8-15-1997

The Ontology of Enterprises and Information Systems

John Dobson
University of Newcastle, John.Dobson@newcastle.ac.uk

Mike Martin
University of Newcastle, Mike.Martin@octacon.co.uk

The Ontology of Enterprises and Information Systems

John Dobson and Mike Martin
Centre for Software Reliability
University of Newcastle upon Tyne
Newcastle NE1 7RU, U.K.
{John.Dobson@newcastle.ac.uk, Mike.Martin@octacon.co.uk}

Abstract
The purpose of this paper is to present the ontological and methodological underpinnings for the construction and representation of architectural models of enterprise and information.

Introduction
It has become common to represent complex architectures through a set of viewpoints or projections because it is not possible to describe and reason about all the different facets of complex organisational and systems problems from a single standpoint or within the terms of a single abstraction. Each projection comprises a set of concepts and the means to define and communicate a particular range of issues of policy and design. Projections manage complexity by separating issues so that the systems structuring process may proceed in an orderly and purposeful way.

Since a set of projections must relate to the same system, there is a strong requirement that they are coherent and consistent with each other. If we rely only upon informal diagrams and natural language to define and express our projections, then we have only our individual interpretations to rely on for consistency. While appropriate rigour and precision have been applied in the construction of functional and design projections, this has tended not to be the case for enterprise-related projections. So far, it has not been possible to construct strong justifications which link enterprise and resource projections to the more systems design- and implementation-oriented projections and the former descriptions have tended to remain fragmentary and superficial.

We have developed a conceptual model and a framework which has been developed to support the representation of enterprise and information projections. In this paper, it is not presented as a formal language but as the basis for a practical tool to provide some discipline and rigour to the process of proposing, discussing and communicating architectural ideas. Two benefits are clamed to justify its use:

1. It represents a minimum set of terms and relationships required to make all the distinctions that both policy and design require.

2. A calculus is available, in principle, within which we can demonstrate both in internal consistency of the different levels of representation within a projection and between projections. This does not imply that the projections are correct with respect to their prescriptive or descriptive intent (i.e. that they mean what their authors intend them to mean), only that it is possible that they are logically consistent with each other.

In a project on the Global Information Infrastructure for the European Telecommunications Standards Institute, we have defined a high level architectural framework in terms of *enterprise*, *structure*, *function* and *implementation*. This is an example of a set of projections and, at this stage, the most important methodological issue is how we represent and communicate our work to each other and to the many projects and organisations who need to evaluate and use it. The fact that a new set of terms and concepts may be required is a direct consequence of the expanded scope implied by the Global Information Infrastructure. Our conclusion is that none of the existing architectural frameworks from the information engineering or the telecommunications engineering sectors is adequate, on its own, to meet the need of an inclusive architecture for both service and applications enterprise. We are forced to face the cost and effort to construct and assimilate a new synthesis.

We will proceed by presenting a set of concepts, relationships and transformations. This results in a closed set of mutually interlocked definitions which must be treated as a unit. The selection of which term to use for which concept is essentially arbitrary, the relationship between the concepts as defined in the diagrams (and by the abstract calculus that is represented in them) is the real content of this paper.

The basic concepts

The conceptual framework is based on three fundamental abstractions:

A *role* corresponds to a set of responsibilities, obligations and rights. Examples of roles are doctor, teacher, supplier... It is most important to recognise that, at this level of abstraction, we are referring only to rights and responsibilities, we have not yet arrived at the stage where we can talk about individuals or organisations who may combine a number of different roles.

An *activity* is the unit of behaviour. Concepts such as stimulus, response and invocation fit in this category.

A *resource* is the unit of production, ownership, exchange and consumption. Resources may be physical, such as material, goods or tools. They may be abstract, taking the form of information.

Each of these basic entities can be involved in a reflexive relationship:

Roles may be linked together to form *enterprise relationships.* Roles cannot, in fact, be defined in isolation but only through participation in such relationships. Examples are: doctor-patient, teacher-pupil or supplier-consumer.

Activities may be linked together through *interactions.* These are observable.

Resources are linked by *schema* relationships. Thus, a set of records of stock corresponds, through a schema, to the items on shelves in a warehouse. The physical compatibility of components or tools are also examples of this type of relationship.

Three relations are possible between the basic abstractions:
Acts (or intentions) relate *roles* and *resources*.
Agencies relate *roles* and *activities.*
Actions (or extensions) relate *activities* and resources.

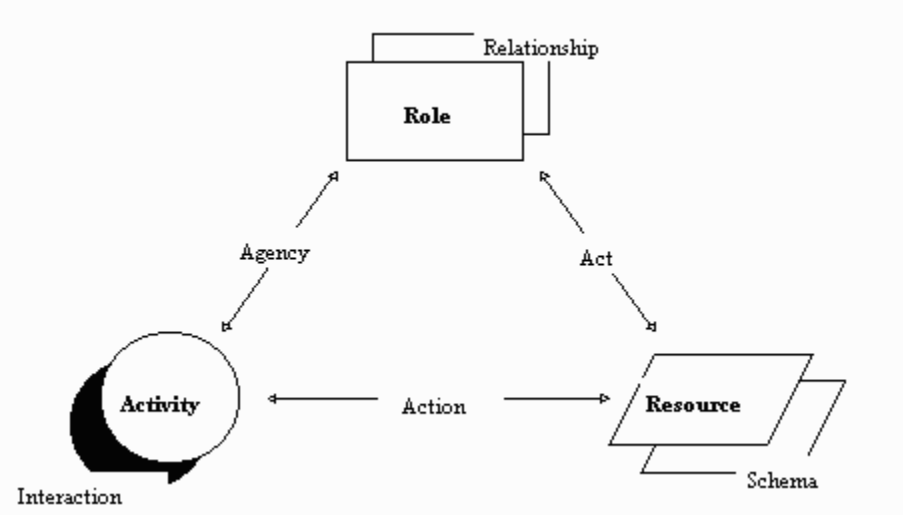

Fig 1: The basic ontology of enterprise

Acts and actions

The concepts of *acts* and *actions* reflect the relationship between *intentions* and *extensions*, between what you observe and the interpretation you place, or are intended to place, on your observations. This is best explained by example. Let us first consider an information resource, a letter. My secretary may write it and sign it for me: these are actions. However, I am taken to have *generated* the letter and so I am responsible for its contents. So terms like *generate* and *interpret* are acts. Terms like *write* and *read*, *file*, *destroy* are actions. In the case of a physical resource, such as the paper on which the letter is printed, this was *allocated* by my office manager which is a act which gives my secretary the right to *consume* it. She does so by *loading* the printer paper tray and *removing* printed pages which, of course, are actions. If a stranger arrived and did exactly the same thing, the completely different interpretations of pilfering or even spying could be made. Note that in these examples, we have allocated roles to people. This operation represents a stage in the completion of an enterprise model corresponding to job design.

Composite entities

Although we have been able to discuss important aspects of enterprise in terms of our basic set of concepts, their real purpose is to provide a common underpinning for projections: in practice it is not particularly useful to construct and reason about models of enterprise at this very abstract and atomic level. We will construct three composite concepts which are created by encapsulating the basic entities in our model in different ways. A set of useful projections for defining and reasoning about enterprise and systems emerges from this process.

Agents as enterprise objects

If we take our basic conceptual model and group roles and the activities associated with

them together we produce a model of the form of Fig. 2.

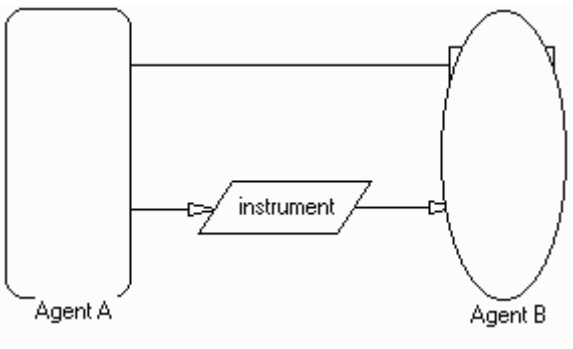

Fig. 2: The relationships between agents

The relationship between roles appear as a binding between agents which is distinct from the exchange of resources. In fact, what we see represented are the observable actions of writing and reading, transmitting and receiving, dispensing and consuming or whatever else is appropriate for the particular resource which is exchanged and we also see the context for interpreting the significance of the actions. In this view, the resource is represented as an *instrument* which has two jobs to do: the exchange between the agents. For example, the exchange between a provider and a consumer may be defined in terms of acts such as offer, counter-offer, commit and discharge. The instruments of such a conversation may take a number of different forms such as a shop window display with price tags, the exchange of goods for money and the giving of a receipt. An instrument provides evidence which may be presented in subsequent conversations. The receipt, for example, is a record which shows that the holder purchased the goods and who supplied them. Where the significance of the exchange is very high, then concepts like third party notarisation are used to ensure the dependability of an instrument.

Systems objects

The second encapsulation of the basic abstractions produces another type of object which is required to model enterprise. In this case we group together activity and resource to make systems objects. There are a number of different types of system object depending on the type or resource which is encapsulated and the sort of actions which are supported:

1. *Controller objects* support *sensing* and *manipulation* of plant and material.
2. *Manager objects* support *configuration* and *monitoring* of plant and material.
information resources.

Fig 3 shows the case of the encapsulation of information and computational resource to construct *computational objects*. Here the interaction takes the form of invocation.

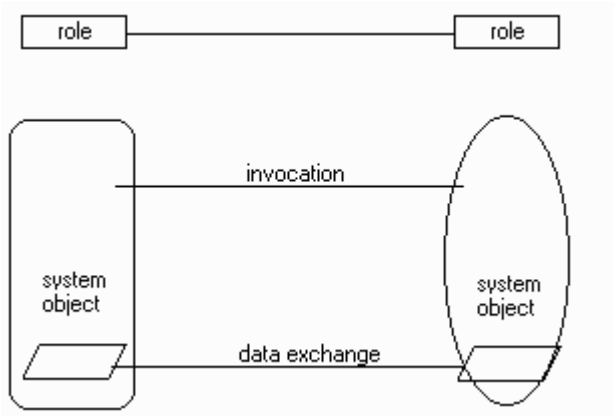

Fig. 3: Computational objects and roles

Our basic model implies that all activities, even those executed by objects, remain associated with a role which ensures that there is a context of interpretation within which intentions may be associated with behaviour. So, in Fig.3 we are representing a very simple case where the invocations between two information systems objects represent an implementation of a role relationship. The automation of activity does not remove the responsibilities associated with it but redistributes them between a systems design epoch and an operational epoch onto roles such as architect, designer, maintainer, operator and user.

Enterprises

The final grouping of our basic set of abstractions take in role, activity and resource to construct an *enterprise*. It is clear from our previous definitions that an enterprise includes both agents, physical resources and systems resources.

People, organisations and agents One of the most difficult aspects of the concepts of agents, objects and enterprises is that they are all richly compositional, allowing more complex types to be constructed from more basic types. The following rules and constraints seem to be useful in the composition of models of enterprise:

1. The most basic agents represented in any domain correspond to the units of success and failure of the roles defined at the lowest granularity. For example, the doctor-patient relationship may be usefully analysed into diagnosing, prescribing, dispensing, administering and counselling relationships with the client analysed as a patient and a civil person. The main criterion which dictates the granularity of the analysis is the need of policy makers to express their interests and concerns. These medical roles are grouped together in different ways in primary health care and secondary care.

2. When basic agencies are grouped together conflicts or synergies of interest can be created. We have done some work on an outline of the theory of composition of roles based on conversation analysis.

3. Job design involves the grouping a specific set of agencies and assigning them to an individual person. A person brings a set of capabilities and resources and a set of external commitments to this composition and human and social factors are critical in evaluating the resulting policy and design decisions. The critical question in this process is whether it is rational, appropriate and acceptable to llocate and accept the implied set of obligations given the access and rights over resources which are associated with the composite role.

4. Similar considerations apply to the allocation of roles to organisational units. Such units are termed *units of enterprise* and the resulting role is termed a *mission*

5. One or more units of enterprise can be defined as an *actor* by assigning its resources and relationships to create a *market actor*, an *institutional actor* or an *association* depending on the nature of the mission and the sphere of action. In each case, the set of units of enterprise must be composed with an appropriate organisational structure to provide the required direction, management and execution of the enterprise mission.

Summary

We have now named and illustrated our basic concepts, identified the set of relationships that can exist between them and constructed a set of composite concepts. In subsequent work we have defined a particular set of conventions in which different aspects of an architecture (which we name projections) may be articulated and explored. We have ensured that, just like the object models which have been developed to structure computation, our enterprise concepts are also highly compositional - it would be surprising if this were not the case. So, each projection of an architecture will comprise a number of models at different levels of granularity and scope. The most important methodological principal in the organisation of such models is that they remain consistent in their level of representation and the types of modelling entity they contain.