ENABLING AN ENTERPRISE MODEL REPOSITORY

Lawrence E. Whitman and Danny Santanu

Industrial & Manufacturing Engineering Department, Wichita State University

Abstract: Due to the confusion of model contents and use, the reuse of existing enterprise models is limited. The inability for various aspects of an enterprise to be aware of its existing models, further exacerbates this problem. This paper presents an approach to integrating models and then proposes a methodology that will significantly aid in the comparison and evaluation of various enterprise models. This will lead to an enterprise-wide enterprise model repository. Two sample enterprise models are represented using the methodology. A direct benefit is the potential for increased model reuse.

Keywords: Enterprise integration, Enterprise modelling, Architectures.

1. INTRODUCTION

1.1 Enterprise Models.

An enterprise model is defined as "a symbolic representation of the enterprise and the things that it deals with. It contains representations of individual facts, objects, and relationships that occur within the enterprise" (Presley, 1997). The above definition entails the kinds of items that are of interest to the modeller. The use of symbols to represent the enterprise presents these facts, objects, and relationships in an easy to understand manner. According to Frasier (1994), Enterprise Modelling enables:

- Serving as a mechanism for the analysis for design implementation at strategic, tactical, and operational levels.
- Providing decision support by providing access to required information, simulation of alternatives, and real time implementation of decisions.
- Providing a competitive edge - The company that has an enterprise model will be able to react faster than its competition and gain a competitive advantage by studying the behavior of the organization based on changes in the environment.

An enterprise model can be a tool for understanding how a person in a cross functional team can quickly comprehend information and see the big picture to make decisions. An enterprise model can aid in visualizing the handoffs between the processes clarifying important relationships" (Burton and Pennotti, 2003).

1.2 Multiple Views.

The key to success of business process is the ability to manage change from the customer and from the organizational boundaries (Davenport and Short). The variety of views and scheme can assist the decision maker to make decision a lot easy and faster. A number of different views have been defined by previous researchers. The Computer Integrated Manufacturing Open Systems Architecture (CIMOSA) work promotes four views: Function, Information, Resource, and Organization (Vernadat, 1992). The Zachman Framework of 1987 (Zachman, 1987) was extended by Sowa in 1992 (Sowa and Zachman) and describes data (what), function (how), network (where), organization (who), schedule (when), and strategy (why) as the dimensions that must be described. Curtis, et al. (1992) define four views: functional (what process elements are being performed, and what flows of information entities are relevant to these process elements), behavior (when process elements are performed (sequencing)), organizational or resource (where and by whom processes are performed, physical communications mechanisms, storage media and locations), and informational (what information entities produced or manipulated by the process, including data, artefacts, products, and objects). ARIS (Architecture of Integrated Information Systems) also has four views. The three main views used are data, function, and organization. Depending on context (information or business system) the fourth view is either called the resource or control view (Scheer, 1994). Previous work in the development of architectures by the Automation & Robotics Research Institute (Presley, et al. 1993) describes a five-view approach which will be used for this paper:

- Business Rule (or Information) View defines the entities managed by the enterprise and the rules governing their relationships and interactions,
- Activity View defines the functions performed by the enterprise (what is done),
- Business Process View defines a time-sequenced set of processes (how it is done),
- Resource View defines the resources and capabilities managed by the enterprise,
- Organization View describes how the enterprise is organized which includes the set of constraints and rules governing how it manages itself and its processes.

Having five different perspectives for viewing a single model can reduce the complexity and provide a real advantage for the user, especially where there is much change, and where a quick decision must be made. The integration of different views is vital to achieving a complete representation of the enterprise. This does not, however, mean that all these views must be present in all models. A model is an abstract representation of reality which should exclude details of the world which are not of interest to the modeller or the ultimate users of the model. Models are developed to answer specific questions about the enterprise. However, multiple views provide a clearer picture of the enterprise and multiple views are useful to answer multiple questions about the enterprise.

1.3 Categories of Processes.

Presley, et al., (1993) propose that business processes may be placed into three categories: (1) those processes which transform external constraints into internal constraints (set direction), (2) those processes which acquire and make ready the required resources, and (3) those processes which use resources to produce enterprise results. By providing categories to organize processes, more holistic enterprise designs may be achieved. The business processes are organized into an enterprise represented by the larger box. At this high level of abstraction, the enterprise itself is represented as an activity that takes inputs and transforms them into outputs using available resources under the bounds of a set of constraints. Figure 2 shows activities (boxes) arranged into business processes (ellipses).

Frequently, the only activities or processes considered in modelling and improvement activities are those listed as category 3 which transform inputs into products and services. However, it is as important to consider the strategic and acquisition activities in an enterprise. Understanding the different process categories is vital to develop useful representations. Categorizing the different processes helps to ensure that the frequently overlooked categories of setting enterprise direction and acquiring and preparing resources are considered.

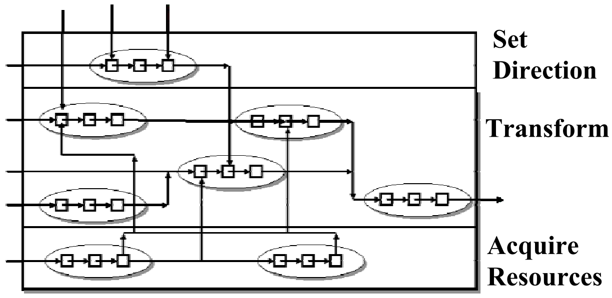

Fig. 1. Categories of Processes.

2. MODELING APPROACHES

2.1 Definitions.

In the Introduction to Enterprise Integration Modeling, Petrie describes three approaches to model integration. These approaches are called, Master Model, Unified Models, and Federated Models. These approaches have been modified and applied to a specific form of model integration, that of view synthesization. This section describes these approaches applied to this research as:

- Master view approach – This approach attempts to define all the required information in a single view and then feed the other views from this view. A key component of this approach is the concept that any changes may be made in the master view and then the other views are regenerated from this view. This approach can create a very large master model as all information must be included in this single model (an example of this approach may be found in (Whitman, et al., 1997).

- Driving approach – This takes a more global approach and then extracts information from different models to form a meta-model that contains all required information. This approach is similar to the master view approach except that the driving approach does not expect a single view to contain all relevant information about an enterprise. The driving approach chooses the largest content view, populates it, and then attempts to populate the other views from that information. Presley (1993) and Kim (1995) provide two examples of this approach.

- Federated approach – Federated means that information is gathered in its native format and then placed in other formats. The federated approach is similar to the driving approach except that it allows the iterative population of each view while maintaining consistency between views. The driving approach assumes that one view contains the driving knowledge and then additional knowledge is added in the other views. This requires all information to be added to the master view. The federated approach allows the user to populate each view as information becomes available in that view. The advantage of this approach is that it allows the addition of knowledge in the view most conducive to the form of knowledge captured. For example, if process knowledge is captured then knowledge can be placed in a process view and then populated in the other views. This makes the approach ensure the consistency between views rather than requiring the user to determine how to enter information in the master view. This method is highly tool dependant. The rigor of the tool capability in ensuring the proper mapping between views is critical to the success of this method.

2.2 Issues.

Equifinality was described by Von Bertalanffy (1968) as different paths leading to the same result. This is the ultimate goal of a modelling approach. If the approach is well defined, in theory different modellers with different backgrounds would arrive at the same model. However, according to Vernadat (1996), "If a part of an enterprise is modelled separately by 20 different modellers, we will come up with 20 similar but different models."

By promoting awareness of models within an enterprise, the methods for creating and using the models will progressively mature. This paper presents a method for cataloguing the models within an enterprise, enabling model reuse and aiding the understanding of the breadth and depth of models available.

3 ENTERPRISE MODEL CHARACTERISTICS

A living enterprise model must have the following characteristics to be effective (Whitman and Huff, 1997):

Maintainable. A key feature of the model is that the model accurately represents the enterprise at all times. Enterprises change, therefore the model must change. The model must be easily extended to incorporate changes to one aspect of the enterprise, and those changes must be easily incorporated. This leads to the question of a "top-down" or a "bottom-up" approach. The "top-down" approach leads to a more holistic model. The "bottom-up" approach tends to allow for the modeling of an aspect of a system and then connecting the various components as they are validated.

Dynamic. Again, as the system changes, so must the model. Most enterprise models are static. A living model of the enterprise must change as the system changes. It must also provide important information on both the rate of change and the reason for change.

Expandable. The model must also support the addition of new subsystems. Especially in phased implementations, additional aspects of the enterprise will be assimilated into the living model of the enterprise. Therefore, it is imperative the modelling methodology be expandable to include these new models.

Decompositional. Models currently provide multiple levels of detail. This is primarily to provide understanding of the enterprise by various levels of management. The living model of the enterprise must support not only the understanding, but also the decision making and control of the system at various levels of detail.

Consistent with key enterprise metrics. One of the primary goals of a living enterprise model is to ensure that the model has intrinsic value. By creating the model to be consistent with current enterprise metrics, and even creating the model to drive the metrics, the model becomes an integral part of the enterprise.

Driven directly from actual enterprise data. The inputs to and the outputs from the living enterprise model must be actual data from the enterprise. The model must drive the enterprise and the enterprise must drive the model. This ensures model realism and 'believability.'

The dimensions of living enterprise models are proposed. Combining the like features of the requirements listed, three dimensions of a living model of the enterprise are identified (Whitman and Huff 1997). The decompositional nature of enterprise models provides the scope dimension of the model. The model's consistency with key enterprise metrics (drives the enterprise), and the extent the model is driven from enterprise data defines the dual role of the enactment dimension. The maintainability and the expandability of the model define the model dynamicity. The three dimensions of scope, enactment, and the dynamicity of the model are now described.

Scope is the pervasiveness of the model throughout the enterprise. Enterprise modelling by its very nature is intended to provide a holistic representation of the entire enterprise. It is sometimes necessary to bound the model to a subset of the enterprise. The bounds describe the scope of the model.

Enactment is the level in which the model drives and is driven by the system. There is a wide variation in the enactment capabilities of a living model. A model can range from no enactment at all to driving the entire enterprise and providing all inputs and reporting the status of the enterprise when requested.

Some more likely phases of enactment might be to use a workflow arrangement, which can provide either direction to enterprise personnel allowing them to deviate slightly from the process or require strict adherence to the process.

A model that is dynamic is able to respond to both permanent and temporary process changes to the system. As has been previously discussed, an important living characteristic of an enterprise model is its ability to change. This dimension denotes this ability. Most models today are not easy to change. The phases of dynamicity range from no capability to the model changing itself. A model could change itself by being capable of learning from its environment and then modifying itself to reflect and implement the new process (Wood, 1994). This dynamic dimension is not to be confused with simulation models, which are often called dynamic representations.

4 ENTERPRISE MODEL CLASSIFICATION METHODOLOGY

The main focus of this research is to establish repositories of enterprise models. This paper establishes a method to classify models for the repository for enterprise models. However, the enterprise is multi-dimensional, therefore, so is the classification. This research is also not about defining a metric that defines the various attributes of a model regarding complexity, maintainability, or interfacability; although these would be excellent topics for future research. Rather, the primary intent of this paper is to propose a methodology for classifying enterprise models to provide a mechanism for the common understanding of what the model is and thereby provide a starting point for recognizing opportunities of improvement in the model. This is the first step in a useful enterprise model repository. It should be noted that the authors do not propose that all models 'be all things to all enterprises.' Rather, an understanding of what the model is as well as what it is not will lead to more useful models in the business of the enterprise.

The remainder of the paper discusses the proposed approach to classify enterprise models with the four dimensions: view, scope, enactment and dynamicity discussed previously. The view is designated by the first letter of the view used; activity, process, information, resource, or organization. The scope is designated as shown in table 1 based on the three categories of processes. The dynamicity dimension refers to how often the model is updated and the scale is listed in table 2. The final dimension of enactment is divided into the two aspects of enactment, how much the model drives the enterprise and how much the model is driven by the enterprise. Again, the scale for this dimension is shown in table 3. This information is represented by:

$$V(S,D,E)$$

Where: V is the view (A, P, I, R or O), S is the scope level, D is the dynamicity level, E is the enactment level. Tables 1, 2, and 3 provide the details of the characteristics of each level.

The classification system proposed is intended to improve visibility of enterprise models, thereby establishing an enterprise model repository framework. This framework would provide the parameters about existing enterprise models enabling model reuse.

Table 1: Scope levels of a living model of the enterprise

Level	Characteristic
Multiple Enterprises (5)	• All three process categories are modeled across multiple enterprises
Multiple Division (4)	• All three process categories are modeled at multiple enterprise sites
Enterprise (3)	• All three process categories are modeled
System (2)	• Models are increasingly considered an asset and are therefore required for major single time decisions
Initial (1)	• Models are not considered an asset and are therefore needed only for single small decisions

Table 2: Dynamicity levels of a living model of the enterprise

Level	Characteristic
Mature (5)	• A repository is used for ensuring that version control is used for enterprise models.
Evolution (4)	• A formal plan is in place for integrating major enterprise changes to the models as well as medium changes.
Adaptation (3)	• A formal plan is in place for the continued updating and maintenance of models.
Adjustment (2)	• Models are updated as time allows
No Modification (1)	• Models are not considered an asset and are therefore needed only for single small decisions. Subsequently, models are not updated.

Table 3: Enactment levels of a living model of the enterprise

Level	Characteristic
Optimizing (5)	• A suite of models is used which both drive and are driven by the enterprise in a systematic manner.
Managed (4)	• A formal plan is in place for models to drive *and* be driven by the enterprise when deemed appropriate..
Defined (3)	• A formal plan is in place for models to drive *or* be driven by the enterprise when deemed appropriate.
Ad Hoc (2)	• Models are driven/Models drive infrequently when convenient (less than once a year)
No Enactment (1)	• Models are not considered an asset and are therefore needed only for single small decisions. Subsequently, models do not drive and are not driven by the enterprise.

Two examples are now provided of the enterprise model classification methodology. The first is an activity model and the second is a process model. One example is taken from previous work at the Automation & Robotics Research Institute (ARRI). The other example is from work in Wichita at a small aerospace supplier.

The activity model used is from a modelling effort of an aerospace company performed by ARRI. It is fairly easy to determine the scope of the model, as its A0 level activities are direct enterprise, manage assets, acquire customers/orders, design products/processes, and fill orders. This model was one of the base models for the manufacturing enterprise reference model (Whitman, et al. 2001) and it is easy to recognize that only the support product activity is not listed. The model is of a single division and therefore a value of 3 is assigned for its scope. This model has been updated less than once a year, which is when it is convenient to update the model; so, a dynamicity value of 2 is assigned. The model provides input to the enterprise on a quarterly basis and therefore R is 2. So, the enterprise model values are:

A(3, 2, 2)

The process model used is from a modelling effort of a small aerospace supplier. The model is of very limited scope. The only activity addressed by this model (and that only partially) is the design products/processes activity. The model is considered valuable to make certain decisions. Therefore, this model has a scope of 2. This model has never been updated, so a dynamicity value of 1 is assigned. The model provides input to the enterprise on a one time basis and therefore R is 2 for minor enactment. So, the enterprise model values are:

P(2, 1, 2)

5 CONCLUSION

This paper presented a classification methodology towards a repository of enterprise models. It presented the dimensions of models of the enterprise. Scope is the pervasiveness of the model throughout the enterprise. Enterprise modeling by its very nature is intended to provide a holistic representation of the entire enterprise. The model's consistency with key enterprise metrics (drives the enterprise), and the extent the model is driven from enterprise data defines the dual role of the enactment dimension. The maintainability and the expandability of the model define the model dynamicity. This classification methodology for a living model of the enterprise can serve as a tool for enterprise engineering. The methodology will allow for comparison and evaluation of various enterprise models. A direct benefit of this research is a more clear understanding of how the enterprise modeling community uses enterprise models. Future research will apply these concepts to a collection of models of an enterprise. Future enterprise frameworks developed should be agile enough to cater to constantly changing enterprise needs.

The classification system proposed in the paper is the first step towards a useful enterprise model repository. The intended result is to improve the visibility of enterprise models, thereby establishing an enterprise model repository framework. Awareness of existing model content as well as scope, dynamicity, and enactment levels will provide information required to make enterprise models more pervasive both within and between enterprises. This framework will also enhance enterprise integration.

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