be essential for representing the reference models.

The table below indicates some of the concepts used in the FEA-RMO. Note that, because of changes that were underway, the DRM was not modeled at the time of this work.

Table 1: FEA-RMO Ontologies

Model	Ontology	Example Concepts
Performance Reference Model	PRM	Measurement Area Measurement Category Generic Indicator
Business Reference Model	BRM	Business Area Line of Business Sub-function
Service Component Reference Model	SRM	Service Domains Service Type Component
Technology Reference Model	TRM	Service Area Service Category Service Standard Service Specification
Data Reference Model	DRM	*Out of Scope*

FEA-RMO also includes a model, the FEA Core Ontology that is not explicitly called out in the FEA RM, where concepts and properties common to all the reference models are defined. This provides modularity to the ontology design that allows for simplified maintenance and integration of the models.

More information on FEA-RMO can be found on the web (Allemang et al., 2005a), and also in a technical paper published in the International Semantic Web Conference (ISWC) 2005 Proceedings (Allemang et al., 2005b).

4. THE E-GOV ONTOLOGY

A candidate application of the FEA-RMO is a system that can advise agencies on who has or intends to have what capabilities in support of services within lines of business. Such a system needs the FEA-RMO but also an ontology about agencies, initiatives, programs and capabilities. This was the motivation for the E-Gov Ontology, referred to in short as EGOV.

The starting point for EGOV was a model of US Agencies and their bureaus and offices. Finding a current list of all the US Agencies and their bureaus and offices was not easy. At the time of the project the best source turned out to be a site at Louisiana State University (LSU Libraries, 2003).

A small RDF graph, with about 3 concepts and 4 properties placed at each agency, would have solved this problem. The remark "*A little RDF goes a long way*", attributed to Professor Jim Hendler, is very apt and in fact was a motivation to see this as an ideal application of RDF. Placed on a server at each agency, the small RFD graph could be populated with instance triples. Aggregating these triples using an RDF crawler would then produce the bigger picture of all offices of all agencies of government.

Getting all the agencies to adopt RDF is of course no easy matter. Nonetheless, this graph is at the heart of the eGOV ontology and is ready to be deployed to realize this vision.

The ontology model goes beyond this simple graph and Figure 4 shows an overview of some of the main concepts that drive the *FEA Capabilities Advisor*. Some relationships have been simplified to simple "*has*" links. In the real model, relationship naming and relationship qualification (in particular, inverse, transitive and sub-property qualifiers) is very important to support inferencing.

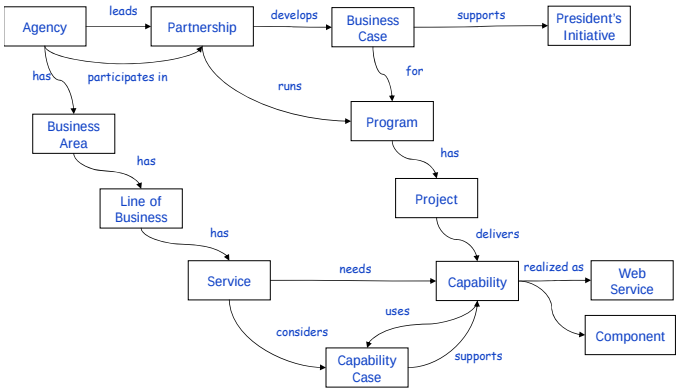


Figure 4: Some Classes in the Capabilities Advisor Ontology Model

It is rarely a good idea to have one large ontology and a number of OWL ontologies are involved in the *Capability Advisor* system. Some dependencies of the Ontology Architecture are depicted in Figure 5.

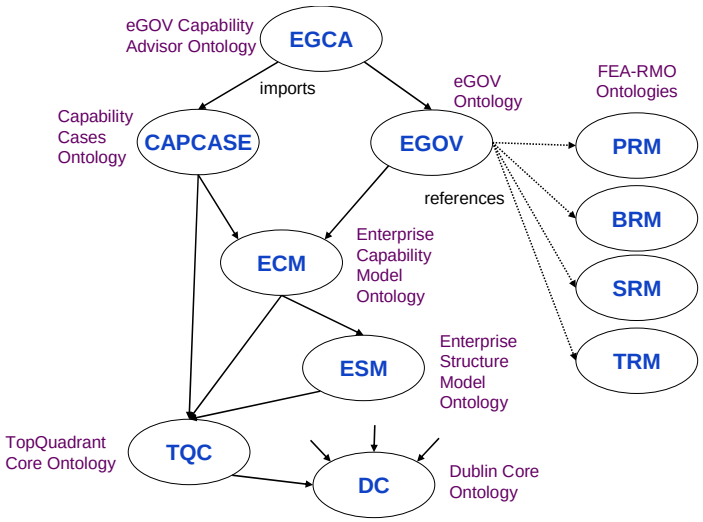


Figure 5: Ontology Architecture of the FEA Capabilities Advisor

Dependencies to other ontologies are also listed in Table 2. The *eGOV Capability Advisor Ontology*, EGCA, is an application-level ontology whose main purpose is to import the EGOV Ontology and the *Capability Cases* Ontology.

Table 2: FEA Capabilities Advisor Ontologies

Domain	Ontologies	Example Concepts (*properties*)
e-GOV Ontology	EGOV	Agency, Bureau, Partnership
Capability Case Ontology	CAPCASE	Capability Case, Solution Story
Enterprise Capability Model	ECM	Capability, Challenge, Force, Goal, Initiative, Measure, Mission, Objective, Strategy
Enterprise Structure Model	ESM	Association, BusinessArea, Company, Consortium, Department, Division, GovernmentBody, Institution.
TopQuadrant Core	TQC	Artifact, Activity, Organization, Resource
Dublin Core	DC	*contributor, coverage, creator, date, description, format, identifier, language, publisher, relation, rights, source, subject, title, type*

A common pattern in the modeling has been to make use of OWL restrictions to enable the OWL Reasoner to do efficient classification. In many cases, the reasoning required is graph traversal. An example of graph traversal is shown in Figure 6, where the so-called "Line-Of-Sight" between entities of the Enterprise can be inferred from the ontology models.

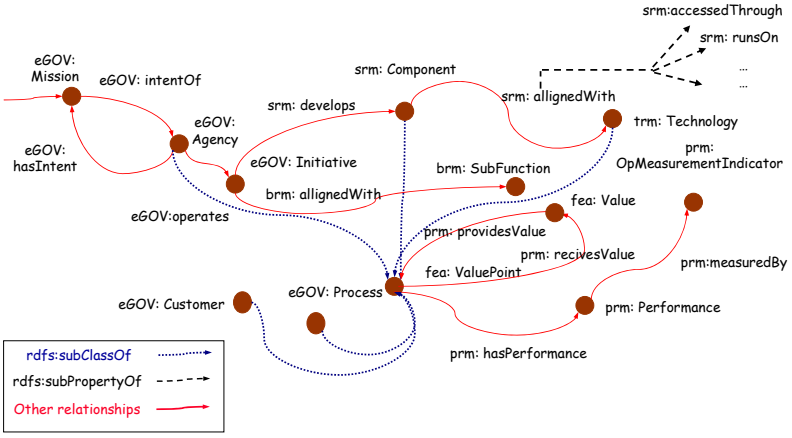


Figure 6: How "Line-Of-Sight" is enabled by the FEA and eGOV Ontologies

5. EGOV FEA-BASED CAPABILITIES AND PARTNERING ADVISOR

The *Capabilities Advisor* uses a semantic engine driven by Ontologies to advise different stake-holders on the capabilities that are available or are being developed to support the Federal Enterprise Architecture and the President's e-Government initiatives.

The system was envisioned as a set of capabilities accessible through WEB Services that would allow agencies, other governments, businesses, and citizens to make queries about the FEA model, to find capabilities that support agency services, to be advised of relevant partnerships, and to assess compliance of their agency business models and architectures with FEA models.

5.1 Motivating User Scenario

One proposed use of the *Capability Advisor* is a "*Business Case Constructor*". This idea is well aligned to government imperatives to have more effective business cases from agencies and better system support for business case decision support. Through such a system, redundancy, compliance, overlaps and opportunities for synergies across business cases could then be assessed.

In FY04, agencies' capital asset plans and business cases required a demonstrated capacity for collaboration across agencies. In support of this requirement the *Capabilities Advisor* focused on improving quality of agencies' business cases (Exhibit 300) by providing them with:

- Project-specific guidance for completing forms (Exhibit 300 and Exhibit 53)
- Information on how their project needs to comply with the FEA
- Knowledge of what related initiatives exist and who can be candidate federal, state and local partners for their project

For the Office of Management Budget (OMB) the *Capabilities Advisor* provides business management insights. For example, the system could provide insights into how the OMB process was being followed, the reasons and patterns of conformance issues and how different projects may relate to each other. In this way, the system

focuses on improving the quality of agencies' business cases[2] by providing them with:

- Project-specific guidance for completing forms (Exhibit 300 and Exhibit 53)
- Information on how their project must comply with the FEA
- Knowledge of what related initiatives exist, and candidate federal, state and local partners for their project

For the Office of Management Budget (OMB), the system provides business management insights such as how OMB process is being followed, the reasons and patterns of conformance issues and how different projects may relate to each other.

For business case authors, the system helps with questions such as:

- Who can be candidate federal, state and local partners for my project?
- How do agencies integrate their business cases with FEA?
- How do agencies develop the credible commitments, risk mitigation, and foresight in contracting needed to develop successful business cases?
- What are the new roles and relationships that central agencies, such as GSA, must explore to leverage government wide progress?

5.2 Design of the FEA Capabilities Advisor

The system uses *Capability Cases* as a way to communicate the value of potential IT Capabilities (Polikoff et al., 2005). A *Capability Case* is a way to express aspects of a solution through stories of real (or envisioned) use within a business context. Capability Cases are a way to do requirements that allows business people, technical people and other stakeholders to identify with the emerging solution. Upstream from Use Cases they support the conversation about "*what the system should be"* as opposed to "*how the system will work"*.

Figure 7 shows the US President's eGOV initiatives as depicted in the *Capabilities Advisor*. The system is ontology-driven and uses a Datalog engine, RDF Gateway from Intellidimension[3], to drive the web screens and to reason over user actions. On the left is a browser that shows those concepts in the ontology that have been tagged as

[2] In the US, an agency's business case for budget allocation is submitted on an "Exhibit 300" form.

[3] RDF Gateway is a platform for the Semantic Web from Intellidimension, on the web at www.intellidimension.com.

"*browsable*". The figures in parenthesis are the number of instances of each class in the system.

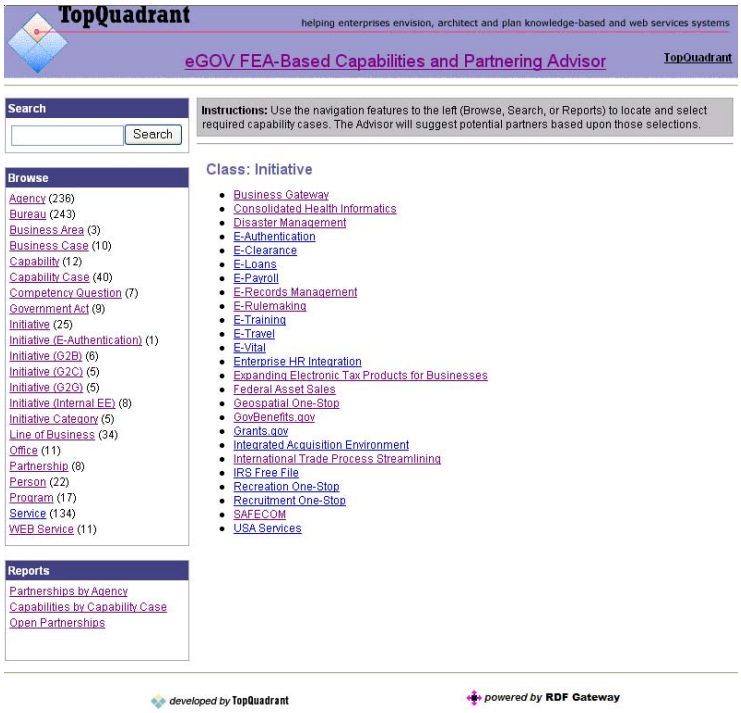


Figure 7: The 24 President Initiatives in the Capability Advisor

Clicking on a class displays a list of instances. Clicking on an instance provides a detailed view as illustrated in Figure 8. The *Business Gateway* Initiative is described along with links to enabling capabilities and to the IT program that is realizing the initiative.

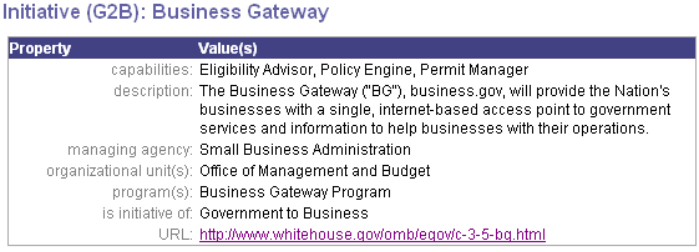


Figure 8: The Business Gateway Initiative

By following the link to the "*Eligibility Advisor*" Capability, the details of that capability appear, along with links to where else the capability is applicable, see Figure 9. These are links inferred through the "*inverseOf*" property.

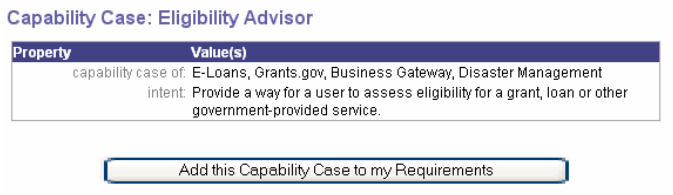


Figure 9: The Capability Case "Eligibility Advisor"

The "*Add*" buttons acts in the metaphor of a shopping cart and allows the system to suggest potential partnerships. As each capability is added, the list of possible partnerships is updated, as illustrated below in Figure 10.

The system finds partnerships by following relationships in the model. Given a *Capability Case* the system can find *Capabilities* that are enabled. Each *Capability* is linked by to an IT *Program*. From the IT *Program* the *Partnership* can be discovered. Many of these links

are *inverse* properties in the model.

Figure 10: Selected Capability Cases and Suggested Partners

The rule, written in the RSL scripting language of RDF Gateway, is shown below in Figure 11

```
function getSuggestedPartners()
{
 var ds = session.contents["data"];
 var rs = (select ?a ?al ?b ?bl ?c ?cl ?d ?dl
        using #ds, fea_full
        where {[rdf:type] ?a [ex:SelectedCapability]}
        and {[rdf:type] ?a [CapabilityCase]} and{[rdfs:label] ?a ?al}
        and property("realizesCapability", ?a, ?b)
              and {[rdf:type] ?b [Capability]} and {[rdfs:label] ?b ?bl}
        and property("isImplementedBy", ?b, ?c)
              and {[rdf:type] ?c [Program]} and {[rdfs:label] ?c ?cl}
        and property("hasPartnership", ?c, ?d)
              and {[rdf:type] ?d [Partnership]} and {[rdfs:label] ?d ?dl}
        order by ?dl);
 return rs;
}
```

Figure 11: Example of an RDF Gateway rule, 'getSuggestedPartners()'

Capability Cases are either realized as components or as Web Services. Some envisioned Web Services are listed in Figure 12.

Class: WEB Service

- Find a Capability
- Find a Service
- Find an Agency
- Get Status of a Business Case
- Get Status of a Grant Application
- Get Status of a Loan Application
- Register for a Loan
- Submit a Business Case
- Subscribe to a Capability
- Unsubscribe to a Capability
- Verify Policy

Figure 12: Web Services listing in the eGOV Capability Advisor

By associating Web Services with the eGOV and FEA-RMO ontologies a much richer directory service can be implemented.

The FEA-RMO Ontologies have been used to build a prototype of an ontology-driven FEA Registry (TopQuadrant FEA Registry, 2005).

A working prototype of the Capability Advisor can be accessed on the Web (TopQuadrant eGOV Capability Advisor, 2006).

6. CONCLUSIONS

The entire development process for the ontologies of FEA-RMO and the *FEA Capability Advisor* took just about three months, from project inception to delivery, confirming that it is possible to deliver semantic technology solutions in short time frames. A key to this speedy development was a good starting point; the published FEA RM. Although it was developed and delivered as a natural language publication, FEA RM was highly structured and quite consistent. Along with the use of ontology design patterns, this allowed the modeling process to proceed smoothly and with minimal ambiguity.

RDF as a foundation technology provided a great deal of the functionality needed to support distribution of the models in a coherent and semantically consistent way. The role of OWL was more subtle. While the reasoning capabilities of OWL were essential in allowing the models to express the appropriate constraints between the elements, the actual reasoning capabilities required were considerably less than those specified in the OWL standard (Patel-Schneider, Hayes, Horrocks (ed), 2004).

Reasoning could be achieved with a simple reasoner for RDFS reasoning, combined with A-box reasoning on inverses, transitive properties, and *owl:hasValue* restrictions. This reasoning can be handled quite easily by technologies such as Rete (Forgy, C, 1982), Datalog (Ceri, S., Gottlob, G., Tanca, L., 1989), Prolog (K. L. Clark and F. G. McCabe, 1982), and need not make use of tableaux algorithms. This suggests that perhaps other reasoning strategies could have considerable applicability in the semantic web.

The FEA-RMO project suggests a whole area of applicability of semantic web technologies. Enterprise Architecture is by its very nature a distributed knowledge capturing problem and needs technologies that can support the aggregation of knowledge held in different locations. The features of the FEA Reference Model that made RDF/OWL so appropriate (distribution of modifications, the need for modifications to be able to specify just what part of the model is being modified) applies to reference models in general, not just the FEA RM.

The *FEA Capabilities Advisor* has demonstrated the power of inferencing in supporting portfolio management across agencies. In any reuse initiative that attempts to save money through collaboration, having timely and accurate information, is crucial for efficiency and effectiveness. The appeal of this pilot project is how the federation of simple OWL models can enable an up-to-date representation of the structure, services and IT capabilities of government agencies. Using semantic technology enables a federated approach to IT Portfolio Management.

7. QUESTIONS FOR DISCUSSION

Beginner:

1. What is an Enterprise Architecture?
2. How might an Enterprise Architecture help an organization be more efficient, effective and innovative?
3. Mention was made in the paper about the power of traversing graphs to make connections across concepts in the model. Consider what connections within and across enterprises would be interesting to make and discuss how they may be supported by EA ontologies.
4. What aspects of an Enterprise might you want to model? Which aspects of an Enterprise should be left out of a model and why?

Intermediate:

1. In a project involving multiple ontologies, what factors influence how you determine which concepts reside in which ontologies?
2. When ontologies need to be re-factored, how might concepts and properties from one ontology be migrated to another? In addition to the concepts, what other modeling constructs would need to be moved?
3. What are the alternative ways to model an Enterprise Architecture? How do they compare with the ontology approach?
4. How could a Federal Enterprise Architecture improve government services at the state level? What role could the Semantic Web play?

Advance:

1. Referring to Figure 6: Suppose that a component named Atlas is *alignedWith* technology "J2EE". What else can you say about Atlas and J2EE, based on the semantics of RDFS and OWL?
2. The Federal Enterprise Architecture has four *subfunctions* under the line of business "*education*", "*Cultural and Historic Exhibition*", "*Cultural and Historic Preservation*", "*Elementary, Secondary and Vocational Education*", and "*Higher Education*". The EPA has a charter to provide information to the population about environmental factors that affect their health and well-being. What extra sub-functions might the EPA want to add, under the line of business "*Education*"? What other agencies might also provide services that operate under that same sub-function?
3. Information modularity and reuse are good engineering practices. Why did the eGov initiative require a Presidential Order? What forces might have prevented the agencies from cooperating in the absence of the order? Which of these forces are particular to government, and which ones could be a factor in other semantic application areas?
4. What aspects of an Enterprise would need to have rules in addition to OWL?

Practical Exercises:

1. Explore the FEA-RMO Ontologies using an ontology editor (e.g., Protégé, or SWOOP).
2. Browse the FEA Capabilities Advisor prototype at http://www.solutionenvisioning.com/tq/prototype/eGOVAdvisor. Use the "*Capability Cases*" to look for partnerships.
3. Run the FEA Ontology-Based Registry demonstrator, FEA-RMO, at http://www.solutionenvisioning.com/tq/prototype/FEARMO.
4. Visit the US government official list of executive agencies at http://www.loc.gov/rr/news/fedgov.html. What capabilities can you think of that could be shared between different agencies? Try the same thing with governments of other countries. Could capabilities be shared from one government to another?

8. SUGGESTED ADDITIONAL READING

- Antoniou, G. and van Harmelen, F. *A semantic Web primer.* Cambridge, MA: MIT Press, 2004: An excellent introduction to Semantic Web languages.
- The FEA-RMO papers provide more insight into how the ontologies were modelled (Allemang et al., 2005a, 2005b).
- The FEA-RMO Ontologies themselves may make interesting reading. These are on the Web at the following URLs:

FEA - http://www.osera.gov/owl/2004/11/fea/FEA.owl
BRM2PRM - http://www.osera.gov/owl/2004/11/fea/BRM2PRM.owl
PRM - http://www.osera.gov/owl/2004/11/fea/prm.owl
BRM - http://www.osera.gov/owl/2004/11/fea/brm.owl
SRM - http://www.osera.gov/owl/2004/11/fea/srm.owl
TRM - http://www.osera.gov/owl/2004/11/fea/trm.owl
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- Polikoff I. and Coyne R.F., "*Towards Executable Enterprise Models: Ontology and Semantic Web Meet Enterprise Architecture*", Journal of Enterprise Architecture, Fawcette Publications, August 2005: gives a more detailed coverage of enterprise architecture models.
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