Leveraging the power of the Internet for optimal supplier sourcing

David Tucker and Laurie Jones

Manchester Metropolitan University, Manchester, UK

Abstract *Intelligent software agents offer the potential to unleash the power of the Internet to optimise the process of supplier sourcing. Aims to promote an awareness in the buyer/supplier community of the potential for using intelligent software agents over the Internet for this purpose. The traditional relationship between suppliers and buyers is contrasted with that of Internet-based trading. This comparison confirms that trust is a critical component in the traditional relationship and that an understanding of the nature of trust is necessary in revealing where and how agent technology will have maximum benefit for both buyers and suppliers. It is shown that the technology that can enable this form of sourcing is already well established, and a range of conceptual agents are described. Finally, identifies the benefits that will accrue to organisations that adopt agent technology as part of their supplier-sourcing portfolio, and recommendations for further work are made.*

Introduction

The Internet is now a truly global medium and is gaining new users at a staggering rate. Recently published figures show that the number of host computers or servers connected to the Internet in July 1999 was 56.2 million. This is more than a tenfold increase since 1993 (Network Wizards, 1999). When the World Wide Web (WWW) first attracted the attention of businesses, it was generally conceived of as a new method for advertising, providing traditionally local firms with a potential worldwide market (Oldfield and Burnham, 1997). While many firms are setting up Web sites and making themselves more visible to customers and potential customers, other firms have gone beyond just advertising. Hoffman *et al.* (1996) have identified six distinct categories for the commercial use of the Internet including online storefront, Internet presence, content, mall, incentive site, and search agent. These categories provide the foundation for the commercial exploitation of electronic commerce (e-commerce). This paper, however, does not seek to address the broader issues relating to e-commerce, rather it is concerned with identifying the potential for using intelligent search agents for the purpose of sourcing suppliers on the Internet. It has been estimated that business-to-business transactions will represent 25 per cent of all Internet commerce by the year 2000 (Commerce.net, 1998). The implications for the process of supplier sourcing in the twenty-first century are immense.

Supplier sourcing on the Internet

In the traditional approach to supplier sourcing it is highly unlikely that every potential candidate supplier will be considered in the pre-negotiation stage.

There are two main reasons for this. First, organisations do not have perfect market information and hence cannot be aware of all the potential suppliers who may be best able to fulfil a particular order requirement. Even if near-perfect market information were available the process of manually selecting the most appropriate supplier from a pool of thousands would be overwhelming. Second, there is a tendency for organisations to deal with suppliers with whom they have had satisfactory dealings in the past. While this is understandable, it can mean that a more appropriate supplier for a particular need is overlooked. With customers demanding better quality, lower cost products, organisations must be prepared to be more dynamic in the process of supplier sourcing if they are to remain competitive.

With the number of suppliers having a presence on the Internet growing rapidly, buyers have an enormous global supplier base accessible through a single computer connected to an Internet service provider (ISP). With many ISPs, particularly in the UK, now offering free connection (e.g. www.Freeserve. co.uk), the cost implications for using the Internet as a medium for supplier sourcing is negligible. There are, however, certain difficulties associated with this approach. First, there is the issue of training procurement personnel to navigate the Internet effectively. The most common way to find information on the Internet is to use one of the many search engines specifically designed for this purpose. To find relevant Web sites a user has to construct a string which is used by the search engine to examine its index of key words. In the case of supplier sourcing such a string would typically include the type of product sought and the quantity required. Constraints such as the maximum delivery lead times and the highest price payable would also need to be included. Many novice Internet users find difficulty in constructing a search string which returns all possible candidate sites whilst leaving out irrelevant sites. Reasons for this include a lack of formal training in information science and an unfamiliarity with the use of Boolean operators to construct search strings (Webtools, 1999). Furthermore, it is estimated that even the most powerful search engines cover only about 35 per cent of all documents available on the Internet (Lawrence and Giles, 1998). Hence, for maximum coverage, the buyer would have to perform the same search using several different engines. This is time-consuming and will also return duplicate sites. The problem can be partly resolved using a meta-search engine which is effectively a "search engine of search engines". These, however, do not guarantee 100 per cent coverage and many will still return duplicate sites. Even if it were possible to construct near perfect search strings and a search engine could guarantee 100 per cent coverage, there would still be practical difficulties. Thousands of potential supplier sites could be returned as the result of a single query, and finding the most appropriate supplier would be practically impossible, particularly if the buyer used multiple criteria to rank suppliers. It is in addressing these key issues that intelligent agent software shows significant promise.

Intelligent agents

It is not the purpose of this paper to describe the technicalities of intelligent agent software; however, it is useful to have some appreciation of the nature of Internet-based agents and their uses. There is no agreed definition of the term agent, as used within the information technology community (Nwana, 1996), but a dictionary definition of an agent is someone or something which acts on behalf of someone or something else, for example, a travel agent or estate agent. The Internet has provided access to far greater quantities of information than has ever been possible in the history of mankind, but the complexity of this new environment demands a new style of human-computer interaction where the computer plays an intelligent and active role (Maes, 1994). Interface agents are computer programs that employ artificial intelligence (AI) techniques to provide active assistance to a user with computer-based tasks. The agent acquires its competence by learning from the human user as well as from other software agents with which it interacts, thereby acting as a type of personal assistant to the human buyer (Maes, 1994). As with its human counterpart, the software agent becomes more experienced over time. As the human buyer grows more confident in the competence of the software, more responsibility for the negotiation will be delegated to it. Ultimately, some buyers may delegate the entire process to the software.

The type of software agent which is able to perform supplier sourcing must be both intelligent and mobile. The major characteristics of intelligent agents are:

(1) *Autonomy*: agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state.

(2) *Social ability*: agents interact with other agents (and possibly humans) via some kind of agent-communication language.

(3) *Reactivity*: agents perceive their environment (which may be the physical world, a user via a graphical user interface, a collection of other agents, the Internet, or perhaps all of these combined), and respond in a timely fashion to changes that occur in it.

(4) *Proactiveness*: agents do not simply act in response to their environment, they are able to exhibit goal-directed behaviour by taking the initiative (Wooldridge and Jennings, 1995).

Mobility refers to the ability of the agent to independently wander the Internet searching for other agents or Web sites which can move it towards its goal. Also known as travelling agents, these programs will transport their being, code and state over the Internet. This often improves performance by moving the agents to where the data reside instead of moving the data to where the agents reside. To act as supplier sourcing agents the software needs to possess some degree of artificial intelligence. Although no agents yet exist for the specific purpose of business-to-business supplier sourcing, the technical

infrastructure is already well established. For example, the Internet Softbot (software robot) is a fully-implemented AI agent developed at the University of Washington. It uses the WWW to interact with a wide range of Internet resources (Etzioni and Weld, 1994) and could form the ideal platform for a supplier sourcing agent.

Two other prototype agents have been developed at the media lab of Massachusetts Institute of Technology. These are "Tête-à-Tête" and "Kasbah". Tête-à-Tête is designed to help both the retail consumer and the retail merchant by enabling the shopper to perform searches for products based on criteria other than just price, such as performance, brand, delivery times and extended warranties. Kasbah is different from Tete-a-Tete in that it is an agent-based marketplace that closely resembles an online classified advertisements system (Chavez and Maes, 1996).

Nelson (1997) describes how in a traditional classified advertisement, a seller gives a description of the item for sale, together with a price. He suggests that it is understood that this price is only an initial asking price and that the buyer will enter a complex social process of negotiation to reduce this initial asking price. Kasbah automates both these search and negotiation processes. When selling an item, the seller creates a software agent and provides it with the knowledge necessary to negotiate a price, i.e. the selling agent is told what price the seller would like to get for the item, the minimum acceptable price, and some bargaining strategy for lowering the price over the course of a negotiation. Similarly, buyers create a software agent with its own strategies for finding the products they require and provide it with acceptable target prices. When created, these agents then exist in this virtual marketplace, seeking agents of other organisations who are buying or selling the required items and then negotiating. This initial phase of the negotiation process is completely handled by the buyer and seller agents and it is only when negotiations have been completed successfully that the human buyer or seller is notified. Tête-à-Tête and Kasbah are regarded as intelligent applications because of their ability to act autonomously. That is to say that they operate with little or no direct intervention from humans and have control over their own actions (Wooldridge and Jennings, 1995).

From the above description it can be seen that these agents have characteristics that are very similar to that required for establishing buyer-supplier relationships in a business-to-business environment. A buyer would specify appropriate primary criteria, which a potential supplier must be able to fulfil. These would include the product required, delivery lead times and costs. Additionally the agent would be provided with a bargaining strategy. The agent would then search the Internet looking for suppliers that appear to be able to meet the primary criteria. Initial negotiations between the buyer and seller agents will result in the discarding of those sellers that cannot comply with the buyer's bargaining strategy. If the number of suppliers returned was still too great to be manageable, the buyer could define secondary criteria such

as evidence of a total quality management policy and consistency of delivery performance (Saunders, 1997). This process may be repeated several times until the human buyer is satisfied (Figure 1).

By using intelligent agents for supplier sourcing, the bulk of the effort in finding the most appropriate supplier for a given product or service at a given time could be delegated entirely to the software. The intelligent agent application would handle the tasks of finding potential suppliers and of ranking them against selection criteria as demanded by the customer. In this way, a buyer could be presented with an on-screen list of the most appropriate suppliers with minimum of human effort. Hence intelligent agents have the potential to automate the buyer-seller negotiation process (Fisher Centre, 1999). This can relieve a potential bottleneck in the supply chain as well as improving labour utilisation rates.

The possibility of delegating most or all of the procurement process to software will impact greatly on the traditional relationships between human buyers and suppliers. In agent-negotiated relationships, the reliance on past experience, word-of-mouth recommendation, personal relationships and "gut feelings" will be replaced by pre-programmed negotiation strategies. It is not suggested that these human qualities always have a detrimental effect on the supplier sourcing decision process. Undoubtedly, the tacit knowledge held by human buyers can and does have a significant impact on purchasing decisions. However, the complexity inherent in many sourcing decisions means that the selection process cannot be undertaken in a rational manner and buyers become subject to the phenomenon of bounded rationality. Bounded rationality means that decision makers are limited in their ability to make perfectly rational judgements by such factors as cognitive capacity, lack of perfect information and time constraints (Simon, 1955). The huge amount of data
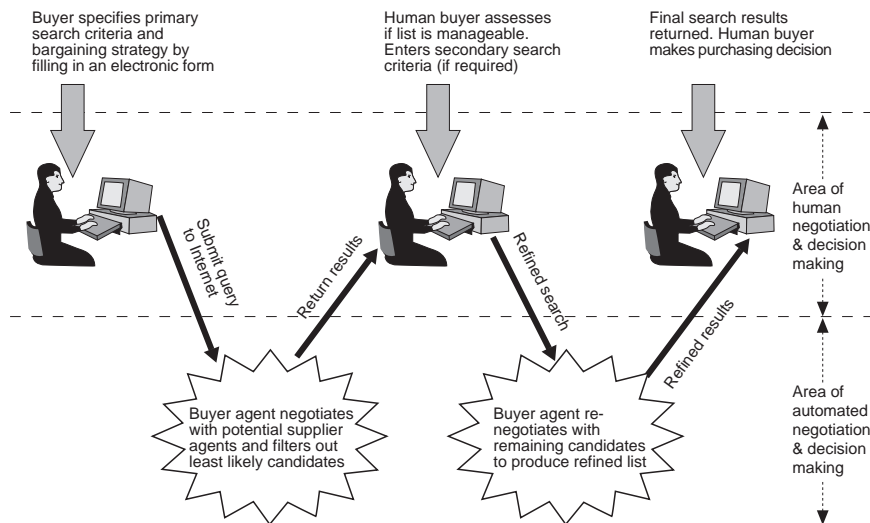

Figure 1.
Conceptual model of the agent-based supplier sourcing process

available over the Internet markedly increases the degree of information overload, extending the boundaries of the decision domain and increasing the complexity of the supplier sourcing process. Bounded rationality theory suggests that in these circumstances the human buyer will become increasingly unlikely to make the optimal purchase decision. It is important, therefore, to examine the basis of buyer-supplier relationships and to determine where and how agent technology is likely to have most benefit.

Buyer-supplier relationships on the Internet

In the Internet-based approach to supplier sourcing, a buyer has access to a far greater supplier base than is available using conventional sourcing techniques and suppliers could be located anywhere in the world. While international supplier sourcing is common, the intelligent agent is likely to identify potential suppliers previously unused by a buyer and negotiations between buyer and supplier will often consist of no face-to-face contact. This being the case, it is useful to examine the nature of the relationship between supplier and buyer in an agent enabled Internet environment.

The procurement literature broadly defines two distinct approaches to supplier sourcing:

(1) adversarial; and

(2) partnership (Saunders, 1997).

The adversarial relationship is an "arm's length" approach and is often described as a "win-lose" situation, characterised by lack of trust between the supplier and the customer. By contrast the partnership approach is based upon a strong bond of trust which is established over a long period of time and aims to bring about a "win-win" outcome. Consequently the adversarial approach is more typical in single transaction or short term relationships whilst partnerships are associated with longer-term strategic alliances. The benefits of partnerships approach have been well documented in the literature. Kanter's (1994) empirical study likened successful business partnerships to the human situation, observing successful relationships as emerging after five distinct stages:

(1) courtship – where organisations are attracted to each other and discover if they are compatible;

(2) engagement – where a commitment to a lasting relationship is made;

(3) housekeeping – where it is discovered that the partners have different ideas about the way the business should operate;

(4) devising mechanisms and techniques to overcome the differences;

(5) discovering that each partner has changed internally as a result of accommodating the other partner's position.

As the relationship progresses mutual trust becomes stronger. In much of the literature, the partnership approach is seen as superior to the adversarial

approach (Lamming, 1993). Whilst there are benefits to the partnership approach, such as the opportunity to lower costs and improve quality, there are situations when a partnership approach may not be appropriate. For instance, when there is a single transaction for a low cost product which is in plentiful supply. Even for long-term multi-transaction relationships, partnerships are not always appropriate. For example, an examination of a defence procurement contract in which the partnership approach was adopted suggested that cost savings would have been larger if an adversarial approach had been used (Parker and Hartley, 1997). This suggests that there is no single best way to source suppliers and therefore buyers should adopt a portfolio approach – choosing the type of relationship which best matches specific situations (Cox, 1996).

Some buyer-supplier relationships that start as adversarial may mature into partnerships. An explanation as to how this process is accomplished is provided by Ellram who has applied the well established life-cycle model to the development of the buyer-supplier relationship (Ellram, 1991). The development stage of a new relationship is characterised by frequent face-to-face communications and low levels of trust. As the relationship matures into the commitment stage, trust grows and there is less need for face-to-face contact. In the integration stage, mutual expectations are established and the relationship stabilises. Finally the relationship may or may not dissolve depending on specific circumstances (Figure 2).

In the agent-based approach there may be little opportunity for face-to-face contact and hence it will be difficult to move from the development stage to the commitment stage. Additionally, organisations may need to rapidly switch between suppliers so as to maintain a competitive advantage. In this situation the probability of relationships maturing in the manner described by Kanter (1994) and Ellram (1991) seems remote.

Figure 2.
The life-cycle model of
buyer-supplier
relationships
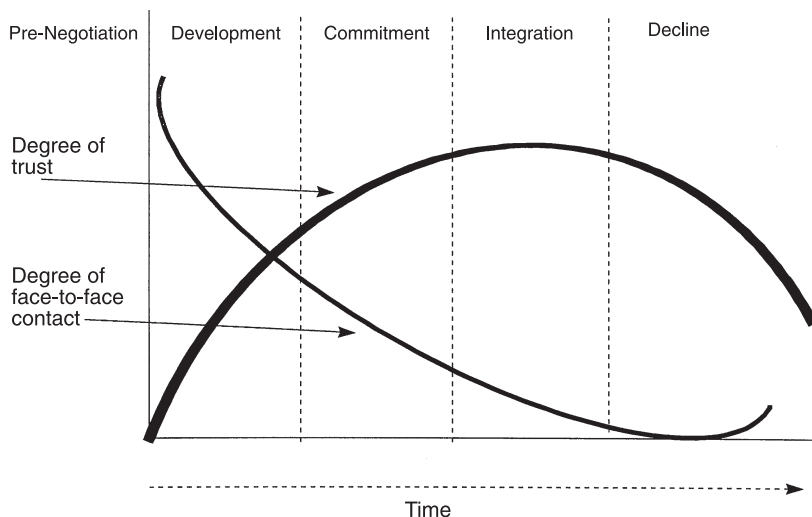
Source: adapted from Ellram (1991)

This suggests that buyer-supplier relationships which are facilitated by agents are likely to be adversarial and, therefore, characterised by lack of trust. Consequently an examination of trust in buyer-supplier relationships will provide useful insights.

Trust in the Internet-based buyer-supplier relationship

Trust is a complex subject as few relationships are completely static and the dynamics of trust can change over time even within the same relationship (Lewicki and Bunker, 1996). Nevertheless trust is an important factor in business relationships not least because its presence can reduce transaction costs (Handy, 1995). In this paper we make a clear distinction between trust between trading partners and trust in the transaction medium. When businesses elect to trade over the Internet, issues such as data privacy and integrity become critical. These points are being addressed with technologies such as data encryption and digital signatures. This does not, however, offer any protection from untrustworthy or unreliable trading partners (Clarke, 1997). It is this facet of a trusting relationship that is the concern of this paper.

In the partnership approach there is a prolonged period of bilateral adjustment during which time mutual trust becomes established. One example of this is Marks & Spencer which has established partnerships with its fresh sandwich suppliers based on mutual trust (Christopher, 1997). The approach is appropriate because the perishable nature of the ingredients and the wide fluctuation in demand for the end product requires the type of close co-operation inherent in the partnership approach. Marks & Spencer deals with only four sandwich suppliers and has long-term, trusting relationships with each thus typifying the competitive alliance described by Kanter (1994). In the adversarial approach it may be assumed that trust plays no part in the relationship. However, this appears not to be the case. Sako (1992) proposes that there are three distinct types of trust. The first is contractual trust in which both parties fulfil their contractual obligations; the second is competence trust where both parties perform their roles competently; and the third is goodwill trust which is characterised by a willingness to share information and a predisposition to do more than is actually required by the formal contract. Applying this concept to buyer-supplier relationships, the adversarial approach can be seen to consist of mainly contractual and competence trust, but little goodwill trust, whilst in the partnership approach goodwill trust becomes highly significant.

A further insight is provided by consideration of loyalty in buyer-supplier relationships. It is possible to differentiate between subjective and objective loyalty, the former being based on emotional attachment and the latter on reasoned self-interest (Mowshowitz, 1997). In this analysis, agent-negotiated relationships are based on objective loyalty with the buyer agent assessing how well potential suppliers could meet quantitative selection criteria such as quality, price and delivery. Subjective loyalty consists of qualitative factors such as the state of personal relationships between buyers and suppliers.

Buyers may remain loyal to a supplier who may not be the most appropriate to fulfil a particular requirement perhaps because of a strong and long-lasting interpersonal relationship. In this situation agent technology could identify better potential suppliers than the human agent because the element of subjectivity is removed from the selection process. The differences between the adversarial and partnership approaches are summarised in Table I.

Using the information from Table I, it is possible to analyse where and why intelligent agents will be most effective in the Internet-based buyer-supplier relationship. As depicted in Figure 1, the agent finds all potential suppliers according to the criteria and bargaining strategy as defined by the buyer. The returned list is compiled using quantitative search criteria, as presently it would be extremely difficult to define qualitative search criteria in this way. Consequently, the relationship will be based on contractual and competence trust rather than goodwill trust. Because the search criteria are quantitative in nature, relationships will be based on objective loyalty. This being the case, the most promising area for the use of intelligent agents for supplier sourcing will be to establish adversarial relationships. If the transaction is low cost and represents little risk to the customer organisation, then the entire negotiation process may be delegated to the agent. For higher cost transactions that represent a greater risk, agent software can be used to provide a list of the most promising potential suppliers, further communications taking place in more traditional ways.

Although ideally suited to establishing adversarial relationships, intelligent agents also have a role to play in partnerships. This role is in the pre-negotiation stage (Figure 3).

It is at this point that contractual and competence trust needs to be established, based on quantitative and objective criteria. As the relationship

Factor	Adversarial competition	Partnership sourcing
Trust	Contractual and competence	Goodwill
Loyalty	Objective	Subjective
Selection criteria	Quantitative	Qualitative
Frequency of interaction	Low or single transaction	Initially high, then low when goodwill trust is established
Duration of relationship	Short-term or single transaction	Long-term
Communication media	Telephone, fax and e-mail	Initially face-to-face, then telephone, fax and e-mail at integration stage
Communication style	Formal	Informal
Managerial involvement in relationship	Low	High at development stage, then diminishing

Table I.
Comparison of the
adversarial and
partnership approaches
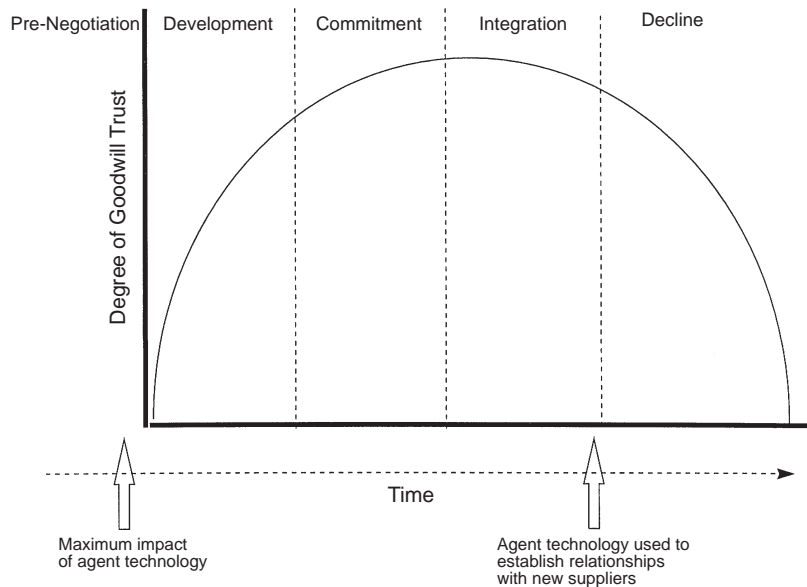to supplier sourcing

Figure 3.
Impact of intelligent
agent technology on the
partnership life-cycle

progresses, the role of goodwill trust assumes greater importance and the effectiveness of agent-led negotiations diminishes. Should the partnership begin to decline, agents can be used to source alternative suppliers.

Summary
As the Internet continues to develop as a rich source of potential suppliers, the problem facing organisations is how to effectively source the most appropriate supplier for a given requirement while simultaneously making the most effective use of buyer labour. The aim of this paper has been to raise awareness in the buyer/seller community of how intelligent agent software may be used to leverage the power of the Internet for optimal supplier sourcing. It has shown that agent technology will be of most benefit when establishing short-term, adversarial buyer-supplier relationships. Agent software is ideally suited to specifying and searching for quantitative criteria and will therefore source suppliers with a greater degree of objectivity than a human buyer. Long-term partnerships are characterised by the presence of goodwill trust and subjective loyalty. However, buyer organisations wishing to establish new partnerships must first put together a list of quantifiable criteria which will be used to filter out unsuitable candidates. Hence, this paper has also shown that agent technology does have an important role in partnership sourcing and will have maximum impact at the pre-negotiation stage.

All potential suppliers who have a presence on the Internet will be considered as candidates. This provides a buyer with easy access to a world-wide supplier base and the possibility of finding the ideal supplier for a

particular requirement. The low cost and simplicity of use means that even small organisations can benefit. The agent software can filter out the least likely candidates automatically, thus relieving the buyer of tedious and time-consuming manual effort. Furthermore, allowing agents to negotiate autonomously will lead to the removal of a bottleneck in the supply chain. A further benefit will derive from the agent's ability to provide ongoing scanning of the supplier base. Important factors such as the emergence of new suppliers, or the fluctuation of prices between different suppliers, can be reported to the human agent. It is recognised that maximum potential benefit will only be achieved when agents are available for both suppliers and buyers and are able to negotiate autonomously. In the interim, it is recommended that sellers take the initiative by proactively publishing their own Web pages. The pages should contain the type of data that will be of most interest to potential customers (products supplied, cost, availability, etc.). Buyer software agents will locate these pages in much the same way as a human buyer would seek out suppliers through advertisements placed in trade magazines and journals. Those suppliers who have deliberately placed an advertisement are far more visible to the potential buyer than those who have not.

Recommendations
The use of intelligent Internet-based agents for supplier sourcing as discussed in this paper is entirely theoretical. The discussion presented here is limited in that risk assessment processes for Internet-based supplier sourcing have not been considered. It has been established, however, that the technological basis for using the agent-based approach to Internet searching is well established in other fields. Hence, there is a need for applications to be developed for this specific purpose. It is hoped that this paper will stimulate research into the development of software agents for the specific purpose of supplier sourcing. For maximum impact, agents will need to be developed for the needs of both the supply side and the demand side. It is recommended that research and development efforts should be directed at meeting these requirements. It is not suggested that intelligent agents will replace existing methods of supplier sourcing, but rather that it will become part of the portfolio of supplier sourcing methods available to buyers.

Conclusions
As increasing numbers of suppliers recognise the business benefits of having a Web presence, so the potential supplier base will grow. Because of the bounded rationality phenomenon, this is likely to increase the complexity of the sourcing decision. In this situation, intelligent agents are likely to bring the following benefits:

- evaluation of a wide range of possible alternative suppliers based on pre-defined quantitative selection criteria including price, availability and delivery;

- a reduction in time and cost factors by delegating part or all of the supplier sourcing process to the software;

- important information not being overlooked or ignored; and

- the impact of the limitations in human cognitive capacity being lessened.

Organisations adopting the agent approach as part of their procurement strategy are likely to enjoy a substantial competitive advantage over those organisations which do not.

References

Chavez, A. and Maes, P. (1996), "Kasbah: an agent marketplace for buying and selling goods", *Proceedings of the 1st International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology*, April, London, UK.

Christopher, M. (1997), *Marketing Logistics*, Butterworth-Heinemann, Oxford.

Clarke, R. (1997), "Promises and threats in electronic commerce", available at: http://www.anu.edu.au/people/Roger.Clarke/EC/Quantum.html

Commerce.net (1998), available at: http://www.commerce.net

Cox, A. (1996), "Relational competence and strategic procurement management", *European Journal of Purchasing and Supply Management*, Vol. 2 No. 1, pp. 57-70.

Ellram, L.M. (1991), "Life-cycle patterns in industrial buyer-seller partnerships", *International Journal of Physical Distribution & Logistics Management*, Vol. 21 No. 9, pp. 12-21.

Etzioni, O. and Weld, D. (1994), "A softbot-based interface to the Internet", *Communications of the ACM*, July, Vol. 37, pp. 72-6.

Fisher Centre (1999), available at: http://www.haas.berkley.edu/~citm/nego-prog.html

Handy, C. (1995), "Trust and the virtual organization", *Harvard Business Review*, Vol. 73 No. 3, May/June, pp. 44-50.

Hoffman, D.L., Novak, T.P. and Chatterjee, P. (1996), "Commercial scenarios for the Web: opportunities and challenges", *Journal of Computer-Mediated Communications*, Vol. 1 No. 3, pp. 36-49.

Kanter, R.M. (1994), "Collaborative advantage", *Harvard Business Review*, July/August, pp. 96-103.

Lamming, R. (1993), *Beyond Partnership: Strategies for Innovation and Lean Supply*, Prentice-Hall, London.

Lawrence, S. and Giles, C.L. (1998), "Searching the World Wide Web", *Science Magazine*, Vol. 280, pp. 98-100.

Lewicki, R.J. and Bunker, B.B. (1996), "Whither trust?", in Kramer, R.M. and Tyler, T.R. (Eds), *Trust in Organizations: Frontiers of Theory and Research*, Sage, Thousand Oaks, CA, pp. 114-39.

Maes, P. (1994), "Agents that reduce work and information overload", *Communications of the ACM*, Vol. 37, July, pp. 31-40.

Mowshowitz, A. (1997), "Virtual organisation", *Communications of the ACM*, Vol. 40 No. 9, September, pp. 50-56.

Nelson, M. (1997), "Kasbah: an agent marketplace", available at: http://nelson.www.media.mit.edu/people/nelson/research/kasbah/node3.html

Network Wizards (1999), available at: http://www.nw.com

Nwana, H.S. (1996), "Software agents: an overview", *Knowledge Engineering Review*, Vol. 11 No. 3, pp.1-40.

Oldfield, C. and Burnham, N. (1997), "Internet brings home the bacon", *The Sunday Times*, 2 March, p. 10.

Parker, D. and Hartley, K. (1997). "The economics of partnership sourcing versus adversarial competition: a critique", *European Journal of Purchasing and Supply Management*, Vol. 3 No. 2 , pp. 115-25.

Sako, M. (1992), *Prices, Quality and Trust*, Cambridge University Press, Cambridge.

Saunders, M. (1997), *Strategic Purchasing and Supply Chain Management*, 2nd ed., Pitman, Boston, MA.

Simon, H.A. (1955), "A behavioral model of rational choice", *Quarterly Journal of Economics*, Vol. 69, pp. 27-8.

Webtools Company (1999), "A guide to effective searching of the Internet", available at: http://thewebtools.com/searchgoodies/tutorial.htm

Wooldridge, M. and Jennings, N. (1995), "Intelligent agent theory and practice", *The Knowledge Engineering Review*, Vol. 10 No. 2, pp. 115-52.