Managing Change through Enterprise Models [1]

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Abstract

In this paper we present a perspective on enterprise modelling which is emerging under the Enterprise project. Enterprise modelling can be used as a catch-all title to describe the activity of modelling any pertinent aspect of an organisation. We present a more restricted use of the term, which implies the need to focus on the organisation as a whole: taking a more "total systems" approach. We describe the main motivations for enterprise modelling. We identify features of enterprise models and suggest how they might be used. A key element which we discuss is the use of an ontology which permits the interchange of information and knowledge between different users, tasks and systems. Finally we give a high level view of a computer toolset to support enterprise modelling.

1 Introduction

In this paper we present a perspective on enterprise modelling which is emerging under the Enterprise project [15]. In doing so we identify features of enterprise models and suggest how the existence of ontologies can help in their construction and maintenance.

This section includes our working definition of enterprise modelling and an overview of the Enterprise project. In section 2 we present the main reasons for building enterprise models; in section 3 we identify some features of enterprise models; in section 4 we suggest how ontologies might be useful in enterprise modelling and in section 5 we show a high level view of a toolset for enterprise modelling.

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1.1 A Working Definition

As with many such terms, enterprise modelling is widely used as a catch-all title to describe the activity of modelling any pertinent aspect of an organisation's structure and operation, in order to improve selected measures of the organisation's performance.

In this broad sense, it encompasses most aspects of classical operations research, process optimisation, human resource allocation, organisational design, business process re-engineering *etc.* There is nothing new in these activities: organisations have been carrying them out for as long as they have appreciated the need to improve business performance.

So what is new? Why do we now need to define something which is specifically "Enterprise Modelling"?

What is new is that the strength of the drivers for change which an organisation needs to manage, together with the reduced time available to make the changes, is increasing the breadth and the depth of the organisation which is affected by the need to change. That is, there is increasingly a need to focus on enterprises as a whole, or at least on a larger set of interacting components within the organisation – taking a more "total systems" approach.

Economic, social and market pressures are such that this is likely to be a continuing state of affairs. At the strategic level, there is a need to manage changes in such areas as rationalisation of manufacturing capacity, extended supply chain management, reduced innovation time, sociological changes and assessment of futures. At the tactical level, there is the need to re-engineer processes, to redefine organisational structures and to ensure tactical operations are in synchronism with strategy. A common element is the need to manage complexity under reducing time spans and conditions of greater uncertainty.

Thus, within this project, we view enterprise modelling as encompassing the activities of enabling:

- capture and description of all relevant aspects of an enterprise (*e.g.* its processes, strategy, organisational structure, resources, goals, constraints and environment);
- specification of business problems and requirements;
- identification and evaluation of solution options and alternative design and implementation paths at strategic, tactical and operational levels;

- reuse of the models.

The enterprise model is typically characterised by:

- the kinds of enterprise;
- the types of problems;
- the purposes of building the models;
- the contents of the models;
- the forms of representations.

A closely related field to enterprise modelling is "enterprise integration", which is defined in [9] as "the consistent sharing of information and coherent scheduling of tasks over the set of distributed agents working on a set of interrelated problems within an enterprise."
This goes further than enterprise modelling, where the focus is more on the consistent sharing of information than on the coherent scheduling of tasks. Consistent sharing of information refers to having semantic and syntactical structures for the information common to all the providers and users of the information.

1.2 The Context: The Enterprise Project

Enterprise is the largest project being supported under the UK government's Intelligent Systems Integration Programme (ISIP). The Enterprise consortium is led by AIAI and includes IBM UK, Lloyd's Register, Logica and Unilever. The main aim is to provide a method and computer toolset which will help capture aspects of a business and analyse these to identify and compare options for meeting the business requirements. This requires the creation of a framework for integrating methods and tools which are appropriate to enterprise modelling and the management of change.

2 Why Build Enterprise Models?

In this section we describe three main reasons why an organisation might build enterprise models:

- to provide insights into the options for change or for keeping things the way they are;
- to communicate the existing situation and the new options in a comprehensible way to interested parties;
- to help carry out the existing processes and any selected changes.

2.1 Enterprise Models for Insight

There are two separate sets of influences that motivate an organisation to try and bring about change.
First, there are those that can be considered internal to the organisation and are the goals the organisation wishes to achieve. Examples are:

- improve customer satisfaction
- increase profits
- improve quality
- decrease costs
- decrease cycle time
- increase staff satisfaction
- better decisions under uncertainty

Second, there are the external influences where an enterprise may be forced to change something due to changing external effects. Examples are:

- competitive activity
- political legislation
- economic trends
- social influences
- technological advances

- industry structural changes.

Several of these factors may act simultaneously to create a need for improved or changed business performance at any time, and the factors (and strengths of influence) may vary through time.
Once an enterprise decides to improve its business performance it has to consider what areas are under its control that can be changed to achieve this goal. Examples of areas that can be changed are its:

- processes
- organisational structure and human issues
- communication, *i.e.* information flows and information access
- resources, *e.g.* capital, people.

In order to change these areas the organisation has to understand how it is currently functioning, and to understand how they can be changed to meet the new business need or environment. Enterprise models can help with this understanding and in intelligent selection from among alternative change strategies.
Note that an organisation might be able to exercise control over these things not only within its own walls: it may be have strong relationships with suppliers or contractors and be able to influence them, to mutual advantage.

2.2 Enterprise Models for Communication

Many people have a direct interest in the contents of an enterprise model: decision makers, analysts, software specialists, shop floor managers, operators, sales staff, help desk operators, *etc.* Access to a common model helps ensure that the needs, functions, responsibilities, activities and authorities of people can be communicated to those who need to know them.
The importance of communication *from* the people doing the work is often overlooked: this can be encouraged by letting them see the constraints and assumptions behind strategic decisions.
This raises a challenge for enterprise modellers: how to provide interested parties with views of the enterprise model appropriate to their needs and experience.

2.3 Enterprise Models for Enactment

By enactment we are referring to any system, whether automated or followed by humans, which carries out an organisation's processes. Using enterprise models to assist in enacting an organisation's processes can be of benefit both at time of establishing or at time of changing such processes.

Having taken the trouble and the expense to create the model for insight or communication, an organisation does not want the added expense of creating separate models to help in building its enactment systems: it makes sense to reuse the same model.

Reuse also helps to ensure consistency between the model of what is supposed to happen and what really does happen in the enactment systems. If this consistency can be achieved, then change can be initiated by changing the enterprise model. If the generation of enactment systems from enterprise models can be automated, then so much the better.

3 Features of Enterprise Models

In this section we define the contents of enterprise models; discuss who might use them and how; describe what form they take; and consider how they might be managed.

3.1 Contents

In general an enterprise model consists of a description of things over which the organisation has control (such as people, material or processes) and a description of what the organisation can do with those things (such as hire, purchase or analyse respectively).

The model need not be all encompassing: it could be a significant subset of things over which the organisation has control and still fit the definition in 1.1.

An organisation can choose to include things over which it does not have complete direct control, such as the parts purchased from a supplier or the interactions with the supplier. Thus we can distinguish between "intraenterprise" and "interenterprise" modelling [4]. The difficulty with interenterprise modelling is that other organisations may have different goals, so it is ap-

propriate only in cases where the interactions are well defined and have a common goal, such as the building of a large aircraft.
The Suppliers' Working Group (SWG, composed of enterprise integration suppliers in the USA), have distinguished in their Reference Taxonomy [5] between "services" and "information". Services are those things which "perform some processing or state-transition function". Examples might be the manufacture of a widget, the sale of a product, the hiring of a person or the improvement of a process. Information is "the collection of all of the knowledge found in an enterprise". Examples might be the definition of a manufacturing process, the cost of manufacture, the technical specification of the material used or the profile of the expected customer. Thus information "can be a model OF a service, be ... ABOUT a service, be ... USED BY a service, or have any of many other relationships." Information is any description of any aspect of the service.
Thus the enterprise model really contains what the SWG have called "information". Usually the motivation for enterprise modelling, as suggested in section 2, is to model a variety of services with the intention of managing, improving, modifying or redesigning them.

3.2 Users and Modes of Use

There are four types of people who might use enterprise models: modellers, analysts, managers (or decision makers) and operators. An individual user may belong to more than one of these types. The tasks which any user is likely to carry out come under one of five categories: capture, visualise, analyse, synthesise and enact.

Modellers are usually skilled in methods that originate in science, engineering or information technology (IT). The modelling processes and results are often abstract and graphical. In general, modellers can be expected to be comfortable with computers. Most modellers have some expertise in analysis of models, at least of the kind needed to determine the models' completeness and consistency. Modellers will capture and update components of the enterprise model and analyse it to determine whether it is correct.

Analysts use models to explore the space of possible solutions (configurations, ways of working, options for change *etc.*) in order to obtain the information required for making business decisions. Certain analyses may lead to information that could be added to the model (possibly as annotations) or to new instantiations of the model (such as a newly synthesised process).

Managers make business decisions on the basis of (implicit or explicit) models and their analyses. Managers often have analysis expertise.

There are two types of managers with quite different characteristics: top managers are responsible for high level decisions and tend to be interested in summaries only, whereas lower level managers require more detail. Top managers usually obtain the information they require from lower level management rather than from information systems. They are unlikely to want to use systems themselves but may work with them through others (e.g. lower level managers or analysts). Indeed, top managers would probably not work through the detailed analysis themselves, but would need to be talked through the results of an analyst doing it – to understand the assumptions, constraints and data used in the analysis – and have a detailed discussion of the "best" solutions.

Managers will use analysis tools and visualisation tools (directly or through others) and will probably want to be able to annotate the model. Managers can initiate changes to high level strategies and objectives, which may effect changes in the enterprise and thus require the model to be changed.

Operators carry out activities which are the results of business decisions. Operators might require to visualise parts of the model to generate a set of activities for themselves or to execute their work.

A key feature of an enterprise model is therefore its *visualisation* in ways that are appropriate to the particular users. The same model should be viewable from a number of different perspectives, *e.g.* the analyst's view of a process might include access to metrics used to assess the process, while the operator's view might include a step-by-step set of instructions.

3.3 Form

Much of the "information" referred to in 3.1 is held in stores such as databases, spreadsheets, mathematical modelling programs, graphics and knowledge bases. A key to enterprise modelling is the ability to make use of information stores without having to redesign and rebuild them: there are usually very good operational reasons for a store having a particular form and its redesign may upset its users and their way of working. (Once an enterprise model is in place, then newly created stores might be designed to match the model better.)

Implicit in our notion of total systems is the fact that interdependencies between aspects of the enterprise model should be noted and maintained. These include constraints between parts of the model and the intentions behind model components. These call for knowledge-rich representations to be used for enterprise models, such as the triangle model of activity [14] or those used in O-Plan [13] and PLANIT [1].

3.4 Model Management

An enterprise model as we have already defined it contains many submodels of many different types, probably stored in several different ways. These models need to be managed in several ways, during creation, implementation and maintenance. A field which covers all of these is "model management", a term which was coined about 20 years ago within the larger field of decision theory. A recent survey of model management, which includes 75 references, is [10]. Much of this research is reported in Operations Research journals.

Models, it is recognised, play a key role in the decision making process. Most models in this field are mathematical, usually linear programming ones. However, the issues addressed and the modelling life cycle are general.

It is important for a user to be able to locate and access relevant models at appropriate times, without having the overhead of actually knowing where models are stored and what their forms are. Much work is currently going on in the field of object management (*e.g.* [6] to shield the user of heterogeneous applications from such effort. O-Plan [13] includes the concept of a Knowledge Source Framework language. This gives a wrapper for each knowledge source (or processing asset) which allows an understanding of what it can do, what platform it needs to run on, what parts of the plan (enterprise model in our case) it can access in read and write modes, *etc.*

4 Ontologies for Enterprise Modelling

In this section we consider the use of ontologies to assist in enterprise modelling. We first define "ontology", then emphasis its potential for reuse and finally comment on the value of its use.

4.1 Definition

In spite of the growing interest in the term, the meaning of the word *ontology* is not easy to define or grasp, nor is it used in the same way by different people. The term is borrowed from philosophy where it is used to describe the study of reality and objects independently of our knowledge of them.
In application, a necessary characteristic of an ontology is that it expresses or embodies some sort of world view, *i.e.* a perspective, a way of thinking about or carving up of some aspect of the natural or artificial world. It might be thought of it as a model or paradigm. The world view is often conceived as a set of concepts (*e.g.* entities, attributes, processes *etc.*), their definitions, and their inter-relationships [3].
Any piece of application software will reflect a world view of the application domain. For example, an accounting package embodies a generic model of accounting concepts (*e.g.* an invoice; a department in an organisation.) Normally, this world view is implicit, and exists only in the heads of the people designing and/or using the software. In the case of accounting software, the world view is also expressed in any number of textbooks.
However, exactly which world view is it? Problems arise when similar terms are used in different ways. There is no one single universally agreed accounting world view, though there may be a core of concepts that most people agree about. Because of this, ambiguities may arise and it can thus be useful to record explicitly the world view that the software is based on.
The ontology offers the vocabulary for input and output. An ontology implies a high degree of buying-in to the definitions contained in it on the part of its users.
Ontologies have been derived within the Knowledge Sharing Effort [12] for

areas such as bibliographic data, configuration design, job assignment, numbers, sets and time.

4.2 Reuse

A key aim in much of our lives in a material world is to be able to reuse things.
In IT the reuse of technology (*e.g.* methods and techniques) and the resulting technological applications (*e.g.* models or software) can save time and money. Experience shows that designing software to be reused takes significantly more effort than designing one-off software, even if the latter is extremely well designed. Therefore, principles for achieving reuse are continuously being sought. Of course, one always has to determine whether the potential for reuse justifies the extra effort.
There is scope for reaping considerable benefits from reuse in enterprise modelling. As mentioned in 2.3, an enterprise model may serve a variety of purposes, such as forming a basis for process re-engineering, establishing the requirements for IT systems or even for specifying enactment systems.
A key potential way of achieving reuse in enterprise modelling is through ontologies. At the First International Conference on Enterprise Integration Modelling Technologies (ICEIMT) [9], Working Group 3 reported the following relationship between business modelling and ontologies:
"The Business Modelling Process is one of modelling the business for enterprise integration purposes; the output and products of the process are generic ontologies, business domain ontologies and business models. The Business Modelling Process includes both the making of ontologies and models and integrating the models for enterprise integration purposes."

4.3 Their Value in Enterprise Modelling

As well as reuse, some other reasons for using ontologies in enterprise integration are:

- to assist in communication;
- to translate semantics among various lexicons (synonyms, etc.) so that connections can be identified;
- to eliminate redundancies;

- to resolve unnecessary and/or missing content.

Working Group 3 [9] notes that the use of ontologies is a relatively new engineered approach to enterprise modelling and software development but they have have proven their value in many other areas, like data integration and library science.
The value of using ontologies in this new way in enterprise modelling remains to be proven. Some exciting work has been going on within the Knowledge Sharing Effort [7] and on the TOVE [8] and SHADE [11] projects, but there often appears to be a basic assumption that ontologies are cost beneficial. The assumption may be valid, but we know of no practical examples where this has been demonstrated, and we intend to explore this issue within the Enterprise project.
Some of our earlier views on ontologies are summarised in [14]. We have recently been focussing attention on two aspects of ontologies: how they are *built* (and maintained) and how they are *used*.

Building Enterprise Ontologies

There is no generally accepted method of building ontologies. The best that can be said at the moment is that there are some criteria that one can use in determining how good an ontology is. Gruber [7] lists *clarity, coherence, extensibility, minimal encoding bias* and *minimal ontological commitment.* Fox [2] adds the criterion of *competency*, which can be measured by setting out a list of questions which should be answerable by deduction from the ontological definitions. [2]
However, beyond trying to ensure that a set of good quality, representative people are involved in building ontologies, there is little definition of the process, or best practice method.

[2]This leads to an important question of whether there is a fundamental difference between an ontology and a knowledge base. Some say that an ontology should be runnable as a knowledge base and can be incrementally changed to create application-specific knowledge bases. The arguments of others would imply that what is included in, say, the enterprise ontology defines and characterises the domain of enterprise modelling, and thus constrains what is possible to include in the knowledge base or enterprise model. What is actually included in the knowledge base or enterprise model defines and characterises a particular model of a particular enterprise.

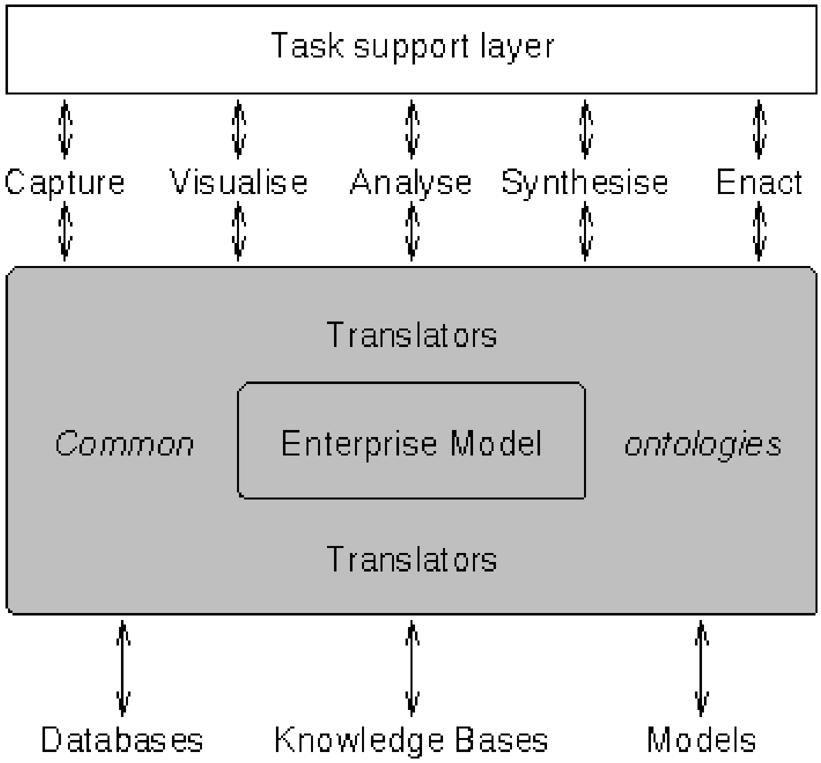
Using Enterprise Ontologies

An obvious use of enterprise ontologies is to guide modellers and application builders so that they use terms which are consistent and commonly accepted. Then new models can be easily communicated to others who accept the ontologies and new models can be used for multiple purposes. New applications can be built which access, handle and present information in shared terms.
What is harder to see, and is one of the biggest challenges in the building of an enterprise modelling toolset, is how ontologies can be used to integrate existing applications and information repositories. As we note in section 5, the loss of detail is inevitable in translating the terms of existing information and services into and out of the terms in the enterprise ontologies.

5 Support for Enterprise Modelling

One of the main deliverables of the Enterprise project will be a computer toolset which will help capture aspects of a business and analyse these to identify and compare options for meeting the business requirements. A high-level view of the toolset, showing how ontologies are used to support the enterprise model, is shown in figure 1.
Ontologies define the commonly accepted world views in which enterprise models are built. The information in the models is typically distributed through various repositories (databases, knowledge bases and models of other kinds) whose vocabularies may differ from the ontologies. Thus translators are needed to map information into and out of the terms of the ontologies. Information necessarily gets lost in some of the translations and it is an open question whether this loss of information is in general serious enough to throw the use of ontologies into doubt.
Similarly, translators may be needed to allow users to carry out the tasks described in 3.2. (For example, a standard analysis report may require figures for staff turnover, while the ontologies define terms only for employee, contract, begin and end: a conversion is needed between these terms and the one required for the report.)
A task support layer helps the user understand and execute the activities required for a particular task, for instance the formulation of a strategic plan or of a business case.

Figure 1: High Level View of the Enterprise Toolset



6 Summary

The Enterprise project aims to provide a method and software support for enterprise modelling with a view to managing business change. Enterprise modelling assumes a "total systems" approach. Enterprise models may be used by modellers, analysts, decision makers and operators. They may provide insight, aid communication or define enactment systems. One of the key concepts being investigated in Enterprise is that of ontologies.

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