THE REINFORCED ENTERPRISE BUSINESS ARCHITECTURE (REBAR) ONTOLOGY

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ABSTRACT
Understanding organizations and their needs for new technology has never been more challenging than in today's high-tech business world. Enterprise managers are required to coordinate with other departmental managers, direct their personnel and solve problems along the way. Communicating new designs to IT for needed applications may not be in the manager's skillset. When the enterprise grows rapidly or tries to compete in new areas, a set of basic diagrams illustrating common workflows may no longer accurately reflect the complex environment. What is needed is a simple method for illustrating the enterprise as a whole, interoperable structure so managers and workers alike can describe their requirements in the unique vocabulary of their industry. REBAR offers a novel approach for using key strategic and operational business documents, written in natural language, as the basis for the formal enterprise ontology. Popular semantic web standards, including RDF, FOAF and DC, provide generic terms already designed to convey the subject–predicate–object structure of natural language in a social structure. The REBAR enterprise ontology extends these existing standards, thus evolving a socio-technical model of the functional organization distilled directly from existing enterprise documents. REBAR captures the essence of the unique enterprise in a graphical application that can be queried and dynamically recombined to illustrate details of complex workplace collaborations. An enterprise ontology should unite all defined departmental functions authorized by executive enterprise managers. Additionally, findings indicate the REBAR ontology has the potential to provide a reusable structure for linking core social business functions of the enterprise to other explicit enterprise knowledge, including policies, procedures, tech manuals, training documents and project metrics. The REBAR methodology offers evidence that the enterprise is more than the sum of its parts, it is the bridge unifying explicit and tacit knowledge during work projects across the entire enterprise.
Keywords: business plans, enterprise, knowledge management, ontology, semantic web, strategic goals, systems engineering.

1 INTRODUCTION

This paper proposes an enterprise ontology solution that can extract enterprise organizational models from the natural language document enterprise owners and executives implement as their strategic and business plan documents. Reinforced Enterprise Business ARchitectures (REBAR) provides formal, reusable models suitable for developing requirements for interoperable systems that support the entire enterprise.

1.1 Background

In 2009, President Obama issued Executive Order 13520 [1] declaring a focus on reducing improper payments government-wide and eliminating waste and fraud in all government programs through better tracking of government spending and more transparency in the administration of government dollars. Federal agencies are encouraged to analyze their existing rules and strive to achieve greater coordination across agencies to simplify and harmonize redundant, inconsistent, or overlapping requirements, thus reducing cost. To this end, the Government Accounting Office (GAO) [2] is taking on, as its responsibility, the task of pointing out the good, the bad and the ugly of federal technology while providing constructive criticism to help agencies dealing with the highest risk technology investments. US Chief

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Information Officer recommends expanding the awareness that these initiatives exist. 'So much of what we do in federal IT is in stovepipes and what we need to do more is leverage existing contracts more – sometimes within an agency,' he said.

2 ANALYSIS OF ENTERPRISE GOALS

Program managers would probably choose to skip building enterprise architecture models of their projects and go right into the system development cycle. Many project managers claim they already know what is wrong with the current system and where it needs to be more efficient. However, because technology vendors want to know the fine details of each process, projects can get bogged down in constructing elaborate, proprietary diagrams.

2.1 Model-based systems implementation

We contend that much of the lack of progress in successfully implementing today's model-based systems engineering methods may be explained by a misplaced focus on detailing numerous how-to activity models. This focus on activities ignores the important elements of who, what, when, where and especially why, that shape and constrain all levels of the enterprise framework: developing, maintaining and facilitating the implementation of a sound and integrated information technology architecture for the executive agency; and promoting the effective and efficient design and operation of all major information resources management processes for the executive agency, including improvements to work processes of the executive agency [3].

Managing a federal program is complicated, and requires that all work that is contracted out is to be managed according to the strict guidelines required by Congress in order to administer the US federal budget. Enterprise models are the blueprints that both program managers and contractors alike can use to agree on a specific set of requirements for the system development project.

2.2 Need for a holistic approach

The role of formal enterprise ontology would be to point to models built during the period of the project as the authoritative reference that should be used as a basis for making decisions on all aspects of the programs (i.e. systems and applications) that follow. However, it is clear from past GAO audits, and other metrics regarding IT project failures, the processes currently used to construct models from bottom-up activity modeling cannot support this claim when scrutinized by independent reviewers. As identified by the audits, core artifacts regarding the enterprise strategic and business levels, which support the agency/segment level mission and business outcomes, are not comprehensive. Instead, models focus on applications, networks and security. While all of these functions are necessary, when built as a separate system, the enterprise will have severe integration problems when attempting to implement the project as a whole. Without a proper foundation regarding the agency/segment level mission and business outcomes, the sub-level architectures will continue to result in stove-piped solutions that do not answer the critical needs of the whole enterprise.

3 ONTOLOGY AS AN APPROACH TO UNDERSTANDING THE ENTERPRISE

An ontology grounded in philosophy is defined as a theory of the nature of existence (e.g. Aristotle's ontology offers primitive categories [4], such as substance and quality, which were presumed to account for *All That Is*). Tom Gruber, a computer scientist at Stanford University, presented a paper in 1993 that formally introduced the analogy of *ontology* to the

computer science community [5]. Gruber described his concept of *ontology* as a technical term denoting *an artifact that is designed for a purpose, which is to enable the modeling of knowledge about some domain, real or imagined* [4]. It conveys rules about terms and how they should be used. For that reason, and because ontology languages such as Resource Description Framework (RDF) and Extensible Markup Language (XML) are open standards, they offer the promise of non-proprietary, and therefore reusable terms. When ontology is referenced by an agent or application, it is reasonable to expect greater understanding and increased communication [6].

3.1 Ontology formality continuum

There appear to be two core components of any ontology: a vocabulary of terms and some specification of meaning for the terms. On one end of the continuum would be lightweight ontologies, such as terms, thesauri, and ad hoc hierarchies, consisting mainly of terms with little or no specifications. At the other end are explicit semantics and mathematical logic. Semantic Web technologies, such as Friend-of-a-friend (FOAF), Dublin Core (DC), XML and RDF, occupy the arbitrary center of the continuum, as they appear to have the potential to bridge the gap between natural language descriptions and the formality required for automated processing of semantics [7]. For example, the mature W3C standard for FOAF [8] has been recognized as a formal yet light-weight Semantic Web ontology. Since computers have difficulties interpreting the common language of human beings and in using contextual cues to resolve them, efforts to develop modeling languages specific to the industry classification still require additional resolution [9].

3.2 Enterprise architectures as ontology

Enterprise architectures have been regarded as the blueprints used to understand and change large, complex organizations [10, 11]. As the complexities surrounding development of business information systems, frameworks that conveyed unique facets of enterprise models were necessary as a way to determine equivalent enterprise views. The Zachman [12] framework, as shown in Figure 1, uses tables to categorize the who, what, when, where, why, and how of architecture viewpoints so that systems engineers could facilitate users' decisions on how to manage technology projects. On the ontology continuum, the Zachman framework would be considered lightweight and informal. While it provides a vocabulary for understanding the various facets of the enterprise change management, it lacks a standard methodology of how to model the architecture within the views. The problem this presents to complex business organizations who attempt to construct enterprise architectures is that *they cannot be read by anyone but the people and programs that created them*, therefore causing the same work to be done over and over again [11].

4 THE NEW ONTOLOGY OF DOCUMENTALITY

The philosophical ontology regarding documentality probes ways in which social reality is created and used [13–15]. The thesis regarding documentality finds that words not only convey information, they *bring new types of social entities into being*. For example, there is no physical manifestation of a debt. It is only after two or more specific humans make a promise that the entity of debt can exist. Left unwritten, that debt relies on human memory for its existence. Documents evolved through time have provided humans a way to make up for short or inconsistent memory, since *a document is something that is able to endure*

ENTERPRISE ARCHITECTURE – A Framework						
Level/ (Owner)	DATA (What)	FUNCTION (How)	NETWORK (Where)	PEOPLE (Who)	TIME (When)	MOTIVATION (Why)
ENTERPRISE Scope (Strategic Mgrs)	Lists, Maps and Rich Pictures					Mission Vision, Goals, Objectives
ENTERPRISE Dept (Owner)	Semantic Model	Business Process Model	Logical Network	Work Flow Model	Master Schedule	Business Plan
SYSTEM (Designer)	Logical Data Model	Application Model	Distributed System Architecture	Human–Interface Architecture	Processing Structure	Business Rule Model
TECHNOLOGY (Builder)	Physical Data Model	System Design	System Architecture	Presentation Architecture	Control Structure	Rule Design
DETAILED REPRESENTATIONS (Sub–Contractor)	Data Defintion	Program	Network Architecture	Security Architecture	Timing Definition	Rule Specification
FUNCTIONING ENTERPRISE	e.g. Data	e.g. Function	e.g. Network	e.g. Organization	e.g. Schedule	e.g. Strategy

Figure 1: Zachman-style framework.

self-identically through time. Ferraris extended the documentality concept as he described how social objects come into existence [16]. He asserts that because *Object = Recorded Act*, the social object that results from a given social act is characterized by being registered on a piece of paper, in a computer file, or in the heads of persons. Documents do not write themselves or file themselves away. Humans intentionally create them, sign them, and save them for later use. Without the possibility of inscription there would not even be social objects, such as stocks, pensions or mortgages [17]. Ferraris further identifies a grand divide between strong documents and weak documents. Strong documents are defined as the actual records that represent the social act itself. Weak documents record facts regarding the social object, but are secondary derivatives. And it is the creation and implementation of the strong enterprise documents that provide explicit governance over the entire enterprise.

4.1 Examples of strong documents

The United States Department of Defense (DoD) conveys enterprise strategic and operational plans in the form of military doctrine that is written at a level of detail general enough to cover numerous mission variations. Yet this library of information is specific enough to convey the requirements that military leaders have agreed are important. These strong documents define authorized social acts, in the form of required communications with various segments of the organization. Included in doctrine are references to inter-governmental and non-governmental organizations, as well as various Federal organizations involved in mission success. As such, doctrine describes the social entities and their networks, with emphasis on authorized and required communications [18]. When the REBAR extension of the FOAF ontology is applied to a sample of Joint doctrine, the model of a diverse and creative organization begins to takes shape. In this way, REBAR models at the strategic and business-level describe the *minimum critical specification* of what is absolutely required, that is, the strong documents that instantiate the enterprise [19].

With this knowledge specifically linked to users' needs and wants, enterprise project managers will be able to accurately describe their requirements, including *hyperlinks back to the specific paragraph* in the document that illustrates *why* these elements are required. This REBAR model is necessary in order to convey not only the technical standards required for new technology, but also governance standards required by law, policy, rules, regulations and the formally accepted culture of the organization.

5 THE LACK OF FORMALITY GAP

It is not difficult to see how detailed process diagrams became the official artifact used to convey what was going on in our organizations currently. The assumption inferred that if workers identified *how* they accomplish work now, vendors could supply technology that would take them to the next level in productivity. While industries that use automation to mass produce precision parts can see benefit from detailed activity study, the practice becomes problematic when, as Zachman recommends, the analogy of the factory system is extended to the non-routine technical system. Sociotechnical systems (STS) theory was applied to engineering around 1982, providing the shift from emphasis on the activity to what results from the action, i.e. the product [20].

5.1 REBAR, the proposed solution

At the strategic and operational levels of the enterprise, governance documents are written [2] in general language so that the directives may still be relevant in a variety of situations. This level of direction dictates *who* is responsible *when* a triggering event occurs, and *what* should be considered at that time.

When a document is implemented in an enterprise, this action effectively authorizes action to occur. Looking at the whole enterprise document library, it becomes clear that the enterprise is a complex social network, relying on interactivity between teams to solve problems within the boundaries set by these governance documents. In order to have utility when used in a variety of situations, details describing the specific activities and tools that support these activities are left out of doctrine. It remains up to the discretion of the well-trained team tasked with performing the activity to collaborate on *how* they will carry out the plan.

5.2 REBAR, the rapid, authoritative, holistic approach

REBAR is a patent-pending process for tagging governance documents with meta-data so they can objectively illustrate the holistic enterprise at its essential level. REBAR follows the standards established by the World Wide Web Consortium (W3C) [21]. The resultant visualizations go well beyond basic cluster diagrams indicative of social network representations. By capturing interactivity between working groups that include what they produce and the implied subjects regarding their collaborations, dynamic threads of communications can be pulled to represent a wide variety of events.

Unique models that depict specific context surrounding events can be dynamically constructed using the REBAR working model builder. These visualizations show actors collaborating together on their enterprise process. They are able to choose from lists of authorized options that satisfy the requirements of the situation. They can then customize their version of the scenario based on specific contextual criteria. These new scenario threads retain links back to the overarching, unmodified strategic or operational policy, goal, or

objective that the project participants are seeking to satisfy. Perpetual linking provides the basis of comparison and a qualitative method for assessing how well the solution achieves the performance goal. The core requirements of the enterprise remain stable and visible throughout the analysis, thus continuing to provide references as justification of the requirement [19].

5.3 Configuration management for strong enterprise documents

Since strong documents at the governance level are maintained using stringent configuration management controls, are regarded as authoritative, and are written to remain in effect for long periods of time, effort required to tag these documents quickly returns a benefit higher than the cost of populating this enterprise knowledge library. The natural language and rich but unstructured pictures of doctrine documents is parsed by personnel trained in using a research technique, namely content analysis. The result was the creation of the interactive, semantic REBAR model methodology. Importantly this model is traceable, that is, each object in the model is linked by a uniform resource locator (URL) back to its original position in doctrine, and can be displayed at the click of a mouse. Functional requirements developed using REBAR references are objective, i.e. they are not influenced by personal opinions, only by authorized written words and rich pictures.

Current enterprise models are built and stored using complex modeling tools. While technically oriented personnel may be able to follow the logic of these models, functional subject matter experts would not be able to review and assess the models produced using these tools. As a result, the models that are supposed to provide the *blueprints* for the future enterprise may not get the reviews and corrections necessary to prevent errors. The REBAR methodology instead offers models built using unique vocabulary of the industry the enterprise already uses on a daily basis. Using the REBAR visual tools for queries expands the utility of the methodology. Enterprise personnel can be given access to techniques for conveying their natural language requirements to their IT providers in a way that makes sense to the most important people on the project, i.e. their sponsors and customers.

6 RESEARCH RESULTS

For this study, the research design directed construction of the REBAR XML schema using W3C Semantic Web standards to capture the essential components of the organization. This schema was then used as a data-coding and collection instrument designed to facilitate content analysis of the selected sample of Joint doctrine. The first-stage analysis culminated in an assessment of the potential of the approach for representing Joint doctrine as a dependable strategic/operational-level enterprise model of Joint force logistics. Using the W3C standards for constructing a schema [22], this process was completed in several iterations.

6.1 Sample application selection

First, the entire collection of Joint doctrine publications in the Joint Electronic Library was examined. Collectively, all publications that are approved for use by Joint Forces would be considered as the holistic description of the mission known as the Department of Defense military decision-making process. The approved Joint Doctrine publication, JP 4-0, *Joint Logistics* was selected as a good sample. It was freely available online, representative of the Library population because it embodies both strategic and operational tenets of Joint doctrine, and includes descriptions of planning, execution and control operations; including those in cooperation with multinational partners and other US Government agencies.

6.2 Schema correction and use

The construction of the XML schema was finalized. It was composed of three classes; organization, agent, and document, from the FOAF standard [23] for the initial REBAR schema. Several FOAF predicates that could also describe types of communication between DoD organizations were selected. For example, the statement 'Agent (is a) *member* (of the) Organization' would represent the block of text in Joint doctrine stating the Secretary of Defense (is a) *member* (of the) Office of the Secretary of Defense.

The FOAF standard uses the predicate *knows* to indicate linkage between two organizations. However, when scanning various blocks of text in doctrine, it became clear that communications between organizations were of a more intense nature than mere acknowledgement. Accurately representing Joint doctrine that assigns required tasks or requests urgent information necessitated more descriptive predicates. Also, in some cases, the directionality of communication is described in doctrine, indicating message traffic flow. Therefore, in order to represent the text *as written* in doctrine, several predicates were added to the REBAR schema, including *sendMessageTo* and *receiveMessageFrom.* Having several ways to represent doctrine-implied communication proved useful for replicating authorized directives to accurately convey their meaning. For example, the block of doctrine text that indicates ongoing collaboration between two organizations is represented by the use of both *sendMessageTo* and *receiveMessageFrom* predicates. This dual-predicate use serves to characterize continuous communications when this is what is implied by doctrine.

6.3 Resolving missing elements

While assessing the use of FOAF standards in an early draft of the REBAR schema, the researcher noticed there was no way to communicate *what* the teams were exchanging information about, other than to link to their *workplaceHomepage*. The researcher resolved this dilemma by constructing *message* as a type of Document that could convey topics. Since *message* is a type of document, the attribute *type* was added to the REBAR schema Document class. By adding the attribute *type,* doctrine text that describes a planning document is referred to as *type* = *document*, while a document that is a message is referenced as a document *type* = *message*. In the REBAR schema, the predicate *title* that is associated with Document is now coded as the message subject line, while the predicate *description* is coded to signify the word-for-word description referenced by doctrine.

The document type *message* is useful for illustrating two aspects of Zachman's enterprise architecture taxonomy. First, the act of receiving a message can trigger some event, that is, *when* the message is received, something needs to happen. Second, doctrine also describes *what* should be done in response to events, or triggers. These details of doctrine text are conveyed as the message *title* and *description*, directed at Organizations who are required to act *when* these events occur.

6.4 Validating presence of event descriptions

The researcher also noticed that Joint doctrine describes various events using action verbs. In Joint doctrine, the actions are described in general language; i.e. no specifics are used to describe *how* to perform *what* needs to be done. This observation confirmed that the REBAR approach was appropriate for uncovering important triggers and events described at the

enterprise strategic- and operational-levels while also providing rules for parsing doctrine text describing actions.

Adding the implied message title and specific message description adds the formality required for more precise search descriptions. For example, when personnel want to search through procedural documents or tech manuals to find the details regarding *how* to accomplish a task, the REBAR message metadata provides more precise search returns from online libraries the enterprise has processed using current rule-based artificial intelligence (AI) technology. REBAR has the potential to eliminate a good portion of the tedious work personnel must perform in order to *train* off-the-shelf learning systems for use with their specific enterprise content.

The amount of text that could be coded during content analysis using the REBAR schema increased substantially when the message *type* was added to the data collection schema. There were several other changes and additions made to the initial version of the REBAR schema based on execution of the research design. The following modifications served to refine it for use as the prototype: xReference – the third *type* of Document class. This attribute represents documents that are cross-referenced in doctrine for more information about the topic described, and swimlane – an attribute that describes the level of hierarchy of an organization.

6.5 Research – in summary

Stage one of the research was designed to provide answers to the research question, that is, *what are the most significant factors to consider when translating authoritative text and rich pictures into semantic models*? To start with, a representative sample of Joint doctrine was selected. Then the REBAR schema, based on the FOAF standard, was developed in iterations. The FOAF standard was extended with several new predicates so that the text *as written* in Joint doctrine could be accurately represented. An important discovery was made while developing the schema. It became apparent that service-provider organizations react to events that trigger certain responses. Therefore a message type of document object was created to handle event descriptions. Once the instructions for defining this message object were added to the parsing instructions, the amount of doctrine text that could be categorized using the REBAR schema increased greatly. The process for parsing sample documents was reevaluated periodically and revised to include more specific details that would make the parsing process less subjective. Also, acceptable criteria for parsing certain Joint doctrine blocks of text and rich pictures, such as how to identify key words as used in tables of contents, overviews and summaries; were added to the parsing instructions.

7 VISUALIZATIONS

Once the completed XML document is saved to the server, it can be made available to authorized users. As shown in Figure 2, the digital library for the enterprise can be viewed as web pages. Queries in the form of logic statements regarding various teams within the parent organization are displayed based on selections the user wants to research. Organizational descriptions, memberships, work products, communications and collaborations are linked together to show specifics regarding both details and references back to the original document block.

Along with interesting profiles of the teams, came the emergence of the knowledge structure of the enterprise. Cross-referenced documents became visible, and access to documents was facilitated by direct links to portable document formant (PDF) so the user could examine the reference on the spot. Document cards and documents chart visualizations started to show

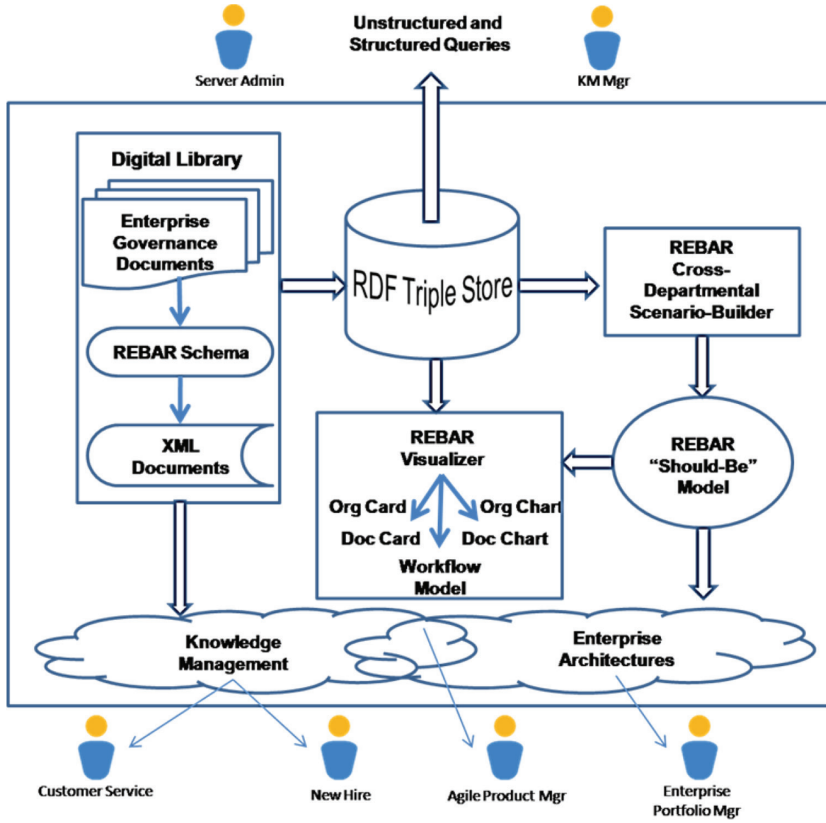

Figure 2: REBAR digital library.

links from the Joint doctrine strong documents to weaker derivative documents, such as Universal Joint Task Lists (UJTLs), Joint Capability Areas (JCA), and Joint Staff policies, plans, procedures, lessons learned and more. Growing the enterprise digital library of documents as linked sets was another happy surprise.

Natural language processors, such as IBM's cognitive AI application Watson, identify methods for *training* an installed instance of the application. This involves humans feeding search terms into the application and then verifying or correcting Watson's response. It would seem that the meta-data provided during the parsing phase of populating a REBAR digital library would provide a good start on the training an application like Watson needs.

8 CONCLUSIONS

Changing the approach from activity-focused models to collaboration and communication visualizations of the enterprise organization unleashes powerful parallels to social network metaphors. Stove-piped solutions that produce islands of technology can be avoided by employing better enterprise change planning. When innovative solutions are sought in answer to complex conditions and an array of standards, strategic and operational governance has proven its value as guidance to its users. It promises no less when used to form the adaptable and flexible ontology of the entire enterprise organization, including valuable links to the many diverse organizations that make up the complex enterprise. The REBAR methodology

produces models at the strategic and business-level of the enterprise. As an example, the DoD provides strong documents in the form of military doctrine, DoD policy, procedure, laws, rules, regulations and other documents that it keeps current and makes available to it personnel. Because they are written in natural language, strong documents are difficult to query using intelligent, semantic web tools. The REBAR methodology offers a corresponding formal semantic model that enables users to interact with the mission threads discussed in authoritative documents, and produce dynamic models of the challenges they face as they work to implement that guidance as they carry out their mission assignments. While there are numerous uses for this concept in both military and non-military institutions alike, the REBAR methodology was developed to provide a new means for making sense of complex enterprise organizations. Because of the formality of REBAR, it is possible that derivative documents could be processed by automated applications using the parsed REBAR metadata. And considering that many participants in the enterprise become expert in performing only a unique part of the mission, it is important to always be able to research and understand the organization as a whole.

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