Software Acquisition: a business strategy analysis

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Abstract

This paper argues that there are new insights to be gained from a strategic analysis of requirements engineering. The paper is motivated by a simple question: what does it take to be a world class software acquirer? The question has relevance for requirements engineers because for many organisations market pressures mean that software is commonly acquired rather than developed from scratch. This paper builds on the work of Fine [13] who suggests that product, process and supply chain should be designed together – 3D concurrent Engineering. Using a number of reference theories it proposes a systematic way of carrying out 3-D concurrent engineering. The paper concludes that the critical activity in supply chain design is the design of the distribution of skills and the nature of contracts.

1. Introduction

Software acquisition is where requirements engineering significantly meets business strategy. For many organisations software development is not an option. Cost, skills and the availability of software solutions on the market mean that acquisition is always the chosen route and requirements engineering is always done in this context. For many software engineering organisations too, cost, skills, and the pressures of time-to-market mean that acquisition from, or outsourcing to, a 'supply chain' are a key element of their development strategy. Technological developments such as the use of COTS (commercial-off-the-shelf) software [22], GOTS (government-off-the-shelf) software, SOUP (software-of-unknown-provenance), ASP (application service providers), open or community source licensed software, component markets, and so on, render this an increasingly complex task. At the same time however they open up new possibilities for organisations that can synchronise their requirements engineering and software acquisition processes.

This paper applies a business management perspective to an analysis of the software acquisition process. Such an analysis is not typical in the requirements engineering literature but allows us to draw on some novel insights that we believe are of importance to the area.

2. Overview

"What does it take to be a world class software acquirer?" The question came uninvited in an e-mail. It came from an executive in a Fortune 500 company who had been browsing the Web wondering how to improve a complex, but little studied, acquisition process. Since we had not ourselves formulated the question in quite that up-front a way, we gratefully seized on his formulation.

The motivation for becoming a world class software acquirer is straightforward. Strategically it is to gain an advantage over competing supply chains. Operationally it is to tackle perennial problems in software management - achieving better value, better quality, greater usefulness and ease of use, bringing systems in on time, on budget - via better use of available skills across the chain, including the customer. Academically the question is of interest because the idea of a supply chain for software is new, and only exists because of the variety of acquisition options now available. Because each of these options represents not only a different technical option, but an organisational one too, there is a need to systematise and articulate the choices and their organisational and commercial implications in a comparative framework.

The paper's starting point is that the acquisition of software is a strategic matter as well as a matter of operational efficiency. To be a world class software acquirer is good. To develop a strategy for software acquisition that outpaces world class competitors is even better. The paper therefore takes a managerial approach to the problem of software acquisition, basing itself on largely on theory, but also on research and practice as reported in the literature. The aim is to provide a series of well-founded steps by which organisations can build business architectures related to software acquisition, architectures which are hard to imitate, and therefore a potential source of competitive advantage. This paper sets out a series of propositions which, taken together, suggest what those steps might look like.

The paper's principal proposition is that if software acquisition is to be world class, the software, the process by which it is developed and the software supply chain should be designed together. This follows the work of Fine [13].

Second, the paper proposes that software acquisition can be a source of competitive advantage, arguing that in

designing the supply chain, the organisation is simultaneously building a business architecture which will be specific to that chain and hard to imitate [17]. Third, the paper proposes a "learning ladder" for supply chains, in which associated firms move from communities linked only by contract, to communities of practice ([20]; [5]) to communities of creation [27]. Each step in the ladder increases the chain's ability to learn and innovate and reinforces the strategic nature of supply chain design.

The paper is structured as follows. Section 3 presents an outline of the theoretical basis for the arguments used and the proposed methods. Section 4 expands on the stages in 3-D concurrent engineering as proposed by Fine and adapted to the case of software. Section 5 presents a ladder for organisational learning and innovation. These two sections are the practical centre of the paper. Section 6 is a brief reminder that human and organisational issues will have to be addressed if the proposed changes are to take hold. Section 7 revisits work by Ferguson and de Riso on best practice in software acquisition and asks whether we can improve on their suggestions by incorporating our own. Section 8 discusses the limitations of the current work and indicates where further research is required. Section 9 presents brief summary conclusions.

3. The Theoretical Foundation

The argument presented in the paper builds on a number of reference theories including: a definition of "world class"; Systems Engineering; Strategy; Economics, Finance and Accounting; and Concurrent Engineering.

A World Class Organisation

Gattorna and Walters [15] define a world class organisation as one "with an international reputation for overall effectiveness". They find the world class organisation to be one distinguished by: customer focus; orchestration of technology; continuous improvement; flexibility and responsiveness; human resource management. Translating this into the very specific activity of software acquisition suggests two things. First, the software process as a whole should contribute directly or indirectly to all the elements listed and directly to the "orchestration of technology". Second, Gattorna and Walters' reference to "reputation" is to be taken very seriously. Reputation is a key plank of competitive strategy [17]. A world class ability in software acquisition needs to be advertised, both within and beyond the company.

Systems Engineering

Systems engineering says that a supply chain can and should be designed alongside the design of the product and the production process, and that this can be accomplished using decomposition and flowdown to allocate pieces of system development to a network of suppliers [14]. Figure 1, adapted from Fine and Whitney [14] to use software terminology, illustrates the general process. Of particular interest is Fine's articulation of what, precisely, is the basis for the Request For Quotations at each point: customer needs if both design and manufacture (development) are outsourced, the specification if the system is to be bought or only system development outsourced. Fine includes the activity of

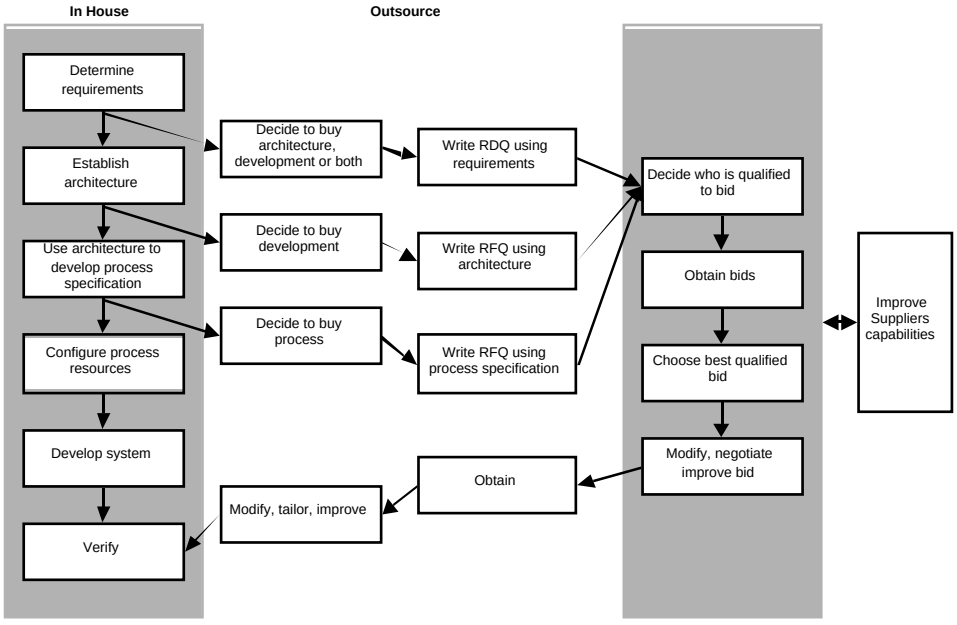


Figure 1. Decomposition and flowdown

buying or developing tools, thus drawing the development process under the same umbrella scheme as the product.

Strategy

Strategy is used to give shape to the ambitions for software supply chain design. The design should enable world class performance through cost reduction, increased value, organisational learning and innovation. Taken as strategic innovation, the aim is to so improve both the actual design of the chain and the strategy for design that it amounts to a competitive breakthrough [3]. Specifically, the strategic view opens up the question of whether it is possible to realise competitive advantage for members of a supply chain, for example through building up hard to imitate skills and supply partnerships which can learn and leverage knowledge [9]; [24].

Further, a strategic view allows us to interpret "world class" in a way that suggests there will be stages in the effectiveness of a chain as follows: There are three strategic possibilities [3]. First, the chain may not be operating to world class standards. In the language of economics it is "behind the production frontier" Here the first priority is to catch up. There is no longer any competitive advantage. It is a question of keeping up. Second, a company can be a world class software acquirer but want to change the balance of its acquisition strategy, from commissioning to COTS or ASPs, for example. Third, the company can attempt to change the rules of the game, for example by managing the supply chain in a way that allows the whole chain to be creative and innovative, more so than competing chains. Potentially that does provide competitive advantage, at least until everyone else catches up. Figure 2 informally and pictorially illustrates the argument.

This view implies that an organisation must first undertake a benchmarking exercise to ascertain its current position; second create the organisational and interorganisational understandings and practice that will allow the chain to stay at the leading edge, even if the acquisition policy changes; and third create the structures for innovation within the chain that will allow the possibility of a breakthrough.

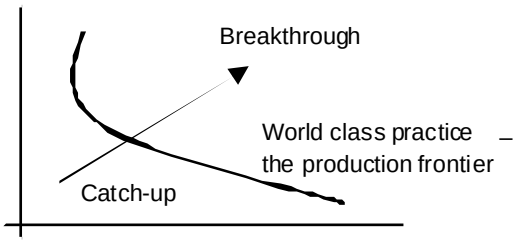


Figure 2. Strategic possibilities. Source [2]

Economics

Economic theory provides a view of what is to be designed, what buttons, as it were, to push. Reve [25] describes a firm as a nexus of internal and external contracts. Further, in Reve's view a contract is a function of skills and incentives. Regarding the supply chain as a network of contracts therefore implies seeing it as a network of skills, internal and external skills, held together by a series of incentives.

This formulation throws the spotlight onto the distribution of skills in the network and the incentives to use those skills. A substantial number of incentives, and disincentives, will be formally articulated in contracts. Others will be more like "understandings", not formally set out, but present nevertheless. It follows that designing a supply network is in large part designing the distribution of skills across the network and designing the contracts to make best use of them.

Economic theory also argues the notion of incomplete contracting. Not everything can be exhaustively specified in a contract. There are too many contingencies. When not everything is decided in advance, vital decisions will be made by those with the power to do so. It follows that a key issue in the design of a network is the allocation of power and control. In practice this implies considering, as part of the supply chain design work, the governance mechanisms that will operate. It also follows that, where contracts are incomplete, interorganisational trust may act as a partial governance mechanism. Designing a network in practice means designing ways to establish and maintain trust (for a careful discussion of conceptual issues and empirical studies relating to trust (see Lane, Bachman and Sako's [26] essays in [19]).

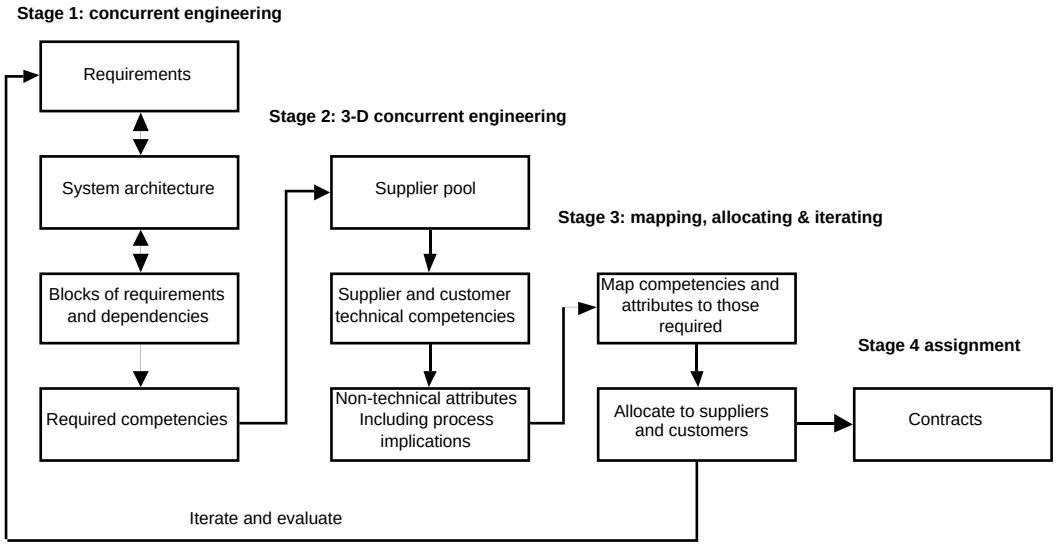
Summarising, economics suggests that the key design areas are the allocation of skills and the design of contracts to provide a framework for governance, including attention to trust.

Accounting and Finance

Accounting and Finance give us the criteria for evaluating a design. In designing a supply chain one is generally aiming to reduce costs and create value for shareholders, customers and suppliers. Following the notion of a Balanced Scorecard [16] as well as newer ideas on Knowledge Management ([9]; [4]), a strategic view additionally requires a strong emphasis on knowledge assets, learning and innovation. Two relevant ideas here are "communities of practice" and "communities of creation".

The first, which is as old as the idea of a mediaeval craft guild, is a network of people, often informal, who exchange information in order to improve their working practice. A world class software acquisition process ought to involve the conscious creation of such good practice networks across the supply chain, lifting the whole to world class level.

Figure 3. Four phases in designing a software supply chain



The second, the "community of creation", is an idea recently developed as a new governance mechanism to manage distributed innovation, that is innovation that takes place across the boundaries of a firm as it would in a supply chain [27]. In a community of creation governance is still essentially hierarchical. There is control and co-ordination form the centre. But the "locus of innovation" is shifted from the individual firms to a community of people and firms, allowing new ideas to enter the system. Sawhney and Prandelli use the analogy of a "gated" community, to imply that access is restricted, but within that the flow of knowledge is, ideally, free.

Concurrent Engineering

Concurrent Engineering provides a method for building teams, based on matching the competencies of the people involved to the required competencies. Further, it provides a way of prioritizing team members with respect to each block of work and then optimising the allocation of team members to each block so as to create the best value overall. By analogy the problem of designing a supply chain is a problem of building a team and leaning on the analogy we can follow the lessons of Concurrent Engineering. Kusiak and Larson [18] adopt a three stage process: Quality Function Deployment to map competencies to suppliers, Analytic Hierarchy Programming to reconcile preferences and then, if there is more than one supplier in each case, Linear Programming to optimise the allocation. The combination of QFD and AHP is not the only possibility. Mapping the competencies required to develop the system to available supplier competencies could be done by a different combination of a method for identifying competencies and another for allocating blocks of work.

4. Designing a Software Supply Chain

This section illustrates how the ideas in Section 2 can be combined to provide a plausible, systematic procedure for designing a software product, process and supply chain concurrently. The motivating idea throughout is to so design the supply chain, alternatively "configure a community", so that the people and organisations within it find a context which is highly conducive to innovation. We conjecture that they will then be in a position to make an innovative breakthrough, pushing out the boundary of what it takes to be world class. A four-stage process for designing a software supply chain is suggested as shown in Figure 3.

Stage 1

In Stage 1 the system requirements and system architecture are developed as part of a tightly coupled process. The result is the allocation of requirements to a configuration of components and connectors and an associated analysis of their dependencies. A schedule of components can then be compiled together with any competencies that are required to develop it and attributes required of the supplier, financial stability for example.

Stage 2

Next a schedule of possible suppliers, together with their technical abilities and non-technical attributes is drawn up. According to good supply chain practice, the customer should be included on this schedule, as they too will have to take a share in making the system work, in the same way that IKEA, for example, expects customers to be able to wield a screwdriver [28]. Although we refer throughout to the "value chain" since that is the best-known term, it is perhaps easier to recognise the role of the customer using the metaphor of a "value star" [28]. Figure 4, taken from Wikström et al [28], illustrates the

two concepts. Similar concepts are the "interprise" [24] and the "Extended Enterprise" [7].

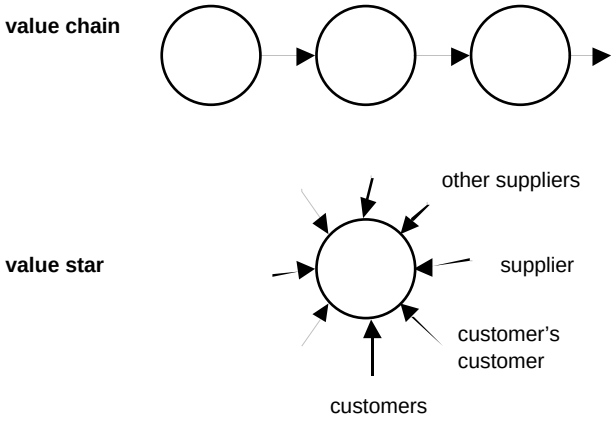


Figure 4. Value chains and value stars

Stage 3

In this stage the blocks of work are allocated to the available pool. One way of doing this is to follow Kusiak and Larson [18] in their 3-step procedure:

- Use Quality Function Deployment (QFD) to produce a matrix with components as one dimension and possible suppliers as the other. Figure 6 illustrates the broad steps.
- Use Analytic Hierarchy Programming (AHP) to establish a rating of suppliers.
- If necessary use Linear Programming to optimise the allocation given the rating and availability of suppliers.

The advantages of the Kusiak and Larson approach are that it is systematic and, if followed as they explain it, deals with soft measures in a way that leads to an agreed decision. In practice the approach may be too complex for small systems and limited numbers of suppliers. Essentially the problem is one of melding individual preferences into a consolidated ordered list of group preferences. Such problems are extensively researched in the literature on evaluation and on social choice [11]. Perhaps the most important rule in selecting a method is to make sure it fits with the cultures of the organisations involved. In an interorganisational setting this is not a trivial problem, but one requiring concentrated attention.

Following this it is likely, unless there are a very small number of suppliers for each component, that the process will need several phases of iteration and evaluation until an acceptable allocation is found.

Stage 4

Contracts influence behaviour. An example of a deliberate attempt to change the culture of an entire industry via contract is "The New Engineering Contract" (NEC) proposed in the Latham Report [10]. The NEC contract was explicitly intended to lessen the conflict-ridden attitudes that characterised the UK construction industry. Similarly, in setting up a supply chain the formal basis of the chain, the collection of bilateral or multi-lateral contracts, which constitute the chain, can, if so designed, shape the nature of the relationship.

Three types of contract are distinguished by Kay [17]: spot contracts; classical contracts; and, relational contracts. Spot contracts are short term and limited. As Kay writes "I sell, you buy, and that is that". Classical contracts are longer-term and spell out explicitly what happens in a variety of contingencies. Relational contracts are less explicit, dependent on the relationship between the parties and, as Kay writes, implicit and based on mutual trust. A marriage contract for example is largely relational.

Given our emphasis on learning and innovation, and the medium to long-term view of relationships within the chain that implies, at least some of the contracts will be relational. That is to say, contracts will be necessarily incomplete and enforced not by legal sanction, but by the need for continued co-operation [17]. Figure 5 shows diagrammatically the diverse contracts within and without an organisation. The central circle depicts the formal and informal contracts and relationships within the organisation (see for example [8]). The outer circles show the suppliers and customers. Some are linked only by spot contracts, as illustrated by those mainly at bottom left and right of the diagram linked by a unidirectional arrow. Others, as depicted with bi-directional arrows in the upper part of the diagram, are linked by relational contracts to the central organisation and sometimes to each other.

Together these constitute the firm internal and external "architecture" [17] and, using Reve's interpretation above, the network of skills held together by contracts. Spot contracts can be used for highly commoditised components, and where the expertise is also highly commodified. Where there is a need to learn, classical, long-term contracts may be more appropriate, or relational ones as discussed above.

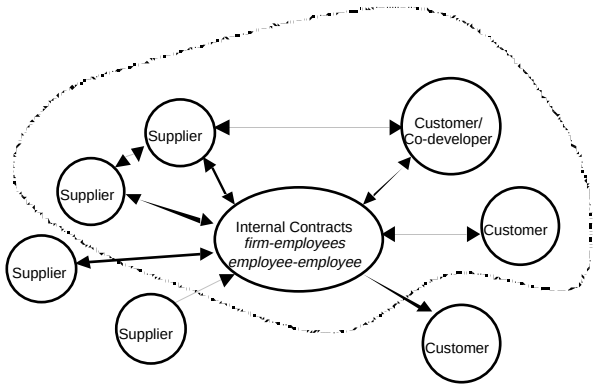


Figure 5. Internal and external contracts

5. A Ladder for Organisational Learning and Innovation

Learning, and the making of relationships, take time. The different types of contract described by Kay [17] suggest different depths of relationship between firms and different timescales. Bearing these two factors in mind, we suggest a "developmental" or "ladder" model in which the focal firm develops its business architecture over time, with each "step" on the ladder reflecting a deeper and more creative relationship. This is shown in Figure 6.

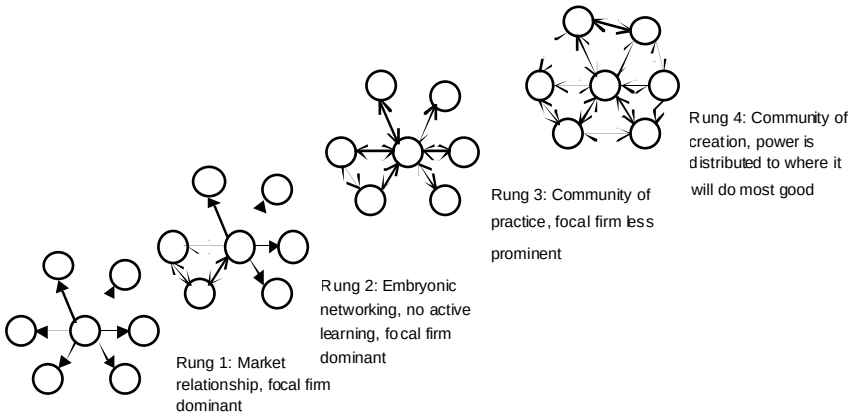


Figure 6. A "ladder" model for inter-organisational relationships

Rung 1: Creating a network of suppliers

Focus on establishing a network of suppliers, using a variety of contracts and allocating skills as described above. Reflect on experience with different types of contract and note how the allocation of skills has worked out.

Rung 2: Creating a community

Focus on supply chain design, developing relational contracts and gathering experience of how the informal relationships, and the contracts, work.

Rung 3: Creating a community of practice

Focus on learning in supply chain partnerships. Share experiences across the chain in a timely way, gradually lifting the level of expertise across the board.

Rung 4: Creating a community of creation

Focus on innovation.

6. Organisational Preparation

The argument in this paper has been technical and managerial. It has set out a series of plausible steps by which a software development organisation and its supply chain, could aspire to outdo other competing chains. A competitive advantage created in this way can be maintained until the knowledge residing in the chain is overtaken.

However, the technical, rational side of the argument is only a part of the story. Managing a diverse set of relationships, across several organisations, with different micro-cultures and different interests, is not easy. The foundations for change have to be in place and these will be personal, human and socio-technical. In this section we can only hint at the kinds of structure necessary, and add a further warning, which is, that the way things work out in a complex situation is, by the nature of a supply-chain as a complex system, emergent and unpredictable [6].

Specific steps that we see as necessary for creating the foundation for change are:

- Put in project-specific procedures for managing evolution and change
- Put in the project-specific administrative and technology infrastructure for a network to operate efficiently and in a co-ordinated way, including the customer [24]
- Put in project-specific knowledge management infrastructure and processes [21]
- Put in project-specific negotiation and contract management structures.
- Put in project specific internal "contracts" i.e. project-related incentives [9]
- Put in project-specific procedures for quality control and V&V
- Put in a way to learn from project specific experience in order to raise the general level of procurement performance and capability (see for example [23])

7. Comparison with Existing Work

As a demonstration of how the ideas put forward in this paper might affect current thinking in software acquisition, we have taken a study by Ferguson and de Riso for SEI [12].

Ferguson and de Riso "compare best commercial practices with the then current Department of Defense (DoD) processes for acquiring software and "… recommend some steps that can be taken to streamline DoD software acquisitions to minimise overall life-cycle costs". The paper contains a series of comparisons. The first is a comparison of commercial and DoD practices with respect to requirements definition. The comparison is a record of lessons learned and shows where DoD practice could be improved in line with commercial practice. We have taken their comparisons and considered on a point by point basis the effects of the strategic setting we envisage on their notion of best practice. We cannot reproduce it here but we have made it available on the web at http://www.cs.ucl.ac.uk/staff/A.Finkelstein. The key observation from the analysis is the manner in which requirements *and* requirements processes are meliorated by skills/offerings in the network. Further it is clear that many organisations will have to substantially adapt their technical practices in order to adapt to new business imperatives.

8. Critical Evaluation

There are a number of limitations of our work to date that are evident and will need to be addressed by further research, as follows:

The scheme described in this paper derives from theory. It is plausible, and broken down into small chunks which could be implemented, or substituted by other mechanisms for achieving the same goals. We believe it will be practicable and have begun to test the ideas on a number of case studies.

Five organisations have been interviewed to date: a leisure-retailer, three organisations in the leisure-heritage sector and a university department. The focus on leisure related organisations is somewhat unusual, but in practice these organisations provide a rich variety of software acquisition needs and policies for study. They comprise three very large organisations who can bring considerable resources to bear on the problem of software acquisition, and two much smaller ones where software acquisition is the responsibility of either one person, or a small team.

From these we have gained a number of insights. In the case of the leisure retailer for example, which had outsourced virtually all its development, we learned at first hand the crucial importance of developing software acquisition skills in the IT department. This organisation was also very clear about the need to develop supplier skills.

The two small organisations focused our attention on the crucial role of relationships. For example, one had established sufficiently close links with a supplier to be able to influence the course of COTS development. Both parties benefited. The acquirer has a system more closely tailored to its own needs. The supplier had the benefit not only of a test site that is typical of many such around the world, it had the endorsement of a venue which is recognised by the "trade" as world class, thus enhancing its own reputation.

We have also been given some insight into the complexities of consortium purchasing. Although much of the literature is written around a single purchaser, in practice there are often consortia of purchasers, as when a group of like institutions band together to commission tailored software for a common task. Although each institution is essentially doing the same thing, the institutional requirements of the larger and more experienced organisations can be more complex than those of the smaller ones. As against that, the larger organisation may have more experience, and be more realistic, than the smaller enthusiasts. All this leads to a need for positive management of tensions and differences within the purchasing group, as well as across suppliers and customers.

Lastly, and really emphasizing the importance of domain, where the domain is highly specialised, as in concert halls or museums, the range of suppliers is often limited. Advantage, where it is to be had, will come from getting the most out of the relationship, not necessarily the system as such.

However the scheme as proposed in this paper has not been tried in practice.

There will also be questions as to how far to go, or, bluntly, how much money is available to spend on elaborate software acquisition scheme when the proposed investment is small, or when there are very few, well-known, suppliers. For example in the case of the leisure-heritage sector the number of suppliers for specialist concert management systems is tiny. Supplier network design is likely to be limited to "Go with A - or go with B". Nevertheless, questions about the quality of the relationship with A, or B, and questions of interorganisational knowledge management will still need to be considered if the organisations concerned are to make the most from co-operation.

To strengthen, or rebut, the arguments presented in the paper more work is urgently needed on the economics of software systems, and in particular on the way criteria such as those provided by the balanced scorecard relate to the economics of software intensive systems. Specifically we do not know the value of knowledge management in software development, or how value is created and shared in software development partnerships. The idea of a balanced scorecard is appealing, precisely because it should include measures of value for innovation and creativity, alongside value for a community of customers and suppliers. However, although some work has been

done, interorganisational accounting is not yet well articulated [1] and this whole area needs special attention before it can be applied to software systems.

9. Conclusion

Treating software acquisition as a problem in strategic analysis has led us to consider the strategic role of software acquisition and its possible use as a source of competitive advantage. Accepting Fine's contention that product, process and supply chain should be designed simultaneously, this paper has sought to develop that proposition by attempting to answer practical questions such as "In strategic terms, what are we trying to achieve?, "What is it that we are designing?, "How do we evaluate the design?" and "What kind of process is involved?" Our principal conclusions are that in designing a chain, the critical activity is designing a network of skills and contracts, that the interplay between "product" as represented by the requirements and supply should in the long term be managed to optimise the use of current skills, and that by a judicious use of contracts and incentives, the whole supply chain should be geared to learning so that future requirements may be more accurately met.

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