

Business Evolution and Enterprise Integration – Concept Group

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Abstract

The development of a theory of design for virtual organisations or enterprises has been identified and presented in form of a potential research programme. The required results include a theory that explains the dynamic interactions among partners that create the virtual enterprise and a proposal for the representation of the result. Ensuing would be a methodology specialised to the case of the dynamic creation of enterprises using design transactions, typical models for the enterprise engineering process, typical models for virtual enterprises (to be reused in this process), and the potential extension of the enabling enterprise modelling languages and tools.

Keywords

Enterprise integration, virtual enterprise, business evolution, enterprise engineering

1 Introduction, background

This group was assigned the task of identifying a major direction for future development in the area of enterprise integration. It was requested that the report of the discussions be presented in the form of a project proposal, to make it easier to operationalise the findings in terms of turning them into new research projects.

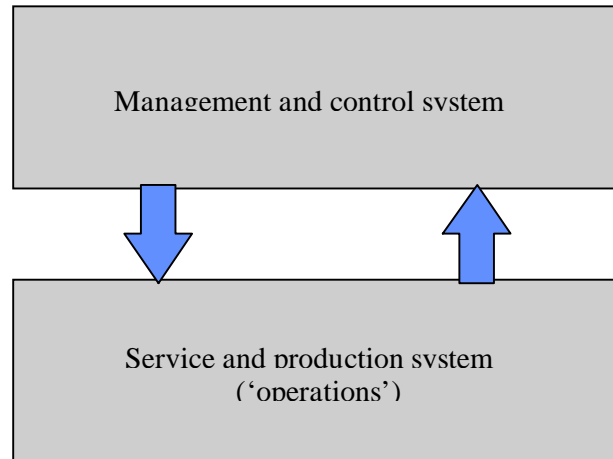


Figure 1 - The management and control system and the service and production system ('operations')

1.1 Definition of virtual enterprise

This group decided to concentrate its efforts on the problems of virtual enterprise design. We meant by *virtual enterprise* an association of entities, or partners, formed with the view of together satisfying some jointly agreed-on mission. Virtual enterprises are different from incorporated ones in that their constituent entities are highly autonomous and their association with the virtual enterprise is restricted to a well defined domain. Generally, partners will be autonomous incorporated entities, but some could be virtual enterprises themselves.

There is a growing interest in the methodologies and models available for 'engineering' virtual enterprises. If engineering virtual enterprises was made easy, then many endeavours would be better organised in that way because of the greater flexibility of organisational design than is usually available for an incorporated entity.

Typical virtual enterprises are:

- Project enterprises, which have a one-off production or service mission, (eg. a one-of-a-kind engineering and construction project, a space mission, etc.);
- Repetitive service- or manufacturing consortia (eg. a manufacturing consortium).

1.2 Engineering virtual enterprises

Enterprise design involves

- the design of the 'operations', ie. the transformation process that produces the service or product (no matter whether the enterprise is virtual or not), and
- the design of the management and control system for the enterprise.

The design of the management and control system further involves the satisfaction of three basic requirements:

- 1 Specifying the management functions (or roles) and how these functions relate to one another and to the 'operations';

- 2 Delineating the organisational entities to be involved (individuals and groups);
- 3 Determining how organisational entities fulfil these roles.

'Specifying', 'delineating' and 'determining' stand for a rich set of descriptions, which we could call the Design Description of the management of the enterprise. (Note that 1, 2 and 3 are usually designed simultaneously, because of the many constraints that need to be satisfied).

The resulting Design is not static: enterprises which have strategic management in place will carry out a constant design process which is preoccupied with creating or changing the enterprise. Enterprises *evolve* and this evolution takes place through transactions

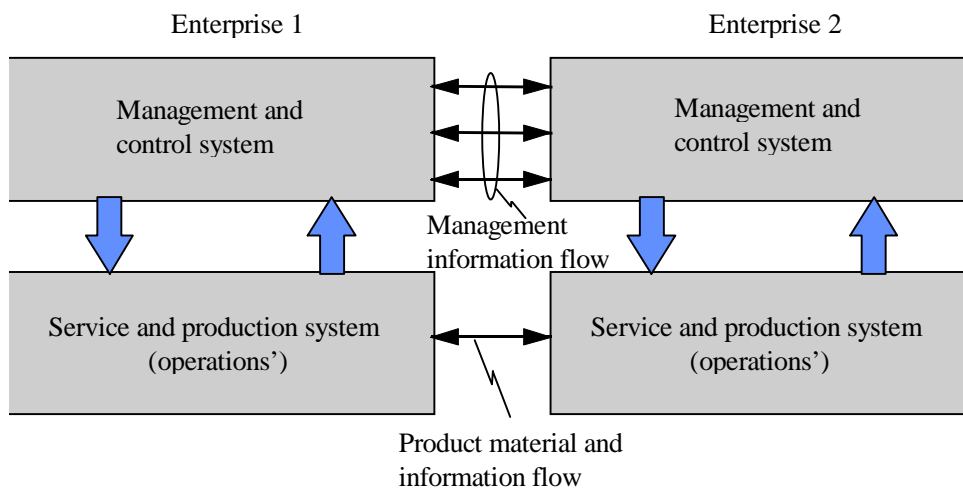


Figure 2 – Inter-enterprise connections among individuals who represent either themselves, or a present- or future entity. Under special circumstances these transactions result in change in the present entity (Uppington and Bernus, 1997), or the creation of a completely new enterprise. In case of VE the creation process dominates.¹

The following cases are worth exploring:

- 1 The evolution happens through explicit design transactions among a dynamically changing set of participants, ie. with the explicit intent of creating a VE;
- 2 The evolution happens organically, such that the Virtual Enterprise is an 'emergent entity'. (After the fact however, an external observer may describe the participants who conducted the transactions as if they acted by intent.)

¹ Although the design process is using previous experience thus it can be argued that the new design is somewhat similar to changing an existing VE.

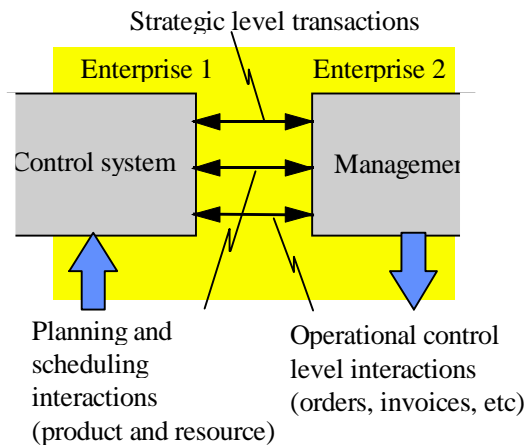


Figure 3 – Transactions of interest for enterprise engineering

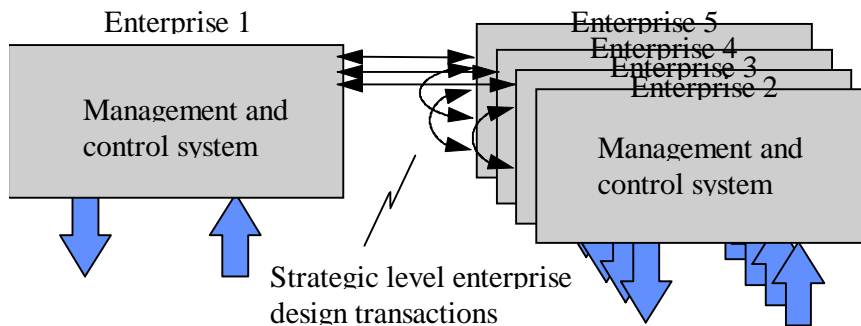


Figure 4 – Transactions among multiple partners

The transactions of interest are the interactions among the management systems of the partners that support the value chain. (The value producing processes are those in the bottom of Fig.3). In Fig.3 we represented three types of management and control level transactions.

From these the strategic level transactions are of the most significance for enterprise engineering, because it is these transactions that determine the design of the new enterprise. Lower level transactions also have an important role in the process, whenever the new design is based on, or is using in any form, the fact that the partners have been in earlier connection.

Figure 3 is only a simplified picture of the real situation – in reality many partners (some potential, some eventual) engage in enterprise engineering- or design transactions (see Fig.4).

2 Aims and significance

2.1 Business needs

Virtual enterprise is a form that offers high flexibility, agility and resilience for businesses to survive and prosper in the globalised economy. Globalisation means that changes in the

business are a constant need, and managers need support in their enterprise engineering efforts. This is true of virtual project enterprises, which are typical of one-off endeavours, and stipulate that those creating the virtual enterprise are able to do so in a quite limited time frame (eg as part of a tendering process).

Also, repetitive type virtual manufacturing and service enterprises are important forms of business, for many reasons, such as the desire to present the semblance of a single enterprise to the customer whereupon the enterprise is only an alliance of partners for the purpose of a well defined business mission. High quality business processes in an integrated value chain require properly designed operations (with integrated material and information flow connecting the transformation of goods and services in the value chain). To ensure a quality an integrated system of management is needed, with all levels of management properly set up for the purposes of managing this virtual enterprise.

Given that the commitments of the partners to the virtual enterprise are only part of their full set of commitments, objectives, and missions it is vital that co-ordination of these take place in the process of enterprise engineering, and further during the operation of the new enterprise. It is a basic business interest to be in the possession of methodologies, paradigmatic models and enterprise engineering tools that help in the design of such virtual enterprises which satisfy the above briefly elucidated requirement.

A number of approaches advocate various solutions for reusable enterprise models, ie typical models which ensure one or another desired property of the enterprise.

- Quality standards and Capability-maturity models are, for example, requirements level models for achieving predetermined levels of maturity.
- Agent based models are specific functional models, which serve as a blueprint for what functional structure is necessary for the enterprise in order to display agenthood. The agent model is therefore a pattern of functional model. Corresponding design and implementation level models of agents exist, but existing implementations are concentrating specific lower level agents, eg as part of the integrating infrastructure, not enterprise level ones.
- Holonic models are more specific functional models of the enterprise, which intend to build the enterprise as an agent out of agents (Minsky, 1996) – perhaps based on some recurrent (fractal-like) patterns of agent interaction (Deen, 1993).

2.2 Aims of this project

There exist today an extensive set of support for enterprise engineering in the following form.

- Enterprise engineering methodologies which describe management processes for enterprise integration, eg. Purdue Guide for Master Planning (Williams, 1994), GRAI-GIM (Doumeingts *et al*,1994);
- Enterprise modelling languages as CIMOSA (Vernadat, 1992), IDEF0,3 (Menzel-Mayer, 1997) and supporting enterprise engineering tools for the design of individual business entities;
- Paradigmatic enterprise models are also emerging for organisational design (Malone, 1993).

- Ontological models have been in development to improve the competence (usefulness) of the tools for organisational modelling (Fox, 1992, Vernadat 1996). (These latter are important for the tool developers, the end user does not need to know about them, however the end user sees the effect on the quality of the capabilities of the enterprise engineering tools used.)

The above components are proving themselves very useful in pilot applications. GERAM² describes these as components of a complete set, but provides for the fact that specialised needs, such a *virtual* enterprise design may need specialised versions of these – compatible, but extended for the specific needs of virtual enterprise design.

This research programme is proposed as a response to the specific business need for a complete set of methodology, languages, tools and models for virtual enterprise design. It is expected that these could be based on an extension of the existing set listed above.

What are the questions and what answers are needed? Maturity in organisational behaviour: adaptive, agile, resilient, and optimising behaviour needs to be a property of the virtual enterprise being designed. Present practice is an art, and we would like to know how is it possible to carry out the design of organisations with more predictable results?

Organisations seem to evolve either organically, with rules of their own, in a reactive manner (and evolution takes its toll) or by using patterns largely supported by case studies. Neither method is sufficient in itself for the mature organisational behaviour alluded to in the preceding paragraph. Organisational design lacks a comprehensive theory which could propose the requisite modelling methods, design methodology, and paradigmatic models (or components thereof) as required by the generalised enterprise reference architecture and methodology.

Methodologies exist, which are suitable for enterprise engineering, such as the Purdue methodology (Guide for Master Planning) and GRAI-GIM, but both of these have been utilised for the design of single organisations and do not yet address specifically the particular problems of the case when the designed enterprise is virtual.

The Purdue methodology is generic and as such no doubt is applicable to virtual enterprises. Of course its generic nature does not allow it to go into specific details of what particular methodological activities would be most efficient to use in the case of virtual enterprises.

The GRAI GIM methodology, with its many editions as it evolved during the past 15 years, has come to include aspects that are relevant to virtual enterprise design, but its focus (ie. its most detailed, or developed method) at present is the management of the single enterprise. Therefore we anticipate that specialised forms of that methodology could be developed.

Virtual enterprise management is a particular case, because the design transactions among partners (potential partners) are part of the strategic management activity of the very enterprise which is engaging in the design activity. It is therefore expected that methodologies for virtual enterprise design could be based on either of the above, with proper extensions using the numerous methods developed in areas listed in Section 2.1 (agility, holonics, agents, co-ordination, situated interpretation, assessment of change, globalised enterprise / Globeman 21 etc.)

² GERAM: Generalised Enterprise Reference Architecture (Bernus and Nemes, 1996a, 1997)

Even in the case of incorporated enterprises, there is a minimum level of maturity of strategic management that is needed for successful enterprise engineering (or re-engineering). Consultancy firms have realised this and adopted a new approach to dealing with client requests: instead of redesigning the enterprise for the client, they more and more tend to teach the client the change method itself. (From the consultancy company's point of view this is re-compensated by the enlarged client base.)

Once change capability is established in an enterprise, this faculty has to be exercised. The identification of the need for change is carried out in an open environment, where management interacts with many potential partners and the concept of the changed enterprise is created in this interaction.

The interaction among enterprises with the intention to create a new enterprise is an important study object. Companies which understand these interactions well and can apply them efficiently, would have a definite competitive advantage, through being able to adapt to and utilise new opportunities. This is not only a proportionality issue, of course, but the issue of first to market, or the issue of being able to tender for a project for which the ability to tender was not available before.

3 Research plan

3.1 Overview of the intended results – What the theory should contribute to general knowledge

The research would develop a) a design theory of virtual organisations, and based on that theory b) an architecture and methodology for virtual enterprises, which latter would be a specialised case of GERAM components for virtual enterprises.

3.1.1 Development of a design theory of virtual organisations (virtual enterprise)

A design theory of organisations covering virtual enterprises would have to describe the dynamics of the design interactions among participants, and have the ability to describe, analyse and predict relevant system level properties of the designed enterprise.

For example, the theory should be able to describe the system of commitments, objectives, goals and plans of the virtual enterprise and of its constituents, allow these to be analysed from the point of view of dynamics, conflicts (eg. conflicts of interest among partners or among individuals and groups, etc).

Based on the theory, interaction patterns could be designed which ensure that when agreement is reached, the resulting structure is feasible and has a set of desired properties, such as being functionally adequate, having suitable cost and time characteristics, etc.

The theory would include:

- 1 Theory of virtual enterprise design- and configuration transactions that covers the entire life-cycle, and is applicable to the entire life history of the virtual enterprise; and
- 2 Corresponding design representation of the current state of design of the VE (including its management and operational systems).

These transactions are of two types

- operational level transactions
- design level transactions / conversations (eg. to establish a common goal for the designed enterprise).

The domain of this second type of conversation is open, and its types of commitments are different from the commitments normally made explicit in operational level transactions.

Virtual enterprise design, as any collaborative design activity, depends on the possibility of bringing about mutual understanding among participants, and that all partners can prove to themselves that this happened. This is a hard task with participants who may be from diverse cultures, countries, and backgrounds. Consequently a design theory should be able to explain the aspect of mutual understanding brought about by the transactions among participants and how it is helped by shared design representations (Bernus *et al.*, 1996b).

The target audience for this theory would be the next generation of MBAs – upper level management with Industrial Engineering Education.

The problem has been approached from various angles by many disciplines, therefore it is expected that the theory would be able to give a joint account of respective contributions of

- transactional analysis (Williamson 1975; Bakos, Brynjolfsson, 1994)
- theory of social interactions / behaviour
- production management (Doumeingts *et al.*, 1992)
- information systems and organisational analysis (Malone *et al.*, 1993; O’Leary, *et al.*, 1997; Bernus-Uppington, 1997b)
- general system theory (vanBertalanffy, 1968)
- situated interpretation / situation semantics (Barwise and Perry, 1983)
- co-ordination science; (Malone, 1994) co-operative systems (Winograd and Flores, 1990; Schmidt and Simone, 1996)
- artificial intelligence / constraint satisfaction planning (Balasubramanian, 1997; Hasegawa *et al.*, 1994; Erman, 1980); co-operative scheduling and planning (Tamura, 1995)
- general design theory (Tomiyama, 1986)
- holonic systems (Mathews, 1995)
- conversation theory (Pask, 1977)
- enterprise integration (Bernus *et al.*, 1997a)

3.1.2 Development of an architecture and methodology of virtual organisations (virtual enterprise)

Based on the above design theory and design representation an Architecture and Methodology of Virtual Organisations would have to be developed. Such an architecture and methodology would consist of components, such as the ones listed below.

- 1 *An Enterprise Reference Architecture for Virtual Organisation, or Enterprise* –identifying typical participating entities and describing their respective life cycles and life histories. The architecture would define the most important aspects of modelling or otherwise describing virtual enterprises and the relationships among these. It would

have to account for the business, human³, and technological sides of the virtual enterprise design and creation;

- 2 *Enterprise Modelling Languages for the Representation of Virtual Organisation, or Enterprise* – this is a complete set of languages which are deemed necessary to describe, manipulate, externalise, store, analyse, simulate etc. the design representations. It is expected that these languages would be extensions or variations to the set of languages utilised for enterprise engineering in general, at least they would share most of their underlying ontological theories.
- 3 *Enterprise Engineering Tools* – As virtual enterprise engineering has special analysis requirements, the competency of respective design tools must reflect the needs of the virtual enterprise engineering, organisational design and construction process.
- 4 *Paradigmatic enterprise models for virtual enterprises* – To enable efficient, reliable and high quality organisational design it is necessary to develop typical reusable models. These models could form a handbook of organisational design (Wall, 1984; Lawson, 1986; Malone, 1993; Mathews, 1995) with reusable models of virtual organisations, with proven properties. The reusable models would guarantee quality, functionality and reliability such that designing the management and control structure of the virtual enterprise on the basis of these models would become a ‘drag and drop’ type activity. These models should be represented using the above enterprise modelling languages, manipulated and analysed by the above enterprise engineering tools, and utilised as blueprints by the participants in the design transactions.
- 5 *Ontologies of virtual enterprises* – The underlying semantics of the modelling languages could be captured in *shared* ontological theories, or ontologies of enterprise engineering. Many pertinent ontologies have been developed, on the basis of predetermined competency questions (Gruninger and Fox, 1995, Fox *et al*, 1996) and it is recommended that shared ontologies be based on a standard language designed for this purpose, such as Ontolingua (Farquhar *et al*, 1997). The development of ontological theories that treat design transactions based on the above theory is necessary.
- 6 *Methodology of organisational design for virtual organisations, or enterprise* – Such a methodology must be somewhat different from a methodology that is designed to be suitable for individual incorporated companies. The reason for the difference being that within one organisation it is possible, at least for a defined period of time, to enforce the use of one methodology. In virtual enterprise design this may not be so – partners will never follow one single methodology. The challenge is to develop a methodology framework which allows partners to interoperate among different locally used enterprise engineering methodologies so that the overall set of design transactions may appear to be following a higher level methodology (described by the theory of virtual organisation or enterprise design). The role of standardisation and de-facto standardisation based on the availability of tools will probably be decisive in this case. Industry experience shows that it is possible to adapt major existing methodologies to the situation of the virtual enterprise, but practical and theoretical research work to do this extension is necessary.

³ The human side may extend to the individual, social and perhaps even political issues surrounding virtual enterprises, especially because of the global nature of virtual enterprises.

- 7 Building blocks and infrastructure elements ('modules') which are specifically needed for virtual enterprise design and construction. would be developed as a system of widely available building blocks. Such a system would be based on many existing and some new technologies,. The innovation and research component of this work would be the determination of the *system* of modules which actually works as an integrated support infrastructure. Although today almost all functions necessary are available, a consistent, interoperating system of elements is not available yet. These modules include all communication, computing (integrating infrastructure) elements and modelling-, analysis-, design-, and possibly construction activities (enterprise engineering tools) which need to be specifically supported in virtual enterprise engineering.

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