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SWP 17/95 INFORMATION MODELLING FOR MANAGEMENT

ANDY BYTHEWAY
Cranfield School of Management
Cranfield University
Cranfield
Bedford MK43 0AL
United Kingdom

Tel: +44 (0)1234 751122

Fax: +44 (0)1234 751806

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INFORMATION MODELLING FOR MANAGEMENT

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ABSTRACT

A review of the literature shows substantial interest in new ways of modelling business, and a tendency to adopt a process or technological perspective in so doing. The information perspective is less often used and can present difficulties in terms of achievement and acceptance by non-specialists.

A new approach to business analysis incorporates entity modelling (as well as other techniques) and provides a more flexible approach than is normally applied. It allows different starting points to be chosen, including entity modelling as a means of brainstorming management's ideas about what comprises the fundamental aspects and building blocks of the business.

Three case studies - based in manufacturing, retailing and systems services respectively - provided an opportunity to test the usefulness of this more flexible approach. By undertaking model building and reviews with senior management, outside the context of systems planning and requirements analysis, it is shown that there *is* an acceptable form of information modelling which is useful to managers. A general topological framework was derived through these case studies which proved resilient and helpful.

A particular feature of the third case study is the extension of information modelling to permit the construction of a completely new process model for a new business. This has potential for development at a time when businesses are more and more likely to consider a "fresh start" as an alternative to the conventional development and improvement of established business units.

INTRODUCTION

There is an increasing level of interest in the use of modelling techniques to analyse business. There are different modelling approaches, from purely quantitative to wholly qualitative and based upon different perspectives on the business. This paper investigates business modelling based upon concepts of *information in business*, in order to assess the unrealised potential in the information modelling approach, and its relevance to business managers.

Shifting paradigms for business thinking

For decades the "command and control" idea has ruled business, leading to the organisation chart as the principal mechanism by which to understand who does what in a business - the *functional* view of a business. Today this is being supplanted by the idea of the *business process*.

It is said that business process redesign and reengineering provides a means to improve a business in ways not possible using the functional view alone - also that it is a way to escape from traditional, entrenched, functional thinking. Hammer & Champy [1993] provide a popular introduction to this topic. Early academic research was undertaken within the "Management in the 90's" programme at MIT [Scott Morton, 1991].

Given the importance of information in business today we might expect that some form of universal or generic information model would be evident in this work. In fact, neither Hammer & Champy nor Scott Morton provide an explicit treatment of information modelling and analysis. Other management literature is equally sparse in this matter, and the treatment in the specialist information systems literature is unhelpful to general business managers.

The research question

The principal question addressed here is: *how relevant and effective might information modelling be as a tool for general business management?* This paper examines some experiences with high-level information modelling from an empirical viewpoint, and explores the potential of information modelling as a tool for business management.

The paper operationalises the research question by deriving and testing an approach to information modelling that addresses the following more detailed issues:

- How can information modelling be made acceptable to management?
- Which high-level entity types are perceived by management to be important?
- How can the impact of strategic change be seen through information models?
- What variety of information is there within a business, and how complete is it?
- What are the key performance indicators that management need, and where are they to be found in an information model?
- Is it possible to derive a view of the ideal arrangement of business processes, from an alternative starting point?

The paper demonstrates that information modelling can be successful outside the context of information systems specification and development, and that it can be acceptable to senior management. This is achieved by taking a different starting point and a different approach to that normally adopted by IS professionals. Although the modelling technique adopted is based in entity

modelling¹ - the natural "medium" for thinking about information - the approach to creating the models was different to that found in typical structured business analysis methods.

As will be shown, a generalised topological framework emerged in the early stages of the work and this was used to assist the modelling and analysis processes.

Background to the work

Unexpected interest

In 1991 and 1992 a project researching Electronic Data Interchange (EDI) was working with process and information modelling, as means to a better understanding of the potential for EDI [Bytheway, Dyer & Braganza, 1993]. An aspect of this work revealed the potential of entity modelling as a general business modelling tool: a conceptual entity model of EDI in its business context [Bytheway, 1991a] found unsolicited and enthusiastic acceptance by EDI business management within a global soft drinks organisation. This suggested a deeper exploration of the potential of the technique would be worthwhile, independently of its traditional application to systems development and specification.

Previous problems with data and information modelling

It is known that the detailed results of data analysis can present difficulties in terms of corporate acceptance and understanding [Goodhue *et al*, March 1992]. How many corporate data models are truly owned and understood by the whole company? Is there a different form of these models which is more acceptable to management? Is there a different approach, for example by simplification or reduction of traditional analysis techniques?

The idea of a framework

Simplification can always be achieved by the use of a generalised framework. For example, it has previously been shown that the value chain can provide an effective framework for process modelling [Bytheway 1994b], but at the time of the project no generalised high level framework for information modelling was evident in the literature. There were very many other frameworks of different kinds, but none that were identified addressed information modelling².

For these reasons it was decided to evolve a framework empirically and to apply it in a number of different business situations, in order to test and develop it to the point that it might have general usefulness.

Structure of the paper

The paper first briefly reviews the state of systematic business modelling. The method of working is then explained and high level information modelling is illustrated using three case studies. The paper concludes with an appraisal of the technique and its potential for further use and development.

¹ The terms "information modelling" and "entity modelling" are used interchangeably in this paper, on the grounds that the most commonly accepted definition of an entity is "something about which we wish to keep information". The general approach to the work required that we avoid rigid definitions - the intention was to remain open minded and flexible at all stages. Note however that the term "data modelling" is *not* used here except where others have used it (Goodhue *et al*), or where a distinction between data and information is to be made.

² Available frameworks tend to be based upon soft models (for example the cultural web at the strategy end of business [Johnson & Scholes, 1989]), or have a strong process orientation at the technology end of the business (for example the stage model for EDI integration developed by Swatman *et al*, [1994]).

ISSUES IN BUSINESS MODELLING

Business process redesign

The extensive current interest in business process redesign and process reengineering has brought a clearer focus to the question of how we view business processes through models, and how we can manipulate them. A question that is rarely if ever addressed, however, is how we might derive a model of business processes from a "clean sheet", other than by means of pure intuition. Perhaps the process viewpoint is not the only one that we could choose to take?

A broad search of the academic and practitioner literature led to a clearer understanding of the state of play, and indicated where additional work could be done.

Evidence of business modelling activity

In areas as diverse as product development, manufacturing (especially computer integrated manufacturing), product design and customisation, logistics, retailing, direct marketing, media and advertising - even in insurance and other information intensive industries - there is evidence that new forms of business and enterprise modelling are a critical factor in dealing with today's challenges [Sheridan, 1993; Takeuchi and Nonaka, 1986; Lopes, 1992; Pine, 1993; Stecher, 1993; Smith, 1991; Stahlman and Brody, 1993; Zahniser, 1993; Novack, Dunn and Young, 1993; Cole, 1992].

At the more practical level there is extensive work being undertaken to develop business modelling methods and techniques, and one area of development is the extension of systems modelling techniques into the management and strategic activities of business. Some organisations have had good experiences, and a number of recent papers argue the case for systems models at the enterprise level, in order to:

- unify the many aspects of corporate systems,
- find opportunities for innovation,
- manage concurrent operations,
- break out of current barriers - both to thinking and to business itself, and to
- improve the health of the organisation.

[Haeckel and Nolan, 1993; (anonymous), 1991; Li and Juster, 1993; (anonymous), 1988; Aranow, 1991]. We can also find an increasing number of references to the idea of the virtual enterprise in both the academic and practitioner literature [for example: Flaig, 1992], and evidence that Japan is also awakening to the potential for more abstract business modelling [Shibata, 1991]. These examples all lend evidence to the argument that managers will be more effective when they can share in the business modelling process, and contribute to it in an informed manner.

In the world of cost management activity based costing (ABC) demands a careful analysis of business processes in order to provide proper foundations for enterprise wide cost management [Tham *et al*, 1994]. Advanced practitioners of ABC insist that it is a key strategic tool for developing partnership agreements [Nagle, 1994].

Architecture and modelling: problems with definitions

On the other hand, closer inspection of reported experience suggests that we do not yet agree what we mean by terms such as "virtual enterprise", "enterprise modelling" and "architecture". One report of an "enterprise architecture" is largely based upon the geography, organisation and technology of the organisations involved [Richardson, Jackson & Dickson, 1990; Allen & Boynton 1991]. Whilst this

is not wrong it reflects our long history of always thinking about the physical rather than the abstract. Other evidence provides enthusiastic reports of experiences with more abstract information resource modelling [Shah and Leja, 1991] and practical experiences with architectural ideas (for information systems!) in the construction industry [Eastman, Chase and Assal, 1993]. There are some early cases where entity-relationship models are explicitly referenced [Armitage & McCarthy, 1987].

The evidence is that there are a large number of possible "perspectives" on a business, which are claimed to be helpful in thinking about it, analysing it and developing it. The information systems specialists had addressed this, but the result is frameworks for studying frameworks [Olle *et al*, 1988; Heym & Österle, 1991] - withdrawing further into the world of the abstract is unlikely to help the world of management, although this work does make an important contribution to our understanding of modelling, in the more general sense.

Although there is an apparently intense interest in information architectures and data resource management (in a survey of selected businesses in the US, these two issues rated highest [Niederman *et al* 1991]), the most favoured perspective in the general literature seems to be the *process* viewpoint. There is only a minority of papers dealing with the *information* viewpoint (most from information systems specialists). In the "information age", this is a surprising result which warrants investigation.

Business modelling and the world of systems

The world of information systems continues to develop and promote ideas about systems modelling for the general benefit of business. Work by Zachman is often quoted [Zachman, 1987; Burgetz, 1992] and the theme of linking the business and technical levels through the medium of systems models is recurring [Robotham, 1993 and Radding, 1991]. Some suppliers (for example IBM and D&B Software) are nailing their flags clearly to the business and enterprise modelling mast [Eckerson, 1992 and Cusack, 1991; also Vizard, 1993]. The stimulus to business modelling that derives from the increasing use and capability of CASE (Computer Aided Systems Engineering) tools is also evident [Gibson and Snyder, 1991; Scholz-Reiter, 1992]. Information technology standards making is also increasingly dependent upon its modelling capability³ and has undertaken interesting and authoritative work on conceptual modelling [ISO, 1987].

Techniques such as *Information Engineering* [Martin, 1986], *Structured Systems Analysis and Design Method*⁴ [Ashworth and Goodland, 1990] and *AD/Cycle* [IBM, 1990] all provide structured techniques for dealing with information or data modelling as well as process modelling. *BSP* [IBM, 1975] preceded *AD/cycle* and is often cited, as is *Method/1* [Arthur Andersen & Co, 1983]. These methodological approaches to the problem have begun to mould our thinking and have achieved a high level of use for application systems planning and specification. Today, some companies (for example Texas Instruments) are offering templates upon which to build business systems, but experience of this interesting idea is still limited.

Despite the fact that these are still early days enthusiasm is widely evident, especially in the practitioner literature. For example, Feldman and Miller [1986] describe an entity clustering technique developed by a large UK brewery in the context of information engineering, and used for high level modelling; Sager [1988] illustrates the use of data models on an enterprise-wide basis. As recently as 1991 Gibson and Snyder [1991] were arguing equally enthusiastically that that computer

³ Consider for example the Open Systems Interconnect (OSI) seven-layer reference model and the way that it has shaped thousands of man years of standards making effort.

⁴ Widely used in the United Kingdom public sector, and universally referred to as "SSADM".

modelling tools would empower the wider business community to embark upon information and knowledge engineering projects.

Despite the widespread practitioner optimism research demonstrates that not all aspects of these methods are successful or easy to implement, especially in the area of information modelling. For example, there are serious and recurring problems in achieving success with strategic data planning [Goodhue *et al*, March 1992] and with entity life history analysis⁵, both of which are directly related to information modelling in business. Goodhue *et al* present a total of 15 propositions dealing with the difficulties that are faced. Five are particularly relevant here:

"Data integration must be *critical* to the strategic goals of the organisation,
as perceived by top management" (*Proposition 2*)

"It is not clear what the most appropriate form for a data architecture is"
(*Proposition 5*)

"Too large a scope spells trouble" (*Proposition 7*)

"For a systems priorities goal, strategic data planning does not narrow its
scope fast enough before it begins the time consuming process of modeling
business functions and entity types" (*Proposition 11*)

"Creativity is swamped by the volume of detail" (*Proposition 12*)

From this we can deduce that we need to:

- find a way to get management more involved, and to reduce the time and effort needed;
- contain the volume of detail and find a scoping device for information modelling;
- find a way to effectively compare information models from different sources;
- establish an acceptable common form for a data architecture.

The work of Goodhue *et al* is clearly important. It is based upon four case studies in three organisations, where strategic data planning was undertaken on a large scale: the costs of the studies varied from \$450,000 to \$1,900,000. In each case, a formalised method was adopted in order to structure and drive the work. Whilst some success was achieved it was not always as expected and other cases are quoted where there was complete failure. Their work did not attempt to provide evidence of the use of information modelling on a small scale, at senior management level, without regard to the identification of specific information systems applications. The possibility therefore remains that there is unrealised potential in the techniques in this more contained and focused context.

Earl [1993] also identifies that method-driven approaches have their limitations. They are too weak for business strategy, IS department sponsorship is not helpful, and the adoption of methodological working seems to remove the work from the reality of the business. He also indicates that there are often unexpected benefits. His conclusion is that the organisational approach is most likely to succeed, and this confirms that we must remain adaptable to circumstances. Too much method is not such a good thing, perhaps?

In order to investigate problems with information modelling and to find possible ways to deal with them, a different approach was adopted. It was decided to examine the use of information modelling in an informal way, with small groups of managers, and outside the context of information systems planning and development.

⁵ Based upon PhD research undertaken by Helen Edwards, SSADM Research Centre, Sunderland University, UK.

METHOD

Introduction to the method

A complete, cyclical method of systematic business analysis had already been established within the context of the EDI research project mentioned earlier [Bytheway, 1991b]. It is based upon three different kinds of modelling and analysis activity⁶:

- The identification of business activities and processes by means of a hierarchy model.
- The identification of the flows of information and goods amongst and between those activities and processes.
- The identification of the fundamental entities in a business, and the requisite activities to service the needs of those entities during the lifecycle of their existence.

It can be seen that the nature of this analysis approach is circular:

... from processes we find flows, within flows we see evidence of entities; from entities and their life histories we can assemble the detail of required processes ...

No single starting point is defined in the method: it is allowable to start at any of the three possible entry points. This paper is concerned with information modelling, and it is therefore appropriate to start with entity analysis. In this case the sequence becomes:

... from entities and their life histories we can assemble the detail of required processes; from processes we find flows; within flows we see evidence of entities ...

.... and so on. From a larger number of case studies outlined elsewhere [Bytheway, 1994a], three were suitable for the use of entity modelling as a first step, either because of the uncertainty about business processes or because of an overriding interest in information.

Justification of the use of case studies

The nature of the project was practical, being supported by a total of 20 European organisations - all interested in an early understanding of the likely effects of EDI on business. After a period of conceptualisation, certain ideas were tested with the sponsoring organisations.

It follows that the approach to the work was necessarily empirical. There was no intention to hypothesise and test a theory, but merely to devise, test and develop concepts so that they became useful (or discredited). The use of case studies is therefore axiomatic to this work. The question of whether there might be a theory underpinning the ideas presented here is left for others to ponder and explore.

Approach to the task

The nature of the three case studies helped to determine the sequence and detailed method by which the work was undertaken.

The case studies

- *First, there was a prototyping stage using a case study of a manufacturing company undergoing a major strategic change programme.*

⁶ It is a radical simplification of the cycle of analysis embodied within SSADM.

The modelling approach was explored and refined using available data from an early case study of unequivocal success, and the results were then reviewed critically with the managing director of that time, who had sole responsibility for the change programme. His comments were encouraging, and allowed the approach to be further refined and validated to the degree that it could be tested in other, less well known situations.

By starting with a successful case, it was hoped that other (incomplete or potentially less successful) cases could be assisted by a process of comparison.

- *The second case provided a contrasting (but still well contained) situation in a retailing business, at the start of a major EDI implementation programme.*

The modelling approach was used to simplify and summarise an existing corporate data model, in order to understand more clearly the opportunities to exchange and share business information with retailing business partners. The model was reviewed with and approved by the EDI steering committee, largely consisting of business managers. The EDI project itself was led by a business manager. She was more closely involved with the research and provided other assistance in developing and testing the ideas.

A comparison with the first case is informative and reveals interesting differences between the two.

- *The third case study was different yet again, being a systems services organisation within the public sector, setting itself up as a free trading company.*

The managing director designate and the senior technical manager were involved with the work. They undertook a brainstorming session and subsequent review sessions which led to a stable entity model, and then to a first cut process model for the new business. This was an extension to the analysis undertaken in the first two case studies.

Again, the comparison with the first case led to the development of a more complete information model than would otherwise have been possible. Further, it shows how it is possible to derive a completely new process model⁷.

Elicitation and refinement of the models

The same essential process was used in each case: the development of an entity model on the basis of the perceptions of management. Typically, the opening question would be:

"What's this business really all about?".

Follow-through was accomplished with questions such as:

"What resolves the obviously complex relationship between employees and the tasks you ask them to undertake?",

or *"You haven't mentioned anything in the general area of corporate resources - what's important there?"*.

The topological framework

The first case study was examined carefully for generic content. By simplification and abstraction it became evident that there were seven primary domains of interest, and these became the basis of a topological framework. By "topological" is meant a spatial arrangement of high-level concerns, such as "marketplace" and "product" - roughly equivalent to the idea of subject area databases propounded

⁷ Work has been initiated to test the theoretical basis for this idea.

by Martin [1986], but derived by a different means. The derivation of the generalised framework is described in more detail within the presentation of the first case study.

It was then used and adapted as the need arose; in the event it was remarkable resilient. Only minor changes to the names of the domains were made, and there was one entity type which could not easily be located within it (in the third case - see the concluding sections of this paper).

THE CASE STUDIES

Heenan Drives: the prototype

Background

In the 1980s Heenan Drives made a range of variable speed electrical drives based upon eddy current couplings. This product is similar to an electric motor, but the variable speed capability makes it suitable for a wide variety of applications in industrial production systems, for example in ventilation and conveyor systems.

The purpose-built factory in Worcester, England was capable of production to the value of £20 million per annum, but actual turnover was less than £5 million (and falling). The prospects were grim⁸. A new managing director, Brian Morgan, was appointed to initiate a major reorientation of the business based upon a new product concept. Because of the high cost of manufacturing in the UK, and the rising competition from overseas sources, it was decided to design a range of digital control systems that would be targeted at the same end market - industrial process systems - but which would add value by the provision of a *fully engineered solution* to a control problem rather than just basic components.

The consequences for the business were:

- The approach to the market, which was traditionally through agents and distributors, had to be re-oriented directly to the end user of the system.
- Rather than selling from a catalogue of standard items (control systems components made for stock), the company needed to offer bespoke solutions (complete control systems made to order).
- The manufacturing facility had to be converted in stages to clean conditions (from metal working and engineering assembly, to digital systems production).
- A substantial software development and production capability was needed, for the local operation of the digital control devices and for remote communications with control centres.
- The work force had to be replaced or retrained, in order to provide the necessary engineering, management and marketing skills.
- The company's commercial systems had to be replaced with a modern MRP II system in order to deal with a greatly increased number of procured components, and to provide improved management control.

The changes to the company touched upon all its aspects: the product, the marketplace, purchasing, the workforce, and all the activities within the company⁹. Mostly, perhaps, the changes impacted on the management of the company.

⁸ This commentary is based upon the situation at Heenan Drives some time ago; it should not be taken as in any way indicative of the current situation.

The changes were a great success. New business followed as the market recognised the merits of the new product range. One early sale was to a regional water utility, providing them with centralised control of remote water distribution plant. Another was to Jaguar Motors: a new automatically controlled ventilation system for the paint spraying booths.

Internally, the MRP II system was also a success, being installed and implemented ahead of schedule and well within budget, and delivering the benefits that Brian Morgan had hoped for. A key feature of this success was the leadership and commitment provided by Brian himself as managing director. At a time when the confidence of the workforce and marketplace were at risk he maintained clarity of purpose by holding on to certain basic principles:

- The company was still addressing the same market, *but offering substantially more added value by providing complete systems.*
- The product was still addressing the same ultimate market need, *but the company was to shift its attention to directly address end-users rather than agents and distributors.*
- The same premises and the same company identity were to be maintained, *but the skills base required was to completely change, being focused on software development and digital systems design and production.*
- The same basic management team was to be kept to lead the process of change, *but the commercial and management systems were to be completely replaced.*

The problem

A study of Heenan Drives in the early stages of this period provided detailed models of the business, based upon its processes and the way that they were to be changed to achieve the new business purpose. These process models were complex, and when they were reviewed with the senior management team they had only limited usefulness. The management team was guarded in taking ownership of the models. Success derived from Brian Morgan's leadership and not from the business models, although they were the basis for the detailed project planning that enabled success.

In this context, given the arguments presented earlier in this paper, and in order to study how the features of a changing business can be more clearly seen, it was decided to experiment with high-level entity modelling.

Approach adopted in this case

[take in Table 1 here somewhere]

Table 1 provides a rough identification of some key features of the old and new forms of the business, under the headings *marketplace, product, purchasing of procured inputs, commercial activities, production activities, factory workforce and management*. These headings are empirical, being based on domains of change *as seen by the management*. This was the starting point for an entity model dealing with the business in more detail, and with a greater degree of rigour. In order to develop this model as an accurate reflection of management's viewpoint, three steps had to be taken which distinguish the resulting model from the more typical form of entity model in a business.

■ ***Organisation of the model into domains***

It was decided to preserve managements' view of the seven domains and use them as an overall framework or topology for the model. The risk arises that it might not be possible to

⁹ Today this case would be treated as an example of business process redesign, but these were early days and it was not seen as such.

classify the entity types into one or other of these domains, and also that the relationships between them would be so complex as to not fit easily across them. This required some experimentation but a suitable topology was developed, preserving the domains already identified (see Figure 1).

[take in Figure 1 here somewhere]

■ ***Treatment of activities as entity types***

It can be seen that the seven domains include two that are potentially ambiguous: *commercial activities* and *production activities*.

Because of the extent of change to the overall processes of Heenan Drives it was clear that many individual business activities would have to be redefined: there had to be training in the new activities; management wished to be able to assign the workforce to different activities with more precision. This led to the conclusion that activities were *things about which it was necessary to keep information*, and it was decided that they could be treated as entity types¹⁰.

This is a potentially useful idea because it enables us to incorporate the concept of process within the entity model without becoming embroiled in the detail of process modelling (with inputs, outputs, data stores, material stores, and so on). It is not often seen in traditional entity models.

■ ***Treatment of associative entity types***

As soon as any detail is exposed (and sometimes even earlier) the question of associative entity types arises. These are those entity types that relate two or more primary entity types to each other, resolving a many-to-many relationship, as shown in Figure 2.

[take in Figure 2 somewhere here]

In the example, the simpler form at the left shows that **EMPLOYEES** may have many **TASKS**, and a **TASK** may be serviced by many **EMPLOYEES**. This many-to-many relationship would have to be resolved in database design; in this case the resolution is achieved by the introduction of **ASSIGNMENT** (at the right side), an entity type that was uppermost in management's mind in this case. Identifying such associative entities can be a critical step, as anyone who has had to deal with data analysis and database design knows.

In working with business models for management these associative entity types are often identified intuitively. It was decided to pay special attention to these associative entity types when they occurred, especially in mapping them to the seven domains.

The model

Table 2 provides a listing of key entity types that were identified. This was achieved by inspection of the process models and by a further review with the managing director¹¹. A pictorial form of the

¹⁰ In conventional structured analysis activities are usually named by a verb-object phrase, such as "sell goods" or "deal with customer query". These are not appropriate to name an entity type, and where there is no obvious alternative it is sometimes possible to take the gerundive form of the verb (ie a noun that is derived from a verb) instead of the transitive form to deal with this. Thus, **specify requirement** becomes **requirement specification** - the former clearly indicating a process which will have inputs and outputs, and the latter the act of specification, at a more abstract level which we can relate to other entity types such as the employee who produced it, or the customer who required it

¹¹ Note that for purposes of clarity this listing is a simplified version of the original.

model is presented in Figure 3, which shows the entity types mapped to the domain model, and includes relationships between them (the "v" end indicates multiplicity, but the treatment of cardinality of relationships at this level can not be rigorous).

[told in Table 2 and Figure 3 here somewhere]

Analysis

The following comments arise from an analysis of this model and its use in this case.

- It was more acceptable as a basic model of the business than the process models. The whole business can be represented on one page and significant changes (such as the elimination of agents and wholesalers, and the introduction of REQUIREMENT SPECIFICATIONS and formal ASSIGNMENTS) can be easily incorporated.
- The principal effects of these changes can be seen through the consequent modifications to relationships. For example, the consequence of ASSIGNMENT of EMPLOYEES to tasks according to their SKILLS can be easily seen, and detailed procedures to achieve this can then be devised by turning to conventional activity analysis techniques.
- The model (both in the simplified form presented here and in the full form) shows that each of the seven domains within the framework is addressed to some degree or another, and there are no areas where there are major omissions. There seems to be a reasonable degree of balance.
- Features of the model can be challenged, on the grounds that they may reflect on the quality of the business. For example, why is there no apparent relationship between the CUSTOMER and COMPETITORS? Is it because the business knows nothing about the competition, or because there is no mechanism to garner information about competitor relationships with existing customers?
- Residual many-to-many relationships can be resolved. This version of the model has been refined to eliminate them. In so doing several points of significance were exposed (see the comments on detail and associative entity types below).
- The importance of apparently low level detail comes out. For example, ELEMENT OF REQUIREMENT and USE OF PRODUCT are exposed as key connections between the company's product capability and the customers need - they obviously need to be managed carefully. The management relevance of individual customer ORDERS, DELIVERY and COMPONENT DELIVERY may seem tenuous, but in fact they are all critical to the successful management of the overall logistical balance of the business and they need to be monitored carefully, both separately and in relation to each other.

Discussion: the role of associative entity types

The model shows that associative entity types sometimes act as a "join" between one domain and another and are therefore potentially important. There may be a rule that they are *always* important when they lie between domains in this way.

There will always be more instances of associative entity types than primary entity types in a typical business. The detailed business information that attaches to these entity types may be high volume and is often seen as mundane, but the story that it tells is essential to successful management. We must have high quality, reliable data which shows how our customers derive benefit from our products and how our people are assigned to their tasks if we are to have any chance of seeing operational improvements and the benefits of strategic developments. The organisation that fails to

manage this critical information will never know whether it has achieved anything, except by a subjective process of simple observation.

Brian Morgan summarised this in a straightforward and effective way. "If it moves on the factory floor," he was given to saying, "then moments later I can see it in the general ledger". How many executives could say this with their hand on their hearts? The information in the general ledger will only ever make sense when it is properly associated with other operational information about the processes and resources that constitute the cost drivers.

This model displays a reasonable balance in each of the seven domains. One might ask: what would be the consequence of an imbalance between the domains? Should we seek balance, or is it irrelevant to the business? An examination of an equivalent model for a retailer helps us to formulate an opinion about this.

A retailer: ASDA Superstores

Background

ASDA Superstores are well known as a multiple out-of-town superstore operator in the UK. They do not have the greatest share of the market, but in recent years their business performance has been exceptionally good.

Earlier in the 1990s they embarked upon a major implementation of EDI with suppliers, trailing some of their competitors in simple numerical terms but adopting a more earnest approach to partnership, and sponsoring the development of high quality supplier EDI workstations by a third party. This was at a time when their business performance was perceived as marginal. At the time they were considered ripe for a take-over bid.

The problem

The problem was simple and not particularly critical: to be able to identify EDI-related benefits, and to take stock of information sharing opportunities. Also, to find a justification for business improvement ideas such as self billing and automatic replenishment. This was a good opportunity was taken to experiment with the modelling framework and to gain further experience of its use.

Approach adopted in this case

A high level entity model was developed. It was based loosely on the content of the ASDA corporate data model, but it was significantly simplified (the original corporate data model was very complex and included many low-level operational and technical entity types; it was also classified as highly confidential). Despite this simplification the key entity types relating to the EDI opportunity and the essential structure of the business were preserved, and the balance of information in the different domains was maintained. It was reviewed with the EDI steering group and it was found by them to be informative about information management issues relating to the problem, and it was accepted.

The model

A simple form of this model is presented in Figure 4. Only one modification was required to the basic topology: one of the domains has been renamed in order to generalise it: WORKFORCE has become RESOURCE. This permits the positioning of resources other than the human resource, such as DEPARTMENT, retail STORE and LOCATION (Heenan Drives was a single-location organisation, and so this issue had not arisen).

[take in Figure 4 here somewhere]

This is a simpler model than for the manufacturing company, but then some would argue that retailing is a simpler business¹². There are only 15 entity types, located in five of the seven domains in the overall topological model. There are no references to entity types within the domains of management and production.

Analysis

The model leads to a quite different kind of analysis than with the manufacturing company.

- Why is there such a preponderance of information about supply (CONTRACT, information about SOURCE, PURCHASE ORDER, DELIVERY, INVOICE and PAYMENT), and none about production? Is this a real reflection of the nature of the business?
- Why do we have so little evidence of MANAGEMENT information? In fact, the performance of individual stores was very closely monitored but the general visibility of information about corporate performance was limited (especially in comparison with the manufacturing example). What could be done about this? Might EDI implementation make a difference?
- Why is the CUSTOMER not highlighted within the model? It seems so fundamental to have information about customers within a business, and yet the analysis reveals that there is none in this case. Again one must ask whether this is a real reflection of the nature of the business, and whether this is what the management would wish?
- The lack of evident information within the production domain relates to the nature of retailing. We can argue that it is just bulk breaking. Commodity goods get into customers' shopping bags by diverse processes involving trunking, regional distribution centres, local distribution and in-store operations. Nothing actually happens to the product, and many customers would as readily buy from the original manufacturer if appropriate packaging quantities were available. As it happens they are not, and so we have to go to the retail store.
- The main "product" of the retailer, as interpreted here, is not the ITEMS which are procured from suppliers but the AVAILABILITY of those items. The role of the retailer is to make available those items that people want, in pack sizes and quantities that suit their needs. This is a well understood feature of any retail business, and the management of the "availability matrix" in ASDA was the principal means to make sure that the right items were made available in the right stores at the right time.

Discussion: the issues of customer information and value adding

In reviewing this model with the EDI steering group it was found that there is indeed a preponderance of information on the supply side of the business. This is a direct result of the intense concern to reduce operational costs and to tighten the relationships with suppliers to the maximum possible degree. This problem was not unique to ASDA: shortly after this study Tesco realised that their marketing had suffered in the period of supply optimisation, and mounted a major promotional and image rebuilding campaign. There followed a period known as the retailing "price wars", which still persists.

We use this model to examine the question of balance. Does the future success of the business depend upon balancing the model with "production" information? What does "production" mean in this context? Is customer information going to be helpful?

¹² No doubt others would take the converse view

The customer information available to retail management in the past has been limited. Instead of embracing detailed customer information within their information management regime, large retailers have chosen to largely ignore it. This has been compensated by the use of market research information, and the use of third party sources for specific information on category and item performance.

Until retailers can associate sales details with individual customers, retailing will always be an approximate business. Here begins the justification for affinity clubs, and the idea that charge card and debit card data can be used to start maintaining information about individual customers.

On the other hand we might note that there is a trend to warehouse clubs which do acknowledge that bulk-breaking is the only real value adding, and it is interesting to observe the readiness of the buying public to go to these alternative outlets. But what about the "shopping experience" which the retailers argue is the real contribution of the retailer? If this is truly so, then we must find value adding processes that deliver the shopping experience, and entity types in the high level entity model that reflect this experience. Without this, the notion of a good "shopping experience" will remain an arguable and possibly unmanageable aspect of the business.

At a more practical level, retail outlets such as ASDA in the UK are introducing real value adding. The availability of freshly baked bread is one illustration, where a part of the store is given over to an in-store bakery. This has the benefit that the bread is delivered to the store in component form (far more compact than the finished loaf) and the customer gets a totally fresh product, but it needs some additional information - about the process of baking and the batches that are produced. Also the quality control requirements, which are quite different than for a bought-in product.

Another trend is to extend the number of lines sold, to provide more than any customer will ever actually need. This all sounds good for business, but if we are to succeed with it we must have a clear vision of the entity types that reflect the customers' needs so that the balance between supply and demand can be preserved. For example, for any customer what are the typical buying patterns? What are today's special needs, and what is the particular condition of the customer and the local circumstances on this occasion?

In summary, good information management allows the retailer to become "smarter". By knowing more about product availability and customer's needs, the retailer can provide a more satisfactory service to customers.

A systems and services company: Norwich Systems and Accounting (NSA)

Background

There is a high level of change taking place in the public health service in the UK. There are great pressures to privatise those parts of the overall "public-owned" health industry which are not central to the care of patients. Not surprisingly, this includes computer services.

In the East Anglian region of England the Norwich Area Health Authority had a computer department which was perceived to be highly competent in the provision of financial systems services and EDI. It was decided to launch the computer department as a free trading company. This has since been successfully achieved.

The problem

The problems facing NSA begin with the considerable differences between the values and culture of the public service and those required for a free trading company. Once these problems were understood the more mundane question arose of the shape and form of the new business. This required that the new management team discard all previous "business" processes (as being appropriate only to a public body). New models were needed to show how the operation could work in a cost-conscious and profitable manner. This demanded a complete redefinition of business activities and some deep thinking at a time when the immediate imperative was to generate revenue - *any* revenue.

It was agreed that the high level entity modelling approach would be used to derive a completely new business process model, in accordance with the intentions of the new analysis approach. Critical questions concerned the speed with which this could be done and the effort required, and the need to identify value adding potential in the new business model.

Approach adopted in this case

The general approach adopted was the entity life history approach, but interpreted loosely at the highest possible level¹³. Briefly:

- Any entity that has been identified can be considered to have a *life cycle*.
- The normative stages of the life cycle are *initiation*, *execution* and *disposition*.
- Any event in the total lifecycle may involve one or more other entities, requiring some reconciliation of events across all entities.
- Every event identified in the lifecycle must be serviced by a defined business activity or (at the highest level) a business process.

The analysis was then extended to include the mapping of the resultant activities into the value chain [Porter, 1985] in order to check the completeness and balance of the resulting overall process model.

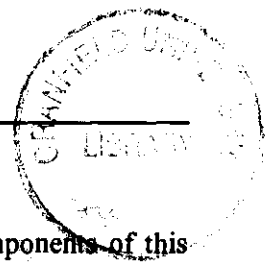
In practical terms, a brainstorming session with the management team provide the first rough cut at the model. The entities identified were sorted and positioned within the basic topological framework and reviewed with the management. Sparse areas were examined carefully and augmented as appropriate, and within three iterations the model was stabilised. During this stage commercial and technical activities were added, and the relationships between the delivered solution and its component parts was clarified.

The model

The full form of the entity model for this IT services company is probably the best developed example, in that it was the focus of management's attention for important strategic reasons, and it provided useful input for the development of their corporate strategy at a critical stage in the development of their enterprise. In presenting the model here (Figure 5) the relationships between entities are not provided - just lists of key entities within (and between) each of the seven domains. The life cycle approach did not require identification of relationships, it was thought.

The entities included in the figure are indicative of the content of the model at this stage, but once again the model has been simplified to aid clear presentation and so as not to overburden the reader.

¹³ This can be compared with the "Customer Resource Lifecycle" idea favoured by IBM, except that *any* entity can be considered to have a lifecycle, not just Customers.



The full form of this model includes more than 40 entity types. Each of the components of this emerging enterprise model - the entity types of the business - was then analysed for its lifecycle activity requirements. The resulting total set of high and low level activities (over 150 in number) was mapped into an "empty" value chain. This led to the first statement of the business process requirements of the new enterprise, as shown in outline (ie the higher level activities only) in Figure 6. The rigour of the modelling process again works for us here: this mapping showed that there was no activity yet emerging in certain areas of the value chain, including outbound logistics (service delivery), service and technology management. This required a further iteration: a review of the entity model, and further analysis of lifecycles.

[take in Figure 6 here somewhere]

Analysis

This case shows how the modelling technique can, by starting with entity modelling, derive a business process model from a completely clean sheet. This may become more important in the future.

In the case of NSA, the overall modelling exercise permitted a number of important benefits.

- The management team were able to develop a first cut vision of the operational needs of their business, very rapidly. The whole elicitation and review process took only a matter of hours, with one or two days' desk work being required in between meetings.
- In particular, the means whereby value would be added for customers became much more clearly understood, by mapping to the value chain.
- The business wanted to assess the application of new information technology solutions to operational requirements. The model allowed this to be done with a high level of confidence. In particular, it identified a number of opportunities for the innovative use of EDI.
- It exposed the opportunity to differentiate through good information management: information about business solutions, the use of EDI and related technologies, bought-in products which go to make up business solutions, suppliers and sources of products, and the processes whereby NSA delivers solutions to its customers. This information is not typically well managed by competitors.

This case presented the first real problem with the classification scheme embodied in the topological model: one entity type was identified that did not fit easily in any of the seven domains. The area health authority remained involved as a major shareholder; it is thereby a *stakeholder* in the business - not a natural fit to any part of the framework.

One must ask whether some form of stakeholder analysis might not clarify this, and even provide another perspective on things? This is left as an open question.

Discussion: Deriving completely new process models

This case study showed how, by avoiding immediate development of process models, a business can build firmer foundations for a fresh start. We can expect more and more turbulence in future business, leading to a preference for "starting over" rather than struggling to maintain the development of a mature organisation with entrenched attitudes.

The case exercised questions about required competencies and led to thoughts about a competency-based strategy. At a time when the effort and energy of the management team could

easily have dissipated in short term operational issues the model provided a means of standing back so as to see the deeper structure of the business.

It is interesting to note that there are examples of the "fresh start" approach. A bank providing personal banking services in the United Kingdom has completely re-written the rule book about how banking service can be (and should be) provided¹⁴. A 24 hour telephone-based banking service was developed and implemented in only ten months following approval of the business plan. Not only was the technical implementation a success, but the marketing success astonished even those who championed the idea. At one point it was necessary to suspend marketing because so many people were applying to open accounts. Customer satisfaction runs at about 85-90%, compared with 35-40% in the traditional "high street" banks, all simply by taking a fresh start and redefining the banking process.

RESULTS AND CONCLUSIONS

Summary of results

By analysing reported experiences of modelling in business, this paper has shown that entity modelling is neither the most frequently used nor the most successful technique, when compared with more easily understood process-oriented techniques. In well specified analysis methods like SSADM the stages and steps concerned with entity type identification and lifecycle analysis are known to particularly poorly executed in the majority of cases.

The potential for the entity modelling technique has been examined in a specific context: *business management dealing with management problems*. The results can be assessed by reference back to the questions asked at the start of this paper.

- *How can information modelling be made acceptable to management?*

A simple topological framework for entity modelling has been derived empirically which survived the test of three case studies: all entity types identified were able to be positioned with the framework, except one. The concept of a **STAKEHOLDER** was not able to be positioned in the NSA case. Generally the models developed within the framework were readily accepted, and of course the more it is used the more familiar and useful it becomes.

When compared with process models, the framework has been shown to provide an more acceptable and simpler vehicle for expressing the fundamental building blocks of a business. Process models are more extensive (requiring many pages) and tend to drag down the level of thinking to inappropriate levels of detail. The entity model can be used to avoid both these problems.

When it is the first step in a strategic analysis of a business, entity modelling has been found to be very rapid and immediately acceptable to senior management¹⁵.

¹⁴ The bank referred to is **Firstdirect**, a division of the Midland Bank (which itself is a member of the Hongkong and Shanghai banking group). Comments made here are based upon conference presentations by Firstdirect in 1992 and 1993.

¹⁵ Note however that where management have had previous unsatisfactory experiences with entity modelling the mention of the word "entity" is enough to throw up the barriers. This can also be a problem with information specialists who have not internalised the ideas of entity modelling, or who do not believe that they can be effective. We need an alternative terminology which will avoid these problems.

The framework provides an easy-to-understand (and easy-to-remember) topology for mapping corporate data models, where several of these need to be seen by a wide audience, where there is a high level of complexity, or where they need to be compared one with another. This is particularly important in cases such as logistics and supply chain operations, where the sharing of information is critical to success.

- *Which high-level entity types are perceived by management to be important?*

Each study provides evidence of the entity types that are considered important by managers, and the differences that occur between different kinds of business. This suggests that it should be possible - through the use of a standard generic model - to quickly assess the differences between organisations and their relative needs for information; equally, to inform management about information that might be important but that they have not recognised.

It has been shown that an entity model can incorporate the concept of process (or activity) as an entity type, and relate it to other more conventional entity types. This is helpful to management and makes the entity model more useful.

- *How can the impact of strategic change be seen at the level of information management?*

The framework is a way of bounding and scoping a business independently of business processes, so that senior management can understand the deeper implications of certain strategic moves, such as the introduction of affinity cards in retailing businesses.

The framework also helps to generate ideas which could lead to strategic advantage.

- *How much information is inherent in a business, and how complete is it?*

The framework provides a vehicle for a "stock taking" of the information that is used by an organisation, and allows analysis of the potential for information sharing and exchange between different organisations (or within larger organisations comprising many business units where information needs to be integrated).

It has been shown that in a retailing business the use of a generic modelling framework helps to expose imbalances in perceptions of information, and opportunities for strategic differentiation.

The framework provides a classification scheme for information in an organisation. Applications can be mapped to it and common data areas can be identified.

- *What are the key performance indicators which management need, and how do they relate to information generally?*

The identification and analysis of associative entities helps us to identify which operational data can provide key performance data to management.

The idea that cost is driven by activities which consume resources is evident in each of the three models developed, in direct support of the activity based costing idea.

- *Is it possible to derive a view of the ideal arrangement of business processes, from an alternative starting point?*

It has been shown that the modelling approach adopted provides a basis for the conception and definition of new processes, independently of current processes (which do not have to be analysed), and additional to more conventional entity types.

Further research opportunities

Being exploratory and empirical in nature, this work can not claim to have established new theory. It has established a base of experience and understanding which leads to a number of ideas for further work. Two ideas with theoretical potential are particularly worthy of mention.

■ ***Information in the supply chain***

A critical issue in manufacturing and retailing concerns the improvement and optimisation of supply and logistical operations. It is now recognised that information in the supply chain is a fundamentally important component of supply management and that information exchange (using EDI or by any other means) is not always enough. Information *sharing* within well developed partnership agreements is a major opportunity, but there are no established mechanisms for undertaking analysis of the information at the interface between businesses, so that shareable information can be easily identified, modelled, discussed and agreed. The kind of empirical topology adopted here might be a means to identify, analyse and clarify information sharing opportunities in the future¹⁶.

Almost all of the literature dealing with supply chain modelling invokes the process modelling paradigm. The challenge to find new process models for supply chains will depend at least partly upon a clear vision of the idealised information needed. We can now argue (based on the experience reported here) that to start with information models, using an enterprise modelling framework, is the best way to find new process structures in business. This argument can be extended to apply to the idea of the virtual enterprise, involving many businesses and requiring consolidation of information within them.

■ ***Business process management***

As experience with business process redesign and reengineering matures, we can expect that the management will want to balance the single minded process viewpoint with other perspectives. The information perspective is a strong candidate, being also based in systems thinking, and (as we have shown) being an effective counterpoint to the process perspective.

The work reported here has shown that process requirements can be derived by analysing the events and activities that sustain entity types through their lifecycle. There may be a more fulsome and complete framework for thinking that can be devised, which will be acceptable to managers; this is also worthy of further investigation.

Other concluding observations

In general, although entity modelling continued to be difficult for some of the people we worked with, the new approach was extremely helpful. It is useful to conclude by noting some general observations and conclusions beyond the constraints of the questions with which we began, especially concerning the basic topological framework developed within this work (Figure 1).

Although it was not an original objective of the work (and it is empirical in origin) it has served well, and may have wider long term potential. The framework:

¹⁶ This is exemplified in CALS - a United States Department of Defense initiative concerning the concept of continuous equipment acquisition and lifecycle support in the defence arena. An obvious step is to examine recent work in that area and to compare the "state of play" with regular businesses. The CALS initiative has made much use of the term "virtual enterprise". If the concept of the virtual enterprise is to mean anything, there must surely be a virtual information model to go with it? Perhaps the virtual information model will be the means to define the process attributes of the virtual enterprise.

- ... *stands as a good companion to the value chain.*
- ... *provides a structure for organising the results of fact finding and interviewing.*
- ... *has the potential to contribute in other areas.*

Where the value chain provides a high level framework for process modelling, the new framework does the same for information modelling. Any one who has taken the framework on board as an aid to thinking can use it to formulate ideas on the fly, and to check the completeness of discussions and presentations.

The third observation is perhaps the most interesting. For example, in the clarification and refinement of *accounting practices*: the way that it rigorously maps activities to the resource that is consumed allows a fresh interpretation (or definition?) of what is meant by "Activity Based Costing". In *marketing*: it prepares the ground for a more complete understanding of how products and services really meet customers needs, and for storing this information in a way that can be accessed and used by those who need it. In *engineering*: it shows how all of the many stages in design, specification and production engineering need to use the same information, and it provides sound foundations for the development of new integrated engineering operations. Some of these ideas are more extensively discussed elsewhere [Bytheway, 1994b; Bytheway & Braganza, 1992].

This is an area that should be interesting to academics. The world of academia suffers the same problems as business: too much reliance upon functional specialism. For the purposes of research and teaching we need models which transcend the different management and functional disciplines and provide common ground for comparative studies. Perhaps the new framework, or some evolution of it, will make a contribution to this need.

TABLES

Table 1: Heenan Drives - business constituents before and after the change			
General area	Primary elements of the old business	Primary elements of the new business	Comments
Marketplace	<ul style="list-style-type: none"> ▪ End customer ▪ Distributor ▪ Agent 	<ul style="list-style-type: none"> ▪ Customer ▪ Competitor 	<i>Distributors and agents are eliminated; heightened awareness of competition</i>
Product	<ul style="list-style-type: none"> ▪ Variable speed drive 	<ul style="list-style-type: none"> ▪ Complete control system 	<i>Greatly increased complexity. Requirement for version and change control.</i>
Purchasing	<ul style="list-style-type: none"> ▪ Basic engineering components (Castings, copper windings, fixings) 	<ul style="list-style-type: none"> ▪ Electronic components ▪ Telecommunications components 	<i>The number of components has increased dramatically; many new suppliers involved</i>
Commercial activities	<ul style="list-style-type: none"> ▪ Sales force ▪ Sales order 	<ul style="list-style-type: none"> ▪ Sales engineering ▪ Invitation to Tender ▪ Tender 	<i>Change to "Sales engineering" is significant: the nature of the sale process completely changed: "make to order" instead of "sell from stock".</i>
Production activities	<ul style="list-style-type: none"> ▪ Simple engineering assembly ▪ Simple quality control 	<ul style="list-style-type: none"> ▪ PCB development ▪ Specification ▪ Software assembly ▪ Hardware assembly ▪ System testing in the factory ▪ Installation and final test ▪ Maintenance 	<i>The factory floor area was re-assigned to "clean production" in stages; completely new skills were needed.</i>
Factory workforce	<ul style="list-style-type: none"> ▪ Craft based 	<ul style="list-style-type: none"> ▪ Engineering design ▪ Software design and programming ▪ Digital systems assembly ▪ Systems testing 	<i>The factory workforce was almost entirely replaced; a new engineering design team was hired.</i>
Management	<ul style="list-style-type: none"> ▪ Reactive approach ▪ Compartmentalisation ▪ Little information 	<ul style="list-style-type: none"> ▪ Pro-active approach ▪ Teamwork ▪ Timely information on all aspects 	<i>The MRP II system gave management the ability to analyse and react much more quickly.</i>

Table 2: A tabulation of key entity types at Heenan Drives, as seen by management (simplified)	
Domain	Entity type
Commercial	BANK ACCOUNT COMMERCIAL PROCESS CUSTOMER PAYMENT QUOTATION SUPPLIER SUPPLIER PAYMENT
Management	ELEMENT OF COST ELEMENT OF TIME
Marketplace	COMPETITOR CUSTOMER CUSTOMER NEED MARKET SEGMENT
Product	PRODUCT PRODUCT USE INFORMATION
Production	BUILD SPECIFICATION PRODUCTION PROCESS STANDARD
Purchasing	COMPONENT
Workforce	EMPLOYEE SKILL
Associative	ASSIGNMENT TO COMMERCIAL TASK ASSIGNMENT TO PRODUCTION TASK COMPONENT DELIVERY DELIVERY ELEMENT OF REQUIREMENT ORDER USE OF COMPONENT IN PRODUCT USE OF PRODUCT BY CUSTOMER

FIGURES

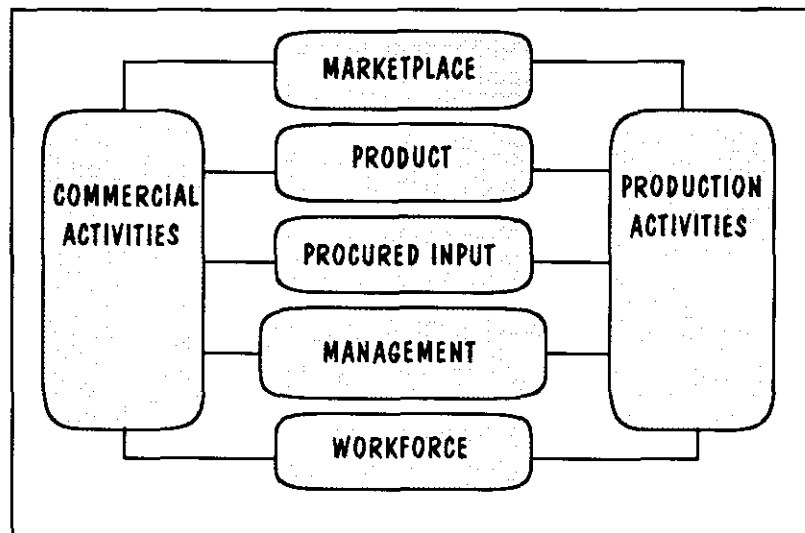


**Figure 1: An empirical framework for modelling,
derived from the Heenan Drives case**

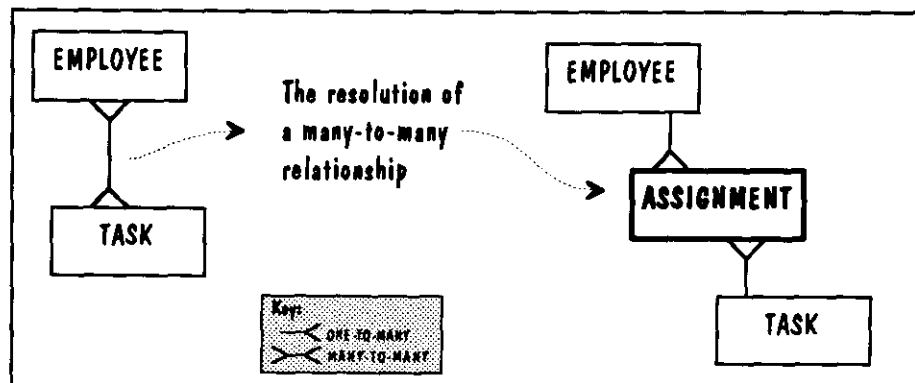


Figure 2: The associative entity type

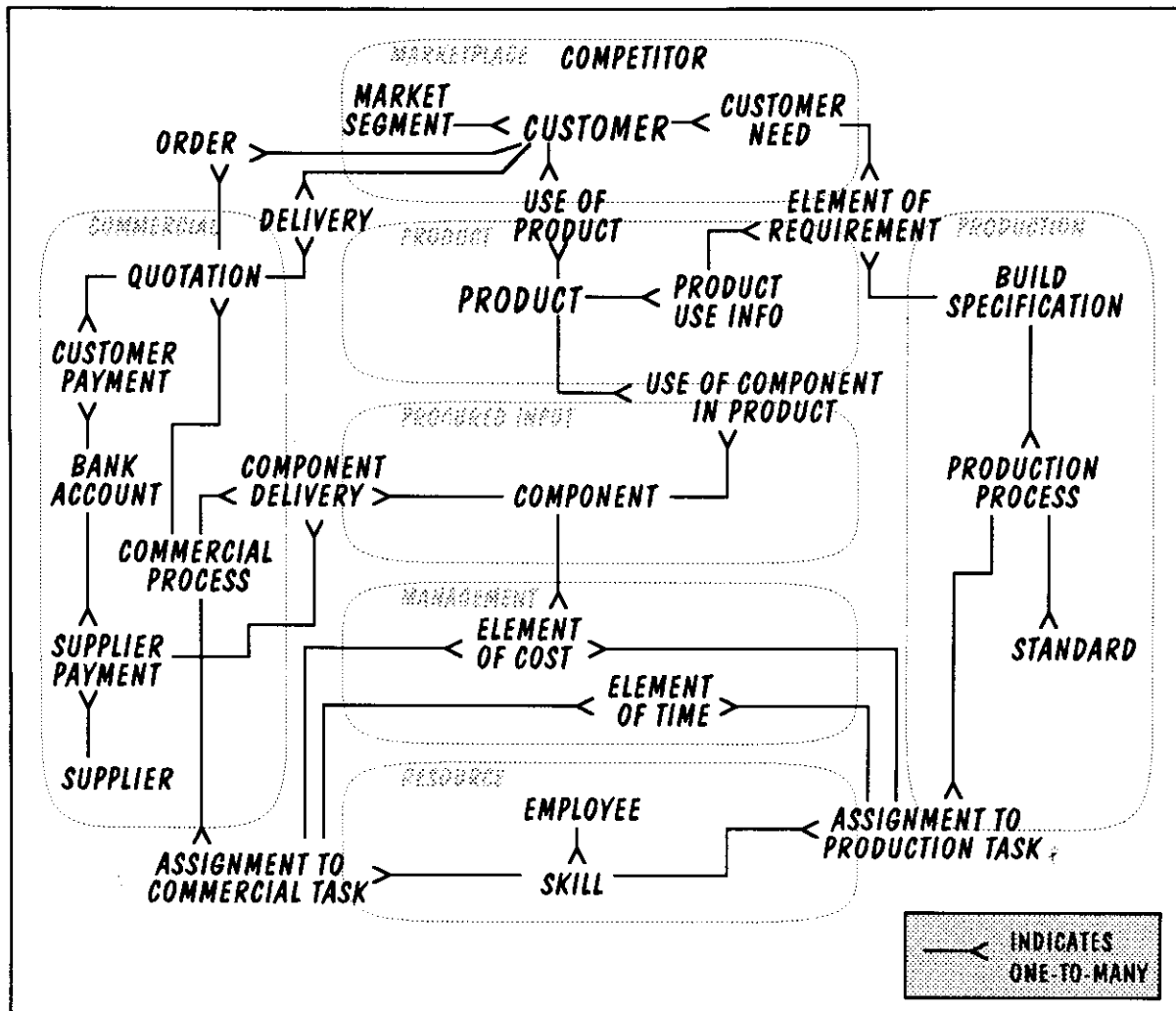


Figure 3: Manufacturing - a simplified entity model for Heenan Drives

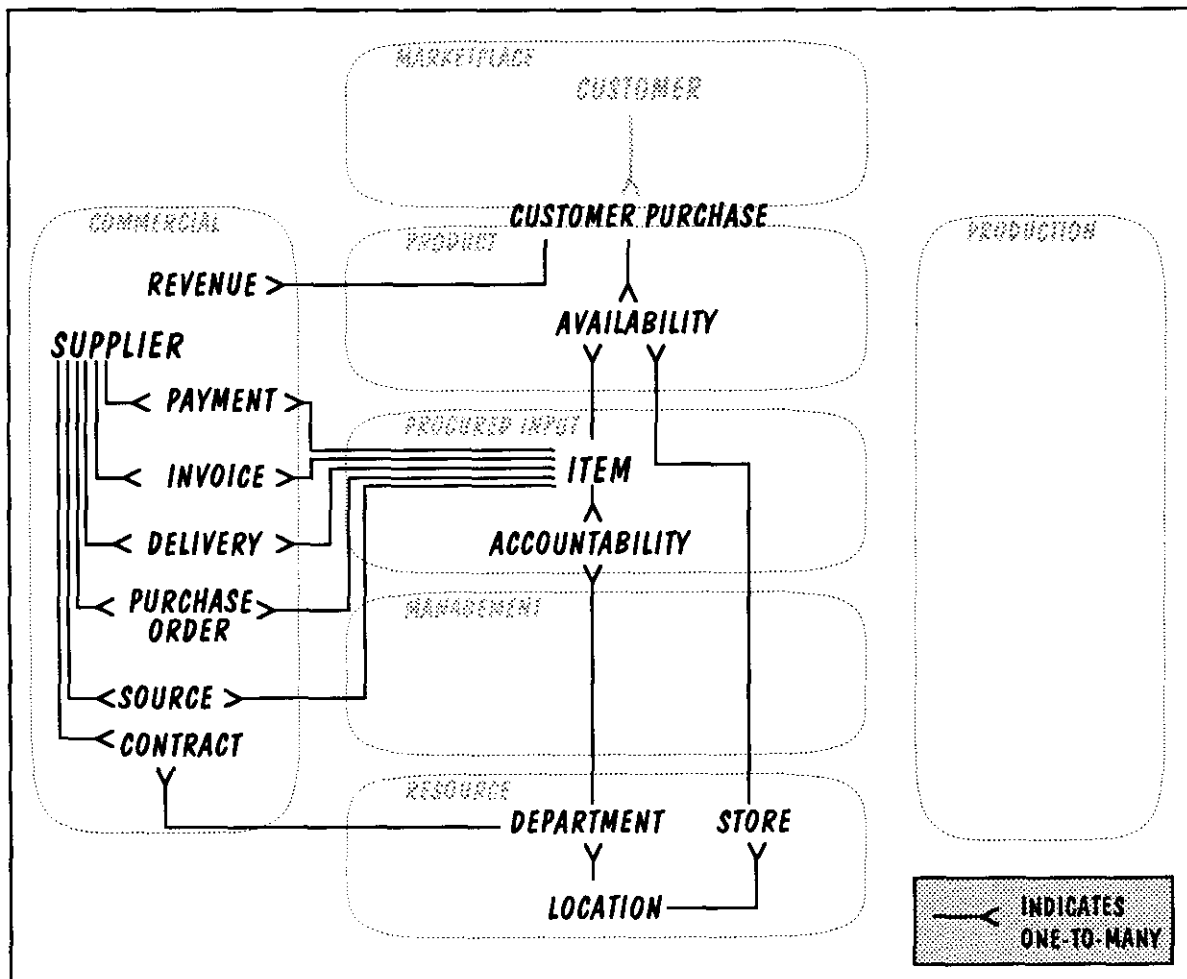


Figure 4: Retailing - a simplified entity model for ASDA superstores

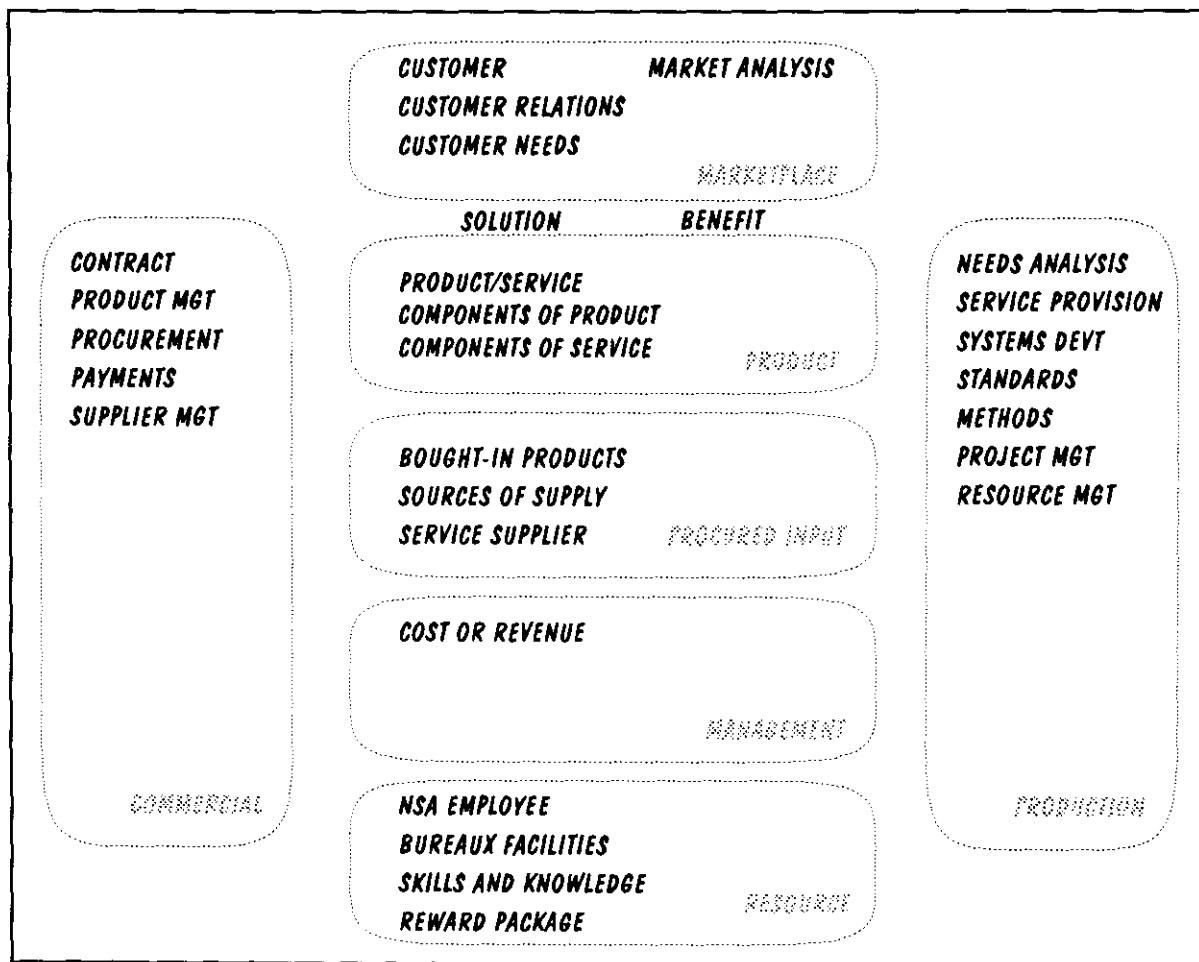


Figure 5: NSA - a systems service industry example

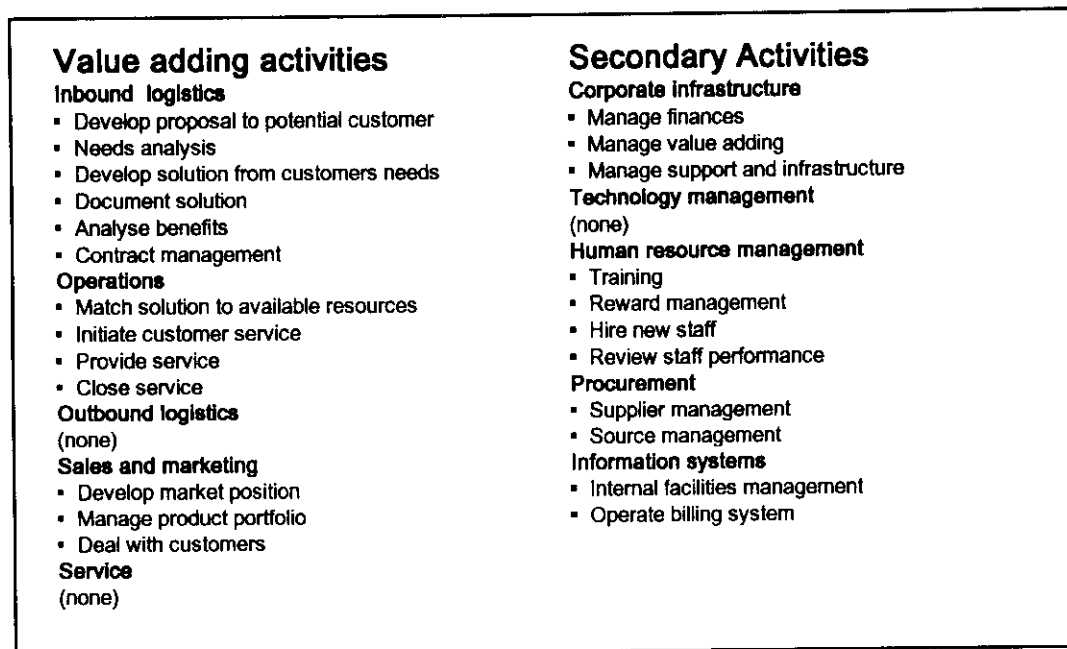


Figure 6: NSA activities mapped to the value chain (first iteration)

REFERENCES

- (anonymous) 1988; When It Pays to Think Big: The 'Extended Enterprise', IBM Directions
- (anonymous) 1991; Fostering Creativity and Innovation, I/S Analyzer v29n9, September
- Allen B R & Boynton A C, 1991; Information Architecture: In search of efficient flexibility, MIS Quarterly v15n4
- Aranow E, 1991; Modeling Exercises Shape Up Enterprises, Software Magazine v11n1, January
- Armitage H M, McCarthy W E 1987; Decision Support Using Entity-Relationship Modeling, Journal of Accounting & EDP v3n3
- Arthur Andersen & Co, 1983; "Method/1: Information Systems Methodology: an introduction", Arthur Andersen, Chicago IL
- Ashworth C & Goodland M, 1990; "SSADM - a practical approach", McGraw Hill UK
- Burgetz B, 1992; Systems modelling: not a hobby, CMA v66n2
- Bytheway A J, 1991a; A conceptual model of EDI evolution, (proceedings of) EDICOMM '91
- Bytheway A J, 1991b; The proposed Cranfield EDI Analysis Method, Cranfield research working paper
- Bytheway A J, 1994b; "Beyond the Value Chain: a new framework for business modelling", Cranfield School of Management Working Paper SWP 5/94
- Bytheway A J, 1994a; "The impact of EDI on Business Process Redesign: The Cranfield EDI Studies", Proc 5th World Congress of EDI Users, Brighton UK, June 1994 pp142-163
- Bytheway A J, Dyer B W & Braganza A, 1993; EDI: the longer term effects upon business - End of project report, Cranfield School of Management
- Bytheway A J & Braganza A, 1992; "Corporate information, EDI and logistics", Logistics Information Management v5n4, pp 10-18
- Cole J P, 1992; Insurer Claims Managed Care Breakthrough, National Underwriter v94n35, August
- Cusack S, 1991; D&B Envisions Place in Relational World, Computerworld v25n38
- Earl M J, 1993; Experiences in Strategic Information Systems Planning, MIS Quarterly, Vol 17 No 1 pp1-24, March
- Eastman C M, Chase S C and Assal H H, 1993; System architecture for computer integration of design and construction knowledge, Automation in Construction v2n2
- Eckerson W, 1992; D&B Software Exec Details New Client/Server Strategy, Network World v9n31
- Feldman P & Miller D, 1986; "Entity model clustering: structuring a data model by abstraction", Computer Journal, v29n4 pp348-60
- Flaig L S, 1992; The "Virtual Enterprise": Your New Model for Success, Electronic Business v18n6, March
- Gibson M L & Snyder C A, 1991; "CASE tools survey: computer aided software engineering: facilitating the path for true software and knowledge engineering", International Journal of Software Engineering and Knowledge Engineering v1n1 pp99-114
- Goodhue D L, Kirsch L J, Quillard J A and Wybo M D, 1992; Strategic Data Planning: Lessons from the Field, MIS Quarterly v16n1 March
- Haeckel S H, Nolan R L, 1993; Managing by wire, Harvard Business Review v71n5, September/October
- Hammer H & Champy J, 1993; "Reengineering the corporation: a manifesto for business revolution", Harper Collins
- Heym M & Österle H, 1991; A reference model for systems development, IWI Report No IM2000/CCRM/15, Hochschule St Gallen, Switzerland
- IBM, 1975; "Business Systems Planning: Information Systems Planning Guide", Publication number GE20-0527-4, IBM Corporation, White Plains, NY

- IBM, 1990; The IBM Systems Journal, v29n2 (this issue focused on AD/Cycle and provides a number of papers describing it).
- ISO, 1987; Information processing systems - concepts and terminology for the conceptual schema and the information base, ISO Technical Report number 9007:1987(E)
- Johnson G and Scholes K, 1989; Exploring corporate strategy, pp41 et seq, Prentice Hall
- Li S and Juster N P, 1993; An exchange strategy for product information, IFIP Transactions B (Applications in Technology) vB-10
- Lopes P F, 1992; CIM II: The Integrated Manufacturing Enterprise; Industrial Engineering v24n11, November
- Nagel M, 1994; based on a conversation with Mark Nagle at Procter & Gamble HQ, Cincinnati, Ohio.
- Niederman F, Brancheau J C & Wetherbe J C, 1991; Information Systems Management Issues for the 1990s, MIS Quarterly v15n4
- Novack R, Dunn S and Young R R, 1993; Logistics optimizing and operational plans and systems and their role in the achievement of corporate goals, Transportation Journal v32n4
- Olle T W, Hagelstein J, Macdonald I G, Rolland C, Sol H G, Van Assche F J M & Verrijn-Stuart A A, 1988; "Information Systems Methodologies: A framework for understanding", Addison Wesley
- Pine B J, 1993; Making mass customization happen: Strategies for the new competitive realities, Planning Review v21n5, Sep/Oct
- Porter M, 1985; Competitive Advantage, Free Press New York
- Radding A, 1991; Linking Databases: Many Paths, Computerworld v25n22
- Richardson G L, Jackson B M & Dickson GW, 1990; A principles-based enterprise architecture: Lessons from Texaco and Star Enterprise, MIS Quarterly v14n4
- Robotham J, 1993; Computers: The business model, Australian Business Monthly v13n11
- Sager M T, 1988; "Data centred enterprise modelling methodologies-a study of practice and potential", Australian Computer Journal v20n3 pp145-50
- Scholz-Reiter B, 1992; CASE tools for modeling and maintenance of a unified information/data model for decision support systems in manufacturing, Computational Systems Analysis 1992 (Proceedings of the 4th International Symposium on Systems Analysis and Simulation, Editor: Sydow A)
- Scott Morton M S (ed), 1991; "The corporation of the '90s", Oxford University Press
- Shah J and Leja C, 1991; Businesses triumph with IRM, Information Executive v4n4
- Sheridan J H, 1993; Agile manufacturing: Stepping beyond lean production, Industry Week v242n8, April
- Shibata R, 1991; The intelligent company: Corporate management strategy and utilization of information, Joho Kanri v34n9, December
- Smith J, 1991; The New Frontier, Direct Marketing v54n2, June
- Springtape, 1993; STEP: Opportunities for the UK Process Industry (video), QMS (Sandhurst, Camberley, UK)
- Stahlman M and Brody A, 1993; Life after commercials The new media needs advertising, Marketing Computers v13n9, September
- Stecher P, 1993; Building business and application systems with the Retail Application Architecture, IBM Systems Journal v32n2
- Swatman P M C, Swatman P A & Fowler D C, 1994; "A model of EDI integration and strategic business reengineering", Journal of Strategic Information Systems, v3n1 pp 41-60
- Takeuchi H and Nonaka I, 1986; The New New Product Development Game, Harvard Business Review, Jan/Feb
- Tham K D, Fox M S & Gruninger M, 1994; "A cost ontology for enterprise modelling", Proceedings of 3rd IEEE Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises, April 1994, pp197-210

Vizard M, 1993; IBM strategy looks to custom applications, Computerworld v27n37

Zachman J A, 1987; A framework for information systems architecture, IBM Systems Journal v26n3 pp276-292

Zahniser R A, 1993; Design by walking around, Communications of the ACM v36n10, October