

Modelling the E-Business Requirements of Manufacturing Organisations

John Dilworth* and Ashok Kochhar*

**Aegeus Systems Consultants Limited, United Kingdom (e-mail: Dilworth@dsl.pipex.com)*

***School of Engineering and Applied Science, Aston University, Birmingham, United Kingdom (e-mail: a.k.kochhar@aston.ac.uk)*

Abstract: This paper describes a model designed to recommend solutions to an organisation's e-business needs. It is designed to produce objective results based on perceived characteristics, unbiased by prejudice on the part of the person using the model. The model also includes a way of encapsulating the potential management concerns that may change for good or ill the likely relevance and probability of success of such solutions. The model has been tested on 13 case studies in small, medium and large organizations.

Keywords: Information Technology, Manufacturing Systems, Management Systems, Modelling, Planning, Requirements Analysis

1. INTRODUCTION

The rapid growth of the Internet has revolutionised business-to-consumer interactions, and many manufacturing and distribution organisations are taking advantage of the new possibilities in business-to-business communications. Although there is significant terminological confusion (for example attempts to distinguish e-business from e-commerce), the theme (for example Damanpour, 2001, Rodgers et al, 2002, Pant and Ravichandran, 2001) is the integration of systems inside an organisation with those of customers and suppliers using the Internet. Also, the common-sense standpoint (Turban et al, 2004 and Croom, 2005 are helpful in this regard), is to regard e-business and e-commerce as equivalent and interchangeable concepts.

Supply Chain Management facilitates the extension of the reach of a company's systems beyond the management of internals to the management of one's suppliers and customers (both immediate and ultimately throughout the supply/demand chain). As it is the Internet that now makes such visibility possible for a wide range of organisations, Supply Chain Management, as something practically effective and accessible, is a concept clearly very closely aligned to that of e-business.

The modern thinking in Supply Chain Management based on the concept of global optimisation as superior to local optimisation, begs the question about whether it is realistic thinking taking into account politics, culture, human behaviour and the realities of business. There is the notion (for example Skjoett-Larsen; 2000; and Manetti, 2001) that everyone wants integration through the supply chain because all problems can be solved if everyone throughout the supply chain has access to accurate timely information.

Cox (1999) makes some very useful observations of power structures, which seem particularly to apply to notions of

sharing information and collaboration. Any approach to supply chain must be based on an understanding that essentially business is actually about appropriating value for oneself; not about passing value. There is an inherent conflict here with "lean" approaches, which apparently need to be based on equity, trust and openness, and this is a possible flaw in modern supply chain thinking.

Scherer (2005) encapsulates the position. He accepts that Information technology is not the constraint to the effective flow of information throughout a supply chain. He recognises that most companies deploying supply chain technology are only getting a small fraction of the benefits that are promised not because of a lack of trust in the systems and technology, but because of lack of trust in each other. The risk is that people adjust data to compensate for how they imagine other people are going to use that data. In short, it seems unreasonable to assume that everyone in the supply chain tells the pure unvarnished truth to his or her business partners. More recent evidence (for example Ghosh and Fedorowicz, 2008; Smart, 2008) would tend further to support this. The Internet may create (or enhance) the ability to network, but this may be of little value if the fundamentals of doing business have not changed.

The e-business domain in particular deals with functionalities that not only are under the control of external organisations (for example customers and suppliers) but often with functionalities that are only of any meaning when such organisations are working collaboratively.

2. E-BUSINESS REQUIREMENTS MODEL

There are many reported examples of "models" (Bakker et al, 2008; Cullen and Webster, 2007; Jackson and Sloane, 2007 are relatively recent), that find ways in which e-business activity can be categorised so that its structure can be understood. While all of these can provide useful insights into the e-business concept, an approach that dealt with

specific detailed functions was felt to be required. Dilworth and Kochhar (2007) confirmed from a review of academic literature that there was a value in providing ways in which organisations can be supported in determining their own specific requirements at a detail level, rather than being put in the position of having to buy the e-business concept blind. They propose a model and systematic process that can generate, at a useful level of detail, the probable e-business requirements of an organisation based on objective criteria.

Figure 1 shows the e-business functional domains supported by the model. The functions are organised as follows.

Demand Side	Product Development and pre-production
	Demand Management
	Supply Chain Planning
	Outbound Logistics
	Customer Accounting
	Service
Supply Side "Outside"	Product Development and pre-production
	Supply Chain Planning
	Purchasing and Procurement
	Inbound logistics
	Manufacturing
	Supplier Accounting
	Maintenance
Supply Side "Inside"	General Finance
	Administration

Fig. 1. E-business Functional Domains

The individual functions within these domains were categorised into one of three "transaction types", as follows.

- Informational Functions. These were envisaged as the one way accessing of information (or the provision of information for other parties to access). The access to a customer's schedule on a web site would be an example of such an access.
- Transactional functions. These were envisaged as the automated one-way routine transmission of instructions between two businesses. The sending of an invoice by Electronic Data Interchange (EDI) is an example of such an instruction.
- Control and Co-ordination functions. These were envisaged as (primarily) two-way processes, which manage issues arising between the business partners. Collaboration to achieve an agreed compromise between a customer's requirement and a supplier's capacity is an example of such a process.

The model can be used to help companies decide which e-business functions are likely to be relevant for them. This represents an approach that provides the necessary objectivity while saving the very considerable time and money

associated with traditional methods of requirements investigation.

The model is based on the factual Characteristics of companies and the Management Concerns in areas relevant to e-business.

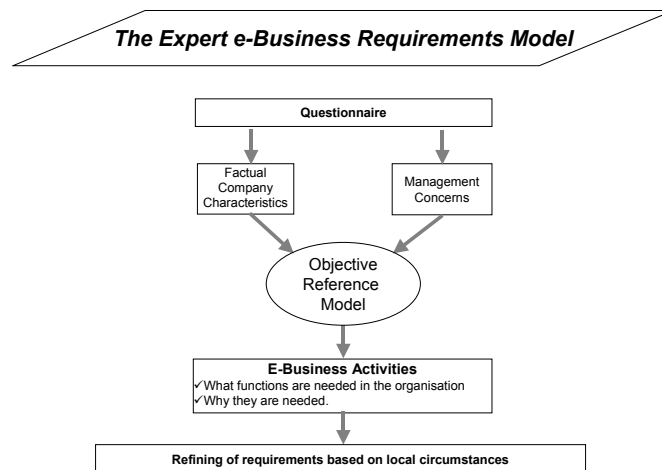


Fig. 2. Expert E-Business Requirements Planning Model

The process starts with the collection of information about factual company characteristics and management concerns. These are matched against a reference model that defines the complete set of functions available and contains logic to decide those situations where a particular function should be relevant (or otherwise). From this a list of recommended functions for the enterprise is produced, and presented alongside a trace of how and why particular selections were made. It should be emphasised that this is intended to be a constructive input to a process rather than a complete process in its own right. (There is no pretence that a perfect functional specification of requirements can be produced automatically from a model). It is expected that the results will be subject to critical review based on local circumstances. The model was initially developed using four main types of input, namely

- Literature sources to inject an academic perspective of e-business
- Material produced by organisations that are involved in influencing, guiding or selling products or services into organisations embarked upon e-business initiatives.
- Subject knowledge residing with the researchers, who have worked in the e-business and related fields for some 20 years.
- A survey into the e-business activities actually considered relevant today by a sample of organisations in manufacturing industry.

A preliminary rationale (i.e. a set of reasons) was produced in order to link these e-business functions to possible characteristics, thus allowing a preliminary list of characteristics and concerns to be produced. Together this functional definition, reasons, and characteristics were

combined into a model containing the logic that linked them all together. An example of a function, a reason and 3 associated characteristics is given below.

<i>Function</i>	<i>The reception of product design information from customer.</i>
<i>One of the Reasons</i>	<i>Significant design activity in partnership with customers.</i>
<i>Characteristics</i>	<i>1. Number of projects per year 2. Percentage of Customers involved in pre-production projects 3. Average number of items to design per project.</i>

The model logic was designed to both reflect intrinsic relevance (e.g. if a company produces many invoices, then electronic invoicing may be indicated) and company size (e.g. "Function X is theoretically of value to a company with these characteristics but the size of the company probably makes it an impractical or non-cost-effective to consider").

Characteristics were intended to be as objective and tangible as possible. The importance of the characteristics is to be able to predict what is likely to be significant and what is not. For example there is no point in asking whether a customer wants EDI invoices (or whatever) and then saying that this is a reason for specifying EDI invoices as a relevant function - this is obvious and of no use. The model needs to predict that a customer is likely to require EDI invoices - even if he has not thought of it.

A simple approach was adopted whereby characteristics were on/off, high/low or significant/not significant. This was considered preferable to recording numbers and then worrying about what size of number should trigger a relevance threshold. In practice it was found easier to ask an interviewee to determine whether a characteristic should be answered as significant or not, than to collect the number!

The importance of the concerns is that they address the issue of how customer/supplier behaviour can make or break the relevance of certain functionalities irrespective of the objective relevance or otherwise of these said functions.

3. TECHNICAL IMPLEMENTATION OF THE MODEL

Such a model could not be managed manually. It was important to ensure that the model, despite its complexity, can easily be used as part of a requirements definition exercise and therefore the processing of a case study can be achieved quickly. It was not however necessary to create a software product to the standard necessary for a commercial product, or to be operated by an inexperienced person.

The model relating the functional requirements, reasons, characteristics and concerns was implemented using Microsoft Excel and "visual basic" macros. A basic facility

was thereby created whereby a researcher can automate the input of characteristics and concerns, the running of the model and the creation of a resulting Microsoft "word" report.

4. MODEL TESTING AND REFINEMENT

The model has been tested on a total of 13 case studies. The reliability of the model improved, and it became stable after seven case studies. Conclusions from the model were presented at a "management" level of detail whereby useful insights could be provided.

The case study process was as follows;

- The case study contact (someone who is authoritative on the case study organisation's e-business current activity and future plans) was interviewed. At this interview the input questionnaire was completed interactively.
- The model was processed and an e-business functional report produced.
- The functional report was then worked through with the interviewee. Areas of disagreement were exposed and explained in terms of the logic of the model. An agreement was reached as to whether the correct functions were being recommended or not recommended, and also whether there were functions thought to be relevant, missing from the report.
- Areas where the model seemed to be incorrect were studied and any flaws or inadequacies in the reasoning exposed, and the model was refined. If the reasoning was complete, but the answer still not "correct", (this was relatively rare), then such discrepancies had to be accepted as a reasonable difference of opinion.

The process of carrying out case studies is illustrated by one particular example. The case study was a company manufacturing high precision, safety critical automotive components. This organisation is part of a major multinational, but for a variety of reasons (historical, market segment addressed), it had its own systems and information strategy. In fact it could be regarded as a medium to large company in its own business sector. The products are safety critical and/or have high technical specification and a significant percentage is exported outside UK.

Relationships with customers tend to be semi permanent. The products are designed for and with the specific customer and then supplied on a regular basis for the product life. The design period typically lasts for around three years, and the supply phase for perhaps five years. During this time it is hoped that future replacement projects for the customer are being worked on. The customer base is therefore relatively stable in the short term. In the medium to long term the customer relationship may break down in the form of the customer going elsewhere for the replacement projects. Customers expect a just-in-time flow of products in accordance with their demand, and the company tries to

manage both manufacturing and supply along similar lines. Suppliers are also involved in pre-production processes. The purchased items are designed either by the company or by the suppliers themselves, but essentially the same principles and type of relationships apply as with the customers.

Fig 3 shows an example of the model output in relation to one of the possible functions. It shows the overall “decision” of the model and also the reasons that contributed to this decision. The overall “decision” was “uncertain. Reasons that contributed to the function being considered potentially relevant are indicated with “R”. Reasons that contributed to the function being considered potentially irrelevant are indicated by ‘N’. Reason that were not triggered and have therefore had no effect are indicated by ‘-’.

ADP210 Reception of product design information from customer

Function Detail - The formal transmission (via EDI) of product data (e.g. product structures), from customer

Model Output – Uncertain Requirement for function

Reasons associated with this output

DP01	Significant design activity in partnership with the customers	R
DP02	Significant number of complex pre-production enquiries	R
DP03	There are a significant number of complex one-off “project” style orders.	R
CD02	Our customers fail to respect industry standards	N
CD04	Customers fail to communicate requirements clearly	N
CD25	We are constrained by the e-business capabilities of our Customers	N

Fig. 3. Example of the model results for one function

Figure 4 presents the e-business requirements profiles obtained by running the model both including and omitting the concerns. The sections in grey show the profile (the analysis of the proportion of functions triggered (in relation to the total of those possible) that would be obtained by the standard practice of running the model including the management concerns. The sections in black show the proportion of additional e-business functions that the model would indicate as relevant if consideration of all the management concerns were omitted.

The first thing to observe is that, in this case study, the effect of excluding the concerns was to increase the proportion of potential e-business functions that could be considered to be relevant. It should be noted that there was a negligible requirement for e-business manufacturing and service functions because only one manufacturing site was involved and sub-contract activity was relatively small, and there was little relevant service activity.

Case Study A e-business concerns analysis

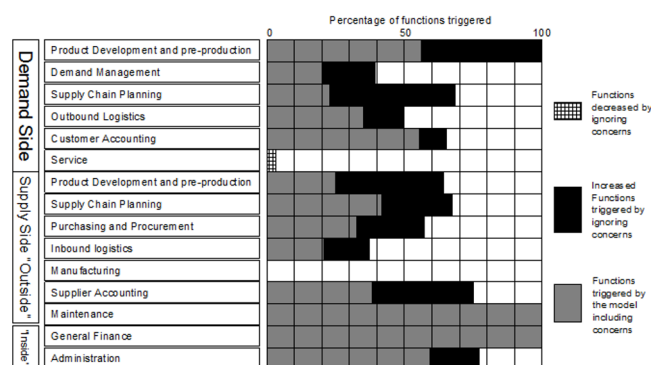


Fig. 4. E-Business Requirements for Company A

An interesting observation is that the supply side e-business functions relating to planning and demand management tended to be considered more relevant than the corresponding demand side. This is at first glance rather surprising given that the automotive industry has for many years been very customer driven in the e-business context. One explanation is that the company operates in a more specialised environment in respect of the demand facing e-business functions, where only a restricted subset of the potential functions could conceivably be relevant (even though this restricted set is very important!). For example a company in this business does not require new order taking functionality because demand is by schedule against a semi-permanent contract. By contrast, a wider range of supply side functions could be relevant because there is more variety in the purchase functions required.

However more interesting explanation for this observation comes when one examines the effect of running the model ignoring concerns. Strongly expressed concerns in this case study included:

- Our customers fail to respect industry standards;
- Our customers dictate requirements without concern for the problems they cause;
- Customers fail to communicate requirements clearly or respond effectively to queries;
- We incur expense because of our customer's non-adherence to industry standards.

It is easy to see how such concerns would tend to depress the relevance of some functionality. For example functions that are collaborative in nature are bound to be less relevant if customers show no inclination to be effectively collaborative! In these sorts of situations, the company would be advised to consider such functions only if forced to by the customer, and to invest as little as possible in them.

One can get more insight into how concerns may impact the relevance of e-business functions, by using an alternative view of the profiles summarising the triggered functions according to type of function (Informational, transactional,

and control and coordination). Figure 5 provides the proportion of functions triggered in relation to the total possible, by type of function, was calculated, and summarised according to whether the functions were:

- Demand Side Functions;
- Supply Side functions relating primarily to “outside” partners; or
- Supply Chain Functions relating primarily to “inside” the organisation.

For this particular organisation it is demonstrated that:

- On the demand side, the primary effect of the concerns was chiefly to depress the potential relevance of the control and co-ordination functions;
- On the supply side, the effect was more spread with both the transactional and control and coordination functions significantly impacted.

Case Study A by Type – Concerns Analysis

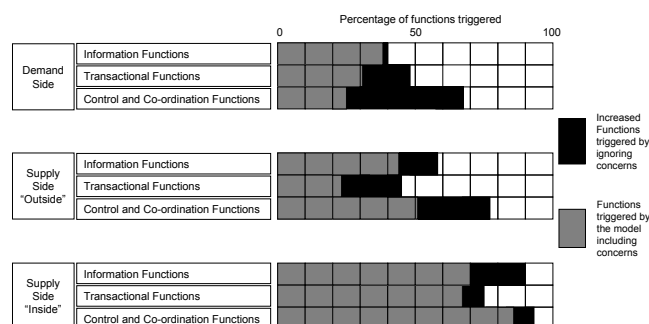


Fig. 5. Impact of Concerns by Transaction Type

This was actually an elegant demonstration of the fact that in respect of customers, concerns related to their attitudes and behaviour. By contrast, in respect of their suppliers, the picture was more mixed with technical capabilities relevant to transactional functions and supplier size and sophistication impacting the control functions.

For this case study it can be clearly seen therefore that there were serious management concerns that are likely to inhibit the likelihood of success of e-business in a number of areas. The next step was to examine the concerns in detail in order to establish whether they were capable of being addressed. It was felt that the customer attitudes and behaviour concerns impacting the demand side control and co-ordination functions were unlikely to be resolvable, and therefore the conclusions must be lived with. In the case of the supply side functions however it transpired that the concerns were capable of being solved, and therefore the conclusions could be regarded as a challenge for the organisation.

5. ISSUES ARISING FROM MODEL TESTING

For the company that participated in this case study, this exercise was part of a continuing process of understanding

where the e-business focus of the organisation should be directed. The case study produced detailed functional recommendations that were of value in directing this understanding. In addition to these detailed functional recommendations, two overall directions were clearly indicated. Firstly, the demand side collaboration functions were unlikely to be of much benefit in the context of the actual customer situations being faced. The recommended direction for the company is therefore to do the minimum necessary to conform to customer dictates as and when required. Secondly, whereas the relevance of the supply side e-business functions was clearly indicated, nothing much had actually been done in this domain. Action to develop both collaboration and transactional supply side e-business functionality was therefore of value, provided that concerns regarding the supplier's technical capability, and other internal constraints could be addressed.

The suggestion, from the work with the e-business requirements specification model described in this paper, is that the incorporation of concerns tends to improve the results, because they expose issues that are of relevance to a decision-making process relating to e-business. This can best be explained by considering an example of an e-business initiative. Let us suppose that the example involved a supply chain visibility initiative that requires the involvement of suppliers. Such an initiative may fit the characteristics of the company in question in a perfect world. However with concerns such as lack of support from management or lack of an adequate capability amongst the supplier community, it may be a waste of time and effort. A model that exposes this must be of value; a model that is not capable of dealing with this must be of less value. Therefore it can be argued that a specification is clearly more right (i.e. more useful) by taking account of concerns.

The contrary argument is that characteristics represent the objective properties of the business and are relatively static, at least in the short/medium term. Concerns on the other hand are more subjective and therefore one might expect them to be capable of being challenged, should they be preventing otherwise feasible initiatives. Also concerns could represent constraints that could be capable of being changed (providing that the motivation was there). The argument then would be that the concept of management concerns is anomalous in an objective specification because it represents an unduly pessimistic analysis in a world where challenges can be overcome.

In the case of this case study, it was easy to appreciate how concerns such as the dictatorial attitude of customers and their failure to communicate effectively or respect standards would tend to make functions that are collaborative in nature of less interest. It might be argued that the organisation being modelled would be forced into such functions anyway (by the dictatorial attitude of customers!), but it is still relevant for the model to suppress their relevance and to discourage adoption. The organisation would at least be pre-warned, and able to do and spend the minimum necessary to achieve whatever conformity was forced upon it.

6. REFINED MODEL

The refined model, following testing in 13 case studies, consists of;

	Number
Possible e-business functions	257
Reasons	207
Characteristics	122
Concerns	63
Detailed model logic lines	2788

The computerised rule-based system is easy to use and leads to a very significant reduction in the time taken, less than one day, to generate an accurate functional specification. In addition e-business profile proved a useful way of generating insights about an organisation's e-business requirements.

7. CONCLUSIONS

The e-business concept is one of technological capabilities made possible by the availability of computing power and the Internet. However it is also one of business attitudes and psychology. The issue is whether practically in real life scenarios in manufacturing organisations, in an imperfect world, with average people, these ideas actually cause a significant benefit to be achieved. The Internet may create (or enhance) the ability to network, but this may be of little value if the fundamentals of doing business have not changed, or if the attitudes of management and employees are counter-productive.

For example, although global optimisation for the benefit of everyone may be the ideal, local optimisation for the benefit of individual enterprises is a fact of life in the world of doing business. To take another example, a system may be technologically robust and theoretically relevant, but its viability may be totally compromised if its users do not trust the other users using it. In both examples the problem is how real people behave.

The model produced recommendations on relevant e-business functions that both included and excluded management concerns. It was concluded that a study of e-business requirements could usefully both include and exclude management concerns. The detailed results should represent those conclusions that take full account of the management concerns expressed (because this represents the best overall advice on balance that can be given). However the results excluding consideration of management concerns should also be calculated and presented at least in summary form so that insights from any differences can be highlighted. The impact of concerns at the individual function level can then be studied further in detail should this be required.

The case studies involving the application of the e-business model generated some interesting results, results that might have been expected *a priori* but were none the less interesting to see demonstrated by the operation of a reasonably objective model. For the case study discussed in detail in this paper, the exercise was part of a continuing process of understanding where the e-business focus of the organisation should be directed, and useful insights were gained.

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