SOFTWARE AGENTS IN ELECTRONIC COMMERCE:

A DECISION SUPPORT SYSTEMS APPROACH

By

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Abstract

This dissertation presents a collection of research projects on software agents in electronic commerce (e-commerce). A common theme throughout this research is that agents are an innovation. We are interested in identifying conditions and design criteria that would lead to their adoption in e-commerce applications.

We define and study a class of agent applications that fall under the Decision Support Systems (DSS) Approach, where users delegate part of a decision-making task to a software agent. We show how findings from traditional DSS research can guide the development of e-commerce applications that include software agents.

Two frameworks are presented that organize research and development activity. The first framework looks at the kinds of knowledge that agents should possess if they are to assist in e-commerce decision-making and identifies some of the major research challenges in designing intelligent agent applications. The second framework is directed at development and design activities. It builds on models of buyer behaviour where perceived risk and frequency of purchase are two characteristics of purchasing situations that can help identify when buyers are expected to find agents useful.

The results of two empirical studies suggested by these frameworks are presented. The first study was exploratory and identified consumer preferences for information display over searching and browsing tasks. This was a first step in a larger project aimed at designing adaptable agents to support consumers in different information-seeking modes.

A second experiment studied consumer behaviour in the actual online purchase of a music compact disk. We found that subjects who used an agent made their purchase decisions in less time and made more-informed decisions than subjects who did not use an agent.

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Chapter 1

Introduction

Software agents are computer programs that run in the background and perform tasks autonomously (Maes 1994). Although there has been much research on this topic, usable software agents are at an early stage of development, and are only now starting to appear in real applications. A fruitful application area for software agents is in the area of electronic commerce (e-commerce) where agents can help buyers and sellers deal with the flood of information that can be exchanged and processed.

This dissertation is a collection of research projects related to software agents and their applications in electronic commerce. These projects include both theory development and empirical studies. Two frameworks are developed from existing theory; One organizes research activity and the second organizes development activity. Two empirical studies were conducted. One was exploratory in nature, to identify consumers' information needs. The other evaluated the performance of an agent application in an actual purchase situation. All of the research presented here is related by a common theme – software agents as an innovation.

1.1 Agents as an Innovation

An innovation can be a new idea, practice or product. The concept of software agents is a new idea and agent applications are new products.

Adoption of innovation is commonly considered to occur in five stages (Spence 1994):

1. *Awareness* - During the awareness stage, potential adopters are first informed about a new idea.

2. *Interest* - In the interest stage, they are motivated to seek for more information about the idea, generally because they believe it may satisfy a personal need.

3. *Evaluation* - Evaluation involves a more detailed assessment of the advantages and disadvantages of adopting the new idea.

4. *Trial* - Trial usually involves a small-scale implementation although it can also involve assessing how the innovation has been implemented elsewhere in similar circumstances.

5. *Adoption or rejection* - At this point, the potential adopter either rejects the idea for personally valid reasons or adopts it and puts the new idea into operation.

Most researchers and practitioners outside the artificial intelligence (AI) research community were first made *aware* of the idea of agents in July 1994, through a special issue of the journal *Communications of the ACM* (Volume 37, Number 7). The ideas presented in these articles sparked *interest* in many other disciplines. The resulting literature can be considered the "first generation" of literature on software agents.

Current literature on agents would indicate that we are still in the *interest* and *evaluation* stages of adoption. *Interest* is still evident in the many applications that are being proposed. However, while there are many agent projects being developed in research labs, there are very few working trials and even fewer real-life implementations. Articles such as Nwana and Ndumu (1999), Wooldridge and Jennings (1999) and Rowley (2000b) have started to critically *evaluate* the progress of agent development and their performance.

During the *awareness* stage, most of the literature focused on agent technology (e.g., Brenner et al. 1998; Durfee 1999; Sandholm 1999). The original ideas and work on agents came from the AI field, which has been saddled, rightly or wrongly, with an image of over-promising and under-delivering. "Many of the same people who have made exaggerated promises for artificial intelligence, natural language processing, voice and handwriting recognition, and robots, are now pushing agents" (Schneiderman 1997). Most AI applications have had very limited success in the real world. As a result, the arrival of intelligent agents is seen by some as a renaissance for AI. In the initial stages of agent development there was a tendency to develop "solutions looking for problems" as researchers latched on to their favourite AI technologies and built agents based on them.

Innovation theory would tell us that a product-focused approach, rather than a technology-focused approach, is needed before we will see widespread adoption of agent technologies in e-commerce (Spence 1994). A technology-focused approach looks at what the technology can do. A product-focused approach looks at the potential adopter's need(s) and how the innovation will meet those needs. The research and development frameworks created in this dissertation start with the functions that agents are likely to perform in e-commerce, regardless of their underlying technology. This is an approach that is under-represented in the existing literature.

To define the needs that agents can meet, the research projects presented here use theories and models from the application domain. The agent's user must be able to develop trust in the agent's behaviour before delegating activities. In order to develop trust, the user must be able to understand, control and predict the behaviour of agents (Erickson 1997; Malone et al. 1997). To design agents that the user can watch, control and understand, the agent's knowledge must be represented in ways that complement how the user conceptualizes the problem in any particular domain.

1.2 Research Objective

An overall objective of this research is to identify areas of e-commerce where agent applications are most likely to be adopted and within those areas to identify how to design agent applications that people will choose to use. This objective is important because it can help direct the efforts of researchers and practitioners to areas where agent technology can be most successful.

1.3 Research Overview

Figure 1-1 provides an overview of our research. In our research, when we look at software agents and e-commerce, our uniting concept is *decision support*. This provides both structure and limits to our research. Later in this chapter we explain how we are examining e-commerce as a process – a complex series of decision-making tasks.

In Chapter 2 we explain how our research is limited to software agents that are classified under the Decision Support Systems (DSS) approach. It does not address agents or agent systems that are completely hidden from the user. There must be at least an initial interaction between the user and the agent where the user "delegates" an action or task to the agent. It also does not address agents whose primary function is to simulate realistic human behaviour and engage in a "social" interaction with the user. These two types of agents are excluded from this research because, from the user's point of view, they are significantly different from agents that we classify under the DSS approach. Because of these differences, they deserve separate examinations of the value they provide and their potential for adoption.

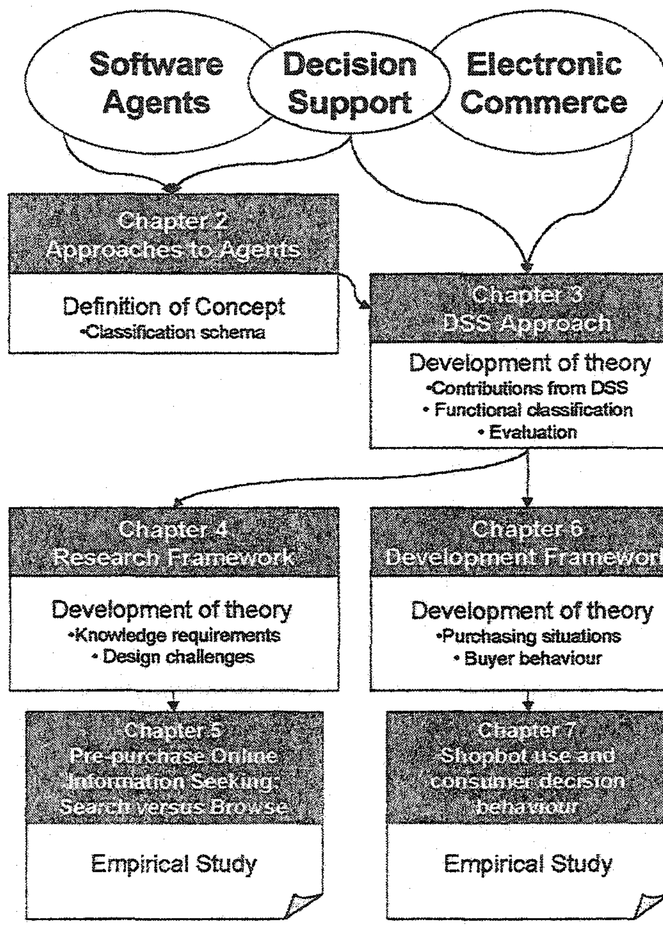

Figure 1-1 - Overview of Research

The DSS approach is one of three approaches that make up an original classification system presented in Chapter 2. This classification system was developed to help organize the disparate literature on agents and their applications and to communicate our specific area of interest. Theoretical development of the classification schema was followed by an empirical test to determine inter-coder reliability. The results of this test indicate that other researchers can apply the classification schema in a consistent manner. It is therefore presented to clarify the type of agent that is addressed in the rest of the research.

In Chapter 3 we show how research from the field of DSS can inform agent development and design. The DSS approach provides insight into how interactive agent applications can provide flexible and adaptive ways of approaching the complex decision-making processes involved in electronic commerce and other applications. We provide a functional classification system for agents based on their associated reference disciplines and suggest effective ways to evaluate agent performance.

In Chapter 4, we examine the knowledge requirements for agents in an e-commerce domain. From this examination we develop a research framework that identifies some of the challenges facing agent designers and suggests applicable technologies and research areas, including those that should be addressed by management academics and practitioners.

One of the challenges identified in Chapter 4 concerns the constructive nature of consumer choice. Consumers do not always know what information they need or how they are going to choose between alternatives. They often switch between modes of information seeking. Chapter 5 describes exploratory research into the information needs and preferences of consumers in browsing and searching modes. Our findings are a first step towards developing agents that can identify a consumer's information seeking mode and assist them to find the information they need at that time.

Chapter 6 uses theories and findings from marketing research to identify purchasing situations where buyers are likely to find agents useful. We use marketing studies of buyer behaviour to predict the consumer's needs in different purchasing situations and then identify the types of agent that can meet these needs.

In Chapter 7 we take one of the purchasing situations described in Chapter 6 and present an experiment that examined consumers' use of an agent in an actual purchase decision. Models of consumer search and choice behaviour were used to develop the hypotheses that are tested in the experiment.

Figure 1-2 summarizes the general research questions from each of these sections and shows how they fit into the overview of our research. The rate of innovation in e-commerce means that developers need to be able to move quickly from research to commercially viable products. We believe that answering these questions can provide guidance to managers who are considering agent technology and its potential for facilitating e-commerce. The answers can also provide direction for researchers in IS and other disciplines.

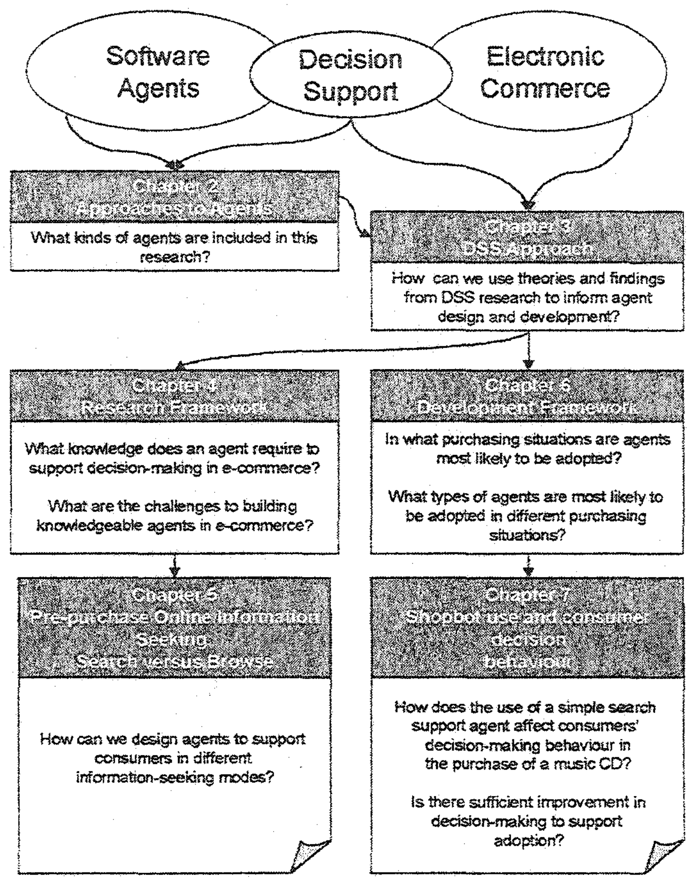

Figure 1-2 - General Research Questions

1.4 Research Orientation

The overview presented in the previous section identified three top-level areas that combine in this research: *e-commerce*, *software agents* and *decision support*. Each of these areas supports wide and diverse research interests and activity. This section provides an orientation for the reader. It identifies starting points in each of these areas and points out the directions in which our research advances through each area. In each of Chapter 2 through 7 we provide more extensive coverage of the literature and research that is related to the specific inquiries of the chapter in question.

1.4.1 Electronic Commerce

E-commerce is the use of information and digital communications technologies to network economic activities and processes. The use of e-commerce is growing rapidly in both the business-to-consumer (B2C) and business-to-business (B2B) environments. In 2001, Canadian e-commerce B2C transactions amounted to $2.3 billion and B2B transactions amounted to $8.1 billion(2002). Estimates of global e-commerce transactions for 2001 were $600 billion for B2C (Pastore 2002) and $919 billion for B2B (Pastore 2001).

The starting point for the research presented in this thesis is the view of commerce as a process that involves at minimum two participants, a buyer and a seller. Many descriptions of the commerce process take the view of only one of these participants. Marketing mix models examine the process from the seller's point of view and buyer behaviour models examine the process from the buyer's point of view. Nissen (1997) proposes an integrated model of the commerce process (Figure 1-3) showing what is exchanged between these two participants at each stage of the process. This model clearly shows that information exchange forms a large part of the commerce process and illustrates why there is considerable potential for applying communication and information technology (IT) to reduce costs or to gain strategic advantage. E-commerce is expected to change the commerce process in many ways.

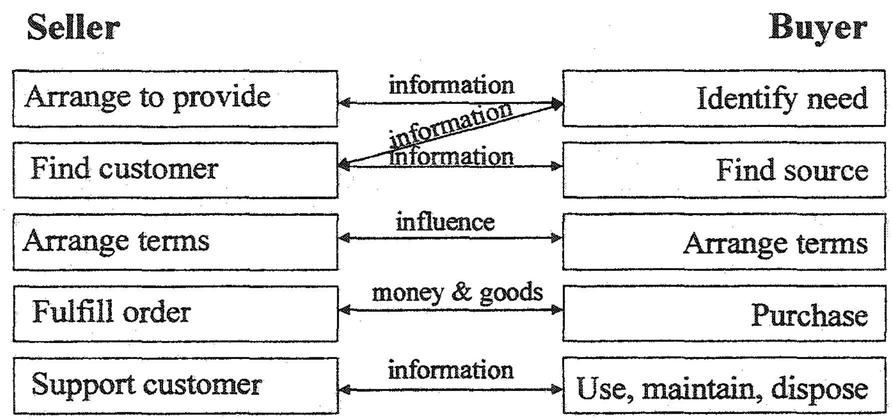

Figure 1-3 - The Commerce Process

Adapted from (Nissen 1997)

While Nissen's model shows only two participants, intermediaries can and often do play important roles in the commerce process. These roles can include aggregation, trust, facilitation and matching. The roles and forms of intermediaries are also expected to change in e-commerce. Many agent applications in e-commerce are new forms of intermediaries (Bailey and Bakos 1997; Bakos 1998; Nissen 2001).

There are significant differences in how the commerce process is conducted within the B2C and the B2B environments. For example, the importance of buyer-seller relationships in B2B commerce is expected to play a major role in the adoption of e-commerce (Wang and Archer 2003). Other distinctive characteristics of B2B commerce include (Gross et al. 1993):

- the buying unit is a group, not an individual;
- personal selling is the predominant form of promotion as opposed to mass advertising;
- markets are more concentrated, and key accounts are important;
- there is greater purchase involvement and purchase risks are higher;
- decision processes are complex and lengthy;
- there are more pre- and post-transactional services than in business-consumer commerce, and
- competitive bidding and price negotiation are common.

The differences between B2C processes and B2B processes mean that while some of the effects of e-commerce will be common to both environments, many of these effects will vary in degree and still others will be present in only one environment. The two frameworks developed in Chapter 4 and Chapter 6 apply to both B2C and B2B e-commerce. Our empirical research in Chapter 5 and Chapter 7 is concerned only with B2C commerce.

At times, this research also views commerce as a market. The economics of markets also are expected to change with the introduction of communication and information technologies. Reducing the costs of search makes markets more efficient. The potential for price discrimination may be greater through customized products and better consumer profile information. Price discovery can be accomplished dynamically through on-line auctions and negotiations (Bakos 1998). Dynamic pricing and more efficient markets could mean drastic changes in the economic structure of markets. Agents can further reduce the cost of search. They can collect and manage consumer profile information and they can act in on-line auctions. Researchers are studying the potential for super-efficient markets, especially when enabled by agent technologies (e.g., Kephart et al. 1998; Crowston and MacInnes 2001). We examine some of the predictions and findings from the market view of e-commerce in Chapter 7 where we compare our results with the results of other researchers that have studied the online music CD market.

1.4.2 Software Agents

An introduction to a research area would normally start with a definition. However, there is no single definition of a software agent that has gained acceptance. This is not unexpected in an emerging field with a number of contributing disciplines. Bradshaw (1997) argues that there are two approaches to defining a software agent: 1) as a *description*, and 2) as an *ascription*.

Most of the definitions proposed in the literature are of Bradshaw's "agent as a *description*" form. In these definitions, various attributes are listed to describe what is meant by the term "agent", often including some or all of: autonomous, persistent, mobile, intelligent, learning, responsive, pro-active, communicating, social, and rational. These characteristics are often used in defining sub-categories of software agents, such as mobile agents, learning agents, and "multi-agent societies" of social and communicating agents.

An agent is defined "as an *ascription*" through an attribution by the user; if the user believes that he or she has delegated a task to the software entity, it is an agent. In this case, an agent is seen as a black box, where the user desires results but does not know (or want to know) how the agent is performing a task.

Our research looks at agents from a user's point of view. Bradshaw's definition by *ascription* works well with this perspective, so we will adopt it at this point. Rather than choosing an exclusive definition of agents, in Chapter 2 we describe three approaches to agents and introduce a classification system that is based on these approaches. This classification system clarifies the type of agent application that is addressed in this research, while recognizing that other types exist.

The concept of agency is often assumed to imply some sort of knowledge base and intelligence. As such, the term "intelligent agent" is often considered to be interchangeable with the term "software agent". However, we can have agents with limited intelligence, and intelligent programs that are not agents (e.g., traditional expert systems).

Artificial intelligence consists of a knowledge base and an intelligent processing system. Techniques from the field of knowledge representation, including the use of predicate logic, frames, semantic nets, or Bayesian networks, are used to build a knowledge base. Problem solving through search strategies, reasoning systems using rules or cases, and learning systems using neural networks or genetic algorithms can all be used to provide intelligence. The level of intelligence required in the agent is related to its degree of autonomy and its mobility (Bigus and Bigus 1998). In Chapter 4 we discuss the types of knowledge and reasoning systems that may be employed in e-commerce agents.

Agents are likely to evolve from using basic intelligence techniques, to more powerful techniques as users become accustomed to the concept. Rules may not be the most sophisticated reasoning system, but IBM research has shown that rules are understandable even to non-technical users and rule systems can be adapted for user editing (Grosof 1997). It is noted that the "current crop of agents are 99% computer science and only 1% artificial intelligence" (Etzioni 1997) and many researchers believe that less intelligent agents, or agents with severely limited intelligence may be the most acceptable and useful. Even if users would like more intelligence in agent applications, the current state of AI and agent development is far from being able to deliver it (Nwana and Ndumu 1999). In Chapter 4 we identify some of the major challenges that are still facing agent research and development.

Etzioni (1997) explains that the emergence of the World Wide Web (WWW) provides an opportunity for the study and development of working AI applications in the form of agents. He warns, however, that AI researchers must recognize that the WWW is a very demanding environment. Its users insist on robustness, speed, and added value to a degree unheard of in the traditional research environment. He suggests a "useful first" approach. Traditionally, the study of AI has tried to model human intelligence and promised that useful applications would follow. To take advantage of the opportunity afforded by the WWW, researchers should be designing agent applications that are useful now, and promise to add more intelligence in the future. Chapter 3 describes how a DSS approach to agent development and design will allow agent systems to evolve as AI technology develops and user acceptance grows.

Jennings and Wooldridge (1998) propose that agents will be an important development in today's open and complex systems. Open systems require flexible and adaptive software that can change as the computing and information environment changes. Modularity can help address complexity and agents are a useful abstraction to design and manage modular systems of specialized components.

The need to "delegate, not manipulate" (Negroponte 1995) is another reason why agent technology is believed to be important. In a future with ubiquitous systems it will be necessary to provide users with simpler ways to utilize the full power of applications. The current human-computer interface is recognized as a bottleneck for both experienced and naïve users. It has been proposed that agents can provide guidance and advice to naïve users. Agents can also let experienced users delegate repetitive but time-consuming tasks (Jennings and Wooldridge 1998).

Jennings and Wooldridge (1998) suggest that the use of agents is most beneficial when there are widely distributed resources. The nature of information on the Internet certainly fulfills this condition. They also suggest that agents will be more easily accepted when there is a natural metaphor for their use. The presence of human agents in traditional commerce provides a wide variety of metaphors for agent applications.

A third condition for agent application is that the user is able to develop trust in the agent's abilities before comfortably delegating tasks. This requires that the delegated activity be repeated often enough that the user can verify that the agent is making reasonable and acceptable decisions (Jennings and Wooldridge 1998). Repetitive activity is also required for agents that must "learn" from their users' actions (Maes 1994).

In Chapter 6 we propose that a user's willingness to delegate an activity to an agent also will depend on the risks involved. Konstan et al. (1997) discuss the consequences of errors in recommendation agents. If an agent is making a recommendation, a sample item can be desirable or undesirable, and the agent can predict it to be good or bad. When the agent predicts a desirable item to be good, the result is a hit. Predicting an undesirable item to be bad is a correct rejection. Errors occur when an undesirable item is predicted to be good (a false positive), or when a desirable item is predicted to be bad (a miss). The consequences of each type of error will vary with the domain. A recommendation for a restaurant that turns out to be undesirable (a false positive) is costly in time and money, whereas the time that it takes for the user to reject a recommendation of an undesirable research article (another false positive) is minimal. Similarly, missing a legal citation could have serious consequences, whereas missing a recommendation for a good music CD is less important (Konstan et al. 1997).

1.4.3 Decision Support

Simon's (1960) three-stage model of decision-making provides a starting point for our discussion of decision support. Simon proposed that decision-making activities fall into one of three stages:

1. *Intelligence* – Scanning the environment for conditions that require a decision
2. *Design* – Identifying, developing and analyzing alternative courses of action
3. *Choice* – Selecting a particular course of action from those available

A decision-maker rarely follows through these stages in a linear fashion. Many decisions are broken down into smaller or staged decisions that require circling through the stages until all of the sub-decisions have been made. Subdivision of the problem can take place at many levels and at each level decision situations may require that the decision-maker backtrack to earlier stages in the process before finally reaching a decision.

Information systems and DSS systems have been created to support users in all three stages of decision-making (Turban and Aronson 1998). In Chapter 3 we introduce the idea of search support agents and choice support agents. Search support agents work in the design phase of Simon's model. They help the user identify and find relevant information about alternatives. Choice support agents may work in both the design and choice stages. They can help the user analyze alternatives (design), make recommendations on these alternatives (design) or choose a course of action autonomously (choice).

In the economic or rational theory of decision-making the decision-maker is assumed to have well-defined preferences, is able to assign a utility value to each alternative and chooses the alternative that optimizes utility (Bettman et al. 1998). The information processing theory of decision making (Simon 1955) proposes that people have limited cognitive capabilities, in both working memory and their ability to process information. As a result they operate under what Simon called "bounded rationality". To reduce cognitive effort, people rely on heuristics and are often satisfied with a decision where the expected outcome is "good enough", rather than optimal. This is called "satisficing" behaviour.

Behavioural decision-making theory has evolved from Simon's theories and other observations that people do not always make economic decisions. A number of systematic deviations from optimal and rational behaviour have been shown to persist in human decision-making and behavioural scientists have tried to understand how the use of heuristics and processing strategies can account for these deviations. As well as cognitive factors, they have also addressed social and psychological factors that affect decision-making (Elam et al. 1992).

The study of consumer decision-making behaviour applies the behavioural science approach to a specific domain. Researchers have looked at how consumers search for information (from both external sources and through memory) as well as how they select and use choice strategies (Elam et al. 1992).

Many factors can affect the choice of decision strategies. Research has shown that consumers often do not start a decision task with known preferences – they "construct" them when required. Decision strategies can be characterized according to whether information is processed consistently or selectively (how much of the available information is used), whether information is processed by alternative or by attribute (the pattern of processing), and whether the strategy is compensatory (requiring trade-offs) or non-compensatory (not requiring trade-off) (Bettman et al. 1998).

It has long been the goal of Information Systems (IS) developers to design systems that can assist in overcoming the cognitive limitations of users (Davis and Olson 1985). More specifically, the study of DSS examines how information systems can help decision-makers make better decisions.

"A DSS is a computer-based system used by managers as an aid to decision-making in semi-structured decision tasks through direct interaction with data and models" (Benbasat and Nault 1990, p. 203). While DSS were originally developed and implemented for managerial use in organizations, the Internet and the WWW now provide possibilities for DSS to be used by more individuals and for a variety of business and personal decisions. Retirement planning is one example of an application where individuals can use the WWW to access various models for forecasting their needs and develop an appropriate savings plan. DSS researchers are looking at ways to make these systems more accessible, including the use of agents to search for and find appropriate systems or components (e.g., Lang and Whinston 1999; Gregg et al. 2002).

In Chapter 3 we elaborate on how current research in DSS is incorporating artificial intelligence techniques to add structure to larger and more complex areas of the decision-making process.

1.5 Summary

This chapter has introduced the various projects that combine in this dissertation. A common theme throughout these projects is that software agents are viewed as an innovation. We want to identify areas where agent applications are most likely to be adopted and how to design agent applications that people will choose to use. The research questions we pose are directed at understanding where we can best direct research and development efforts.

Our research uses the idea of decision support to unite the research areas of software agents and electronic commerce. We have oriented the reader by providing starting points in each of these top-level areas and provided brief descriptions of some general directions our research follows through these areas.

Chapter 2

Approaches to Software Agents – A User's Perspective

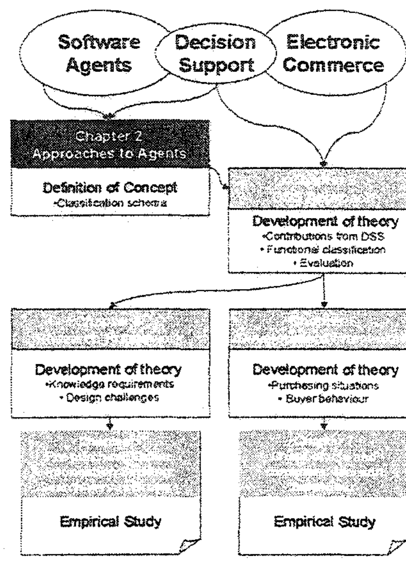

Figure 2-1 - Chapter 2 in the Research Overview

This chapter presents an original classification system for agent applications. This system emerged from a broad review of the literature on software agents. Its purpose is to communicate to the reader the types of agents that the rest of this research will address as well as those that are not being addressed.

Under this system, agents are classified in very general terms according to how the user views and interacts with the agent. This perspective is consistent with a product-focused approach to agent design and development.

2.1 Background

Prior to the mid-1990s, the concept of software agents had been limited to the AI research community. In July 1994, a special issue of the *Communications of the ACM* sparked broadened interest from other disciplines and attention from the popular computing press (Nwana and Ndumu 1999; Wooldridge and Decker 2000).

In Chapter 1 we introduced two areas where agent technologies are considered to be important. The human-computer interface is one area where "first generation" literature promoted the usefulness of agent technology (Negroponte 1995; Bradshaw 1997). As information technology becomes increasingly integrated into everyday tasks, the need to "delegate, not manipulate" (Negroponte 1995) may be required to exploit the full potential of current and future systems. Today's human-computer interface is often considered to be a bottleneck for both experienced and naïve users.

After 1994, many "first generation" books and articles on the subject also proposed that software agent technologies provide new paradigms for abstraction and modularity when designing applications for complex, open and distributed systems (Jennings and Wooldridge 1998) (Bradshaw 1997). The growth and commercialization of the world WWW has continued to provide challenges and real-life problems for agent researchers and developers to address (Nwana and Ndumu 1999; Wooldridge and Decker 2000). The convergence of computing and communications systems also has introduced some unique distributed design challenges associated with mobile computing.

From the introduction to software agents in Chapter 1 we recall that there is still no commonly accepted definition for what constitutes a software agent. The differences between an interface focus and a distributed design focus is signaled in definitions proposed by researchers working in each stream. Focusing on the interface, Bradshaw (1997) suggests that agents can be defined "by attribution", when the user believes that they are delegating a task to an agent. On the other hand, distributed design research defines an agent as "a computer system that is situated in some environment and that is capable of autonomous action in this environment in order to meet its design objectives" (Wooldridge 1999 p. 29). The user does not play a role in this definition.

In the following section (2.2) we develop a description of three approaches to agent applications from a user's perspective, where some of the fundamental differences between these two streams are illuminated. Rather than dismissing agent applications that do not meet the definition adopted by any one approach, a more inclusive attitude can encourage development activity and cross-pollination of research between approaches.

In section 2.3 we describe how this classification system was applied to a small sample of research articles about agents. In section 2.4 we submit the classification schema to a reliability test and apply it across a broader sample of articles from different fields of research.

2.2 Classification by Approach

A broad review of the existing literature on agents was begun in 1998 as part of this researcher's preparations for this dissertation. It was soon discovered that none of the existing classifications and taxonomies of agents were effective in organizing this extensive collection of research or communicating the types of agent applications that we wanted to include and exclude in our research.

The literature described some agent applications that were completely hidden from the user. If the user does not know he or she is using an agent, we cannot treat it as an innovative product to be considered for adoption from the user's point of view.

Another group of agents, often called "interface agents", presented avatars or cartoon characters that employed natural language processing (NLP) capabilities as a way of encouraging a more natural and social way of communicating with systems. These types of agents pose similar research questions as far as the adoption of innovation, but they also have their own set of research problems. How do users react to the introduction of anthropomorphism to the interface? What are the social and emotional dimensions of the interaction between this type of agent and the user? These are important questions, but they deserve a separate inquiry.

Over a two-year period we developed a "personal" classification system consisting of three "approaches" to agents: the AI approach, the computer science/systems (CS/S) approach and the DSS approach. In this section we describe these approaches and how we refined the classification system by trying to apply it to a sample of articles on agents.

2.2.1 The AI Approach

Traditionally, AI attempts to model and replicate human intellectual activity and AI systems are designed as black box systems that focus on results. The classic "Turing test", where an AI system is expected to produce behaviour that is indistinguishable from that of a human being, is evidence of this focus (Turing 1950). There is a significant body of agent research and development that attempts to simulate human behaviour in a similar way. The defining characteristic of the AI approach to agents is an objective of producing "realistic" or "believable" behaviour.[1]

One type of agent that follows the AI approach is where the end user interacts with the system through an agent, as if it were a human agent. These agents are often called "Interface Agents." Improvements to the current generation of direct manipulation interfaces are desired to make it easier for users to make full use of the many features being added to applications. The expanding functionality of the WWW is also drawing more and more inexperienced users to the desktop computer and simplified interfaces may help these users. Thus, the "delegate, not manipulate" (Negroponte 1995) proposition for the next generation of interfaces is an important one.

The original "strong hypothesis" for interface agents proposed that the agent would be able to observe and learn from the user's actions, providing personalized, intelligent assistance and tutoring (Nwana and Ndumu 1999). An example would be

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[1] By labeling one of our classifications as the "AI approach" our intention is not to diminish the contributions of AI in other approaches. Reasoning and learning capabilities developed within AI provide the autonomous and adaptive behaviour required for all agent applications.

Negroponte's "digital butler" (Negroponte 1995). However, current AI techniques are generally inadequate for this task, "leading to the adoption of a much weaker hypothesis" that involves only an initial, explicit profile (Nwana and Ndumu 1999 p. 10).

For e-commerce applications it may be important for Web-based businesses to replicate the type of services found in a traditional environment. Agents developed under the AI approach may provide these services. Examples would be "virtual service representatives" such as those found at *Native Minds* and avatars such as "*My Virtual Model*"[2]. Many of these agents employ natural language understanding and although it is a controversial subject, these agents typically display anthropomorphic characteristics.

Realistic behaviour also is the objective when developing agents for use in simulations such as games and training applications.

2.2.2 The Computer Science/Systems (CS/S) Approach

Agents also are seen as an advanced way to design modular and scalable software for today's open and distributed systems. Agents provide a higher level of abstraction than previous modeling and design paradigms such as functional decomposition and object orientation (Cuena and Ossowski 1999; Wooldridge and Jennings). We can identify four areas of agent research that approach agent development from a systems design perspective, as follows.

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[2] http://www.nativeminds.com and http://www.mvm.com (Accessed February 21, 2003)

System Design and Operation Some developers acknowledge that they use an agent-based architecture primarily to organize decentralized development of the various components of their information discovery system. A multi-agent system is also easily extensible and "goes beyond the client-server model by allowing to postpone the decision about where to do the actual processing" (Simons et al. 2000, p. 3). These issues are related to the system's design and operation and not to its functionality. As another example, a workflow management system (WMS) can be based on simple reactive agents where "these agents are neither intelligent or autonomous agents, since their execution behaviour is derived from the workflow schema…and they behave exactly as defined within the schema. Thus the information system characteristics of the WMS predominates where the agent-oriented execution model leads to a flexible and distributed architecture" (Joeris 2000, p. 5). Again, agents are being employed for reasons related to design and operation, not functionality.

Distributed Problem Solving Multiagent systems for distributed problem solving are often designed to make use of distributed resources or opportunities for concurrent processing. If there is little interaction between the end user and the component agents these systems can also be considered examples of the CS/S approach. While the multiagent system provides intelligent support for the problem-solving task, the end user views the system no differently from a non-agent application that could provide the same functionality. Examples of this approach can be found in Yokoo and Ishida (1999) and Durfee (1999).

Mobile Agents Proponents of mobile agents list advantages such as reducing network load, overcoming network latency, encapsulating protocols, adapting to maintain optimal configuration for execution, platform independence, and fault-tolerance (Lange and Oshima 1999). These advantages are related to system operation and efficiency, not functionality (Nwana and Ndumu 1999), and mobile agents employed for these reasons can be classified within the CS/S approach. However, one important functional advantage of mobile agents is asynchronous, autonomous execution when the user is disconnected from the network (Lange and Oshima 1999; Wong et al. 1999). When mobile agents are used for this purpose, they would not be classified under the CS/S approach

Wrappers Another related area is the use of agents as "wrappers" for legacy systems. Wrappers are specialized software layers that can translate between agent communications languages and the query/control language of the legacy system. The mission-critical nature of many legacy systems and the costly and time-consuming problems of replacing these systems necessitate the use of wrappers (Nwana and Ndumu 1999; Wooldridge and Jennings 1999). Often, the need for wrappers arises from a systems design problem, where agent systems may be used simply to have distributed heterogeneous components of a system to operate in an integrated manner. In this case, wrappers provide no additional functionality for the user than a direct translation interface that is not agent-based.

In the above examples of the CS/S approach, users are not interacting directly with or "delegating" tasks to the agents, and often are not even aware that the system is agent-based. Systems that fall under the CS/S approach are therefore defined as those where the existence of agents is not necessarily known to the end user of the system.

2.2.3 The Decision Support Systems (DSS) Approach

The DSS approach to software agents uses agents to address the needs of decision-makers in today's distributed and heterogeneous information environment. Agents can assist users to retrieve relevant information for decision-making. They also address human limitations in processing the vast quantities of information that may be available for decision-making. The user "delegates" certain tasks in the decision-making process to agents, while retaining control over other parts of the process. The objective of the DSS approach is to reduce the time and effort required by the human decision-maker and to improve decision quality by retrieving and processing more information.

Similar functions may be provided by multiagent systems designed under the CS/S approach. However, in these cases, the user has no interaction with the agents, no way of seeing what the agents are doing and no option to step in and adjust the agent's behaviour or take over the task. A higher level of interactivity between the user and the system therefore characterizes the DSS approach. Users knowingly delegate certain tasks to agents, generally after they have been able to confirm that the agent will behave in predictable and appropriate ways.

We view the commerce process, and thus e-commerce, as a complex series of decision-making tasks performed by buyers, sellers and intermediaries. E-commerce agent applications that assist with these tasks may benefit from a DSS approach.

2.3 Initial Application

To determine if the classification system developed in Section 2.2 could be applied to current agent research and development activity a small but representative set of article on agents was classified by the author. The set consisted of two journals that had recently published special issues on agents. The March 1999 issue of *Communications of the ACM* contains a section on "Multiagent Systems on the Net" and a section on "Agents in E-Commerce". The March-April 2000 issue of *IEEE Internet Computing* contains a section of theme features entitled "Agents on the Net". Some of the articles discussed general agent architectures or foundation areas such as eXtensible Markup Language (XML), and these articles were not included in the analysis. Those articles that describe specific applications were classified according to the schema outlined in the previous section. Appendix I contains a list of the articles classified.

An objective of "realistic behaviour" is the defining characteristic of the AI approach. The classification began by using this characteristic as a "filter" to separate agent applications that fell under the AI approach from the rest of the applications.

The remaining applications were then evaluated according to the level of interactivity between the end user and the agent or multiagent system. If the level of interactivity was classified as low, the end user is not necessarily aware that the system contains agents and is not knowingly delegating actions to these agents. According to the description of the CS/S approach, this low level of interaction acts as a second filter to separate those applications that can be classified under the CS/S approach.

The rest of the applications required interaction between the user and the system and were therefore classified under the DSS approach. This initial analysis identified two additional levels of interactivity to see if they could help us understand differences within the DSS approach. If the end user provides the agent with initial specifications for a task only, the interaction was classified as medium. If initial information is collected and then additional information is exchanged during the process of completing the task, the level of interactivity was classified as high.

For further analysis, the type of knowledge that was modeled in the agent was identified. An application was considered to have general knowledge if it required understanding natural language or using general ontology and logic to perform actions that were not domain-specific. While these intellectual activities are considered "easy" for people, they pose some of the most difficult challenges for AI. An agent built around such general knowledge is designed primarily to save the user's time. Expert knowledge includes ontology, processes and algorithms that are specific to a domain and may be employed in agent applications to save an expert's time and effort or to supplement an inexpert user's knowledge. Profile knowledge is knowledge about individual end users and their preferences.

Table 2-1 shows how the filters were applied to classify the applications described in these articles into the AI, CS/S or DSS approaches. The initial filter, an objective of realistic behaviour, identified three applications that fall under the AI approach. Two of these applications were training or educational simulations. One application created "virtual service representatives" for e-commerce.

The second filter was a low level of interaction - where the user does not necessarily recognize that they are using an agent application. This filter identified three applications that fell under the CS/S approach.

The rest of the applications exhibited characteristics that fit the DSS approach. Five articles described applications that support a single user, conducting a single task. In general these applications had a medium level of interaction, using profile information that was collected only at the beginning of each task.

Table 2-1 - Initial Classification of Articles

Article	**Approach**	**FILTER 1**	**FILTER 2**	**Type of Knowledge**		
See Appendix I for citations		**Objective behaviour**	**Level of Interaction**	**General**	**Expert**	**Profile**
1	AI	Realistic			Y	
2		Realistic			Y	
3		Realistic		Y	Y	Y
4	CS/S	Other	Low			Y
5		Other	Low		Y	
6		Other	Low	Y		
7	DSS	Other	Medium		Y	Y
8		Other	Medium			Y
9		Other	Medium		Y	Y
10		Other	Med/High		Y	Y
11		Other	Medium		Y	Y
12		Other	High	Y		Y
13		Other	High		Y	
14		Other	High		Y	
15		Other	High		Y	

Within the DSS approach the distinction between medium and high levels of interaction is based on the "weak versus strong" agent hypotheses (Nwana and Ndumu 1999). Since the DSS approach promotes a highly interactive interface between the user and the system, it was hoped that we might learn something about how the DSS approach has been applied in various applications. All of the applications supporting single users conducting single tasks had medium levels of interaction, corresponding to the "weak" hypothesis. Nwana and Ndumu (1999) suggest that this is because current AI technologies have not addressed the difficult problems of information discovery, ontology, communication, and how to build a "deep cognitive model of the user and the task" (p. 10). Higher levels of interaction were evident in agent systems that modeled group tasks, but this interaction was generally limited to the ability to monitor the system or notify users of exceptional activity. It was not always clear whether monitoring and notification activity was directed at individual users who had delegated activities to the agents or to a central human coordinator.

Under the DSS Approach, one application assisted a single user with multiple tasks and three of the applications supported tasks completed by groups. All of these applications displayed a high level of interactivity, where users could monitor the progress of the system as it completed its task.

Most of the applications worked within a narrow domain. Even if researchers discussed more general use, the knowledge base in demonstration applications was specialized. Profile knowledge was collected in all of the applications designed to assist individual users, including one of the applications in the AI approach and one in the CS/S approach.

This small survey of agent literature was a first step in trying to understand some of the different directions in which agent research is proceeding and this analysis helped to clarify some of concepts that could be used to categorize agent research. To validate whether these concepts could be applied in a consistent manner we needed to involve other researchers. To test the usefulness and generalizability of the classification system would require a more extensive literature survey.

2.4 Reliability Test

2.4.1 Phase 1

In order to use this classification system to communicate the type of agent we are interested in, it was necessary to find out if the concepts behind the categorization were shared by other researchers in the field and whether the classification system could be applied reliably by others. "A high level of intercoder agreement is evidence that a theme has some external validity and is not just a figment of the investigators imagination" (Ryan and Bernard 2000, p.785).

To this end, we conducted a two-phase test for reliability. In Phase 1 the set of articles described in Section 2.2 were given to two other Ph.D. candidates with interests in agent technology. They were provided with the general description of the three approaches to agents as outlined in Section 2.1 and instructions for applying the "filters" to classify the articles. (Appendix I contains the instructions provided to the coders.)

There was no further task-related communication between the coders or between the coders and the author until they had completed their classifications.

The results of the first phase of the reliability test are shown in Table 2-2. There was perfect agreement (all three coders) on 9 of the 15 articles. Since some agreement will occur by chance we use Krippendorf's method for assessing reliability in content analysis (Krippendorff 1980). Our unit of analysis is a journal article. We calculate Krippendorf's coefficient of reliability, α, to be 0.587 for this set of data. (See Appendix I.) Krippendorf's alpha ranges from 0 for the expected agreement by chance to 1 for perfect agreement. In other words, our results are 58.7% above what would be expected to happen by chance. Acceptable levels of α range from 0.70 to 0.80, depending on the application (Brouwer et al. 1969; Krippendorff 1980; Wimmer and Diminick 1991; Ryan and Bernard 2000). Thus the first phase of the reliability test did not substantiate use of the classification schema.

Table 2-2 - Results of Phase 1 Reliability Test

Article number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Author	AI	AI	AI	CS	CS	CS	DS	DS	DS	DS	DS	DS	DS	DS	DS
Coder 1	AI	AI	AI	CS	CS	CS	DS	CS	DS	CS	DS	DS	DS	CS	DS
Coder 2	DS	AI	AI	CS	CS	CS	DS	CS	DS	DS	DS	AI	CS	CS	DS
		*	*	*	*	*	*		*		*				*
	AI – AI approach, CS – CS/S approach, DS – DSS approach * indicates articles where there was perfect agreement between coders Article citations are found in Appendix I.														

2.4.2 Phase 2

In essence, the next phase of the reliability test was designed to accomplish two objectives. We wanted to examine the reasons behind different classifications and see if these differences could be resolved with clarification of the concepts. The second objective was to take a wider sample of journal articles, to see if the classification schema could be applied to a more general population of academic literature.

To reach the **first objective**, we employed a process similar to the Delphi process. The three coders met to discuss the results of the Phase 1 classification task. The discussion focused on the articles where there was disagreement. Discussion and clarification resolved the differences in two articles (1 and 12) that involved the AI approach. Most of the differences occurred when distinguishing between the CS/S approach and the DSS approach (articles 8, 10, 13 and 14). The coders observed that the articles did not always explicitly describe the interaction with the user. There were often "cues" that would suggest the form of interaction, but the nature of the interaction had to be inferred by the reader. The coders commented that they were often unsure about applying a "black or white" rule when they viewed the nature of the interaction in shades of "gray". It was suggested that a different approach to categorization be applied for the second phase.

In cognitive psychology the classical form of categorization involves applying a set of "rules". This was the form of categorization used in our Phase 1 instructions. The world of concepts, however is not always adequately described by rules. People actually use their perceptions of similarity, their intuitive theories of the world and their goals to categorize things. Cognitive psychologists have found that all categorical structures are "graded" – where some examples are more "typical" of a category than others (Barsalou 1992).

Two other models of categorization are the exemplar model and the prototype model. The exemplar model assumes a category to be a collection of memories of specific examples, or exemplars, of the category. New entities are put in the category where the mind finds the most similar remembered exemplar. Exemplar models do not allow for abstraction.

Prototype models represent categories through average or frequent dimensions, properties or relations. A prototype describes the general characteristics of members of the category. A weakness of the prototype model is that it does not permit the use of exemplars. Combined models have been developed, using both prototypes and exemplars, to better describe how people actually seem to categorize entities (Barsalou 1992).

For Phase 2 of the reliability test, we used a combination of the prototype and exemplar forms of classification. Each approach to agents was described in terms of its general characteristics – things the user might expect to see. The articles from Phase 1 provided exemplars to be retrieved from the coders' memory. The instructions for Phase 2 are also in Appendix I.

The **second objective** for Phase 2 of the reliability test was to sample a larger collection of articles on agent applications. McMaster University subscribes to the on-line journals of a number of academic publishers. Three of these publishers were chosen:

Kluwer Academic Publishers, Elsevier Science Ltd, and Emerald Fulltext (A division of MCB University Press). Each of these publishers produces journals in a number of different research areas, including business and management, computer sciences, engineering and general sciences. The author searched for articles published in the previous 12 months (from approximately July 2001 to June 2002) that contained the keywords "intelligent agents" or "software agents" in the title, keywords or abstract fields. Forty-two articles were returned on the search. The author reviewed abstracts to determine if the article described an agent application, rather than purely theoretical or technological aspects of agent research. The abstracts of twenty-four articles indicated that they contained a description of an application. On reading the full articles, it was found that four did not describe an application in sufficient detail to determine a classification. The remaining 20 articles were classified by all three coders using the Phase 2 instructions.

The results of the classification are shown in Table 2-3. In Phase 2 we had perfect agreement on 16 of the 20 articles. Krippendorf's α for our results on the Phase 2 reliability test was 0.791. (See Appendix I.) Our main reason for developing this classification is to give the reader of the remaining sections of this dissertation an idea of the type of agent application we are discussing (or more importantly, not discussing). It is recognized that this is not a large sample of articles but the classification takes place at a high level and there are only three categories. An α value of 0.791 is acceptable for our purposes.

Table 2-3 - Results of Reliability Test – Phase 2

Article	1	2	3	4	5	6	7	8	9	10
Author	DS	DS	DS	DS	CS	CS	AI	AI	DS	AI
Coder 1	DS	DS	DS	CS	CS	CS	AI	AI	DS	AI
Coder 2	CS	DS	DS	DS	CS	CS	AI	AI	DS	AI
		*	*		*	*	*	*	*	*
Article	11	12	13	14	15	16	17	18	19	20
Author	CS	DS	DS	CS	DS	DS	AI	CS	DS	DS
Coder 1	CS	DS	DS	CS	DS	DS	AI	CS	DS	DS
Coder 2	CS	CS	DS	CS	DS	DS	AI	CS	DS	CS
	*		*	*	*	*	*	*	*	

AI – AI approach, CS – CS/S approach, DS – DSS approach
*indicates articles where there was perfect agreement between coders
Article citations are found in Appendix I.

2.5 Summary

This Chapter presented a classification of agent applications that identifies the type of agents that are considered in the rest of this research. We are not considering agent applications that fall under the CS/S Approach, where users do not know, or need to know that the system is agent-based. Neither are we considering agents that fall under the AI Approach, where the primary objective is to simulate realistic human behaviour and engage the user in an interaction with social dimensions.

We have shown that we get reliable results applying this classification schema over a broad range of agent applications from different research areas. The real validity of the schema will be related to its usefulness. If other researchers find this classification useful in the future, then the concepts behind it will have demonstrated external validity (Ryan and Bernard 2000).

Chapter 3

Software Agents: A Decision Support Systems Approach[3]

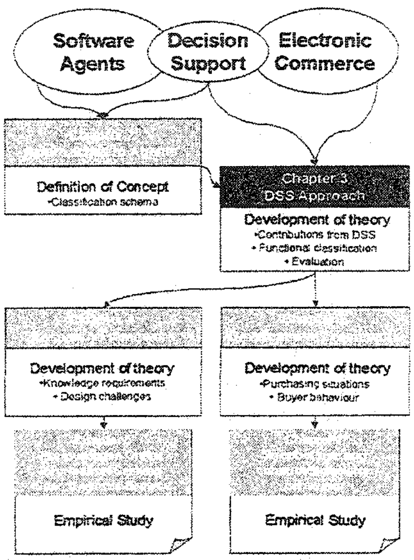

Figure 3-1 - Chapter 3 in the Research Overview

In this chapter we begin to focus on the e-commerce domain. Recall that we look at commerce as a series of decision-making processes where problems are identified, alternative solutions are considered and choices are made. As noted in Chapter 2,

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[3] Based on Sproule, S. and N. Archer (2000b). "Knowledgeable Agents for Search and Choice Support in E-Commerce: A Decision Support Systems Approach." *Journal of Electronic Commerce Research* 1(4) November. The candidate was the primary author of this work and developed the concepts that are described here. It is used with the consent of the co-author, Dr. Norm Archer. Copyright permission has been obtained from the *Journal of Electronic Commerce Research* to re-publish this material in this thesis.

we are looking at agent applications that fall under what we called the DSS approach. Users of this type of agent are aware that they are "delegating" the task to a software agent and have some level of interaction with the agent.

In this Chapter we look back at how researchers have learned to design traditional DSS so that users will find them useful and useable. We would like to discover how we could use theories and findings from DSS research to inform agent design and development.

3.1 Theoretical Foundations

3.1.1 Related Research Areas

In reviewing research and development activity in software agents it is helpful to acknowledge some related areas of research and their different approaches to this new field of IT. As described in the previous chapters, software agents were originally conceived and developed within the Artificial Intelligence (AI) research community. Reasoning and learning capabilities developed within AI provide the autonomous and adaptive behaviour that we want for agent applications. However, traditional AI systems are designed as "black box" systems that focus on results.

Within the field of Management Information Systems, agents are most closely related to the study of DSS. The study of DSS examines how information systems can be used to help decision-makers make better decisions. Decision-making involves activities such as collecting relevant information from the environment, modeling the problem domain and generating alternative solutions, employing a decision strategy to choose between alternatives, testing and justifying the decision, and effecting the necessary changes in the environment to implement the decision. DSS have been developed to support human users across all of these activities (Turban and Aronson 1998).

Expert systems (ES) have been the most successful practical application of AI technologies and can be viewed as a hybrid of AI and DSS. These systems apply rule-based reasoning, developed in AI, to assist human decision-makers in solving real life problems. According to Wooldridge (1999), the main distinction between ES and software agents is that ES do not generally receive information from, or act directly on, their environment. The human user of an ES acts as a middleman in these information exchanges (Wooldridge 1999). DSS researchers have studied ES as they evolved from research projects into successful practical applications and have identified design characteristics that facilitate the way that users interact with these systems. If agent technologies follow a similar path to adoption, and examination of how DSS principles have been applied to ES may provide clues for the successful implementation of intelligent agents in decision support.

3.1.2 A Decision Support Systems Approach

Decision-making is a complex, multi-staged process. DSS research recognizes that computers can complete certain parts of this process faster and more accurately than people. People, however, bring experiences and abilities such as creativity and intuition, that enable them to complete other parts of the process more effectively than machines. The DSS approach is to structure parts of an ill-structured problem. These structured parts can then be performed by the system. Humans interact with the system, using their own knowledge to "join" the structured parts together and develop a complete solution to the problem.

By segmenting the overall problem, components can be defined to require very specific domain knowledge and reasoning capabilities, making them well-suited to the limitations of current AI technologies. Current research in DSS is incorporating AI to add structure to larger and more complex areas of the decision-making process. AI techniques can be used to build systems that learn from experience, deal with ambiguity and uncertainty, apply logical reasoning and inference, and adapt to new situations (Siskos and Spyridakos 1999).

The DSS approach demands a lot of interaction between the decision-maker and the system. Some experienced agent developers propose an approach to the design of software agents that is remarkably similar to DSS design, describing a level of interactivity very different from the "black box" model that is found in an AI approach. From their experience developing the *Information Lens* agent system, Malone, Grant and Lai (1997, p. 110) propose two principles for agent design that fit well within the DSS paradigm:

- "Don't build agents that try to solve complex problems all by themselves... Build systems where the boundary between what the agents do and what the humans do is a flexible one. We call this the principle of *semiformal systems*...", and
- "Don't build agents that try to figure out for themselves things that humans could easily tell them. Instead try to build systems that make it as easy as possible for humans to see and modify the information and reasoning processes their agents are using. We call this the principle of *radical tailorability*...".

DSS are designed to automate parts of a larger decision-making process. The user interacts with the system using his or her knowledge to fill in the missing parts and put together a total solution to the problem. This is similar to the principle of "semi-formal systems" for agent design, where the boundary between what the user does and what the agent does is flexible (Malone et al. 1997).

DSS development methods and tools support a highly interactive, prototyping process that accommodates user learning and allows the user to easily customize the application. This fits with the principle of "radical tailorability" that experienced agent designers recommend, where the user can alter the system in the same way that a user creates custom applications from a spreadsheet program (Malone et al. 1997).

The development process is another area where DSS research may be applied to agent systems. DSS are often built to support individual decision-makers, with one-time or ad hoc problems, and DSS developers recognize that their human users learn during the development process and while using the system. A fast and highly interactive development process is necessary and DSS tools allow changes to be made quickly and flexibly during the process (Turban and Aronson 1998). Similar problems arise in the design of software agents. A defining characteristic of software agents is the ability of an agent to be "personalized" for each user. Agents must be able to satisfy the needs of users with different levels of experience, different perceptions of risk, and different decision-making preferences. This will require tools comparable to those used in DSS development, where users can experiment with "prototype" agents and change their agent's characteristics as they gain experience and trust in the agent's abilities.

Finally, DSS research directs considerable attention to the system's usefulness, as defined by the user. While other organizational information systems, such as transaction processing systems and management information systems are usually "mandated" into use, the use of a DSS is generally considered to be optional (Turban and Aronson 1998). Similarly, we assume that people choose to use an agent, and will do so only if its usefulness is clearly evident. Table 3-1 summarizes the contributions of a DSS approach in agent design and development.

Table 3-1 - Contributions from a DSS Approach

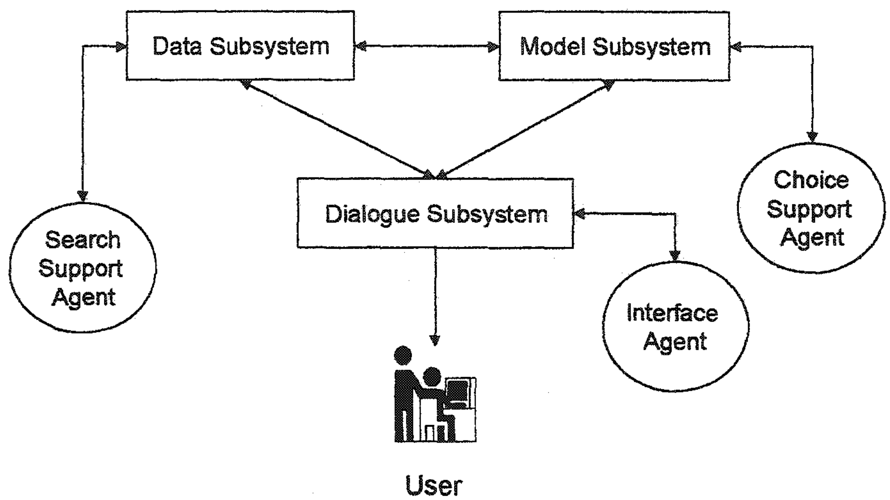
The DSS approach promotes...	**In the development and design of software agents, this accommodates...**
... the segmentation of a large ill-structured decision problem into smaller components	... the limited problem domains that AI applications can adequately address ... the need for different representations and reasoning systems in separate parts of the problem
... flexible boundaries between the user and the system allowing for many levels of interaction	... the development of trust ... user learning ... dynamic situational factors ... constructive search and choice behaviour
... an interactive development process with tools that allow the user to adapt and customize the system	... the need for agents to be personalized for each user
... "usefulness" as a critical characteristic of the system	... the need to consider the voluntary nature of agent use.

In related work, Bui and Lee (1999) take a DSS approach to developing a system of collaborative agents to assist in crisis management. Their development process involves deconstructing the overall problem-solving process into primitive tasks, specifying the required functionality and behaviour of agents for these tasks, and deciding if use of an agent is justified. Coordination and collaboration mechanisms are then designed so that humans and software agents can integrate their activities into an overall workflow.

Cuena and Ossowski (1999) provide a framework for the design of distributed decision support for control systems using multi-agent systems. They argue that knowledge modeling is often difficult when systems are designed using functional decomposition and object-modeling methods. Agent-based models provide a higher level of modularity that can combine knowledge about the problem type and the environment. They believe that this is a more intuitive approach for both modeling and organizing knowledge. It lets the DSS designer balance the "level of specialty" and the "level of autonomy" by integrating a significant set of functions, but restricting the scope of the environment in which they are applied (Cuena and Ossowski 1999).

3.1.3 Agent Classifications from a DSS Approach

DSS are commonly considered to include a data subsystem, a model subsystem and a dialogue subsystem. Turban (1988) suggests that AI can be embedded into DSS to support the model, data or dialogue subsystems, the complete system, or the user. We propose a classification of agents according to whether they support search functions through the data subsystem, choice functions through the model subsystem, or interface functions through the dialogue subsystem. This is shown in Figure 3-2.



adapted from (Turban 1988)

Figure 3-2 - Agents in A Decision Support System

We can distinguish between search, choice and interface agents according to the disciplines from which their techniques are borrowed and the manner is which their performance is measured. Table 3-2 summarizes these disciplines and measures. Agents that support the search function use techniques and measures developed within the information retrieval (IR) community. Agents that support the choice function borrow their techniques from economics, psychology, management science and other disciplines that describe how people make choices between alternatives and how to improve decision quality. The different theories proposed by these disciplines result in a variety of evaluation criteria. Interface support is based on principles developed in the study of human-computer interaction, where various measures can be used to evaluate a system's "usability".

Table 3-2 - Agent Reference Disciplines and Measures

Type of Agent	Reference Discipline(s)	Potential Performance Measures
SEARCH SUPPORT	Information Retrieval	Precision Recall
CHOICE SUPPORT	Decision theory from: – Economics – Psychology – Management Science	Consistency of decisions Compare choice to optimal Amount of information used or processed Time to make decision
INTERFACE SUPPORT	Human Computer Interaction	Usability measures such as: – User satisfaction – Errors – Learning time

The boundary between the dialogue subsystem and the other subsystems lacks clear definition. For example, natural language processing (NLP) is an important area of development for improving user-system dialogue. However, NLP techniques also have important applications in information retrieval, which forms part of the data subsystem.

A very active area of current software agent research focuses on improving the dialogue subsystem. It will be important to find a more natural way for users to communicate with systems as they become more pervasive in our everyday activities. We also need to find appropriate ways for users to deal with software agents that incorporate high-level concepts such as goals, beliefs and intentions. To date, much of the activity in interface agents follows a black box or AI approach and attempts to simulate human behaviour with anthropomorphic characteristics such as emotion and personality. While it is desirable to delegate certain activities to such agents, we believe that users will want to retain control of other parts of the process. The DSS approach suggests a more flexible and configurable interface model that, at times, allows the user to take over and interact directly with the data and model subsystems. The boundary between these areas may vary with the user, the task and the situation. How this boundary varies, and how to design systems that accommodate these variations, are important areas for future research. However, to remain focused on a DSS approach the remaining sections of our research concentrate on search and choice support functions.

3.2 Summary

Software agents may be an important innovation in how people make decisions in e-commerce. In this chapter we have examined theories and findings from traditional DSS research and shown how they can be applied to the design and development of software agents. We have shown how a DSS approach to software agents leads us towards flexible and interactive systems that accommodate the capabilities of AI systems and adjust to the user's individual and changing needs. Erikson (2002) provides more recent support for this view in his comments on "context-aware" computing.

> "I suggest that rather than trying to take users out of the control loop, we keep them in the loop. Computational systems are good at gathering and aggregating data; humans are good at recognizing contexts and determining what is appropriate. Let each do what each is good at" (Erickson 2002, p. 103).

The DSS approach also suggests a classification system according to whether agents support search, choice or interface functions. The techniques used in these functions have different reference disciplines, and suggest that agent performance should be measured differently in each function.

Chapter 4

Knowledgeable Agents for Search and Choice Support in E-commerce[4]

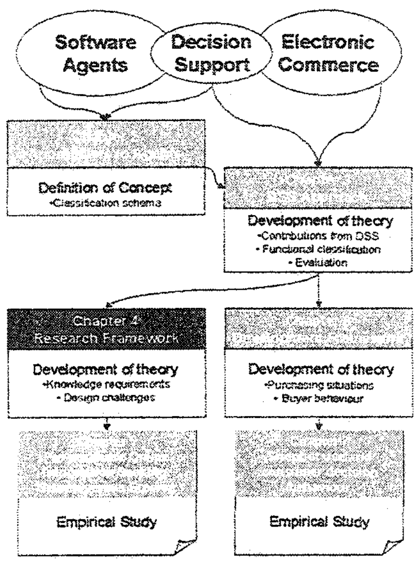


Figure 4-1 - Chapter 4 in the Research Overview

[4] Based on Sproule, S. and N. Archer (2000b). "Knowledgeable Agents for Search and Choice Support in E-Commerce: A Decision Support Systems Approach." *Journal of Electronic Commerce Research* 1(4) November. The candidate was the primary author of this work and developed the concepts that are described here. It is used with the consent of the co-author, Dr. Norm Archer. Copyright permission has been obtained from the *Journal of Electronic Commerce Research* to re-publish this material in this thesis.

In this chapter we develop a research framework for software agents in e-commerce. The distinction between search support agents and choice support agents developed in the previous chapter is used to segregate the roles that agents might perform in e-commerce. From Chapter 1, recall that Jennings and Wooldrich (1998) suggest that the presence of a natural metaphor would help gain acceptance for agent applications. In this chapter we use a metaphor to help describe the functions that software agents could perform in e-commerce and the knowledge they would need to perform these functions.

In related research Wang (1999) identified basic knowledge requirements for agents supporting integrated electronic commerce systems within a business. The framework developed here is more specific to the relationship between a buyer and a buyer's agent or a seller and a seller's agent.

In Chapter 3 we showed how the DSS approach promotes segregating a large problem into smaller components. This can accommodate different ways of representing knowledge and different reasoning systems. Even within the AI community, researchers acknowledge that "we'll frequently need several representations when we face a difficult problem" (Minsky 2000, p. 71).

4.1 Research Framework

The knowledge that human agents use to provide their services is a useful metaphor for the knowledge bases that software agents may employ. We use real estate agents as an example to illustrate the types of knowledge that may be useful within a specific e-commerce domain. We describe how a number of different knowledge representation techniques may be required for different parts of the commerce decision-making process, and how the choice of technique may depend on the nature of the information and the level of interactivity that the system supports.

By examining the knowledge that agents will require in e-commerce we are able to identify a number of design challenges. Current research and development activities such as Extensible Markup Language (XML) and Knowledge Query and Manipulation Language (KQML) promise to enhance the knowledge-acquisition and knowledge-sharing abilities of future agent-based systems.

4.1.1 Knowledge–based Systems

The roles of human agents can serve as useful metaphors to derive models of what software agents may do (Jennings and Wooldridge 1998). Some of a human agent's knowledge replicates the client's knowledge. In this case the agent is valued for being able to reduce the time that the client must spend in the process. Software agents that allow the user to build and add to the knowledge base or where the agent learns from the user's actions would be examples of systems that attempt to replicate this type of support. Human agents also possess knowledge that the client may not have, and in this case they are valued for their expertise. Corresponding software agents are those based on the traditional class of rule-based expert systems (ES) and collaborative agents that combine the knowledge of a number of different users to arrive at decisions or make recommendations.

4.1.1.1 Knowledge Representation

AI research has explored a number of different theories of intelligent reasoning. Davis et al. (1993) classify five of these theories according to the disciplines from which they originate as follows: pure logic-based systems (mathematics), probabilistic reasoning systems (statistics), frames (psychology), connectionist systems such as neural networks and genetic algorithms (biology), and utility theory and rational agents (economics). A fundamental concept in any knowledge-based system is knowledge representation or using symbols to build a model of the portion of the real world that is of interest. Knowledge representation techniques include predicate logic, frames, production rules and semantic nets. The choice of representation will determine the type of reasoning that the system employs, how the knowledge base is processed, and the responses that the system allows (Davis et al. 1993). It is important to choose a representation technique that meets the needs of the problem situation. In many e-commerce applications a combination of representation techniques, each for different parts of the overall problem, may be required.

If the user must interact with the system it also is important to use representations that complement the way that the user conceptualizes the problem. The user's conceptual model provides the "predictive and explanatory power for understanding the interaction" (Norman 1983, p.7). Designers must start with a conceptual model that will be easily understood by users. They must then ensure that the system's appearance, responses and documentation lead users to develop an appropriate conceptual model of the system as they interact with it (Norman 1990). The degree of user involvement and interaction with the system should therefore be an important consideration in the choice of representation. In ES, "explanation" capabilities have been shown to improve performance, learning and users' perceptions and should be considered an important component of any interactive, intelligent system design (Gregor and Benbasat 1999). If "explanation" is a design requirement for a part of the process that we want an agent to handle, representations based on connectionist systems like neural networks should not be used because they provide "black box" solutions and no explanations.

4.1.1.2 Types of Knowledge

In the context of building knowledge-based decision support systems, Holsapple and Whinston (1996) define three primary types of knowledge (descriptive, procedural, and reasoning) and three secondary types of knowledge (assimilative, linguistic and presentation).

Using the human agent metaphor, we can see that human agents in the commerce domain know "facts" about products, buyers, sellers and the market. We call this **descriptive** knowledge. Human agents also know what to do with this information – how to process it to arrive at and implement decisions. We will call this **procedural** knowledge. Finally, human agents know what facts are important, both in general and to their individual clients, and how various facts relate to each other. This allows them to evaluate and assimilate new information and communicate by exchanging knowledge in a meaningful way to others. We will call this **semantic** knowledge.

Our definition of descriptive knowledge is consistent with Holsapple and Whinston's (1996) classification. We use the category of procedural knowledge to discuss knowledge that can be represented in the processing code of systems, including reasoning capabilities, or procedural knowledge that can be stored and retrieved from a knowledge base. Our classification of semantic knowledge combines the three secondary types of knowledge (assimilative, linguistic and presentation), as they can all be considered meta-knowledge, or knowledge about knowledge.

4.1.2 A Model of Search

Figure 4-2 shows a basic search model that contains an information source and its representation, an information need and its representation, and a method for comparing these representations.

Both the information source and the information need may change over time. Information retrieval deals with a "static" set of sources and a "dynamic" set of one-time needs or queries. Information filtering deals with "dynamic" sources and a "static" need or a profile (Belkin and Croft 1992).

Information sources can be unstructured (e.g., full text), semi-structured (e.g., integrated catalogues) or structured (e.g., databases), and the degree of structure will affect the kind of representation used. Full text sources may be represented by sets of index terms. Catalogue items may be represented by minimal information (e.g., a product name and a supplier) with a link to the full information source. The records or objects in a database represent structured information. Similarly, queries or profiles can be unstructured (e.g., a natural language request), semi-structured (e.g., a list of key words or phrases, possibly enhanced by logical operators), or structured (e.g., a SQL command to a database).

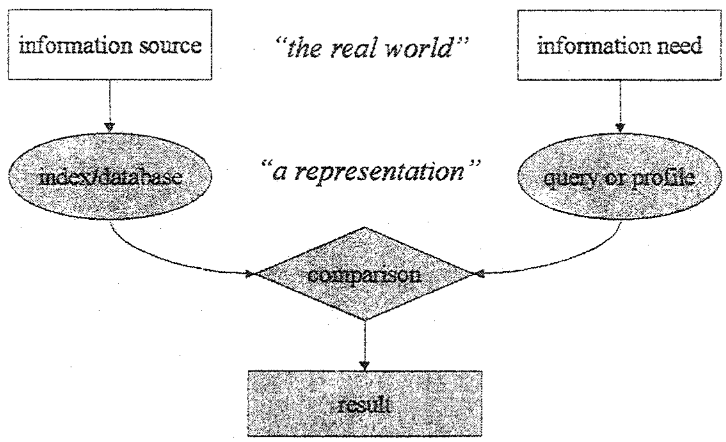


Figure 4-2 - A Model of Search

Adapted from Belkin and Croft (1992)

4.1.3 A Model of Choice

In the real world, the choice problem can be described as interrelated sets of alternatives, criteria and consequences that are processed and analyzed by the decision-maker (White 1975). To model the problem (see Figure 4-3) each alternative can be represented by a set of variables. Parameters are set to represent the selected criteria and any assumptions about the problem situation. A decision model is used to process each alternative, returning a result that represents the consequences of that choice.

Prescriptive models compare results and determine the best choice of alternatives. Descriptive models present the results associated with each alternative to the decision-maker.

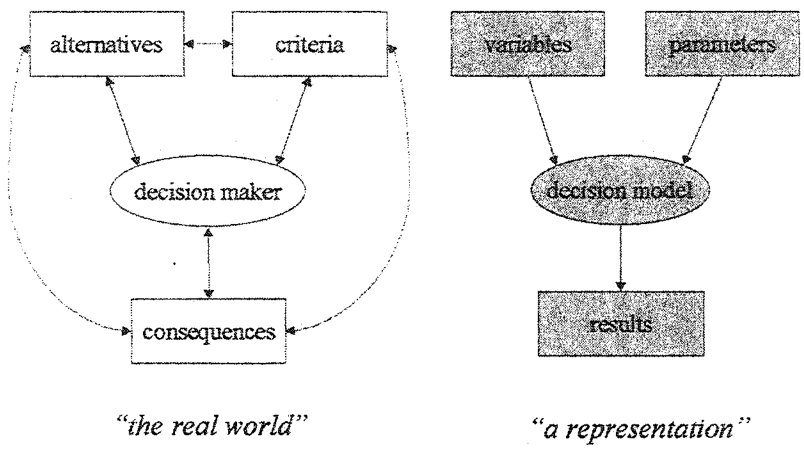


Figure 4-3 - A Model of Choice

Adapted from White (1975)

4.2 Knowledge Requirements for Search and Choice in Electronic Commerce

To show how this framework can be applied within the electronic commerce domain, we first look at the descriptive, procedural and semantic knowledge that a human agent may use to support search activity. We then provide examples of how these knowledge requirements have been built into software agent systems, identify some of the major design challenges, and describe technologies and research areas that show promise in meeting these challenges. Choice support is examined in the same manner.

4.2.1 A Real Estate Agent Metaphor

We will use real estate agents to illustrate the various types of knowledge that a human agent may possess and how this knowledge is linked to the perceived value of their services in supporting search and choice activities. Real estate agents were chosen as our example because they may act for either the buyer or the seller. The real estate agent metaphor can be related to the previous discussion of knowledge-based systems in two ways.

1. Some of the services that a real estate agent performs are valued because they save their client's time. For other services, the client relies on the real estate agent's expertise. To provide these services, the real estate agent uses both knowledge that the client provides and his or her own expert knowledge.
2. A real estate agent is able to use different ways of reasoning and processing this knowledge. If we ask a real estate agent what effect a proposed price will have on our mortgage payments, or if the current zoning is consistent with proposed use of the building, we want a logically sound, correct answer. However, many decisions involve uncertainty and an answer that is "probably" true may be preferable to no answer at all. If we ask our real estate agent to identify the best neighborhoods or schools, we want an informed but necessarily subjective answer.

4.2.2. Real Estate Agents and Search Support

4.2.2.1 Descriptive Knowledge

Real estate agents know where to obtain information about properties, buyers, sellers and market conditions. They have access to directories and catalogues such as Multiple Listing Services (MLS) and gather additional information from first-hand observation and discussions with colleagues. Using these sources, the agent collects "facts" or descriptive knowledge about properties. For an experienced real estate agent, this knowledge covers both the current and past states of the market.

When a new buyer arrives, the real estate agent determines the client's needs. If an initial query that represents these needs fails to find a satisfactory property, it is stored as a "profile" that can be compared to any properties that are subsequently listed. The real estate agent will continually try to clarify a client's information needs, by probing or observing the client's reactions to the information presented.

4.2.2.2 Procedural Knowledge

We expect a real estate agent to develop an efficient strategy that will determine the information sources to be used and the order in which they are used. A seller's agent will construct a listing for the MLS and perhaps develop an information sheet with supplementary information. A buyer's real estate agent will construct appropriate queries to search the MLS catalogue or may discuss the client's needs with other agents. The agent must then compare their client's needs with the information obtained from these sources to find potential matches and produce a "reasonable" number of alternatives.

4.2.2.3 Semantic Knowledge

A real estate agent knows the relationships between objects and concepts, and can therefore determine the relevance and importance of facts. For example, knowing the age of a heating system, the real estate agent can estimate when the cost of replacement will occur and the impact this may have on the purchasing decision.

4.2.3 Software Agents and Search Support

Table 4-1 summarizes the knowledge requirements, design challenges, applicable technologies and research areas for software agents that provide search support.

4.2.3.1. Descriptive Knowledge

Software agent system designers must address the "connection problem" – how does the agent find information sources and other agents to assist in achieving its goals. In controlled systems, collaborative agents can request and obtain descriptive knowledge that has been collected by other agents (Ackerman et al. 1997). In open environments, most agent systems use directories, matchmakers, and brokers to identify potential information sources (Brenner et al. 1998).

Information retrieval often consists of finding structure in predominately free text documents, such as those that make up the Web. Structure can be inferred from features such as hyperlinks (Arocena et al. 1999), header tagging (Guan and Wong 1999), or question-answer formats (Burke et al. 1997). An important area of development involves Extensible Mark-up Language (XML). XML allows creators to encode additional structure into their Web-based information sources, producing more

Table 4-1 - Knowledgeable Agents for Search Support

Type of Knowledge	Knowledge Requirements	Design Challenges	Applicable Technologies and Research Areas
DESCRIPTIVE	Location of information sources	Distributed sources and the "connection problem"	Multi-agent architectures with directories, matchmakers, and brokers
	Data extracted from information sources	Heterogeneous sources with varying levels of structure	XML coding within information sources
	Data describing information needs	Reduce profiling effort	Use of proxy information, learning systems and collaborative systems
PROCEDURAL	Search strategies	Distributed, dynamic environment	Adaptive search strategies that optimize time, cost or quality of search.
	Creating representations	Heterogeneous sources and users	Information extraction and query formation using linguistic analysis and natural language processing
	Matching algorithms	Balance between precision and recall	Probabilistic techniques for information retrieval
SEMANTIC	Ontology	Standardization	Base and domain ontology development
	Communications protocols	Open systems, heterogeneous agents	KQML

"searchable" documents by allowing more complex and complete representations to be built (Glushko et al. 1999).

Software agents can ask clients to state their information needs.[5] A form or questionnaire can be used to elicit the representation requirements where information is highly structured. However, where information needs are complex and ill-structured, more open processes of collection may be required and these processes can be time-consuming and inaccurate. Significant efforts have been made to design software agents that use proxy information to develop profiles (Rucker and Polanco 1997) or learn their user's preferences by observing behaviour (Lieberman 1997; Ngu and Wu 1997). Collaborative filtering compares profiles to find users with similar information needs so that information judged relevant by one user can be shared with others. This is another way to reduce the profiling effort required by each user (Balabanovic and Shoham 1997).

4.2.3.2. Procedural Knowledge

Most software agents have pre-defined search strategies. Some attempts to design adaptive strategies have examined query optimization (Duschka and Genesereth 1997), the efficient use of network resources (Howe and Dreilinger 1997), or balancing source cost against quality (Lesser et al. 2000).

Software agents are able to create representations and translate between source and need representations. Information extraction techniques such as automated indexing

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[5] While the client's information needs may indicate potential decision criteria, this is not necessary at the search stage.

systems are used to create feature-based representations of Web documents. Within a specified domain, systems that use more sophisticated linguistic analysis can create structured databases out of information extracted from full text sources (Cardie 1997). Some meta-search agents are able to translate phrase-based requests into either keyword or phrase-based queries acceptable to popular Web search engines (Etzioni 1997). "Virtual service representatives" can extract key words and patterns from natural language queries.[6]

The agent must be able to compare the source and need representations to find potential matches and produce a "reasonable" number of alternatives. Simple agents may use traditional Boolean systems of information retrieval to match queries to documents, but many agents use more advanced probabilistic systems that weight index terms or look at the statistical distribution of terms within a document. These systems also allow document to document comparisons, creating clusters of sources or user profiles that can be used in retrieval and filtering operations (Pao 1989; Belkin and Croft 1992).

4.2.3.3 Semantic Knowledge

Computers can store vast amounts of descriptive knowledge, and process this knowledge at speeds greatly beyond human capabilities. However, it is semantic knowledge that will produce what we consider to be intelligent and adaptive systems. By using semantic knowledge, unexpected information can be assessed and the agent can

[6] For examples, see http://www.nativeminds.com/ (Accessed February 21, 2003)

broaden or narrow the search if the expected information is missing or the amount of information retrieved is overwhelming.

An ontology is a formal description of the relationships between objects and concepts within a domain. These formal descriptions provide a common vocabulary, allowing agents to exchange information in a meaningful and unambiguous way (Gruber 1993). Frames and semantic nets are knowledge representation techniques that have been specifically developed to model such relationships.

The objects and concepts in a commercial transaction or relationship can be described at many levels. A base ontology covers terms common to all transactions such as those for finance, measurement, and standard contractual conditions. Domain ontologies describe objects and concepts within a product category. Individual suppliers or intermediaries can create a translation ontology that relates proprietary terms to the domain ontology (Keller and Genesereth 1996). Spurred by the potential of XML-based e-commerce, many inter-industry and intra-industry groups are actively developing base and domain ontology (Glushko et al. 1999; Smith and Poulter 1999).

The e-commerce environment is envisioned as an open, decentralized environment where agents must be able to communicate with other heterogeneous agents and systems. The Knowledge Sharing Effort (KSE), a project of the University of Maryland (Baltimore) has developed the Knowledge Query and Manipulation Language (KQML) to facilitate this type of communication. KQML provides communications protocols and has been adopted for use in many multi-agent systems, including matchmaking and brokering systems for information retrieval and filtering. KQML specifies the “intent” of the message, based on speech act theory. The message content can be written in any knowledge representation language that is understood by the recipient (Finin et al. 1994).

4.2.4 Real Estate Agents and Choice Support

4.2.4.1 Descriptive Knowledge

Through the search process, a real estate agent has gathered descriptive knowledge of the alternatives - a set of attributes that describe each property. There may be information about buyers or sellers that will influence the decision process and the agent may use knowledge about market conditions to help define the problem space. The real estate agent has also collected and refined information about the client’s decision criteria including the relative importance of the various attributes, acceptable trade-offs, and threshold levels on specific attributes.[7] To assist the client, a real estate agent is able to select information that is relevant, transform it into the form required, and provide reasonable assumptions about missing information.

4.2.4.2 Procedural Knowledge

A real estate agent is expected to facilitate and assist in decision-making, suggesting different ways of processing information about the alternatives. Experienced agents are likely to have a number of different decision-making techniques that they can

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[7] In the search process the client’s profile represented the information needed to identify a set of alternatives. While a search query or profile may indicate something about the way that a choice will be made, it may be important that other parties be unable to determine the choice criteria from the information request as this could jeopardize future negotiating strategies.

match to the situation and the client's individual preferences. A real estate agent often handles transactions where there is more than one decision-maker (such as a husband and wife or a logistics department within a large corporation). An understanding of the information flows and decision-making processes employed within these groups can be used to ensure that the appropriate information is conveyed to each party at each stage in the process. A real estate agent also knows how and when to negotiate.

4.2.4.3 Semantic Knowledge

A real estate agent is expected to know the "rules" of negotiation, and how to communicate with other parties during the negotiation process in a series of offers and counter-offers. Finally, a real estate agent is expected to be able to communicate the results of a decision in a manner that ensures that the transaction is completed.

4.2.5 Software Agents and Choice Support

Table 4-2 summarizes the knowledge requirements, design challenges, applicable technologies and research areas for software agents that provide choice support.

4.2.5.1 Descriptive Knowledge

Software agents have access to descriptive information about the alternatives collected through the search process. "Restructuring" refers to functions that edit, transform, and infer information so that the chosen decision model can be populated with alternatives (Coupey 1994). To restructure information, software agents must rely on an ontology to standardize attribute values, eliminate redundant information, and infer missing information. Restructuring also can be seen as a constructive process. Transforming attribute data into standardized values, eliminating redundant or irrelevant information, and rearranging information may reveal patterns and regularities that suggest the use of a particular choice model (Coupey 1994). The constructive nature of restructuring is another indication that an interactive process may be preferred by the decision-maker. By restructuring and presenting information in different ways, the system can help decision-makers to choose models they are comfortable in applying to particular situations. An agent should be able to handle market requests in both surplus and shortage situations. Widemeyer and Lee describe the ontological requirements for an AI system that can broaden the search to include substitute products in a shortage situation. The system can also apply increasingly stringent criteria to represent the need in a surplus situation (Widemeyer and Lee 1986).

Software agents can ask the decision-maker to weight the importance of attributes or to set threshold levels for various attributes. Some theories of consumer choice argue that buyers often do not know these preferences in advance (Bettman et al. 1998). These theories again support the need for a highly interactive system, where users can see results and vary their criteria in an iterative process.

The complexity of some commercial transactions and relationships arises from the many outside factors that may or may not warrant consideration. Resource limitations, potential risk and reward, goals, time-pressure, and many other factors can change from one transaction to another. In this context, case-based systems that collect a number of features describing a situation or "case" may be the most effective way to represent the parameters involved in complex purchasing or selling situations.

4.2.5.2 Procedural Knowledge

Theories of consumer choice have developed out of research in economics and psychology. Economic theories of choice assume a perfectly rational decision-maker, able to state clear preferences at the beginning of the choice process. These preferences are used to develop a utility function that can be optimized to form the decision model. Psychological theories of choice have developed out of the belief that humans have limited information-processing capabilities and often use heuristics to reduce the amount of information processing required in decision-making. Heuristic models of decision-making use a series of constraints to eliminate alternatives until a decision can be made with minimal effort (Meyer and Kahn 1991; Bettman et al. 1998).

We can find examples of agents from both of these paradigms. *Personalogic* uses a heuristic approach (Maes et al. 1999), asking the user to specify both hard and soft constraints on the attributes describing alternative brands of a product. It eliminates brands that do not meet the specified hard constraints and presents the remaining alternatives ranked in order of how they compare on the soft constraints. *Tete-a-Tete* is based on a rational model of decision-making (Maes et al. 1999), using weighted-averages and a utility function to recommend a product choice. Consumers often use a combination of decision models (Bettman et al. 1998). In an interactive system, if the agent is to follow a process that is familiar and recognizable to the user, information may need to be passed between coordinating agents with different modeling capabilities.

Table 4-2 - Knowledgeable Agents for Choice Support

Type of Knowledge	Knowledge Requirements	Design Challenges	Applicable Technologies and Research Areas
DESCRIPTIVE	Attributes to describe alternatives	Restructuring	Base and domain ontology
	Decision criteria (weights, thresholds, trade-offs, etc.)	Constructive Choice	Learning and interactive systems
		Situational factors	Case-based reasoning and learning
PROCEDURAL	Decision models and algorithms	Individual preferences and use of multiple models	Multi-model systems and model management
		Sequential decisions	Dynamic decision-making models
	Process and workflow knowledge	Adaptive processes	Learning and reasoning systems
	Negotiating strategies	Non-cooperative environments and multi-dimensional solution spaces	Learning systems using probabilistic networks or genetic algorithms
SEMANTIC	Negotiation protocols	Mechanisms that encourage appropriate agent behaviour	Research from micro-economics and game theory
	Transaction protocols	Standardization	Adapting EDI-type messages for agent systems using KQML

The models of buyer behaviour described above are static models that assume that a buyer's choice is independent of previous purchases. Market researchers have also developed models that represent the dynamic nature of consumer decision-making, incorporating factors such as learning, loyalty, novelty seeking, or inertia (Meyer and Kahn 1991). Today's technologies make it possible to collect large amounts of time-series data for individual consumers. An agent that is able to predict behaviour from historical purchase information could make timely suggestions based on the loyalty, inertia or variety-seeking tendencies in that consumer's behaviour.

In a business-to-business environment, agents can use procedural knowledge to integrate activities within buying or selling organizations. While not an e-commerce application, Bui and Lee's (1999) crisis management system shows how procedural knowledge can be used to coordinate the activities of specialized agents. Agent systems designed to assist in organizational purchasing may require similar procedural knowledge. Reasoning and learning techniques will be required to provide adaptive systems that can handle exceptions and special circumstances.

Negotiating strategies are procedural knowledge in that they describe a plan of action that can be employed to change the set of attributes describing the alternatives. Simple, one-dimensional (price) time-dependent negotiating strategies have been used by buying and selling agents in an electronic marketplace (Chavez and Maes 1996). More sophisticated theories of negotiation can include cooperative and non-cooperative situations and multi-dimensional solution spaces. Negotiating agents must agree to use a common ontology and there must be a way to represent buyer and seller preferences as a utility function. Agents can be preprogrammed with negotiating strategies or equipped with ways to learn effective strategies through techniques such as probabilistic networks or genetic algorithms (Beam and Segev 1996).

4.2.5.3 Semantic Knowledge

A negotiation protocol defines the rules for an economic mechanism and the form of communications between parties. Negotiating agents must have knowledge of these rules in order to communicate with systems, other humans, or other agents. While a protocol is defined for a particular environment, individual agents can have different strategies as they act within the environment. Users must ensure that the chosen strategy is effective with the given protocol (Brenner et al. 1998) and that the strategy cannot be inferred by other parties (Beam and Segev 1997). Many electronic auctions allow participants to “instruct” agents that can monitor for certain events and act on their behalf according to the rules defined for the auction. Multi-agent systems developers are applying research from microeconomics and game theory to more sophisticated negotiation systems. These systems employ mechanisms and protocols that encourage appropriate agent behaviours and consider social welfare, efficiency and market stability (Sandholm 1999).

There are also rules that must be followed to complete a transaction. EDI messages enable systems to exchange information and create contractual agreements between parties in a transaction. Moore (1998) has shown how standard EDI messages can be interpreted in terms of speech act theory. Covington (1998) examines how KQML, based on speech act theory, can provide a way for software agents to exchange similar messages. Both Covington and Genesereth (1997) suggest improvements or modifications to simple KQML message protocols so that they can convey the level of detail necessary for commerce transactions.

4.3 Discussion

Within the DSS framework, we have provided examples of the knowledge bases that agents may use to duplicate the services of a human agent in search and choice functions. We identified some of the many design challenges that these systems will encounter and highlighted some promising research areas.

Some of the design challenges can best be addressed through continuing multidisciplinary efforts. The capabilities of new information and communications technologies are redirecting research efforts in many related areas. The Information Sciences community continues to work on more effective linguistic analysis and probabilistic techniques for information retrieval. Management Science can contribute with innovative and dynamic decision models, and economists with continued development of mechanisms for non-cooperative environments and multi-dimensional solution spaces. Computer Science will need to develop, design and implement the systems architectures where agents can interact. Continued multidisciplinary communication and collaboration will be important in meeting these challenges.

Other design challenges reflect the need for effective industry cooperation and coordination. Base and domain ontology and transaction protocols require broad support across and within industry groups. Ultimately the market will determine the success of XML, KQML and other potential standards.

Norman cautions that the main problems facing widespread agent implementation will be "social" and not "technical". In order to develop trust in the agent's capabilities, users will need to understand what the agent is doing, and receive appropriate reassurance that it is behaving as expected (Norman 1997). From the user's point of view, agent performance in e-commerce will not be likely be satisfactory until we can develop rich user profiles and incorporate relevant situational factors and the user may have to play an active role while this knowledge is acquired. Constructive choice theories and individual decision-making preferences suggest that more than one decision model should be available and that the user may need to interact with the system in order to choose the model that they are comfortable with for the given task and to switch models as the task proceeds. The DSS approach to software agent development and design addresses these challenges by promoting highly interactive, user-centered, systems.

4.4 Summary

In this Chapter we have used the DSS approach and the metaphor of a human agent to examine the functions that search and choice support agents could perform in e-commerce. For each of these general functions we have identified some of the knowledge requirements that agent would have to possess to perform these functions. We have identified challenges that agent developers face in designing agents to perform these functions in an intelligent and useful manner. These challenges are obstacles that will have to be overcome before much of the promise of agents is fulfilled and before we can make a compelling case for their widespread adoption.

Many of the technical challenges will continue to be addressed within the interested research communities. However, we have also identified a number of challenges that must be addressed by practitioners. The business community will have an important role to play in the development and acceptance of standards. In Chapter 3 we derived some lessons from traditional DSS research that IT practitioners can apply to agent design. Until AI technology progresses to the point where we can build systems that learn and adapt, agent applications will have to be highly interactive and user-centered.

Chapter 5

Pre-Purchase Online Information Seeking: Search versus Browse[8]

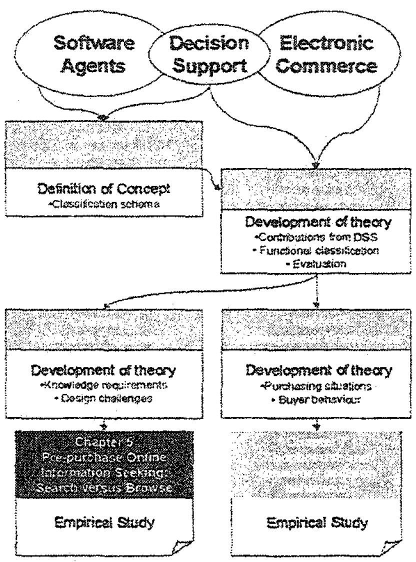

Figure 5-1 - Chapter 5 in the Research Overview

[8] The material in this Chapter is extracted from a paper entitled "Pre-Purchase Online Information Seeking: Search versus Browse" by Brian Detlor, Susan Sproule and Chris Gupta. The paper has been conditionally accepted for publication in the *Journal of Electronic Commerce Research*. The primary author is Dr. Brian Detlor who developed the overall research objectives as part of a larger study. Dr. Detlor and the other co-author did the content analysis of free-text responses to the questionnaire. The candidate was responsible for developing the specific research questions, designing and conducting the experiment, the remaining analysis of results, and significant editorial contributions to the writing of the paper.

In the previous chapter we identified the constructive nature of consumer decision behaviour as one of the challenges to designing useful search support agents. Consumers do not always know what information they need or how they are going to choose between alternatives. In this chapter we present exploratory research into the information needs and preferences of consumers in search and browse modes of information seeking.

The findings from the research presented here are a first step towards developing agents that can identify a consumer's information seeking mode and assist them to find the information they need at that time. These agents could be "personal assistants" like those described by Maes (1994) and Nwana and Ndumu (1999) or agents that reside on the retailer's site. In both cases, the agent would ask or infer what information-seeking mode the consumer's is in and recommend or present information appropriate to that mode (Nwana and Ndumu 1999). This exploratory study looks for "cues" that an agent could use to infer the consumers information-seeking mode. It also looks at what tools should be present and what information might be recommended in each mode.

5.1 Introduction

Product information seeking often is portrayed as a critical early stage in the consumer buying process (Moorthy et al. 1997; Zellweger 1997; Maes et al. 1999; Haubl and Trifts 2000; Hodkinson et al. 2000; Shim et al. 2001). In online shopping environments, as well as in traditional purchasing situations, consumers looking for pre-purchase information can be engaged in two modes of seeking activity: browsing and directed search (Rowley 2000a).

Browsing pertains to instances when consumers are not sure how, or if, their shopping requirements can be met. It is "an activity in which one gathers information while scanning an information space without an explicit objective" (Toms 2000, p. 424). In these cases, users have a less precise view of the product information that might be needed, available, or used, and thus seek out information in more of an exploratory fashion. Seeking in this case relates closely to experiential shopping behaviour (Wolfinbarger and Gilly 2001).

In contrast, directed search refers to occurrences when consumers actively seek out product information with a view to making a decision. Shopping in this sense is more goal-oriented or utilitarian in nature (Wolfinbarger and Gilly 2001). Here, consumers know what they are looking for and usually possess some information about the product being sought, such as its brand or manufacturer's name, that can be used as the basis of a specific search (Berthon et al. 1999).

Complicating this scenario is the fact that consumers do not remain in one particular seeking mode. Rather, consumers may, and often do, refine their strategies, approaches, and information requirements as they reflect upon and consider the information they collect along the way during the initial stages of the buying process (Hodkinson et al. 2000; Rowley 2000a). Some studies suggest that consumers usually start in an exploratory seeking mode and then gradually move towards goal-directed search with a progressively narrow focus (Foss and Bower 1986; Shim et al. 2001). Such strategies and amalgamations of seeking modes may lower transaction and cognitive costs for online shoppers (Liang and Huang 1998). Other studies suggest that browsing and searching can lead to consumer disorientation in the online context (Bryan and Gershman 1999). For instance, with goal-directed search, users may never be afforded a view of the entire shopping space; rather, they jump from subset to subset of an e-tailing site via a local search engine. In terms of browsing, online consumers may experience sudden changes in page design and formats.

In today's Web-enabled world, issues such as these are increasingly important. Due to the convenience and accessibility of the Internet, broad consumer segments now frequently utilize the World Wide Web to obtain pre-purchase product information (Alba et al. 1997; Haubl and Trifts 2000; Phau and Poon 2000). As such, the need to understand and support browsing and search behaviour in online shopping environments is becoming more critical in attracting and retaining customers in online stores.

5.2 Purpose

Recognizing the need to support both browsing and directed search in pre-purchase product information seeking activity in online shopping environments, the purpose of this paper is to explore consumer preferences for Web-based product information display across these two types of tasks within single commercial Web site designs.

The rationale for this objective is that if electronic shopping Web sites better support these two predominant modes of product information seeking behaviour, then consumers visiting these sites would be more satisfied with their online shopping experience and thus more likely to purchase a product, or at least revisit such Web sites in the future.

5.3 Research Motivation

The theoretical motivation for launching this research investigation is based on a conceptual model of flow in consumer hypermedia computer-mediated environments or CMEs (Hoffman and Novak 1996; Novak et al. 2000).

Borrowing from Csikszentmihalyi's description of the flow construct (1977; 1990), flow on the Web is portrayed as a cognitive state experienced by consumers during navigation. It is characterized by a seamless sequence of responses facilitated by machine interactivity that is intrinsically enjoyable, accompanied by a loss of self-consciousness, and self-reinforcing. Creating such compelling and engaging online shopping environments for consumers offers "numerous positive consequences for commercial Web providers" (Novak et al. 2000, p. 22), such as extended visit durations, repeat visits, and ultimately more purchases.

There are three important aspects of this model of 'flow on the Web' that are relevant to this work. First, the theory recognizes that online consumers engage in both goal-directed and experiential behaviours. Goal-directed behaviours are characterized by CME users who have pre-purchase deliberations about a product and are involved in situations which have specific task-completion goals. Experiential behaviours are characterized by CME users with an enduring involvement in building a knowledge base about a product and in engaging in non-directed search for recreational purposes. Second, flow in CMEs may occur with both types of behaviours. Third, and most importantly, "the optimal design of a CME site differs according to whether the behavior is goal-directed or experiential" (Hoffman and Novak 1996, p. 62). As a result, online marketers "should take care to focus not only on goal-directed behaviors in a CME (e.g., product purchase), but also on nondirected experiential behaviors (e.g., net surfing), which are strategically important as well" (Hoffman and Novak 1996, p. 62-63).

Though Novak et al. (2000) empirically validate the workings of their conceptual model in terms of the general components that make for compelling online shopping experiences across many Web sites, they caution that their research does not "consider the specific elements of commercial web site design that facilitate a compelling consumer experience, nor how this experience is likely to vary across the wide range of commercial sites found on the Web today" (p. 40). This work attempts to bridge this gap by conducting an investigation that explicitly examines the aspects of commercial Web site design that consumers prefer when they are placed specifically in browse and search online shopping tasks.

There is a need for more research in the area of pre-purchase online information seeking in general. First, the role of information seeking is significantly heightened in the context of Internet shopping and may be the single most important functional element leading to Web-based purchases (Shim et al. 2001). This is primarily because of the low perceived costs of providing and accessing objective data over the Web (Klein 1998), and the increased likelihood of consumers who shop over the Web to seek pre-purchase information over the same medium (Alba et al. 1997; Bryan and Gershman 1999). Second, there is a lack of research in consumer pre-purchase information seeking over online environments (Haubl and Trifts 2000). Last, the consumer research literature "has virtually ignored exploratory search (browsing) and has focused primarily on the volitional activities associated with goal-directed search" (Janiszewski 1998, p. 290). This is worrisome since the organization of product information displays can have a major impact on consumer purchasing choices (Bettman et al. 1998; Klein 1998).

5.4 Methodology

In terms of specific research questions, this paper addresses three:

1. What information is the online consumer expecting to find, and how does this differ across searching and browsing tasks?
2. What information does the online consumer find useful, and how does this differ across searching and browsing tasks?
3. How do online consumers use site navigation tools and site features during pre-purchase behaviour, and how does this differ across searching and browsing tasks?

To answer these questions, an exploratory study was conducted with a group of thirty-one undergraduate business students who were given two online shopping tasks for common products on five well-known Web retailing sites. The browse task instructed participants to find a gift for a friend. The search task required that participants search for a particular product, namely a digital camera, as a gift. The order of tasks and Web sites were counterbalanced. Participants were not required to make an actual purchase and were told to assume they would be making a purchase at some later point in time, either online or offline.

Prior to each task, participants filled out a questionnaire that asked them to identify and rank the types of information they expected to access on the Web site to help them carry out their tasks. To prevent the possibility of influencing participant response with suggested information items, no information items were listed on the questionnaire. Rather, participants had to self-identify particular information items they felt were important. After each task, participants completed another questionnaire, which required participants to identify and rank information they found useful during their tasks. Again, no prompts for potential information items were suggested.

The experiment also was designed to capture free-form textual responses. This was done in two ways. The first was by asking open-ended questions in the post task questionnaire which polled participants' perceptions on the information displayed and presented on the Web sites, as well as their beliefs about the efficiency and effectiveness of conducting the task on these sites. The second was via the provision of scratch sheets during the execution of participants' shopping tasks. With these, participants were instructed to jot down their ideas, perceptions, and thoughts as they carried out their online information seeking activities.

To analyse both information items identified by participants and free-form textual responses, a code book was developed. The coding of participant responses was necessary since participants utilized different words to describe the same information construct. For example, the responses 'price', 'cost', '$', and 'dollar value' were all coded with the same information category (namely, 'price'). Standardizing responses in this way facilitated comparison of information items identified across participants.

Producing the code book involved several rounds of iterations and verifications amongst the three researchers. Initially, one researcher (Sproule) was responsible for devising a preliminary coding structure. This was accomplished by manually going through the collected data (both the information items and free-form textual responses) and coding the content to a three-level category schema of information categories, with the higher levels loosely adapted from Mowen and Minor (1998) and Garvin (1988). Next, a different researcher (Detlor) independently took this preliminary coding structure and used it in conjunction with concepts from Rayport and Jaworski's (2002) 7Cs framework for Web-based customer interface design to perform a classical content analysis (Ryan and Bernard 2000) on just the free-form textual responses portion of the collected data. Here *a priori* categories identified in the preliminary code book were adapted and expanded as the coding progressed. This is a valid technique used by qualitative researchers (Miles and Huberman 1994), though strictly refrained from by advocates of classical content analysis (Krippendorff 1980). The resulting codebook was an elaborate coding structure comprising three hierarchical levels (see Appendix II, Exhibits 1, 2, and 3). The first level of coding comprised three broad categories: product-related, retailer-related, and interface-related. The second and third levels successively segmented these categories into specific areas of interest. There were 17 and 60 categories generated for the second and third levels respectively.

To perform the classical content analysis, participants' free-form textual responses were broken down into individual recording units. In total, 962 recording units were identified. Each unit represented one discrete thought, statement, or comment. To code participants' textual responses, each recording unit was assigned a single category code from level three of the codebook that best described the recording unit's content. Coding at level three automatically coded the recording unit at levels one and two as well.

To test the reliability of this coding, a third researcher (Gupta) independently classified the 962 recording units. Before doing this, this third researcher was familiarized with the code book and the coding procedure through a training session on sample recording units. Inter-coder reliability was tested using Krippendorf's (1980) agreement coefficient. For the second level, the agreement coefficient was 0.93; for the third level, it was 0.82. These are acceptable inter-coder reliability measures as suggested by other academics. For example, Krippendorf (1980) advocates agreement of at least 0.70 and notes that some scholars (e.g., Brouwer et al. 1969) use a cut-off of 0.80. Wimmer and Dominick (1991) suggest that 0.75 or greater is normally acceptable for qualitative studies.

Discrepancies between the two sets of coding were resolved yielding a final data set of coded recording units. This final data set was then divided into two independent segments: those that originated from the browse task and those that originated from the search task. Final analysis was done by comparing frequency counts of recording units from these two segments across levels one, two, and three of the code book.

Having generated and tested the reliability of the code book, the first researcher utilized the code book to code the information items identified by participants as expected and found to be useful. Once this was done, a ten-point distribution scale was utilized to identify the relative importance of each information category across participants. That is, for each participant's response, categories rated as most important (rank 1) were given 10 points; rank 2 items were given 9 points etc. These points were summed for each information category across all participants to give a final summary score per information category. These final scores were then ranked from highest (rank of 1) to lowest to identify the more salient information categories expected and found useful by the participants across the two shopping tasks.

Steps were taken to ensure that participants were indeed in the appropriate search or browse mode when conducting their online tasks. The researchers felt confident that the search mode task facilitated this since it explicitly instructed participants to search for a particular gift. In the browse task, even though participants were not told to shop for a particular gift item for this task, there was some concern whether participants would self-select a specific product item or category prior to beginning their task – thus putting them more in a search mode than a true browse mode situation. To address this concern, a question was posed in the post-task questionnaire for the browse task which asked if participants had identified a specific product item or category prior to their online browsing. Fourteen participants answered affirmatively to this question. This yielded a subset of 17 participants who performed a "pure browse" task. Within-subject analyses of satisfaction and use of navigational tools were determined for both the total population and for this smaller sample.

Note that the study was inductive in nature. Rather than deductively proving the validity and appropriateness of pre-defined theory, the research focused on theory generation. This approach is valid in circumstances, such as the problem area under investigation, where few previous studies have been carried out and where insights are needed to identify and understand new theoretical constructs and their relationships to one another.

5.5 Findings

For the free-form textual responses, Figure 5-2 shows the overall breakdown of product-related, retailer-related, and interface-related recording units across the two shopping tasks. Top categories across the browse task were those pertaining to the Web site and the retailer, whereas the top category across the search task was product-related.

Table 5-1 outlines the percentage breakdown of recording units across level 2 of the code book. Utilizing a cut-off value of 8% as being meaningful, certain trends were evident from the table. First, certain types of information were important across both the browse and search tasks: product price; advisory information from the retailer to assist consumers in their decision-making process; product description; information about the variety of products available; and the functions and format of the retailer's Web interface. Second, in terms of the search task, participants preferred information pertaining to the searched product's specifications and manufacturer. Third, with respect to the browse task, participants showed a much larger concern for product selection information, placed greater emphasis on information pertaining to the retailer's reputation and delivery process, and were more concerned with the Web site's functionality and form.

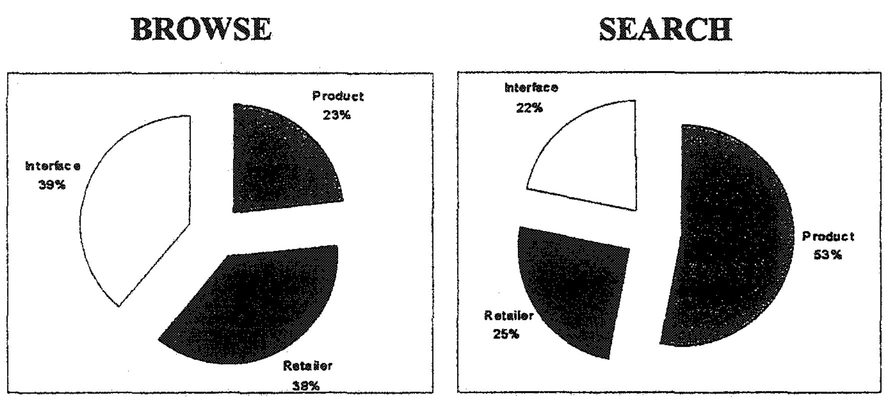

Figure 5-2 - Level 1 Category Breakdown across Browse and Search Tasks

Examination of the recording units at level 3 of the code book further reinforced the above findings. Table 5-2 lists the top ten information categories for both browse and search tasks at this level. Of interest is that these ten information categories account for 63% of browsing-related recording units and 69% of search-related recording units. Stated differently, about 20% of the information categories from the code book at level 3 account for roughly two-thirds of the recording units, working in a similar fashion to the *Pareto Principle* (i.e., the 80/20 rule). The table illustrates how participants in a browse mode were more concerned with the worthiness of the retailing Web site, specifically in terms of its navigation and organization, and of the retailer, especially in terms of the selection of goods offered at the site. In contrast, participants in a search mode placed greater emphasis on information about the product being searched, mainly in terms of detailed product specification information.

Table 5-1 - Breakdown of Recording Units across Level 2 of the Code Book

Level 2 Code	**Browse** (n=330)	**Search** (n=632)
Product-Aesthetics	2 %	2%
Product-Description	8%	13%
Product-Manufacturer	1%	8%
Product-Price	10%	12%
Product-Quality	0%	1%
Product-Reliability	1%	1%
Product-Specs	2%	16%
Sub-total	**23%**	**53%**
Retailer-Advice	8%	9%
Retailer-Delivery	4%	1%
Retailer-Policy	0%	1%
Retailer-Product	2%	1%
Retailer-Reputation	3%	1%
Retailer-Selection	20%	12%
Retailer-Service	3%	0%
Sub-total	**39%**	**25%**
Interface-Commerce	2%	1%
Interface-Content	3%	2%
Interface-Context	33%	19%
Sub-total	**38%**	**22%**
TOTAL	**100%**	**100%**

Table 5-2 - The Top Ten Information Categories at Level 3 of the Code Book

Level 3 Code	Browse (n=330)		Search (n=632)	
	%	**Rank**	**%**	**Rank**
Product-Description-Name	4%	6/7/8	8%	3/4/5
Product-Manufacturer-Name			8%	3/4/5
Product-Price-Amount	4%	6/7/8	8%	3/4/5
Product-Specs			16%	1
Sub-total	**8%**		**40%**	
Retailer-Advice-Recommendations	3%	9/10	4%	7/8
Retailer-Advice-Reviews			3%	10
Retailer-Selection-Offers	7%	3		
Retailer-Selection-Good	6%	4	3%	9
Retailer-Selection-Poor	5%	5	4%	7/8
Retailer-Reputation	3%	9/10		
Sub-total	**24%**		**14%**	
Interface-Context-Aesthetics	4%	6/7/8		
Interface-Context-Navigation	14%	1	9%	2
Interface-Context-Organization	13%	2	6%	6
Sub-total	**31%**		**15%**	
TOTAL	**63%**		**69%**	

Recall that participants were asked several open-ended questions in the questionnaires to poll their perceptions on the information displayed and presented on the Web sites, as well as the efficiency and effectiveness of conducting the task on these sites. One such question asked participants to identify the most helpful site in each task, and to explain why they found this site helpful. In the browse task, 52% percent of participants cited criteria related to the interface context, 35% cited advice features such as recommendations or reviews, and 26% cited good product descriptions. In the search task, the same three criteria were found at the top of the list, cited by 42%, 58% and 65%

respectively. Participants were also asked which site they found the least helpful. In the browse task, poor interface context (48%) and poor product selection (42%) were the most commonly cited criteria. These same two criteria were again the most often cited for the search task, at 45% and 58% respectively. Table 5-4 provides an overall ranking of items found most and least helpful across the two tasks in terms of the percentage of participants who cited these items, yielding findings which are again consistent with those mentioned above.

Table 5-3 - Criteria Cited by Participants for Determining the Most and Least Helpful Retail Sites

RANK	BROWSE		SEARCH	
	Most Helpful Site	**Least Helpful Site**	**Most Helpful Site**	**Least Helpful Site**
1	Interface-Context (52%)	Interface-Context (48%)	Product-Description (65%)	Retailer-Selection (58%)
2	Retailer-Advice (35%)	Retailer-Selection (42%)	Retailer-Advice (58%)	Interface-Context (45%)
3	Product-Description (26%)	Retailer-Advice (6%)	Interface-Context (42%)	Product-Description (23%)
4	Retailer-Selection (23%)	Product-Description (6%)	Retailer-Selection (35%)	Product-Price (3%)
5	Retailer-Reputation (16%)	Product-Price (3%)	Retailer-Reputation (6%)	Retailer Advice (3%)

% refers to the number of participants who cited the criterion item

Table 5-4 ranks the top 10 information categories in each of the browse and search tasks according to the information expected prior to the task and the information found useful. Summary scores for each information category are displayed as well.

Table 5-4 - Ranking of Information Categories for the Search and Browse Tasks

RANK	BROWSE		SEARCH	
	Expected to be Useful	Found Useful	Expected to be Useful	Found Useful
1	Product-Price (269)	Product-Price (271)	Product-Specs (357)	Product-Specs (356)
2	Retailer-Delivery (150)	Retailer-Advice (164)	Product-Price (253)	Product-Price (253)
3	Retailer-Advice (146)	Retailer-Selection (112)	Retailer-Advice (145)	Retailer-Advice (201)
4	Retailer-Selection (111)	Product-Aesthetics (97)	Product- Manufacturer (94)	Product-Manufacturer (105)
5	Retailer-Availability (86)	Retailer-Delivery (97)	Product-Reliability (84)	Product-Description (57)
6	Product-Specs (84)	Retailer-Availability (86)	Product-Description (71)	Retailer-Selection (54)
7	Product-Description (79)	Product-Description (82)	Product-Aesthetics (59)	Product-Aesthetics (53)
8	Product-Aesthetics (76)	Product-Specs (61)	Product-Quality (55)	Product-Reliability (53)
9	Retailer-Policy (64)	Retailer-Policy (54)	Retailer-Selection (44)	Product-Quality (42)
10	Retailer-Reputation (36)	Retailer-Services (47)	Retailer-Policy (42)	Retailer-Delivery (37)
11	Product-Quality (29)	Retailer-Reputation (33)	Retailer-Delivery (36)	Retailer-Availability (31)
12	Prod.-Manufacturer (25)	Prod.-Manufacturer (28)	Retailer-Reputation (35)	Retailer-Reputation (22)
13	Retailer-Services (24)	Product-Quality (16)	Retailer-Services (19)	Retailer-Services (20)
14	Product-Reliability (12)	Product-Reliability (8)	Retailer-Availability (14)	Retailer-Policy (12)

The number in parentheses refers to item's raw summary score

In terms of the rankings for information found useful across the two shopping tasks, there were some interesting patterns. First, while price was ranked number one in the browse task, product specifications was ranked number one in the search task. Second, in terms of the top five rankings, both price and information to assist decision-making, such as FAQs, recommendations, reviews etc., appeared to be important information categories in both browse and search tasks.

Differences appeared in the remaining three information categories within the top five that were found useful across the two shopping tasks. Search tasks seemed to favour specifications, description, and manufacturer information – these pertain to details about the product. Browse tasks seemed to favour selection, aesthetics, and delivery information – these pertain to looser information attributes in that they were not concerned with the actual workings of the product or the manufacturer's reputation but rather with what products were available, how they generally looked, and the cost and time to deliver these products to the consumer.

Kendall's W (coefficient of concordance) was used to determine the degree of association between the rankings of expected and found useful information items both between and within the two tasks. For both tasks, there was a strong association between the information expected and the information found useful within a task (W = 0.957 and 0.952 for the browse and search tasks respectively, $p < 0.05$). However there was a much weaker association in ranking patterns between the search and browse tasks (W = 0.589 for expected information and 0.686 for found useful information, $p < 0.05$).

Recall that participants rated their satisfaction with the Web sites used in the study. As the results in Figure 5-3 show, participants were more satisfied with the Web sites in terms of supporting product search rather than product browsing. A Wilcoxon signed ranks test on the difference in satisfaction levels produced an exact significance of 0.018 at a 90% confidence level. Using only the subset of "pure browsers", these results were still significant at 0.021, despite the reduced sample size.

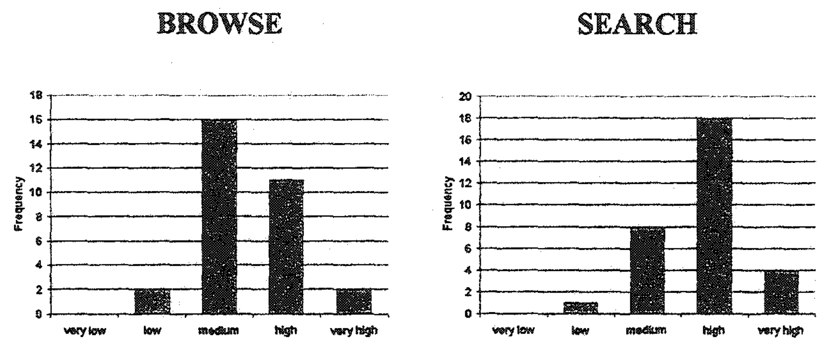

Figure 5-3 - Satisfaction Levels across Browse and Search Tasks

Participants in their questionnaires were also asked to indicate if they used certain navigational tools and features on the Web sites to help them perform their tasks. A McNemar test was used to determine levels of significance across browse and search tasks. Some of the more meaningful results were as follows:

- There was no significant difference found in the use of categorical menus, links to detailed product information, "more like this" links, or featured products pages.
- More participants used a search engine in the search task (74%) than in the browse task (52%) ($p < 0.10$). This result was even stronger when only pure-browsers were examined ($p < 0.05$).
- More participants used gift recommendations (by recipient and by price) in the browse task (30%) than in the search task (6%) ($p < 0.05$). This result was not significant with the smaller sample.
- More participants used product reviews in the search task (80%) than in the browse task (52%) ($p < 0.05$). This result was not significant with the smaller sample.

- More participants used product comparison tools in the search task (61%) than in the browse task (6%) ($p < 0.05$). This result was still significant with the smaller "pure-browser" sample.

5.6 Summary

Admittedly, the results of this study are constrained by certain limitations, namely the use of a student sample and the artificial nature of the shopping exercise. Results would be more generalizable had a more representative test population been used, had participants undergone a real-life purchase, or if a variety of product categories had been used in the search task other than one specific product (i.e., a digital camera).

Recall the purpose of this work was to explore consumer preferences for Web-based product information display across browse and search shopping activities. The above findings provide insight into the differences and similarities in consumer preferences for pre-purchase online information display across these two tasks.

Overall, there were several information items that were relevant in both the browse and search tasks: pricing, product description, retailer selection, and retailer advice. This suggests that online retailers need to present these particular information items on the computer interface in ways that are highly visible and easily accessible for consumers. In addition, it was found that both modes of information seeking required a good interface design, suggesting the requirement for online retailers to make their information displays navigable, organized, fast, and aesthetically pleasing across both modes of information seeking activity.

Further, there were general differences in consumer preferences across the two tasks. Online consumers who were browsing preferred information about the retailer, especially in terms of the retailer's reputation and delivery of goods, while those in a search mode preferred detailed product information, namely in terms of product specifications and manufacturer information.

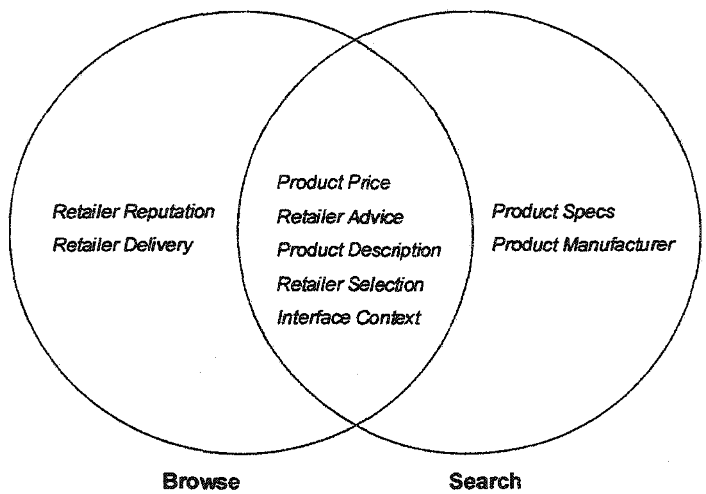

Figure 5-4 - A Framework for Web-Based Product Information Display

Figure 5-4 summarizes these findings into a theoretical framework for Web-based product information display that supports the full spectrum of consumer information seeking activity from browse to search. The figure illustrates that certain Web-based information items (i.e., those in the interesection of the two circles) should be displayed for both browse and search. Additionally the retailing site should be well organized and navigable for both modes. The figure also shows how different information items should be stressed in each of the browse and search modes (i.e., those information items not in the join of the two circles).

The proposed theoretical framework has implications for the design of online shopping sites. First, online sites need to support both modes of information seeking. Evidence from this study indicates that Web retailing sites currently favour goal-directed search over browsing, since more participants were satisfied with the Web site designs for the search task. Second, Web retailing sites need to tailor their information displays based on the consumer information-seeking mode. The results above indicate differences in the use of navigational and site features across the two shopping tasks. Browsers want "starting tools" such as gift recommendations; searchers want "differentiating tools" such as products reviews and comparisons, as well as access to site search engines (Choo et al. 2000). Web retailing sites need to be aware of this difference when personalizing Web site designs to consumers across browsing and searching tasks.

One promising technology that potentially offers Web retailers a means to facilitate shoppers' Web-based information seeking behaviour is intelligent agents. These are software entities that perform specific tasks continuously and autonomously in a particular environment often inhabited by other agents and processes (Shoham 1997). The use of agents has been well-documented in the electronic commerce domain (Jennings and Wooldridge 1998; Maes et al. 1999; Maes 2001). Of particular interest is a recent study by Choo et al. (2000) who devise and empirically validate an integrated model of Web-based browsing and searching that relates search and browse modes of information seeking with specific Web browser-based actions (e.g., page forward, page back, print, stop, selecting a hypertext link, using a local search engine etc.). The results of their study suggest the feasibility of developing interface agents on Web retailing sites that monitor consumer browser-based actions and to use that knowledge to deduce a shopper's information seeking mode. Once deduced, the interface agent could react by tailoring the display of information as per the guidelines suggested in Figure 5.4.

For example, if a consumer were engaged in product browsing, the agent could present more information about the retailer's reputation and the selection of products the retailer offers. Likewise, if the consumer exhibited searching behaviour, the agent could quickly present detailed product information about the product's manufacturer and specifications. The hope of building such agents is that it will increase the usability of the online shopping interface and create a more effective and amenable environment for consumers to purchase goods.

Chapter 6

A Buyer Behaviour Framework for the Development and Design of Software Agents in E-commerce.[9]

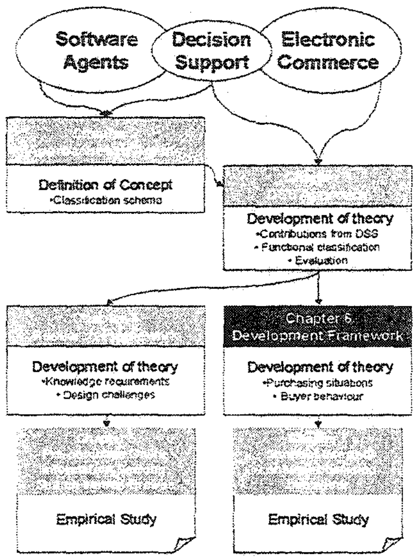

Figure 6-1 - Chapter 6 in the Research Overview

In this Chapter we examine how research from marketing and consumer behaviour can help us identify the purchasing situations where agent applications are

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[9] Based on Sproule, S. and N. Archer (2000a). "A buyer behaviour framework for the development and design of software agents in e-commerce." *Internet Research: Electronic Networking Applications and Policy* 10(5): 396-405. The candidate was the primary author of this work and developed the concepts that are described here. It is used with the consent of the co-author, Dr. Norm Archer. Copyright permission has been obtained from the *Internet Research: Electronic Networking Applications and Policy* to publish this material in this thesis.

most likely to be adopted in e-commerce. We produce a development framework that can help guide managers and IT professionals to develop and design agents that are appropriate for these different situations.

At the time that this study was published, we were extending the work of Maes (1999) and Terpsidis et al. (1997) who looked at a sample of contemporary agent applications in the context of a buyer behaviour model. Our framework was motivated by questions posed by Peterson et al. (1997) and Rowley (2000b). Since that time, other researchers have also examined how theories and models from traditional marketing can be applied and extended to e-commerce Web site design and the design of software agents for e-commerce (Grover and Teng 2001; Silverman et al. 2001; Spiekermann and Paraschiv 2002). These papers all support the premise that we develop in this chapter. That is, the purchasing situation, as well as the stage of the commerce process, will be an important consideration when designing agents for an e-commerce application.

6.1 Introduction

A large part of the study of Information Systems (IS) is concerned with supporting human decision-making. Researchers in DSS and Human-Computer Interaction (HCI) use information on how humans acquire and process information to design systems that are understandable and thereby useful and usable to their human users. Marketing research studies the decision-making processes of buyers, including how buyers acquire and process the information required for these decisions. This paper examines how theories and findings from DSS and marketing research can be used to develop and design software agents that buyers will find useful and usable in electronic commerce.

A DSS model is used to categorize software agents according to whether they support search, choice or interface activities. The buyer must be able to develop trust in the agent's behaviour before delegating activities. In order to develop trust, the buyer must be able to understand, control and predict the behaviour of agents (Erickson 1997; Malone et al. 1997). Frequency of purchase and perceived risks are two characteristics of a purchasing situation that will determine how this trust can develop. Marketing researchers have studied how both frequency of purchase and perceived risk influence the search and choice behaviours of buyers. This information is used to suggest ways to design agents that represent the purchasing problem in a form that is understandable and predictable for the buyer.

For this discussion, commerce is defined as "the process flow associated with a commercial relationship or transaction" including activities such as purchasing, marketing, sales, and customer support (Nissen 1997). Electronic commerce is this same process, enabled by the use of communications and IT. Moving these activities to an electronic platform is expected to change the process in many ways.

Nissen's model (1997), which we presented as Figure 1-3 in Chapter 1, clearly shows that information exchange forms a large part of the commerce process. Because of the information-rich nature of the Web, we will focus our attention in these areas. The Web relies on a "pull" model of information flow so the buyer is expected to drive the adoption of new technologies such as software agents. The starting point for the framework is therefore the buyer's information needs and decision-making process, but we also discuss facilitating roles for sellers and intermediaries in the exchange of information.

There are significant differences in how the commerce process is conducted within the business-to-consumer (B2C) and the business-to-business (B2B) environments. Because of these differences, the changes introduced by e-commerce are expected to vary across environments. Research in B2C marketing examines how an individual buyer behaves in the commerce process. Research into B2B marketing uses this same information about individual behaviour, but incorporates organizational factors and group decision-making into the process.

While human agents work for the benefit of their employers or clients, we acknowledge that they also have self-interests. An agent is trusted only when the goals of the employer/client and the agent converge. The issue of who designs and "owns" the software agent, and for whose benefit the agent is working must be clearly addressed in e-commerce applications. Business models for agent applications that address this issue are still evolving. A product-focused approach to agent development must consider appropriate agent "ownership" as a critical factor in user acceptance. Sellers may have to provide systems to accommodate the requirements of different agents acting for buyers with different needs.

The rate of innovation in e-commerce and the Web means that developers need to be able to move quickly from research to commercially viable products. Related developments in e-commerce, such as Extensible Mark-up Language (XML), and efforts to migrate traditional Electronic Data Interchange (EDI) transactions to more flexible platforms will remove some of the remaining technical and process barriers to agent-enabled e-commerce. As agent developers move past a technology focus to a product focus, we will see the adoption of agent technologies into e-commerce processes. This paper provides an initial framework that can guide agent developers to suitable commerce domains, and guide agent designers to suitable technologies within these domains.

Process models, such as Nissen's proposition (1997), describe the participants and the activities undertaken at different stages in a transaction or relationship. Maes and Terpsedis examine agents in e-commerce using process models of buyer behaviour as a framework (Terpsidis et al. 1997; Maes et al. 1999). As an extension to this line of investigation, we want to examine how buyers acquire and process knowledge over repeated purchases within a product category and how they manage perceived risk. In this way we can identify product categories where buyers will have similar requirements of an agent and learn how to design agents that the buyer can learn to trust.

Two areas of marketing research can assist in this endeavor. In general, **Purchasing Situation** models describe the product, market and buyer characteristics that are present for a specific purchase. **Purchasing Decision** models describe how the buyer arrives at a decision, and include both the buyer's information search behaviour and the buyer's choice processes. These models can be used to represent the problem space in a form that is similar to the way that the buyer processes information and makes a decision.

6.2 A Buyer Behaviour Framework for Agent Development

The purchasing situation is believed to be an important determinant of buyer behaviour (Robinson et al. 1967). As the starting point for the agent development framework, the purchasing situation is used to indicate domains where agents are most applicable. Since repetitive activity is essential for the successful application of agents, frequency of purchase should be one dimension of this model.

The risks associated with a purchase are linked to frequency of purchase, in that uncertainty is generally reduced through repeated transactions. However, there are other factors that will contribute to the amount of perceived risk, such as the amount invested, the importance of the goal, and perceived psychosocial risks. Thus perceived risk is a second dimension in the situation model.

Marketing research has explored how both frequency of purchase and perceived risk affect the search and choice behaviours of the buyer. The following sections show how this information can be used to design agents to support search and choice activities in different purchasing situations.

6.2.1 Search Behaviour

According to Klein (1998), a buyer's search for information can be characterized by its extent (the number of sources used, depth and breadth) and the types of sources consulted (retail, media, neutral, interpersonal). Economic principles argue that buyers will search for information until the marginal cost of further search exceeds the marginal benefits. By reducing search costs, the Internet is expected to increase the extent of search activities over all types of purchasing situations. The Internet has also changed the mix of sources available to buyers. It provides a number of ways for buyers to share their experiences with products and new information-bundling intermediaries are aggregating different types of sources in one location. Marketing research has examined how buyers use different types of information sources and how buyers allocate search effort among sources, but we do not yet understand how buyers will value these new sources or how the new mix of sources will be used (Hauser et al. 1993; Klein 1998)].

6.2.1.1 Extent of Search

A buyer who is unfamiliar with a product needs "concept-forming" information, to learn about the relevant attributes of the product category and determine the appropriate choice criteria. Once the choice criteria are formed, the buyer collects brand-specific information to compare the important attributes to these criteria.[10] Through this process, the original set of alternatives is limited to a manageable set of potential brands. A buyer familiar with a product category, but buying infrequently, will continue to use previously developed choice criteria, but needs new information about relevant brand attributes. With frequent purchases, the buyer's information needs are reduced to a small set of situational attributes, such as price or availability, to compare between acceptable brands (Kaas 1982). Thus, the information requirements change from unstructured to structured as the buyer accumulates knowledge about the product category.

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[10] The choice criteria may influence whether a supplier is chosen before a brand, or vice versa. If supplier-related attributes such as product support or product selection are important, a set of suppliers may be chosen before a set of brands.

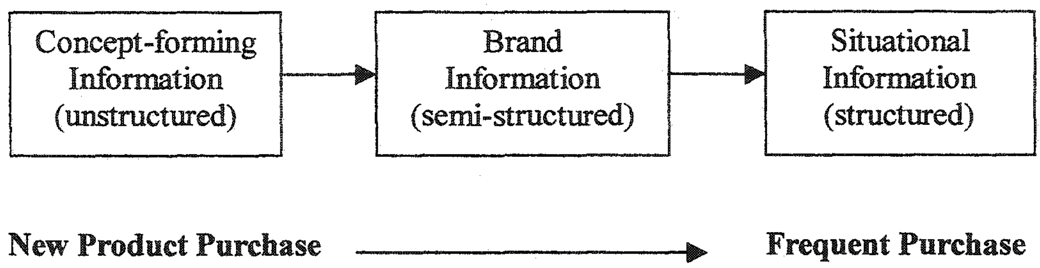

Figure 6-2 - Information Requirements and Frequency of Purchasing

adapted from Kaas (1982)

Marketing research tells us that acquiring and processing additional information (extensive search) is also a common strategy that buyers use to reduce perceived risk (Cox 1967; Webster and Wind 1972; Taylor 1974). In a high-risk situation, the buyer wants in-depth information about potential outcomes and consequences so that the uncertainty associated with these factors can be reduced. In contrast, low risk situations are characterized by shallow search behaviour.

6.2.1.2 Sources Used

The credibility of a source is related to both its expertise and its trustworthiness (Levitt 1967; Webster and Wind 1972). Supplier-controlled sources, such as media and salespeople, are valued for their expertise, while interpersonal and neutral sources are valued for their trustworthiness. Trustworthiness will become less important as the buyer accumulates knowledge and develops the ability to select or reject new information. The type of sources used will therefore change with the buyer's familiarity with the product category. The type of risk also affects the sources used. When performance risk is perceived, buyers place a higher value on information from neutral sources. When psychosocial risk is perceived, buyers will seek out interpersonal sources of information (Cox 1967; Webster and Wind 1972; Bettman et al. 1998; Klein 1998). Figure 6-3 summarizes these general characteristics of search behaviour as they relate to the purchasing situation.

	NEW PURCHASE	FREQUENT PURCHASE
HIGH RISK	• Extensive search • Trustworthy sources (neutral or interpersonal)	• Directed search • Sources with expertise (neutral or supplier-controlled)
LOW RISK	• Shallow search • Low cost sources	• Directed search • Low cost sources

Figure 6-3 - The Purchasing Situation and Search Behaviour

6.2.2 Search Support

Agent development must recognize that individual buyers have varying levels of familiarity with a product category and different perceptions of the risks involved in a purchase. Frequent buyers of a product have structured, situational information requirements. Simple "shopping agents" (also known as "shopbots") can search a limited set of suppliers and return comparative information on a limited set of situational attributes. In developing systems to support buyer's agents, sellers have an opportunity to ensure that the information infrastructure allows for both price and product differentiation (Bakos 1998). Agents can also address the dynamic nature of information content on the Internet by continually monitoring remote sites for relevant changes where market conditions and other environmental variables change frequently. This would be especially valuable in B2B commerce, where raw materials and production goods and services are bought frequently, yet represent large outlays.

More complex content-filtering agents can be used for infrequent but repeat purchases, where the buyer has determined choice criteria but lacks current information about alternatives. These agents can be personalized so that the content of the information selected and presented is closely matched to the user's criteria. Since different types of sources have different values according to the buyer's experience and risk profile, allowing the buyer to select or rank the types of sources would be a useful feature.

The choice criteria may dictate the use of a heterogeneous mix of attribute information from full-text documents, semi-structured sources such as catalogues, or traditional databases. The content-filtering agent must be able to assemble this information using different query techniques. This is an area where cooperating agents may best facilitate information retrieval. The buyer agent would maintain the buyer's individual profile, while the seller agent or an intermediary would hold the knowledge base that "translates" the buyer's request into the necessary queries. Risks in information retrieval can be related to two possible types of errors – a relevant document may not be retrieved (a "miss"), or a non-relevant document may be retrieved (a "false positive"). The possibility of a miss will contribute to uncertainty when using an agent to find information. False positives will reduce the performance and value of the agent. The type of error and its consequences must be considered when designing agents for a specific domain (Konstan et al. 1997). By using semantic knowledge about the specific domain, the seller or intermediary agent could improve the recall of the result, reducing the possibility of a "miss". The buyer agent would ensure precision, and avoid "false positives" by only including information relevant to the chosen criteria in the final response to the buyer.

Collaborative information filtering uses the experience of more than one information-seeker to broaden the search. This is especially valuable when the user has little experience on which to evaluate content. It may therefore be effective in establishing choice criteria for new purchases. Collaborative filtering has primarily been applied in B2C situations such as music CD's and movie rentals, where the risk of a poor recommendation is relatively low. For other purchasing situations, including those in B2B commerce, the idea of using an agent-based system to collect information from "expert recommenders" holds promise (Ackerman et al. 1997).

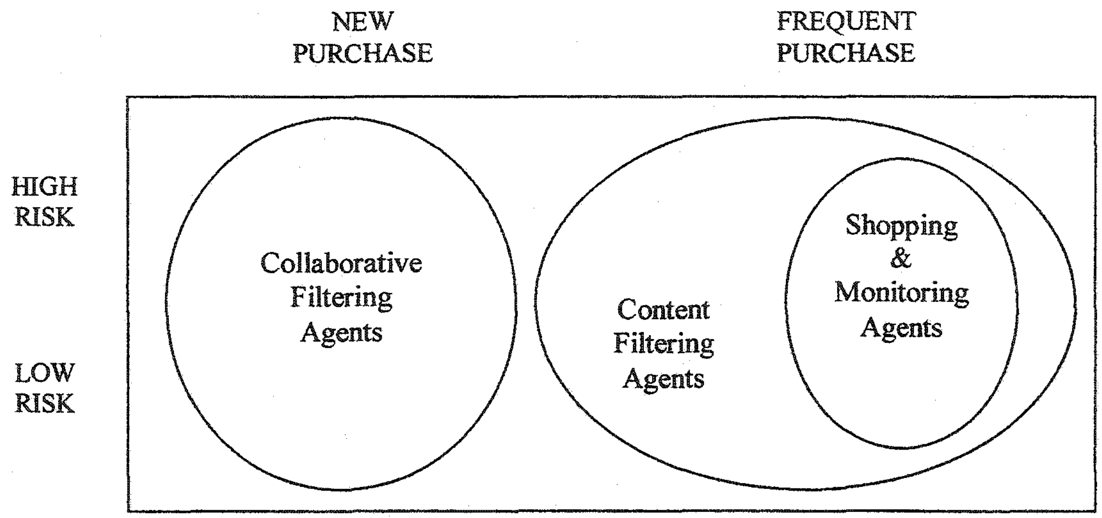

Figure 6-4 - The Purchasing Situation and Search Support

6.2.3 Choice Behaviour

Once the relevant information has been retrieved, the buyer's choice task consists of a set of alternatives, each described by a series of attributes. These attributes can vary in desirability, consequences and the consumer's willingness to trade off one attribute for another. Uncertainty is introduced when the consumer does not have all information about some attributes (Bettman et al. 1998).

Rational choice theory assumes that the buyer determines the expected utility of each alternative and chooses the alternative that maximizes this function by using techniques such as those described in multi-attribute decision theory. The information processing approach recognizes the cognitive limitations of human decision-makers and explains commonly observed, less "rational", choice behaviour such as constraint-based elimination. Theories of constructive choice assume that consumers do not always have known preferences, but rather "construct" them when required in the choice process (Bettman et al. 1998).

In a repetitive purchasing situation, there is little uncertainty. Buyers know the attributes that are important, and have limited the alternatives to those products with the necessary values in these attributes. The decision problem is highly structured.

In a new purchase, unstructured and constructive choice processes are observed. Buyers often use a staged approach where a constraint-based approach is used initially to limit the number of alternatives. A strategy employing more extensive information processing can then be applied to this limited set of alternatives (Bettman et al. 1998).

When there is risk involving serious potential consequences or difficult trade-offs, buyers choose one of two coping mechanisms. In problem-focused coping, a strategy that involves more extensive information processing is chosen. In emotion-focused coping, a strategy that avoids trade-offs is chosen (Bettman et al. 1998).

The choice strategies employed by buyers in B2B commerce are generally seen to be more "rational" than those employed in B2C commerce. Organizational decision-making processes often include more than one participant and information flows and control structures often require explicit definition of the criteria and choice mechanisms to be used (Webster and Wind 1972). However, perceived risk and the minimization of potential problems still play a large part in organizational buying and the type of risk can affect the choice strategies employed (Wilson and Woodside 1995). While additional information processing is a recognized risk-reduction strategy, less rational strategies such as loyalty to current suppliers and investment reduction are also commonly observed (Webster and Wind 1972; Wang and Archer 2003).

	NEW PURCHASE	FREQUENT PURCHASE

HIGH RISK	• Unstructured processes (staged, constructive)
	• Risk reduction through
	  • Extensive information processing
	  • Trade-off avoidance
		• Structured processes
		• Risk reduction through
		  • Use of familiar suppliers/brands
		  • Investment reduction

LOW RISK	• Unstructured processes (staged, constructive) • Minimal information processing	• Structured processes

Figure 6-5 - The Purchasing Situation and Choice Behaviour

6.2.4 Choice Support

Highly repetitive, low risk buying situations will be the most appropriate domain for delegation of the choice process to an agent. Agents can be programmed with simple negotiating strategies (Chavez and Maes 1996). Researchers are also looking at the potential of Bayesian networks and genetic algorithms as mechanisms for agents to learn more complex and effective negotiating strategies (Dworman et al. 1996; Beam and Segev 1997; Maes et al. 1999). Electronic marketplaces are being developed and new multi-issue matching algorithms are being explored to eliminate the price-only focus of the standard auction format (Teich et al. 1999). It should be noted that some of the risk inherent in frequent decisions is masked by risk reduction techniques. The ability to use low cost agent decision support may reintroduce some elements of risk (balanced by related opportunities) in these situations.

While increasing risk in the purchasing situation will encourage the use of agents for search support, it must be seen as a barrier for choice support. It is highly unlikely that buyers will delegate risky decisions to an agent. Nevertheless, intelligent components of a DSS can still be employed to generate and evaluate alternatives and assist buyers in employing strategies that require more extensive processing. Expert systems have been used in some purchasing applications where frequent application can justify the high cost of development (Cook 1992).

In a new purchasing situation, model-based DSS using multi-attribute, constraint-based, or combinations of decision models, can be employed to process alternatives based on the user's preferences and accommodate both staged and constructive choice processes. Marketing and IS researchers have identified areas where buyers are likely to choose dominated alternatives, miss "just discernable differences", or eliminate otherwise attractive options using constraint-based strategies (Arthur 1991; Widing and Talarzyk 1993; Bettman et al. 1998). Intelligent components of a DSS could increase the quality of decisions by alerting the buyer to these situations.

Finally, while the objective of IS should be to assist the buyer in overcoming cognitive limitations and make better decisions, we must remember that only the buyer will judge the quality of the decisions. Information systems can not ignore the emotional and social factors that limit "rational" behaviour. Forcing a buyer to examine trade-offs may be necessary to increase the accuracy of the decision, but may not be accepted when the buyer's preference is for emotional-focused coping.

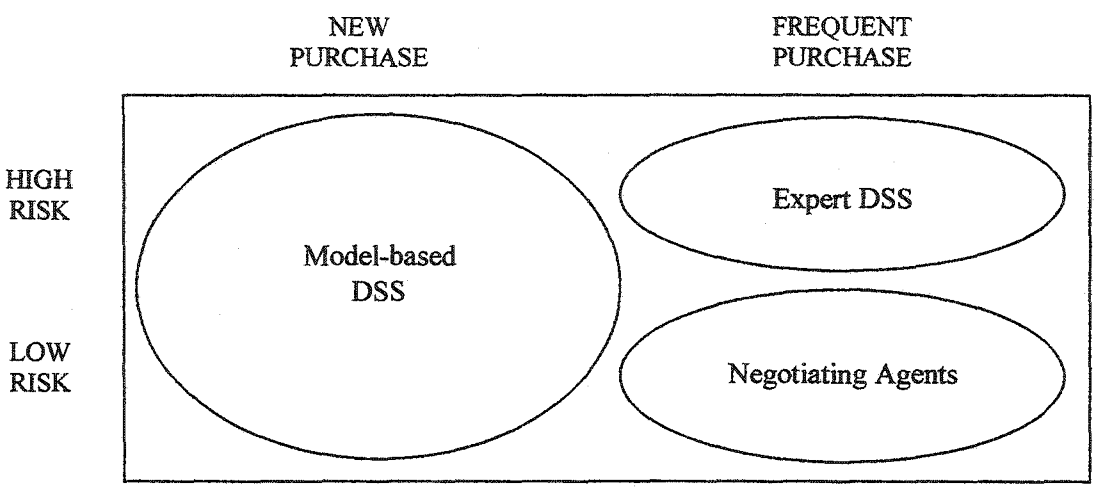

Figure 6-6 - The Purchasing Situation and Choice Support

6.2.5 Interface Support

Much of the current research on agents has focused on the user interface. A user's experience level and frequency of use has been recognized as an important determinant of dialogue and information display preferences.

Natural language processing (NLP) is an active area of agent development and may play an important role in facilitating the dialogue between buyers and agents. However NLP capabilities are still limited. The risks and frustrations associated with miscommunication using imperfect NLP technologies may hamper the development of trust. The use of NLP may also lead to false expectations about the intelligence of the system as a whole (Norman 1997). NLP is expected to be of more value when agents are employed in infrequent or one-time buying situations. NLP may not be necessary, and may even be detrimental, when an application is used frequently.

Decision-makers with experience in a domain have shown different display preferences than those without experience (Montazemi 1991). The choice strategy will also determine how information should be displayed (i.e., by attribute or by alternative) so that appropriate comparisons can be made. Search, choice and dialogue support must be integrated to ensure that information is displayed appropriately.

After a choice strategy is chosen, data may need to be restructured through transformation, editing and inference operations. Restructuring has also been seen as a constructive process where patterns and regularities in the data may suggest the use of an appropriate choice strategy. Constructive restructuring is most commonly observed with inexperienced buyers (Coupey 1994). Intelligent interface support could assist buyers in restructuring operations. Agents could assist constructive restructuring by eliminating redundant or irrelevant information and identifying patterns that suggest the use of a particular choice strategy.

6.3 Discussion

Using the components of the DSS model, the functions that agents perform can be categorized as search support, choice support, and interface support. Despite today's prevalent development focus on the interface, agents can play a role in all three components of a traditional DSS. Intelligent and personalized support for information retrieval and management can assist buyers and sellers with the complex information exchanges required in the commerce process. Intelligent and personalized support can also be applied to the selection and deployment of choice strategies.

Frequency of purchase and perceived risk provide a framework that can help match agent functions to buyer's needs. When buyers purchase a product frequently they develop structured information requirements and choice processes. Simple agent components can provide both search support and choice support in these situations. In other situations, the purchasing situation model identifies important differences in the type of information required, the extent and duration of search behaviour, and the choice processes likely to be used. Because the value of information increases with perceived risk, buyers would be expected to find agents that support search efforts helpful across all purchasing situations, but these agents will have to be designed to meet the different information needs that arise in these different situations. It is unlikely that buyers will delegate high-risk decisions to agents, but intelligent components of a DSS system can be used to help the buyer process more information and use it more effectively.

The purchasing situation model has also helped to address the problem of agent "ownership". In frequent and/or low risk situations, supplier-controlled sources of information are valued and supplier-provided components for search support are likely to be acceptable in these situations. The supplier's expertise can be exploited in frequent, high-risk purchasing situations. Interpersonal and neutral sources will be preferred in high risk, new purchase situations and information bundling intermediaries may be in the best position to provide agent support in these situations. Lowering the cost of search through ease of use will be an important factor in low risk purchase situations.

6.4 Summary

By using models from the application domain of buyer behaviour, we propose that search support agents are likely to be adopted across all purchasing situations, however the capabilities of agents required in new or infrequent purchases will be different from those required in frequent purchases. Choice support agents are only likely to be adopted in frequent, low risk purchasing situations. This framework can guide agent developers to application areas where agents are most likely to be accepted. Agent designers can use this framework to match the capabilities of their agents to appropriate purchasing situations.

Chapter 7

Shopbot Use and Consumer Decision Behaviour

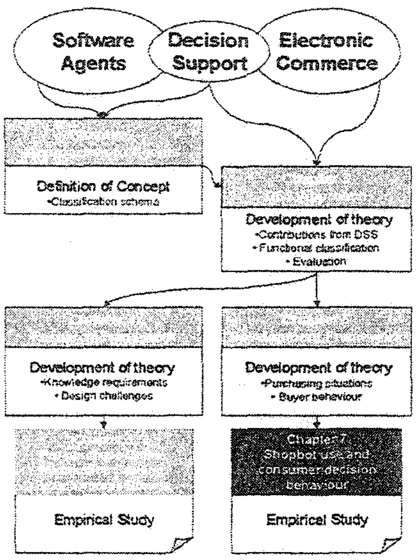

Figure 7-1 - Chapter 7 in the Research Overview

In Chapter 6 we proposed that simple shopping agents (or shopbots) would be an appropriate agent technology for familiar or frequent purchases in a low risk situation. In this chapter we examine a B2C purchasing situation and present the results of an experiment where subjects made actual purchases of music CDs. We compare the decision effort, decision accuracy, confidence and satisfaction of subjects who used a shopbot to those who did not. We also observed and describe search and choice behaviours of both groups.

7.1 Introduction

> "Shopbots – software agents that automatically query multiple on-line vendors to gather information about prices and other attributes of consumer goods and services…" (Kephart and Greenwald 2002, p. 255)

The name shopbot is derived from the term "shopping robot". Shopbots are a form of search support agent as we defined in Chapter 3. In this chapter we describe an experiment that looks at shopbot use and consumer behaviour.

Elam et al. (1992) outline two streams for integrating DSS and behavioural decision-making research. One of these streams takes known decision-making phenomenon discovered by the behavioural sciences and designs DSS to help the decision-maker overcome dysfunctional behaviours. Examples of such phenomenon are biases due to availability, anchoring or representation, preference reversal, overestimation of low probabilities/underestimation of high probabilities, and so on.

The second stream of research looks at "IT as a cause for decision-making phenomenon" (p.58). They describe this approach further in the following:

> "Essentially this style of research takes IT as it occurs, and attempts to develop models that account for its behavioral consequences. The best information technologies to choose for study are those that are currently (or soon will be) in use in real organizations. These are the information technologies for which descriptions and explanations of their effects are of the greatest practical interest. After selecting a technology, a researcher describes the systematic effects of the technology on decision behaviour" (p.59).

Our study belongs in this second stream of research. Elam et al. point out that this stream of research must examine "a wide variety of both process and performance variables" (1992, p. 59). This study examines the use of a shopbot in terms of its performance – the effort and accuracy of consumer decision-making and user attitudes - in the purchase of a music CD. We also observe how the use of a shopbot affects consumers' search and choice behaviour. Our practical interest is the potential for adoption of agent technology.

7.2 Research Objectives

In Chapter 6 we proposed that consumers will find search support useful across all purchasing situations. Simple shopbots, searching a limited set of suppliers and returning comparative information on a limited set of attributes, may be useful in frequent, familiar purchases. More complex content-filtering and collaborative agents may be required for unfamiliar purchasing situations.

The purchase of a music CD was expected to be a familiar purchasing situation for the sample of university staff, faculty and students used in the study. The product is of moderately low value. It is generally considered to be homogenous and easily described (e.g., Brynjolfsson and Smith 2000; Lee and Gosain 2000; Crowston and MacInnes 2001), making it a suitable product for search support. This familiar, low-risk purchasing situation should provide favourable conditions for the potential adoption of a simple search support agent.

Shopbots are designed to facilitate the merchant-brokering phase of the consumer decision process. In the choice of merchants, the online consumer's alternatives differ on price (price having two components: product and shipping) and the retailer's brand (brand having many components such as reputation, secure transaction services, policies on returns, privacy etc.). With the presence of many online merchants, the merchant-brokering phase of the online purchase of a music CD is still a fairly complex decision problem. We are interested in how consumers value these price and retailer attributes. We therefore wanted to study an actual purchase, where familiarity and trust in the retailer is a real issue for the subject in the experiment.

Our research questions and hypotheses are intended to provide insight into whether there is a compelling case for adoption of shopbots in this purchase situation. In order for shopbots to be adopted we expect that they will have to help consumers in one or more of the following three ways:

a) reduce the time and/or effort it takes to make a decision,

b) improve the quality of decisions, and

c) provide a more satisfying experience

The general research questions, from which we develop specific hypotheses as described in Section 7.6, are:

- Will use of a shopbot reduce the time and effort necessary to reach a decision?
- Will consumers who use a shopbot make better decisions?
- Will consumers who use a shopbot be more satisfied with the decision process?
- Will consumers who use a shopbot be more confident in their decisions?
- Will use of a shopbot encourage purchase from the low-cost vendor?

7.3 Related Research

7.3.1 Shopbots

One of the earliest e-commerce agent applications was a shopbot called Bargainfinder, developed by Anderson Consulting. Bargainfinder searched a number of online stores and retrieved prices for a specified music CD. The story of Bargainfinder is widely known for the fact that some of the online merchants, fearful of the effects of easy price comparison, began blocking the agent from their sites (Bakos 1997). There has since been a significant amount of research on shopbots and their potential influence on electronic markets (e.g., Crowston and MacInnes 2001; Kephart and Greenwald 2002).

Rowley (2000b) was an early chronicler of the problems associated with the use of available shopbots. Her results showed that typical search parameters return result sets with poor precision, that shopbot users find a high variability in search results from different agents and that they face surprisingly complex price comparisons. Also in 2000, Crowston and MacInnes reported that in the music CD market "some agents, like Bottom Dollar and Jungalee, give very good results but for very few stores, ...while others, such as ShopFind, search many stores but do not succeed in finding the lowest price" (Crowston and MacInnes 2001, p.7).

A more recent study by Smith and Brynjolfsson (2001) used panel data from a "live" shopbot[11]. Assuming that a consumer's last click-through represented his or her choice of retailer, multinomial logit analysis showed that even these supposedly "price sensitive" consumers relied heavily on a retailer's brand in choosing a merchant. They reported that well-known, "branded" retailers like Amazon.com can command a price premium of up to $1.30 US over their generic competitors (Smith and Brynjolfsson 2001).

7.3.2 Consumer Search and Choice Behaviour

Stigler's (1961) pioneering work on the Economics of Information proposed that consumers will search for price information until the marginal benefits of further search equal the cost of further search. The benefits of search increase with product cost and price dispersion in the market, but increased search yields diminishing returns. Price dispersion exists in large part because of the cost of search (Stigler 1961). Many researchers have studied the presence of price dispersion in markets and have attempted to find reasons for its persistence, especially with the lower search costs that are expected to be present in electronic markets. Price dispersion in the music CD market has been studied by a number of researchers recently, with particular attention to the differences between conventional retail and e-tail markets (Crowston 1997; Brynjolfsson and Smith 2000; Lee and Gosain 2000; Scholten and Smith 2002).

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[11] Now known as DealTime.com, it was then called EvenBetter.com

Our examination of consumer choice behaviour is based on two related areas of consumer behaviour research. The first area studies how consumers trade off effort and accuracy in decision-making and how this influences the choice strategies that they employ and the amount of information they process (Johnson and Payne 1985; Payne et al. 1988; Bettman et al. 1998). The second area examines how information display is related to the selection and use of these choice strategies (Coupey 1994; Haubl and Trifts 2000).

7.3.3 Decision Support Systems

Researchers in DSS use theories and findings from behavioural science to learn how computer-based systems can decrease effort and/or increase the accuracy of consumer decision-making. DSS can reduce cognitive effort by automating or otherwise facilitating the elementary information processes (EIPs) that are involved in multi-attribute, multi-alternative decision-making (Johnson and Payne 1985). Coupey (1994) suggested that consumers also use a separate set of "restructuring" activities to create new information displays. Consumers will expend cognitive effort in restructuring if it will save effort in choice strategies. These restructuring activities can also be automated or facilitated through the use of a DSS.

Our interests are similar to those investigated by Todd and Benbasat (1992). They designed a DSS with features that would reduce the cognitive effort involved in processing information for an apartment selection problem. They wanted to know if decision-makers who used the DSS would "reinvest the effort saved back into the task in order to process more information and make a better decision" (Todd and Benbasat 1992, p.380). They found that decision-makers who used the system put more importance on the system's ability to reduce effort than on its potential for increasing decision accuracy.

Our study also has similarities to two recent studies that examined the use of DSSs in e-commerce. Haubl and Trifts (2000) studied the use of two different DSSs, a recommendation agent and a comparison matrix, on the product-brokering phase of online purchases in a simulated on-line store. They measured the amount of search, the size and quality of the consideration set, decision quality and the subject's confidence in the decision. Their results suggest that these DSSs "can have strong favorable effects on both the quality and the efficiency of purchase decisions – shoppers can make much *better decisions* with *less effort*" (their emphasis) (Haubl and Trifts 2000, p. 4). Lynch and Ariely designed a system that helped consumers: 1) find price information, 2) find quality information and 3) make retailer comparisons in the online purchase of wine. Users rated all three treatments as providing a more enjoyable shopping experience. When products were common to both stores (a situation similar to our shopbot situation), easy retailer comparisons led to increased price sensitivity (Lynch and Ariely 2000).

The behaviours we studied are similar to those investigated by Todd and Benbasat (1992), Lynch and Ariely (2000), and Haubl and Trifts (2000). However, like Smith and Brynjolfsson (2001) we used a real market and actual purchase decisions. (Note that Lynch and Ariely's subjects made actual purchases, but at discounts and from simulated stores.) We are studying the merchant-brokering phase of consumer decision-making, whereas Haubl and Trifts studied the product-brokering phase. Lynch and Ariely studied both product and merchant brokering (between two stores). Both teams chose to study differentiated products. We, like Rowley (2000b) and Smith and Brynjolfsson (2001), studied only the merchant-brokering phase and chose a non-differentiated product.

7.4 Description of Tools

7.4.1 Copernic Shopper

Sample size and resource limitations meant that we could only investigate the use of one shopbot. The shopbot used in this study was Copernic Shopper[12]. The Copernic Shopper agent is client-based, providing the following advantages:

- The stores to be searched can be changed;
- The number of attributes displayed about each alternative can be changed;
- Features that allow the user to process or restructure the information display can be made available or unavailable, and
- Records of each search can be saved and accessed.

Other qualities of the Copernic shopper agent are consistent with how we believe good agent applications should be designed. These qualities include:

- Customization for the Canadian consumer by automatically checking for exchange rates and converting prices to Canadian dollars ($CDN);

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[12] Copyright © 2000-2001 Copernic Technologies Inc., http://www.copernic.com

- Presentation of results in an unbiased manner;
- Display of alternatives in a matrix format that should promote strategies that involve more intensive information processing, and
- Features typical of spreadsheet programs or On-Line Analytical Processing (OLAP) tools. Operations are carried out in ways that would be familiar to users of any of these other systems.

The Copernic Shopper agent conducts a concurrent search of the retailers and retrieves links to Web pages where information about the target CD is displayed. It retrieves the price of the CD and displays it in the search results. For some retailers it also retrieves shipping costs and information about availability. Where this information is not retrieved it shows the phrase ‘see site’ or ‘int’l’ under the shipping costs and availability columns. A sample of a Copernic Shopper result screen is shown in Figure 7-2.

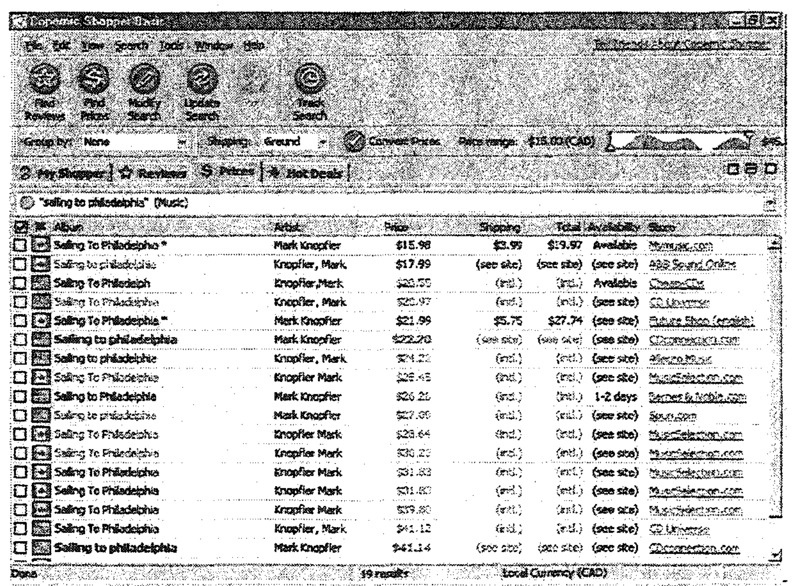

Figure 7-2 - Copernic Shopper Results Screen

Using the retrieved link and an integrated browser, the consumer can examine the item and search elsewhere within the store's site for any missing or additional information. For each result Copernic Shopper also provides direct links to the retailer's home page and pages with information about the retailer's shipping, returns and payment policies. Table 7-1 summarizes the features of Copernic Shopper that should help users reduce cognitive effort by automating or facilitating the use of EIPs and restructuring activities.

We configured Copernic Shopper to meet the expected needs of a typical consumer in our sample. We restricted Copernic Shopper to stores in either the US or Canada, since we expected that the tax and customs regulations for purchasing from these jurisdictions would be familiar to most of the sample. Of 25 US and Canadian stores originally listed in Copernic Shopper's music category, we eliminated those that did not ship to Canada and those who provided French language services only. There were 17 remaining stores. These stores and the store codes that are used throughout this chapter are listed in Appendix III. It should be noted, however, that subjects' final purchases were not restricted to these stores. After the initial data collection we gave all subjects an opportunity to search and purchase at any online retailer.

Table 7-1 – Elementary Information Processes (EIPs), Restructuring Activities and Copernic Shopper Features

EIPS AND RESTRUCTURING ACTIVITIES	MATCHING COPERNIC SHOPPER FEATURES
Elementary Information Processes From (Johnson and Payne 1985)	
READ an alternative's value on an attribute	
COMPARE two alternatives on an attribute	
ADD values of two attributes	Adds and displays total price when shipping cost is available
Calculate *DIFFERENCE* of two alternatives for an attribute	
Calculate a *PRODUCT* by weighting one value by another	
ELIMINATE alternatives	Allows user to delete alternatives
MOVE alternatives	Provides sorting and grouping functions
CHOOSE alternatives	Allows user to "checkmark" alternatives
Restructuring Activities[a] From (Coupey 1994)	
ROUND values	
ELIMINATE redundant attribute information	Delete columns from display[b]
ELIMINATE non-diagnostic information	Delete columns from display[b]
STANDARDIZE attribute information	Automates currency conversion
RELABEL attribute weights or values	
COMBINE information	
SEGREGATE information	Provides grouping function
REARRANGE information	Provides sorting function

[a] The table shows Coupey's editing and transforming classes of activities only. She also describes a class of "Inferring" activities that are not shown

[b] In the set-up for the experiment some of the default columns from Copernic Shopper's information display were eliminated because they were redundant or non-diagnostic for the task. Our subjects were not trained on the use of this feature.

7.4.2 Snag-it

We used a commercial screen-capture program called Snag-it[13] to observe subjects' decision behaviour. Video files of screen activity were saved for both the initial decision-making process and any supplemental search that subjects opted to conduct. Subjects were advised when the recorder was activated and deactivated. Screen-capture is a non-intrusive form of observation that produces a rich collection of data (Rieger and Sturgill 1999).

7.5 Method

7.5.1 Experiment Design

Subjects were assigned randomly to two treatment groups. Subjects in Group One used Copernic Shopper to conduct a search for the CD. Subjects in Group Two were directed to a Web page with hyperlinks to the same online retailers that were searched by Copernic Shopper for Group One (Figure 7-3). The order of presentation of the stores was randomly distributed for each subject. The Web page also contained the current day's Canada/US exchange rate and a "pop-up" calculator.[14]

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[13] Snag-it® was used under license and is a 2002 copyright of TechSmith Corporation, http://www.techsmith.com

[14] Calculator provided by BuddySoft®, http://java.dir.bg/products/calculator/manual.htm

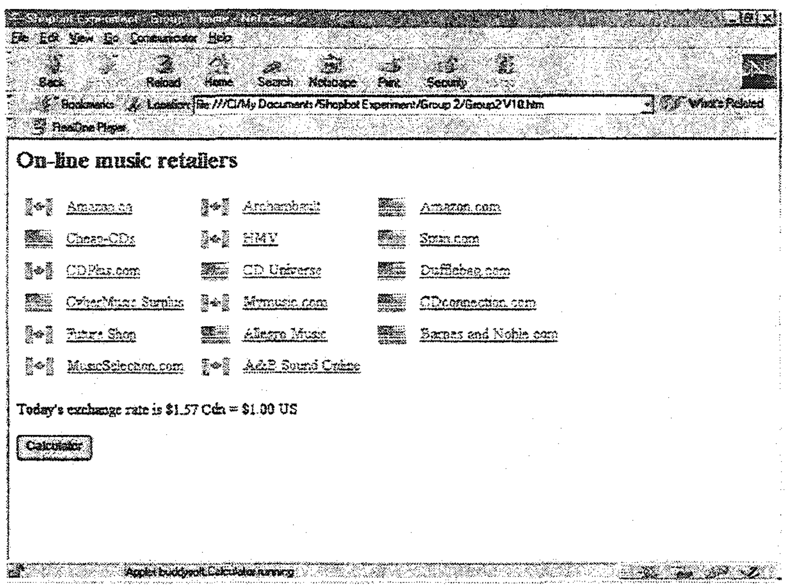

Figure 7-3 - Starting Page for Group Two

7.5.2 Sample

Forty-seven subjects participated - 23 in Group One and 24 in Group Two. Our sample consisted of 25 undergraduate students, seven MBA students, six other graduate students, seven staff or faculty of the University and two subjects who fit none of these categories. Sixty-eight percent were male and 32 percent were female. About half (51%) of the subjects had looked for information about music CDs on-line before. Only 32% had previously purchased a music CD online.

7.5.3 Incentive

Trust is believed to be an important factor in e-commerce and in the use of agents (Singh 2000; Roy et al. 2001; Yoon 2002), so a main consideration behind the design of this experiment was to maximize external validity. Our subjects actually made their purchases, using their own credit cards. They were reimbursed for participating in the experiment with an amount ($30.00) that covered the cost of most purchases.

By offering a fixed reimbursement, we retained important characteristics of an actual purchase situation. Because they would benefit by purchasing the CD at a lower cost, subjects had to evaluate the trade-off between an unknown but low-price vendor and a higher priced but trusted vendor. Subjects assumed all risks associated with the purchase including failure of the retailer to deliver and loss or misuse of personal information. We recognized, however, that this incentive reduced the overall monetary risk in the purchasing situation.

7.5.4 Procedure

Subjects came into a research lab at McMaster University where three computers were set up with the applications required for the experiment. The lab is connected through a Local Area Network to the University's high speed Internet connection. Sessions were conducted over an eight-day period in November 2002. During each session, from one to three subjects were assigned to one of the treatments and they completed their tasks.

We were studying the merchant brokering phase of the commerce process and were not interested in how subjects decided which CD they wanted to buy. If necessary, a suitable amount of browsing time was made available before the experimental session started, to ensure that subjects began the experiment with the title and artist/group of a

CD that they wanted to purchase. All subjects were provided with a blank sheet of paper with which to take notes.

A brief description of the experimental procedure is as follows:

1. Subjects provided the title and artist of the desired CD, the range of prices they expected to find, and basic demographic information. (See Questionnaire 1 in Appendix III.)
2. Group One subjects viewed a training presentation on Copernic Shopper. (See Copernic Shopper Training Package in Appendix III.) When finished, they were offered a chance to "practice" with the shopbot by searching for a different CD from the one they intended to purchase.
3. Subjects in both treatments were directed to their starting pages and the screen recorder was started. They were told to notify the researcher when they had selected the store from which they would make their purchase.
4. Subjects completed their search and evaluation. When they announced that they had made their decision, the screen recorder was stopped.
5. Subjects recorded their decision (store, item price, shipping price) and rated their satisfaction with the process and their confidence in their decision. (Questionnaire 2 in Appendix III).
6. Before making their purchase, subjects were offered time to conduct any additional search and investigation that they wished. If they opted for this opportunity the screen recorder was started again.

7. Subjects who completed additional investigation would again announce that they had reached a decision and the screen recorder was stopped. If they had changed their decision, they recorded their new decision (store, item price, shipping cost).
8. Subjects completed their on-line transaction at the chosen store.
9. After they had completed their purchase, Group One subjects were shown the page of links that Group Two used, and Copernic Shopper was demonstrated for the Group Two subjects. They were then asked to record how they would have rated the other group's process. (See Supplementary Questionnaire in Appendix III.)
10. Subjects were thanked and given the $30.00 payment.

Between sessions, the researcher cleared previous search files from Copernic Basic, and cleared cookies and erased history files from the browsers.

The questionnaire data and each subject's decision as to retailer, item price and shipping cost (if found) was collected from the packages that the subjects filled out in the session. After each Group One session, the results of the subjects' Copernic Shopper searches were saved. After each Group 2 session, the researcher conducted and saved Copernic Searches for the CDs purchased by each subject. These records, along with a file of shipping costs at all of the retailers, were used to determine actual price dispersion and the lowest total cost found by the agent.

The video files captured by the Snag-it® program show all screen activity, including cursor movement. There is a running "clock" associated with each file, so the time that any event or activity occurs can be recorded. This produced a rich set of data from which we could document behaviours of interest. The video files were reviewed to observe and record the stores visited, the number of pages viewed, and any visible restructuring activities. A list of the behaviours observed as well as samples of an agent results file and a subject search log for each group are included in Appendix III.

All data related to the individual subjects was collected in a SPSS data file. Responses to the questionnaires, the chosen store, and the price paid (item and total) were transcribed from the packages the subjects filled out during the experiment. If the subject had not determined the shipping cost it was added from the researcher's list of shipping costs for each store. Observations from the video files were added to each subject's record, including the "time to decision", stores visited or alternatives investigated, pages viewed and restructuring activities. Low item and low total prices for the target CD were then determined from the agent searches and these were also added to each individual record. SPSS was used to generate descriptive statistics of this data and to test all hypotheses.

Another database contained records for each store. Items in these records included the number of times the store had the lowest price (item and total), the number of times it was in the lowest three prices (item and total) and the number of times it was chosen for purchase. SPSS also was used to analyze this data set.

7.6 Hypotheses

We operationalized the concepts in our general research questions within the confines of the experiment design by identifying the dependent variables that would be measured and formulating specific hypotheses.

7.6.1 Decision Effort

The time spent to reach a decision (as recorded in the screen capture files) can be used as an objective measure of effort (Klein and Yadav 1989). Since Copernic Shopper automates the search process, we expect that subjects using the shopbot will take less time to reach a decision.

- **Hypothesis 1a (DECISION EFFORT): Subjects using the shopbot take less time to make their decision.**

Researchers have also used the number of pages viewed as a measure of effort (e.g., Haubl and Trifts 2000). Navigating through Web sites and scanning for relevant information requires both cognitive and physical effort. Since Copernic Shopper provides links directly to the relevant page describing the target CD, we expect that shopbot users will view a fewer number of pages.

- **Hypothesis 1b (DECISION EFFORT): Subjects using the shopbot view fewer unique pages.**

7.6.2 Decision Accuracy

In many studies of DSS, decision accuracy (or decision quality) is determined by comparing decisions to optimal solutions from normative models or to the decisions of experts. In this experiment, we can determine the price attributes of a CD (item price and shipping price), but there is no normative model that would include subjective measures such as retailer brand attributes. Each consumer is the "expert" as far as their own preferences and the trade-offs they will make between price and retailer brand.

Todd and Benbasat (1992) hypothesized that subjects interested in maximizing accuracy would examine or "find" more units of information about the alternatives. We take a similar view – that a more informed decision is a higher quality or a more accurate decision. We determined whether subjects found all of the relevant price information (both item price and shipping price) on their chosen alternative prior to making a decision. This is used as our measure of decision accuracy.

The shopbot presents shipping prices for some alternatives in its search results and also provides direct links to pages with shipping information on most retailers' sites. Since most stores do not provide shipping information on the individual product item pages, subjects not using the shopbot must navigate their way through each retailer's site to find shipping information. This is a time-consuming and effortful process. We therefore propose the following hypothesis for decision accuracy:

- **Hypothesis 2 (DECISION ACCURACY): Subjects using the shopbot make better-informed decisions, by having both the shipping price and the item price prior to making their decision.**

7.6.3 Satisfaction with Decision Process

Satisfaction with the decision process was measured using a questionnaire with a seven-point Likert scale. We used six questions adapted from scales used in similar research (Aldag and Power 1986; Pereira 2000). Since use of the shopbot is expected to reduce the time and effort in decision-making, we expect shopbot users to be more satisfied with the decision process.

- **Hypothesis 3 (DECISION PROCESS): Subjects using the shopbot rate their satisfaction with the process higher than those who do not use the shopbot.**

7.6.4 Decision Confidence

We also used a questionnaire consisting of a six-item scale to measure decision confidence. Again, questions were adapted from similar research (Pereira 2000). Our first measure of decision confidence is based on subjects' responses to these questions. Additional information processing is one way to reduce risk. Since we expected shopbot users to find and use more information, we expected them to be more confident in their decision.

- **Hypothesis 4a (DECISION CONFIDENCE): Subjects using the shopbot rate their confidence in their decision higher than those who do not use the shopbot.**

We provided subjects with the chance to do any additional search and investigation after they had announced that they had made their decision under the treatment to which they were assigned. We use this as another measure of confidence in the decision. Since the shopbot has conducted an extensive search and provided a substantial amount of information for comparison, we expected shopbot users to be less likely to conduct additional search of their own.

- **Hypothesis 4b (DECISION CONFIDENCE): Subjects using the shopbot are less likely to take the opportunity to conduct additional search.**

If the subject elected to conduct additional search, we determined whether they changed their decision on which retailer they would make the purchase from. This is also used as a measure of decision confidence. Switching as a measure of decision confidence has been used by Haubl and Trifts (2000) and by Widing and Talarzyk (1993).

- **Hypothesis 4c (DECISION CONFIDENCE): Subjects using the shopbot are less likely to change their decision after additional search.**

7.6.5 Propensity to Purchase from Low-cost Vendor

With undifferentiated products, it is expected that shopbot use would encourage consumers to purchase from the least cost vendor, resulting in a "winner-take-all" market phenomenon (Bakos 1997; Crowston and MacInnes 2001; Smith and Brynjolfsson 2001). We assume that the shopbot always finds the alternative with the lowest item price. Subjects who do not use the shopbot may not always find the alternative with the lowest item price, and subjects in both groups may not find the alternative with the lowest total (item and shipping) price. By conducting an agent search, and compiling our own database of shipping charges for each store, we determined the alternative with the lowest total price for each subject and determined if the subject paid a premium over this price.

- **Hypothesis 5 (LOW COST): Subjects who use the shopbot are less likely to pay a premium on the total price than subjects who do not use the shopbot.**

7.7 Results

7.7.1 Data Inspection

Using live external applications means that problems can occur that are beyond the researcher's control. One of these problems occurred for three days when Copernic Shopper did not retrieve item prices from one of the stores. Because it did provide links to the CDs and the price was easily visible on the linked page, we did not feel that this had a major effect on our results. Similar problems have been experienced by other researchers using automated scripts to retrieve information from the Web (e.g., Crowston and MacInnes 2001).

After inspection, the data for two Group One subjects were removed from the dataset. One subject was searching for a CD of a popular Broadway production, but did not specify an artist. A review of the video file indicated that this subject was acting in the product-brokering stage – still trying to decide what CD to purchase - rather than the merchant-brokering stage. The second subject missed all of the reversals in the questionnaire. We do not believe that this subject was giving the task the necessary care and attention.

Of the remaining cases, the screen capture program did not work properly for 8 of the decision-making episodes.[15] For five of these files, we were able to determine the total time spent to decision, but could not make observations on behaviour.

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[15] We suspect that this was a hardware problem with one of the computers in the lab.

In summary, this means that of the original 23 Group One subjects we have questionnaire and purchase data for 21, we could measure "time to decision" for 20 subjects, and we had behavioural observations for 18. We have questionnaire and purchase data for all 24 Group Two subjects, we could measure "time to decision" for 22, and we had behavioural observations for 19.

7.7.2 Scale Reliability

Our constructs "Satisfaction with the Decision Process" and "Confidence in the Decision" were measured using a questionnaire with a seven-point Likert response scale. Similar constructs have been investigated in other studies of DSS (Aldag and Power 1986; Cats-Baril and Huber 1987; Pereira 2000; Vinaja et al. 2000).

Both reliability and validity are of concern when developing and using instruments. Reliability is concerned with the consistency and stability of scores obtained by the instrument. Content validity is concerned with the degree to which the items in the instrument actually represent the dimensions of the concept being studied. Construct validity is concerned with how well the items in the scale are correlated when they are expected to measure the same construct (convergent validity) and how well they are differentiated from items in scales that are measuring different constructs (discriminant validity). Criterion-related validity is present if the instrument is able to predict external criteria that are also related to the concepts (Davis 1995).

Our questions were adapted primarily from Periera (2000), who studied interaction effects between a subject's product knowledge and the decision strategy used by an agent. He developed and tested measures for a number of constructs. Factor analysis showed that his scale items loaded onto the a priori constructs as expected, with no cross-loading, providing evidence that the scales have "adequate uni-dimensionality, convergent and discriminant validity" (Pereira 2000, p.16). Two of Periera's constructs are directly applicable to our study: *satisfaction with the decision process* and *confidence in the decision/choice*. Cronbach's alpha provides a coefficient of internal consistency – a measure of how the items in a scale are related and therefore the reliability of the scale. In his study, Pereira obtained Cronbach alphas of 0.86 and 0.73 respectively for these constructs.

Vinaja (2000) used questions from Cats-Baril and Huber (Cats-Baril and Huber 1987) and Aldag and Powers (1986) in his study of agent use for a business decision. We examined these sources as well. Aldag and Powers (1986) included *satisfaction with resource expenditure* as one dimension of a construct labeled "Attitudes-toward-Decision-Process-and-Solution". Since time and effort are important considerations in our analysis, we included two questions from their scale in our questions on satisfaction with the decision process.

Periera (2000) was studying a product-brokering task. Our questions on decision confidence had to be adapted for a merchant-brokering task. We also added two questions on how the subject felt in making the purchase from the particular retailer. None of the other studies involved real purchases, and we felt that confidence in the retailer's ability to deliver on the purchase would be an important part of the subjects' confidence in their decisions.

Our questions and the studies from which they were adapted are shown in Table 7-2. Three reverse questions were included to encourage the subjects to take care in reading and answering the questions.

A confirmatory factor analysis showed that the questions on resource expenditure (DP3 and DP6) from Aldag and Powers (1986) should not have been included in the decision process construct so they were removed from the analysis. The remaining four questions on decision process revealed one factor that accounted for 67% of the variance. The factor analysis on the six decision confidence items produced only one factor as well, with 59% of the variance explained.[16]

Since the two constructs were uni-dimensional, we averaged the scale item scores to obtain two dependent measures. For our measure of Decision Process, the value of Cronbach's alpha is 0.83. For basic research, reliability is generally considered acceptable if alpha exceeds 0.80 (Davis 1995). For our measure of Decision Confidence, the value of Cronbach's alpha is 0.84, which again is acceptable.

7.7.3 Tests of Hypotheses

The hypotheses proposed in Section 7.5 were tested to determine if there were differences between groups in effort, accuracy, satisfaction with the process, confidence in the decision, and propensity to purchase from the low-cost vendor.

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[16] To get a significant improvement in the variance explained (to 79%) would require eliminating three questions (DC2, DC3, and DC6). This provides only marginal improvement in reliability (Cronback's alpha changes from 0.84 to 0.87). The results of the hypothesis test do not change.

Table 7-2 - Decision Process and Decision Confidence: Instrument Origins and Reliability Test Results

		Question adapted from
DECISION PROCESS		
DP1	This was a good way to make my purchase decision.	Periera (2000)
DP2	I would use this same process again to buy a music CD online.	Periera (2000)
DP3 ***	The time and effort I used to make my decision were well spent. ***	Aldag & Powers (1986)
DP4	If my friend wanted to by a music CD, I would be likely to recommend this process.	Periera (2000)
DP5	This process was useful in helping me to make the best purchase decision.	Periera (2000)
DP6 ***	This process took too much time to reach a decision. (reverse) ***	Aldag & Powers (1986)
Cronbach's alpha =0.83		
DECISION CONFIDENCE		
DC1	I feel I have made a good purchase decision.	Aldag & Powers (1986)
DC2	There are probably other alternatives that I should have examined. (reverse)	Periera (2000)
DC3	I feel comfortable purchasing this CD from this retailer.	
DC4	This is clearly the best purchase decision in this situation	Periera (2000)
DC5	I would make this same decision if I had to make the decision again	Periera (2000)
DC6	I am not sure that I should make this purchase. (reverse)	
Cronbach's alpha = 0.84		
*** These questions were removed from the analysis		

Hypothesis 1a (DECISION EFFORT)

Recall that the time spent to reach a decision is one measure of decision effort. Our hypothesis stated that subjects using the shopbot would take less time to make their decision. Table 7-3 shows the results of t-test (one-tailed) on the time spent to decision. It shows that there is a significant difference between the two groups at the α=0.05 level. We can reject the null hypothesis and conclude that use of the shopbot reduced the time to decision.

Table 7-3 - Time To Decision

	N	Mean (min:sec)	Minimum (min:sec)	Maximum (min:sec)	Standard Deviation
Group One	20	10:01	2:39	25:22	01:20
Group Two	21	15:07	6:54	48:08	01:49
t-test (one-tailed): p = 0.016 **significant at the 0.05 level					

Hypothesis 1b (DECISION EFFORT)

The second measure of effort was the number of pages viewed. We hypothesized that subjects using the shopbot would view fewer unique pages. Table 7-4 shows the pages viewed by subjects in both groups and the results of a t-test (one-tailed) on the number of pages. It shows that there is a significant difference between the two groups at the α=0.01 level. We can conclude that shopbot users viewed fewer unique pages than subjects who did not use the shopbot.

Table 7-4 - Number of Unique Pages Viewed

	N	Mean	Minimum	Maximum	Standard Deviation
Group One	18	7.6	1	24	1.57
Group Two	19	28.2	15	46	1.89
t-test (one-tailed): p = 0.000 ***significant at the 0.01 level					

Hypothesis 2 (DECISION ACCURACY)

Our measure of decision accuracy is concerned with how much price information subjects had on their chosen alternative before making their decision. We hypothesized that subjects using the shopbot would make better-informed decisions in that they would be more likely to have both the item and the shipping cost before deciding. In Group One, 83% of the subjects found all of the relevant price information before making their decision. In Group Two only 37% of subjects had this information. See Table 7-5. This difference is significant at the 0.01 level using the Chi-Square test. We can conclude that the shopbot users were better informed when they made their decision.

Table 7-5 - Decision Accuracy

	Found item and shipping price for chosen alternative		Total
	No	Yes	
Group One	3	15	18
Group Two	12	7	19
Total	15	22	
Chi-Square test : $\chi^2 = 8.288$ Asymptotic significance (one-tailed) =.002 *** significant at 0.01 level			

Hypothesis 3 (DECISION PROCESS)

We hypothesized that subjects using the shopbot would rate their satisfaction with the process higher than those who do not use the shopbot. The mean responses and results of a t-test test are shown in Table 7-6. The difference is marginally significant at the 0.10 level. We can conclude that shopbot users were more satisfied with the decision process than subjects who did not use the shopbot.

Table 7-6 - Decision Process

	N	Mean	Standard Deviation
Group 1	21	5.69	1.095
Group 2	24	5.26	1.001
Total	45		
t-test (one-tailed); $p = 0.088$ *marginally significant at 0.10 level			

Hypothesis 4a (DECISION CONFIDENCE)

We hypothesized that subjects using the shopbot would rate their confidence in their decision higher than those who do not use the shopbot. Our test of hypothesis 4a shows no significant differences in how subjects rated their confidence in their decision. Table 7-7 shows the mean responses and the results of the t-test.

Table 7-7 - Decision Confidence (Questionnaire)

	N	Mean	Standard Deviation
Group 1	20	4.87	1.161
Group 2	24	5.09	1.071
Total	45		
t-test (one-tailed); p = 0.255 (not significant)			

Hypothesis 4b (DECISION CONFIDENCE)

For hypothesis 4b we compared the proportion of subjects from each group who conducted an additional search after they had made their initial decision. We proposed that subjects using the shopbot would be less likely to take the opportunity to conduct additional search. Forty-eight percent of Group One subjects took the opportunity to conduct additional searches, compared to only 29% of Group Two subjects. These results are in the opposite direction to that expected, however a Chi-square test shows that the difference is not significant. (See Table 7-8.)

Hypothesis 4c (DECISION CONFIDENCE)

For hypothesis 4c we compared the proportion of subjects who changed their decision after conducting an additional search. We proposed that subjects using the shopbot would be less likely to change their decision after additional search. Since this is a small section of our sample, we have expected frequencies less than 5 in some cells of the 2X2 table. We therefore use Fisher's Exact test on this data. Thirty-six percent of

Group One subjects changed their decision after an additional search compared to 14% of Group Two subjects (Table 7-8). Similar to hypothesis 4b, the observed direction is opposite to that hypothesized but our sample does not provide evidence that there is a significant difference between the groups.

Table 7-8 - Decision Confidence (Switching Behaviour)

	Additional Search		Total	Change Decision		Total
	No	Yes		No	Yes	
Group One	11	10	21	6	4	10
Group Two	17	7	24	6	1	7
Total	28	17	45	12	5	17
	Chi-Square test with continuity correction: $\chi^2 = 0.932$ Asymptotic significance (one-tailed) =0.167 (not significant)			Fisher's Exact test Exact significance (one-tailed) = .278 (not significant)		

Hypothesis 5 (LOW COST)

We wanted to determine if subjects who use the shopbot would be less likely to pay a premium on the total price than subjects who do not use the shopbot. Table 7-9 shows the results of the Chi-Square test (nominal data). Thirty-nine percent of shopbot users paid a premium over the low-cost alternative, while 54% of subject who did not use the shopbot paid more than the low-cost alternative. This is not a significant difference.

Table 7-9 - Paid Premium over Low-Cost Alternative

	Paid premium over alternative with lowest total price		Total
	No	Yes	
Group One	14	7	21
Group Two	11	13	24
Total	25	20	45
Chi-Square test with continuity correction: $\chi^2 = 1.215$ Asymptotic significance (one-tailed) =.135 (not significant)			

7.8 Discussion

In this section we discuss the results of our hypothesis tests. We include a discussion of whether shopbot users "reinvested" some of the time and effort they saved into additional information processing. Finally we discuss other findings from this study, including perceived and actual price dispersion, the search precision in the results returned by the shopbot, and observed restructuring activities.

7.8.1 Decision Effort

Shopbot users took significantly less time to reach their decisions and viewed fewer pages on the retailers' Web sites – our measures of effort.

We tested our second hypothesis on decision effort by examining the number of unique pages viewed. Had we chosen to look at total pages viewed or at the number of stores visited, we would have obtained similar results.

7.8.2 Decision Accuracy

We found that the shopbot users made better informed decisions. Eighty-three percent had determined both the item price and the shipping cost before deciding on a retailer. Half of these subjects had to search for the relevant shipping information. In the other half of the cases, the agent presented the shipping price for the chosen alternative. Only 37% of Group Two subjects had found both pieces of price information before they made their decision.

7.8.3 Trade-off Between Decision Effort and Decision Accuracy

To answer our question about whether shopbot users reinvest the time and effort they save into additional search or information processing we present one way of estimating the time saved and invested. We can divide the observed "time to decision" for both groups into estimated *search time* and estimated *evaluation time*. Evaluation time includes time spent looking for shipping cost or any other information that was not shown on Copernic Shopper results (Group Two) or on the detailed page describing the item (Group One).

For Group One the average total time to decision was 10:02 (min:sec). Copernic Shopper took an average of 37 seconds to return its search results. So we estimate that Group One subjects spent the balance of their time, an average of 9:25 (min:sec), to evaluate the alternatives.

For Group Two the average total time to decision was 15:07 (min:sec). In retrieving prices for their study on books and CD's, Brynjolfsson and Smith (2000) estimated that it took approximately one minute/store to find an item and its price. Subjects in Group Two searched an average of 6.58 sites. This would be equivalent to 6:35 (min:sec) of estimated search time, leaving 8:32 (min:sec) as the estimated evaluation time.[17]

This rough estimate could indicate that the shopbot users saved 6:35 – 0:37 = 5:58 (min:sec) on search, and spent an additional 9:25 – 8:32 = 0:53 (min:sec) on evaluation. We also know that Group Two subjects spent an average of 36 seconds of their evaluation time doing currency conversions. Group One did not have to do conversions for item prices, so the difference in time doing other evaluation activities can be estimated at 0:53 + 0:36 = 1:29 (min:sec).

This estimate could indicate that shopbot users did reinvest 1:29 (minutes) or about 25% of the time they saved on search into additional evaluation of the alternatives – including the retrieval of shipping cost or other information.

We would like to compare our results for effort and accuracy with that of other researchers. Our measures for effort and accuracy are not the same so this discussion is limited to the conceptual level. Our results would concur with those found by Haubl and Trifts (2000): Our shopbot users benefited in terms of both accuracy and efficiency.

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[17] The searchers in Brynjolfsonn and Smith's (2000) study might be considered expert searchers. If our Group Two subjects took longer than one minute/store to find their CDs, their search time would be increased and their evaluation time decreased. In our comparison, this would increase the estimated time that Group One subjects reinvested.

Todd and Benbasat (1992) concluded that for their subjects, effort reduction was more important than accuracy. From our estimated search and evaluation times, it would seem that our subjects reinvested some, but not all of the time saved, and benefited from increased accuracy. Todd and Benbasat note that the incentive for accuracy in their study was weak By studying an actual purchase decision we may have provided a stronger incentive for such reinvestment.

7.8.4 Decision Process

We found that shopbot users were more satisfied with the decision process than those who did not use the shopbot. The difference is only marginally significant at the $\alpha = 0.10$ level and the difference is not large. The mean rating was 5.69 for Group One and 5.26 for Group Two. This marginal difference in satisfaction does not make a compelling case for adoption. Widing and Talarzyk (1993) caution that scales such as ours might be insensitive if no frame of reference is provided and this could be an explanation for the smaller than expected difference.

Recall that we asked subjects to rate the other Group's process after they had completed their purchases. The questions and response data for the supplemental questionnaire are shown in Table 7-10. Results of a t-test show large differences between the two groups in these comparative ratings. Subjects in Group One indicated that they **would not** have been very satisfied with the unaided hyperlink process.

Subjects in Group Two indicated they **would** have been very satisfied with the Copernic Shopper process. In this case a frame of reference was available.[18]

Table 7-10 - Results of Supplemental Questionnaire on Decision Process

Questions			
DP1	This would have been a good way to make my purchase decision.		
DP2	I would use this process the next time I wanted to buy a music CD online.		
DP4	If my friend wanted to buy a music CD, I would be likely to recommend this process.		
DP5	This process would have helped me to make the best purchase decision.		
Test of Difference between the Means			
	N	Mean	Standard Deviation
Group 1 on Group 2 process	15	2.28	0.870
Group 2 on Group 1 process	21	6.05	1.244
Total	36[a]		
	t-test (one-tailed); p = 0.000 *** very significant at 0.001 level		

[a] The supplemental questionnaire was not administered in the first few experimental sessions

We discussed the types of knowledge that agents might possess in Chapter 4. The design of the treatments in this experiment provided Group Two subjects with any "declarative knowledge" that the agent possesses, such as exchange rates and the

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[18] An area of caution in weighing these comparative results is that the subjects in Group Two did not have to "learn" how to use the shopbot. An "expert" user demonstrated it to them.

location of information sources. We are therefore not able to determine how consumers would value this knowledge as part of the shopbot package. There is a cost to discovering sources and/or intermediaries themselves that neither of our groups had to incur (Brynjolfsson and Smith 2000). This may be why both groups were fairly satisfied with the process.

7.8.5 Decision Confidence

We did not find a difference in how subjects rated their confidence in their decision. The other tests that we used for decision confidence (additional search and switching) showed results in the opposite direction from that hypothesized but these were not significant.

Future research should consider the possibility that shopbot users may be less confident in their decision and we can examine alternative hypotheses that would explain the unexpected direction of these results. Decision confidence may be related to the trust that the consumer has in the agent. The consumer is trusting that the agent has truly retrieved all of the relevant results in an unbiased manner. Normally, the consumer would build this trust through repeated use, or other mechanisms such as the recommendations of others. In the experimental setting, the absence of these normal trust-building mechanisms may be reflected in a lower measure of confidence in the decision. Decision confidence may also be related to the degree of control that the consumer feels they have had over the process. The researcher had pre-set the shopbot's default settings, including the stores to be searched and the information presented in the display. This was necessary to establish certain controls on the experiment. If the subjects had gone through the process of setting these parameters, they may have felt more in control of the process and been more confident in their decisions.

7.8.6 Propensity to Purchase from the Low-cost Vendor

We did not find a significant difference in the proportion of subjects who paid a premium over the low-cost alternative. Only 10 of 19 subjects who did not use the shopbot (53%) actually found the alternative with the lowest total price as compared to 13 of 18 shopbot users (72%). We examined the difference between the actual price paid and the cost of the low-cost alternative and there was no significant difference between the groups. These results may be because there was only a small difference in price between a number of the lower-priced alternatives. It may also be because both groups were using criteria other than price.

While there was not a significant difference in the proportion of subjects who paid a premium or in the amount of premium paid, there does seem to be a difference in how the purchases in each group are distributed amongst the stores. Our hypothesis was intended to test whether a "winner-take-all" market phenomenon would occur with shopbot use. Figure 7-4 shows frequencies for the stores with the best item price and best total price on the requested CDs. Since a number of stores can be close in price, Figure 7-5 shows how often each store appeared in the best three results for both item and total prices.

Two stores (CDPL and MYMU) each have the best item price for 24% of the cases, accounting for 48% of the total. Only four stores account for 76% of the best item prices. When we examine total prices, there is a clear price leader. CDPL has the best price in 45% of the cases. Just five stores account for 92% of the best total prices. A chi-square analysis shows that these results are significantly different from random (chi-square p=.001 for item price and .000 for total price). Crowston and MacInnes (1997) also found significant evidence of a price leader in the CD market. In their study, one vendor had the low price for 40% of the 94 CDs searched (chi-square p=.000).

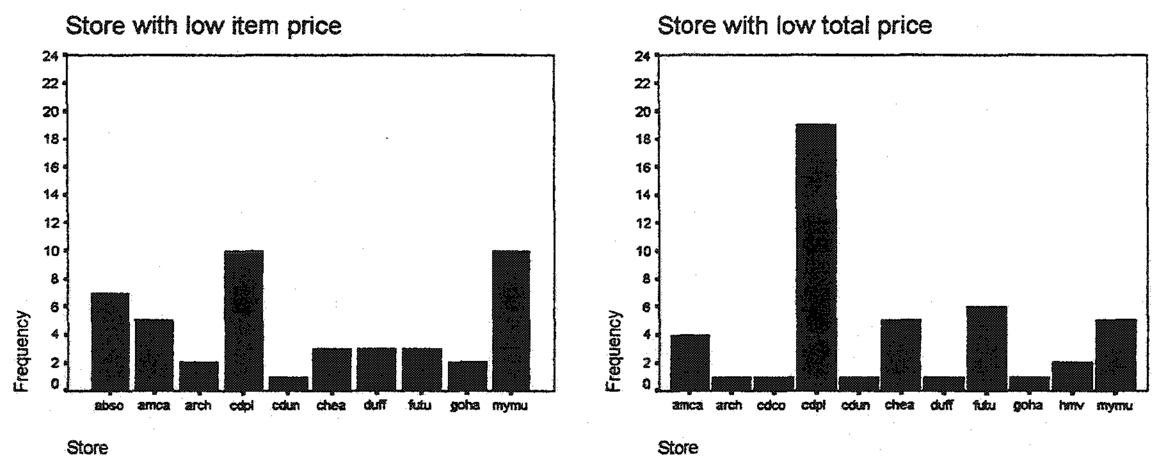

Figure 7-4 - Stores with Lowest Price (item and total)

Only one of these five lowest-priced stores (CHEA) is US-based. Canada Customs applies a $5.00 handling fee to any US purchases delivered to Canada. We did not include this charge in our total price calculations and did not explicitly inform our subjects of this charge although some of them were aware of it. If this fee was considered as part of the total price, the five stores with the lowest total price would all be Canadian.

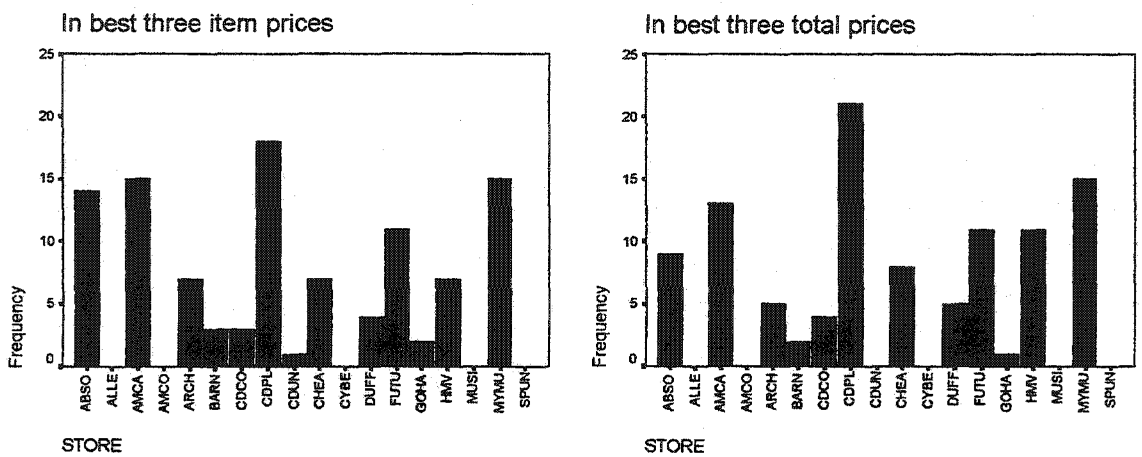

Figure 7-5 - Stores in Lowest Three Prices (item and total)

Figure 7-6 shows how subjects in each group distributed their purchases to the stores. Economic models of search predict that "informed consumers purchase from the lowest priced store(s) while purchases from uninformed consumers are evenly distributed among stores" (Brynjolfsson and Smith 2000, p. 577). A comparison of Figure 7-6 and Figure 7-4 would suggest that subjects who used the shopbot chose the overall low-cost provider (CDPL) more often and distributed their purchases over more stores (11 versus seven). This graph appears to have similarities to Figure 7-4, showing which stores had the lowest total prices. Subjects in Group Two distributed their purchases more evenly, although to fewer stores.

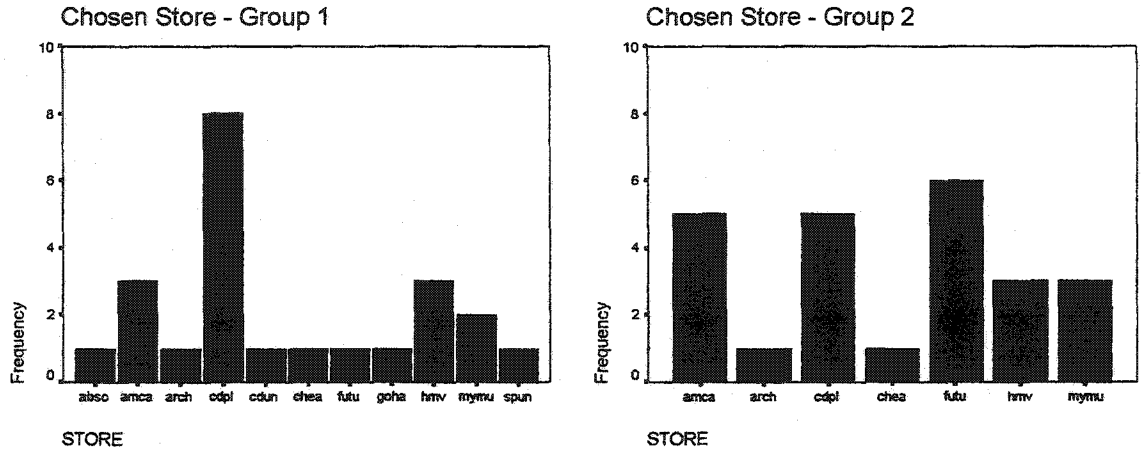

Figure 7-6 - Chosen Stores (Group One and Group Two)

The distribution of Group Two purchases may reflect that Group Two subjects were less likely to have shipping prices, and were therefore comparing item prices only. There is not a clear price leader in item prices. In Group One, where the cost leader's (CDPL) shipping cost was retrieved by the agent, subjects may have been encouraged to compare on total price.

Another explanation for the fewer stores chosen by Group Two could be the retailer's "brand". We might assume that Group Two distributed their purchases more evenly, but only among familiar or branded stores. Although we did not collect any data on brand recognition within our sample, the store that received more sales from Group Two than the price leader is a well-known brick and mortar retailer in Canada. The store that shows equal sales with the price leader is Amazon.ca; Amazon is perhaps the best-known retail brand in e-commerce.

The fact that there was not a significant difference in the prices paid could indicate that there were not large differences in price between the low cost provider and the next best-priced stores. Just over half of our Group Two subjects did not find the low-cost provider, but may have found and chosen a familiar or branded store with a price that was close to the low price. Group One subjects, however, were presented with information that identified the lowest item price and often the lowest total price. Even if the price difference was minimal, they may have felt that they should choose this retailer, despite it not being a familiar and trusted store.

Another indicator of brand reliance is the investigation or choice of a price-dominated alternative. For Group 1, each set of relevant search results was evaluated to determine how many of the alternatives were not dominated on total price. Where a total price was provided, an alternative was dominated if its price was higher than the lowest total price. An alternative for which shipping cost was not retrieved was dominated on price if its item price was more than the lowest total price in the set of alternatives. An undominated alternative would have to be investigated further to determine if it had the lowest total price. If subjects investigated alternatives that were dominated on price, we can assume that they were employing some criteria other than price.

Smith and Brynjolfsson's study showed that brand still mattered to existing shopbot customers, "who might be considered among the most price sensitive consumers on the Internet" (Smith and Brynjolfsson 2001, p.542). We also found that our shopbot users were employing criteria other than total price, since one third of them investigated at least one price-dominated alternative.

Smith and Brynjolfsson sampled experienced e-consumers. Ward and Lee (2000) found that as an e-consumer's search proficiency increased their reliance on brand decreased. They suggest that brand can be considered as a substitute for search. Our Group Two subjects may have been using brand as a substitute for further search. We essentially provided "search proficiency" to Group One in the form of the shopbot, and they seem to show less reliance on brand.

7.8.7 Price Dispersion

We wanted to compare our subjects perceived price dispersion with the actual price dispersion and dispersion reported in other studies (Brynjolfsson and Smith 2000; Lee and Gosain 2000; Scholten and Smith 2002). So that we could put our results in context relative to these other studies, the albums that our subjects purchased were compared against a national bestseller chart for the last week of the study and two weeks after the study[19]. Of the 47 albums purchased, 18 or 38% were in the "top 50" best-selling albums for the period.

Our subjects expected to find item prices with an average range of $8.66 CDN. They expected to find a low price that would be 32% below the mean item price. When shipping charges are included, the expected range averaged $9.98 and the lowest total price was expected to be 28% below the mean total price. An analysis of relevant results

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[19] Two participants "pre-ordered" unreleased albums that were best-sellers after release.

of Copernic searches for both groups showed an actual price dispersion of $21.28 for the item only, and $22.93 for the total price.

The coefficient of variation (C of V) expresses the dispersion as a proportion of the mean and can be used to compare between items of dissimilar value. Table 7-11 shows our price dispersion findings and compares our findings with the findings of other researchers. We found a higher degree of price dispersion than that found in other studies. More notably, the actual range of prices and the coefficient of variance of prices retrieved by the Copernic agent were twice as large as those expected by the subjects and three to four times as large as those reported in other studies. However, we believe that these results are related to the nature of our study.

Many of the retailers returned multiple references for the same query. Some of these references are identified as "imports" and these were eliminated from the relevant results before dispersion was calculated. Other multiple references indicate that the music industry may be trying to differentiate their products. For many of the multiple references, title descriptors such as "bonus tracks", "re-mastered", and "limited, special or collectors' edition" were found. Other descriptors indicated that a bonus CD or digital videodisk (DVD) was included with the requested disk. In many cases there was no information that revealed a difference between multiple references, even when the prices differed significantly.[20]

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[20] For example, HMV returned two references for "Pet Sounds" by the Beach Boys. Both references showed the title as "Pet Sounds Live". One was priced at $19.99. The other was priced at $56.99.

Table 7-11 - Average Price Dispersion Indicators

		ITEM ONLY			ITEM + SHIPPING		
		Range ($CDN)	**range /mean**	**C of V**	**Range** ($CDN)	**range /mean**	**C of V**
This study							
Perceived dispersion	All	$8.66	47%		$9.98	45%	
	Bestsellers	$8.19	42%		$10.28	35%	
Actual dispersion	All	$21.28	78%	.266	$22.93	71%	.244
	Bestsellers	$24.95	88%	.303	$26.02	78%	.273
Other studies							
Lee & Gosain	"New hits"		18%	.057			
	"Old hits"		31%	.079			
Sholten & Smith	"Popular titles"			.096			.077
Brynjolfsson & Smith	½ Bestsellers ½ "generally available "				$6.94*	29%	.055

*Converted to $Canadian at the exchange rate used during the study.
(Brynjolfsson and Smith 2000; Lee and Gosain 2000; Scholten and Smith 2002)

Brynjolfsson and Smith (2000) minimized the potential for multiple references of this kind through the use of record label catalogue numbers as the query parameter, thus ensuring an "entirely homogenous product" (pg. 574). Rowley (2000b) also reported that search precision was best with the use of IBSN numbers for books. Consumers do not have catalogue or ISBN numbers as search parameters. As a result, their searches returned heterogeneous products. The information describing the products did not always allow us to discriminate between these products, so we believe that the price dispersion reported is representative of how consumers would view the results of their searches.

7.8.8 Search Precision

For Group One, precision of the search results (the proportion of total references returned that are relevant) ranged from 3% to 100%, with an average of 58% (see Table 7-12). Subjects employed different query strategies, searching by title, artist/group, or title and artist/group. The way that individual stores respond to these queries differs as well. Low precision was evident where subjects used the artist/group only, as stores would return all albums by that artist/group. Low precision was also evident in title-only searches when the title contained common words or expressions (e.g., "greatest hits"). Even when the query contained both the title and the artist/group, some stores returned all titles by that artist. In all cases, however, the subjects could isolate non-relevant results fairly easily by sorting on the title or the artist/group. Three of the 18 subjects modified their original queries and had the agent search again. One of these subjects modified the search eight times.[21]

Table 7-12 - Search Precision (Group One)

	Minimum	Maximum	Mean	Standard deviation
Number of references returned	3	103	27.50	24.37
Number of relevant references	1	31	10.44	7.50
Precision	3%	100%	58%	

[21] This subject was purchasing a classical music album. Classical albums pose unique search characteristics. Titles may identify the composition only. Some databases use the artist attribute to identify the composer, whereas others use it to identify the performer(s). This problem was also evident in one of the pretest cases. Some online stores have a different query mechanism for classical music that asks the consumer to identify the composition, the composer and the performer(s) etc.

Since differentiating between multiple version of a CD was difficult, and we did not necessarily know which options were of interest to our subjects, we can not be sure that we have been able reduce the set of search results to truly relevant items. In judging which items were relevant, we erred on the side of inclusion and have probably included some results that would be judged not relevant by the consumer. In this case, the real values for precision would be lower than those reported.

The precision reported is relatively poor. However, it reflects the way that consumers really search and the variability with which the store databases handle typical keyword searches. While Copernic Shopper translates the query into the format required by each store, it does nothing to filter the responses. Users would expect that specifying both the title and the artist should return fewer results than the artist or the title alone. However, some stores returned all titles by an artist to this query. If the title was unique, a title-only search returned the fewest results; if the title contained common keywords, a title-only search resulted in very poor precision.

7.8.9 Restructuring

Table 7-13 shows the observed restructuring activities for both groups. Eighty-three percent of Group One subjects used at least one of the display manipulation features of Copernic Shopper. While Coupey (1994) discusses restructuring activities in the context of choice, Copernic Shopper features that support these operations were used primarily in the search function. Because of the poor precision in search results, almost all subjects used sort, group and delete functions to segregate or eliminate non-relevant alternatives. These features served a very valuable role in this function and were used easily and efficiently by most subjects. There was some evidence of sorting and grouping in the context of choice – to segregate or eliminate relevant but undesirable alternatives. For example, five of 18 subjects sorted or grouped relevant alternatives by the country in which the stores were based. All of these subjects then examined only Canadian stores.

Almost one half of the subjects in Group Two used the pop-up calculator. These nine subjects spent an average of 71 seconds on the calculator, for an average of 36 seconds over the entire group. Most of the subjects in Group Two also used the blank sheet of paper that was provided. This was expected, as the agent provided an external memory aid to Group One that was not available to Group Two. Most of the notes made on the scratch sheets simply recorded the price information found on the Web sites as they visited them.

Table 7-13 - Restructuring Activities

Restructuring Activity	Group One		Group Two	
	Number of subjects (%)	Number of operations	Number of subjects (%)	Number of operations
Used calculator	5 (28%)	5	9 (47%)	14
Used scratch sheet	3 (17%)	-	16 (84%)	-
Sorting operations	10 (56%)	21		
Grouping operations	7 (39%)	10		
Delete operations	6 (33%)	41		
Performed at least one of sort, group, and delete operations	15 (83%)			

7.8.10 Limitations

Obvious limitations to our study include the use of a convenience sample of university students, faculty and staff and the use of only one shopbot. Our results cannot therefore be generalized outside of this population or to the use of other shopbots or agent applications.

Regarding the first of these limitations, subjects in our sample demonstrated that they were comfortable using the WWW and by consenting to participate in the study, they demonstrated that they were willing to make an online purchase. We are interested in the potential adoption of shopbots in e-commerce. Innovators and early adopters, the first to adopt new products and ideas, have generally been found to be younger, more highly educated, and more widely read than the larger population (Rogers 1983; Spence 1994). These would be characteristics demonstrated by our sample. If our sample is biased, it would be biased towards adoption.

The use of only one shopbot is more limiting. Most Web-based shopbots present results as a list of links, similar to any typical search engine results and have more limited restructuring capabilities than those available in Copernic Shopper. However, we accepted these limitations because we were interested in how consumers would use these features. By observing sort, group and delete activities we were often able to gain some understanding of the choice processes our subjects employed. For example, if we observed someone grouping the alternatives by country, then examining only the alternatives within the Canadian group, we could deduce that he or she was using an attribute-based elimination strategy. While the use of Copernic Shopper limits the generalization of our results to other shopbots, it had the advantage of providing some insight into how consumers would use DSS-like features in a shopbot.

The adequacy of training and the effect of experience must also be considered. After viewing the training package only 5 Group One subjects took the offered opportunity to "practice" with the shopbot before they started their task. This provides some assurance that the subjects were satisfied with the training package. However it must be recognized that insufficient training may still be a factor in our results. Outside of the experimental setting, consumers may want to become much more familiar with the shopbot before actually using it for a purchase. With further experience using the shopbot it is expected that they could also reduce the time taken to search for and evaluate alternatives.

7.9 Summary

We were able to observe consumers' search and choice behaviours as they made real purchase decisions on-line. We believe that this is a start in "identifying the systematic effects of the technology on decision behaviour" (Elam et al. 1992, p. 59)

To summarize our results we return to our original general research questions.

- *Will use of a shopbot reduce the time and effort necessary to reach a decision?*

We found that use of the shopbot reduced the time that it took to reach a decision by one third, from approximately 15 minutes to 10 minutes. Rough estimates of search time per site for the other group suggest that the shopbot users reinvested about 25% of the time that they saved into additional evaluation.

- *Will consumers who use a shopbot make better decisions?*

  We found that consumers who used the shopbot made more informed decisions in that they were more likely to have determined the shipping cost as well as the item cost.

- *Will consumers who use a shopbot be more satisfied with the decision process?*

  We found that shopbot users were more satisfied with the decision process than the other group, but the difference in ratings was not large. However, when we later asked non-users to rate the shopbot and asked shopbot users to rate the unaided process, the shopbot was rated significantly higher.

- *Will consumers who use a shopbot be more confident in their decisions?*

  We found no evidence that shopbot users were more confident in the decision they made. Although our statistical tests did not show significant differences, a larger proportion of shopbot users decided to conduct additional search and a larger proportion changed their decision after such search. These results were in the opposite direction to that expected. This hypothesis should be revisited in future research.

- *Will use of a shopbot encourage purchase from the low-cost vendor?*

  While we were not able to provide statistical evidence that shopbot users bought more often from the least cost provider, graphical evidence suggests that there was a difference in the distribution of purchases to the stores between groups.

Our practical interest in this study was to learn whether consumers were likely to adopt the use of shopbots in this particular purchasing situation. Before we would expect consumers to find and learn to use a shopbot, they must see significant advantages. Three advantages could be that they: a) save time and effort, b) make better quality decisions, or c) have a more satisfying shopping experience.

In this purchasing situation, we found that shopbot users made better-informed decisions with less effort. It may be that our subjects reinvested some of their savings in time and effort into additional evaluation. Other researchers in behavioural decision theory have argued that consumers behave as "cognitive misers" because the feedback on effort reduction is more immediate than the feedback on accuracy maximization (Todd and Benbasat 1992). This would suggest that effort reduction would be more important than decision accuracy in the adoption question.

For adoption, consumers must consider the time and effort that it would take to find a shopbot and learn to use it. With potential savings of five minutes on a purchase, the consumer would have to expect to use the shopbot repeatedly, or expect to become much more efficient in making purchase decisions, before the time invested would pay off.

Shopbot users were slightly more satisfied with the decision process than those who did not use the shopbot, although this difference was only marginally significant. However, once each group had seen the process used by the other group, the comparative rating for the shopbot was significantly higher than the unaided process. This indicates that there is an awareness problem that needs to be addressed. None of the subjects who conducted additional search used another shopbot or "specialized search engine", suggesting that shopbots are not well known. Once our subjects were aware of the capabilities of the Copernic Shopper, there was a high level of interest.

We found no difference in how subjects rated their confidence in their decision. Some of the proposed explanations for this finding are barriers to adoption. However, if a consumer invested the time to find and learn to use a shopbot, they may feel like they are more in control of the process and with repeated use they may learn to trust the information that the shopbot presents.

Purchase frequency and risk were the dimensions of the purchasing situation framework that we developed in Chapter 6. In this experiment, we chose a music CD purchase because it was expected to be a familiar, low risk purchase for the sample we studied. Only 32% of our subjects had purchased a CD online before and the decision criteria for an online purchase would not necessarily be the same as those employed in the traditional retail environment. Perhaps shopbots will be perceived as more beneficial once consumers become more familiar with the e-commerce environment.

We attempted to set this experiment in a purchasing situation that would favour adoption according to the framework developed in Chapter 6. We also choose a shopbot that was designed according to some of the principles of the DSS approach to software agents that was described in Chapter 3. Overall, our results do not make a compelling case for the imminent adoption of this shopbot for the purchase of a music CD,

Chapter 8

Reflections and Conclusion

This dissertation presented a collection of research projects that have examined the potential for software agent applications in e-commerce. These projects considered software agents to be an innovation. Before innovations are adopted, they have to meet a real need and they should provide a significant improvement over the incumbent product or process. A significant improvement is required to offset both the tangible and intangible costs of change.

Understanding conditions for the widespread adoption of software agents in e-commerce is important for both researchers and practitioners. It is important for IS and management researchers to understand how this new technology may evolve and how and when it may change the way e-commerce is conducted. It is important for practitioners in e-commerce firms to be able to move quickly from research to viable applications.

To study agents as an innovation, we have taken a product-focused rather than a technology-focused approach to software agents. We have concentrated on the needs of the user and the problems they face in the e-commerce process. This approach has guided both the theory development we presented and the design of our empirical studies.

With this approach we have limited our research in some ways. We are investigating the use of agents in e-commerce, rather than the larger area of e-business. E-business would include intra-organizational and inter-organizational activities other than those directly associated with a sale or a purchase (e.g., human resources, logistics or planning). Other researchers are active in this area (e.g., Wang 1999). We also view commerce as a process. In this way we have built on early work by Maes et al. (1999). Market effects of software agents were not the major focus of this research. Both the market view of agents in e-commerce and the potential for agent applications in other areas of e-business are important areas of inquiry. They deserve attention, but are beyond the scope of this research.

8.1 Review

Software agent research is a new and emerging area with many contributing disciplines and diverse activity. Our first task was to find a way to organize this activity and to define the type of agent that would be included in this research. To do this we have presented a classification system that identifies three approaches to agents. These approaches lead to applications that present very different "faces" to the user. The research presented here focuses on only one of these three approaches – the DSS approach. This is a limitation to our research as applications from the CS/S and AI approaches also have potential for application in e-commerce. We believe however that applications representing the other approaches pose quite different sets of research questions representing large areas of inquiry in themselves and are also beyond the scope of this work.

We defined the three approaches to agents, including the DSS approach, and were able to show that others could reliably apply this classification system. We were therefore able to answer the first general research question that was posed in Chapter 2.

Question: *What kinds of agents are included in this research?*

Answer: This research investigates agents that fall under the DSS approach. These agents have the following characteristics:

- End users are aware that they are delegating some part of a decision-making or problem-solving task to a software agent.
- The end user has some level of interaction with the agent which can include one or more of: a) providing information, b) observing, c) intervening, d) receiving notifications or reports, and e) providing feedback.
- The end user is not encouraged to believe that the agent has human-like characteristics.

Having outlined our view of commerce as a decision-making process in Chapter 1 and defined the DSS approach to agents in Chapter 2, we then wanted to know how previous research in the DSS field might be applied to agent design and development. This investigation was prompted by similarities between commonly accepted DSS design principles and the design principles suggested by some agent researchers (e.g., Malone et al. 1997). When we looked at models and empirical studies from DSS research we were able to identify a number of areas that provide a foundation for agent research to build on. In Chapter 3 we presented our answers to our second research question:

Question: *How can we use theories and findings from DSS research to inform agent design and development?*

Answer: By segmenting problems into smaller components, we can accommodate the current limitations of AI technology and use different representations and reasoning systems for different parts of a problem. By building flexible boundaries and different levels of interaction users can learn to trust the agent and will be comfortable using the agent in different situations. By using interactive DSS-style development tools, agents can be easily customized by individual users. And finally, by adopting "usefulness" as a critical success factor, we acknowledge the fact that use of an agent is likely to be voluntary.

By considering agents as part of a larger DSS system, we were also able to develop a functional classification of software agents that we used to organize both our research and development frameworks. Agents that fall under the DSS approach can provide search support, choice support or interface support. Most of the agent literature on interface support falls under the AI approach. Although there are examples of interface support agent applications from the DSS approach, their study requires a focus on human-computer interaction that is again beyond the scope of this research. We therefore limited the remaining research work to search support and choice support agents.

The first framework presented in this dissertation is directed at research. Our product-focused approach to agents required that we first look at the needs of a user that might be met by a software agent, and then examine the technologies that might be capable of meeting these needs. This was the motivation behind the framework presented in Chapter 4 where we answered our next two research questions:

Question: *What knowledge does an agent require to support decision-making in e-commerce?*

Answer: The knowledge requirements developed in Chapter 4 represent a 'wish list' for intelligent agent support in e-commerce. Search support agents should know the location of information sources and the information needs of the user. They need to be able to formulate a search strategy, create representations and match the information retrieved to the needs of the user. To do this they must be provided with an ontology for the domain in which they are working and protocols to communicate with other systems.

Choice support agents need an ontology as well, to describe the alternatives to the choice problem. They should know the decision criteria that may be used, models and algorithms that can be applied to the problem, any procedures that have to be followed and negotiating strategies. To communicate with other systems they would have to know negotiation and transaction protocols.

Question: *What are the challenges to building knowledgeable agents in e-commerce?*

Answer: There are a number of technologies under development that have the potential to meet some of these needs (Table 4-1 and Table 4-2). Continuing research in information retrieval, management science, computer science and AI will all play important roles. Challenges related to the development and acceptance of standards for protocols and ontologies will require effective coordination and cooperation from the business community.

In many ways, the DSS approach that we developed in Chapter 3 can help address some of the current limitations to building truly knowledgeable agents. Interactive and flexible systems will allow the user to retain control of the parts of the decision-making task where an agent's knowledge is limited.

Chapter 5 presented an empirical study addressing one of the research challenges identified in our framework. Consumers have different modes of seeking pre-purchase information, and we would like to be able to develop search support agents that can recognize these different modes and recommend information that is appropriate to each mode. The exploratory research we conducted begins to answer our next general research question:

Question: *How can we design agents to support consumers in different information-seeking modes?*

Answer: We found that consumers in search mode were interested in specific product information, while those in browse mode were more interested in general information about the retailer. Information pertaining to prices, descriptions, selection and advice (such as product reviews or comparisons) were considered important by consumers in both modes. There were also significant differences in the use of some site navigation tools between modes. All of these findings can be used in future research to ask or infer the information-seeking mode that the consumer is in and then make it easy to access the tools or the specific type of information appropriate to that mode.

While there are limitations to the experiment that we conducted (use of a convenience sample, hypothetical purchasing situations, and only one search product) it was exploratory in nature and these results point to interesting areas for the future phases of this project.

In Chapter 6 we presented our second framework directed at the development and design of software agents in e-commerce. This framework identified characteristics of the purchasing situation that would be expected to influence the type of agent that is likely to be adopted. Buyers have different information needs in different situations and they employ different choice strategies. If an agent is to meet real needs and provide significant improvement over traditional purchasing processes, these needs and preferences must be recognized. In Chapter 6 we answered the following general research questions:

Question: *In what purchasing situations are agents most likely to be adopted?*

Answer: Buyers are likely to find search support agents useful across all purchasing situations. Choice support agents are expected to meet users' needs only in frequent, low risk purchasing situations.

Question: *What types of agents are most likely to be adopted in different purchasing situations?*

Simple search support agents (shopbots) should meet the needs of buyers making familiar and frequent purchases of a product. More complex content filtering agents will be required in less frequent purchasing situations and collaborative recommendation agents will be most useful in new, unfamiliar purchase situations.

Choice support agents such as negotiating agents can meet users needs in frequent low-risk purchases. In other situations, more traditional DSS systems can assist users to evaluate alternatives in the choice phase of decision-making but it is unlikely that the choice decision will be delegated to an agent.

In Chapter 7 we examined the use of a shopbot in a familiar and moderately low-risk purchasing situation - the purchase of a music CD. We examined the merchant-brokering phase of the purchase decision and could only study the use of one shopbot. We believe these limitations were balanced by our attempt to maintain external validity. Our subjects were making real purchases, from live e-commerce retail sites, using a commercially available agent application. The framework developed in Chapter 6 suggested that capabilities of this type of agent are well matched to the needs of users in this situation. Our general research questions and findings from Chapter 7 are summarized as follows:

Question: *How does the use of a simple search support agent affect consumer decision-making behaviour in the purchase of a music CD?*

Answer: We found that consumers using a shopbot make decisions in less time and with less effort than those who did not use the shopbot. They also made better-informed decisions, in that they were more likely to have both the item and shipping prices for the chosen alternative. Shopbot users were slightly more satisfied with the decision process than non-users. We found no significant differences between shopbot users and non-users in their confidence in their decisions, or their propensity to purchase from the low-cost vendor.

Question: *Is there sufficient improvement in decision-making to support adoption*?

Answer: While we found improvement in effort reduction, accuracy and satisfaction with the process, we were not convinced that these benefits outweighed the costs of adoption. Raising the awareness level will be a critical step towards widespread adoption, as our subjects rated the shopbot much more highly in post-task comparative evaluations. Consumers will have to expect to use a shopbot frequently in order to receive a return on the time and effort it will take to enter the trial stage. Frequent use could improve efficiency, providing increased returns on effort. Frequent use may also lead to improved confidence in the decision.

8.2 Future Research

We can identify a number of interesting areas for future research that follow on the theory development and empirical studies presented in this dissertation.

8.2.1 Approaches to Agents

Our classification of agents, according to whether they fit into the AI, CS/S or DSS approaches, may be useful in tracking the evolution of agent development. It is possible that agent research and development will become focused in one of these areas. It is also possible that, without a commonly accepted definition, the use of the term "software agent" will become restricted to only one of these approaches. A longitudinal study that applies our classification system to regular samples of literature over a number of years could identify if these changes are occurring.

8.2.2 Evaluation of Software Agent Applications

Our research provides some foundations on which to build research around the question of how to evaluate the performance of agents. Nwana and Ndumu (1999) point out that there has been little research on the evaluation of agents, specifically how we can determine if agent systems are adding value over conventional systems solutions. Our research shows that with differing objectives, we would expect different evaluation criteria for agents from each of the AI, CS/S and DSS approaches.

As we showed in Chapter 3, the functional classifications or search support, choice support and interface support suggest appropriate reference disciplines from which we can draw appropriate evaluation metrics specific to each function. Under the DSS approach, adoption and successful commercialization of agent systems will depend on the usefulness of these systems. An overall measure of usefulness should encompass performance in all or any of the search, choice and interface functions that the system performs.

In Chapter 3 we suggested that it would be appropriate to measure the performance of search support agents using metrics such as "precision" and "recall" from the field of IR. Other agent researchers have suggested the use of these and other traditional IR measures for evaluating search agent performance (e.g., Delicato et al. 2001; Chau et al. 2002; Menczer 2002). In Chapter 7 we determined and discussed the precision of the search results returned by the shopbot.

However, tests of precision and recall require a known set of documents and a common standard for relevance. In e-commerce the potential sources of information are extremely dynamic, and users' judgement about what information is useful may differ from individual to individual. IR researchers have proposed a set of "user-centered measures" to deal with dynamic sources and individual perceptions of relevance. Two user-centered measures are "coverage" and "novelty". "The coverage ratio is the fraction of documents known to the user to be relevant which has actually been received" and the novelty ratio is "the fraction of the relevant documents retrieved which was unknown to the user" (Baeza-Yates and Ribeiro-Neto 1999, p. 83). "A high coverage ratio would give the user some confidence that the system is locating all of the relevant documents; a high novelty ratio suggests that the system is effective in locating documents that he has never seen" (Korfhage 1999).

In the study on pre-purchase information seeking described in Chapter 5, we asked consumers to list the information items they expected to find before they began their task. After they had completed the task we asked them to list the information items that they had found useful. We are interested in developing future research that would use measures similar to novelty and coverage to determine how effectively Web-sites and search support agents provide product-related information. Instead of documents, these measures would count items of information about the product or the retailer. Relevance is determined by whether the user considers the information to be useful for decision-making. The determination of these measures is illustrated in Figure 8-1, where:

- *Coverage* = number of items "expected and found"/number of items "expected"
- *Novelty* = number of items "not expected and found"/number of items "found"

Analysis of the data obtained in the pre-purchase study determined coverage and novelty ratios for each participant, and average ratios for each task. The coverage ratio for our search task was 84% (i.e., 84% of the information that participants expected to find was found). The novelty ratio was 29% (i.e., 29% of the information used in decision-making was not information the participants were expecting to find). The coverage ratio for our browse task was 81% and the novelty ratio was 22%. We believe coverage and novelty measures could play a unique and effective role in the evaluation of search support agents.

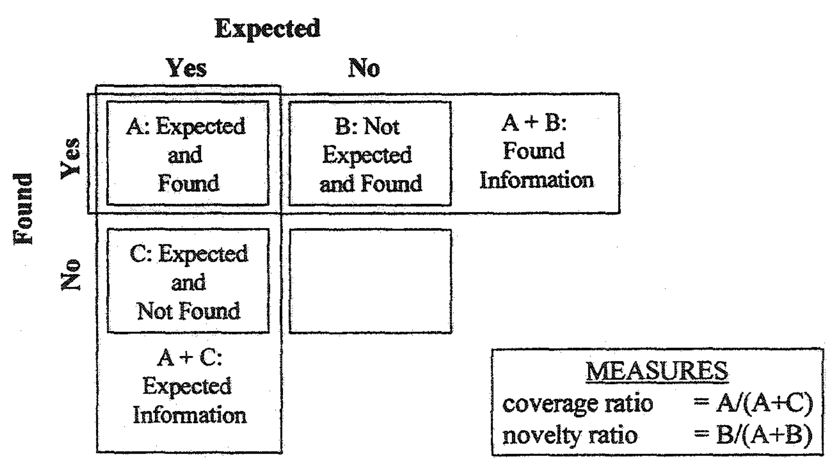

Figure 8-1 - Coverage and Novelty Measures for Evaluating Search Support

8.2.3 Further Investigation of Agent Use and Consumer Behaviour

Our study on the use of a shopbot examined only one of the purchasing situations identified in our development framework. The methodology that we used in this study can be applied to other purchasing situations and the use of other agent applications. This research would be useful in validating the development framework presented in Chapter 6. It would also be interesting to see whether we obtain similar results when consumers use available Web-based shopbots that typically display a list of links to search results but provide little support for EIP and restructuring activities.

One limitation of our shopbot study was that by giving the location of sources to both groups, we missed the opportunity to see how much value consumers place on this knowledge as part of the shopbot "package". A 2X2 factorial experiment could be designed to study aids that varied in both DSS-like capabilities and the knowledge of sources. When knowledge of sources is high, our Group One treatment would represent high DSS capabilities, and our Group Two treatment would represent low DSS capabilities. With low knowledge of sources, subjects would have to find suitable online stores themselves. When knowledge of sources is low and DSS capabilities are high a new treatment would provide the user with a spreadsheet/matrix application, similar to the format presented by Copernic Shopper, into which they could copy and manipulate information. When knowledge of sources is low and DSS capabilities are low, subjects would receive no assistance other than a web browser.

8.3 Contributions to Theory

The research presented in this dissertation has examined software agents and their applications in e-commerce from a management perspective. Because we have concentrated on what agents can do for their users, rather than the underlying technology, this research should be accessible and useful not only to IS researchers but to researchers in other management disciplines.

The DSS approach that we developed provides a way of integrating agent research into the large body of knowledge that has been developed through the study of DSS. By looking at the functions performed by search support agents, choice support agents and interface support agents, we have identified relevant reference disciplines (e.g., information retrieval, decision theory and human computer interaction, respectively) that can be used as foundations for future agent research.

The research framework presented in Chapter 4 identified research challenges that can and should be specifically addressed by management researchers as opposed to other disciplines. The development and design framework presented in Chapter 6 demonstrates how theories, models and research findings from marketing can guide agent research and development, and demonstrates the potential for collaborative research in this area.

Agents are still an emerging area of interest for IS research. The two empirical studies presented in this dissertation are first steps in understanding how users may benefit from agent technology. Both of these studies looked at real systems and applications. In Chapter 5 we examined consumer information needs in different information-seeking modes and how these needs were met by a sample of today's generation of retail Web sites. Through this study and the research that is to follow we hope to learn how consumers and retailers can exchange pre-purchase information more efficiently and effectively. Our experiment on shopbot use is a first step towards building a better understanding of the behavioural consequences of agent use. This and future research in this stream can identify opportunities for collaboration between the IS and behavioural decision-making fields (Elam et al. 1992).

8.4 Contributions to Practice

By taking a product-focused approach, rather than a technology-focused approach we also hope that this research is accessible and useful to both IS practitioners and managers in general. A better understanding of the opportunities for agent applications in e-commerce and the obstacles to their adoption can help managers develop IS strategies and plans that fit the strategic objectives of their organizations.

The research framework presented in Chapter 4 identified challenges for practitioners as well as for researchers. The development and acceptance of standards could play a large part in how agent applications evolve. We expect that the involvement of practitioners and support from industry will be crucial in the acceptance and implementation of these standards. The purchasing situation framework presented in Chapter 6 provides a roadmap for agent development and design. It points out application domains where agents are most likely to be adopted and the type of agent suitable for these domains.

The empirical studies reported in Chapters 5 and 7 should also be of interest to practitioners. Organizations that are developing agents for use in e-commerce can benefit through a better understanding of their users' needs. Chapter 5 starts to identify the information that consumers are expecting to find and the information they find useful when browsing and searching on retail Web sites. These findings can be used to design retail sites that better meet consumers' needs, regardless of whether or not agent technology is employed. Our study of shopbot use should be of interest to retail organizations as it identifies how consumers benefit from shopbot use as well as areas that still require attention before widespread adoption is likely to occur.

8.5 Conclusions

According to Nwana and Ndumu (1999), "a new field is only defined by its problems, not its methods/techniques" (p. 7). The research presented in this thesis has focused on the problems facing participants in the e-commerce process, rather on the technologies that software agents may employ.

There is substantial research activity in other disciplines that addresses the technical challenges to building knowledgeable agents. Once developed and accepted, these new technologies can be applied across many domains. We believe that it will be up to management and IS researchers and practitioners to define problems within the e-commerce domain and identify which technologies are applicable to solve these problems. We have used findings and models from marketing research to start to define and understand the needs of participants within the e-commerce domain.

Agent development also faces important challenges of a "social" nature (Norman 1997). To address these social challenges researchers and designers must recognize that there are important individual differences, task differences and situational differences that will play a role in when people are willing to delegate tasks to agents. A DSS approach to software agents acknowledges and accommodates these social challenges.

The decisions that people make, even in the simplest commercial transactions, are surprisingly complex. Applying principles developed in the study of DSS, complex problems can be segmented into simpler problems where an agent's knowledge requirements and representation can be matched to a specific task domain.

DSS design principles also promote the provision of flexible boundaries so that the user can decide when to delegate tasks to the agent and when to retain control over parts of the decision-making process.

Finally, agents will only be adopted if they can provide useful solutions to real problems and it will ultimately be up to the user to adopt or reject agent-based products that are developed and put on the market. DSS researchers have learned many lessons from studying successes and failures in the adoption of other types of decision support. This knowledge can be applied to focus agent development and design on providing useful systems that e-commerce participants will choose to use and accelerate the transition of agent applications from research settings into viable commercial applications.

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Appendix I

Exhibits for Chapter 2

Approaches to Software Agents – A User's Perspective

Instructions for Classifying Agents by Approach – Phase 1

Instructions for Classifying Agents by Approach – Phase 2

Articles used for Classification of Agent Applications

Krippendorf's Reliability for Content Analysis

Instructions for Classifying Agents by Approach

The classification system involves apply a set of "filters" to the applications described in the journal articles. The "Questions" below act as the filters. See Figure 1. "Cues" are characteristics or statements that may indicate that the agent application belongs in a certain category.

Filter 1 – the AI Approach

QUESTIONS:

- Is the agent application attempting to simulate "realistic" or "believable" human behaviour?
- Is the user supposed to believe (or suspend his or her disbelief) that they are interacting with a human or cartoon-like character?
- Does the application use agents in a "simulation" where the agents are used as actors, designed to respond in a realistic manner to certain events in the environment.

If you answer **YES** to any of the above questions, the agent application should be classified under the **AI Approach**

CUES:

- Use of natural language understanding and processing
- Anthropomorphism
- Agents with "emotions"

Filter 2 – The CS/S Approach

QUESTIONS:

- Is the user aware that the application is agent-based?
- Is there any interaction between the end-user and the agent application?

If you answered **NO** to any of the above questions, the agent application should be classified under the **CS/S Approach.**

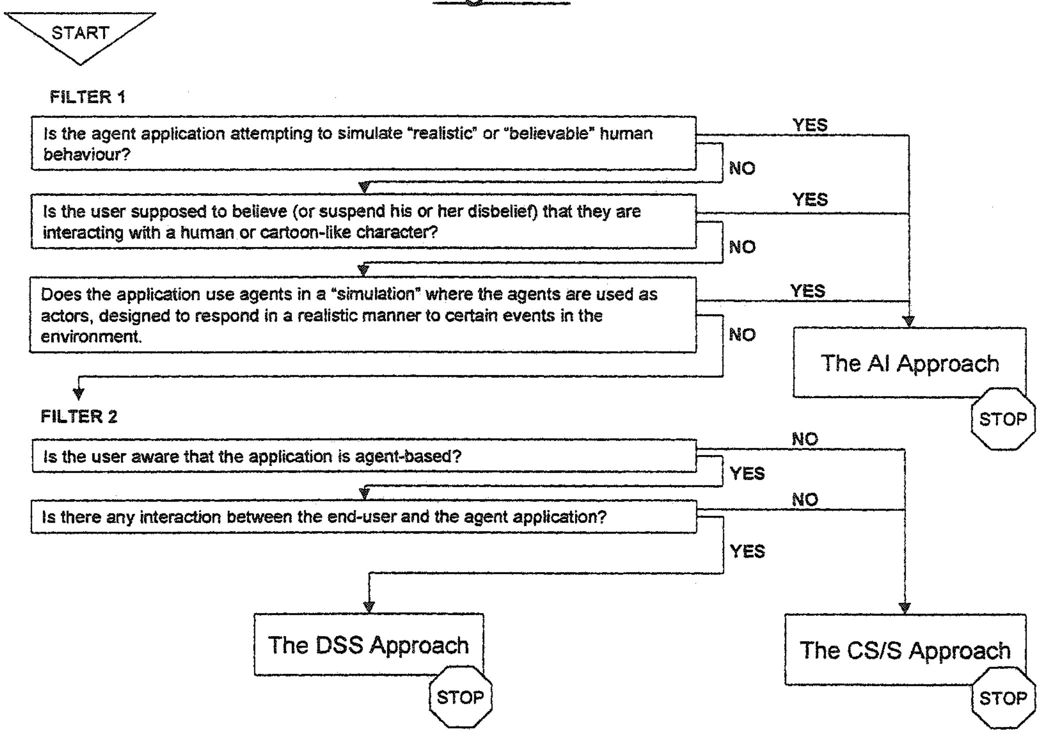
CUES:

- The agent's knowledge base is programmed by the systems designers during design and modified only by systems personnel once implemented.
- The agent application is described as "transparent" or "invisible" to end-users.
- Agents are used to facilitate decentralized or modular system design.
- Agents are used to facilitate distributed systems architecture and/or operation.
- Agents are used to reduce network loads or latency.
- Agents are used as "wrappers" to translate requests and responses from legacy systems.
- Agents are used to employ distributed problem-solving algorithms or concurrent processing.

The DSS Approach

We assume that all other applications will be classified under the **DSS Approach**. If the application passed Filter 2, end users have some level of interaction and are aware that they are delegating some part of a decision-making or problem-solving task to a software agent.

Figure 1


START
FILTER 1
Is the agent application attempting to simulate "realistic" or "believable" human behaviour?
YES
NO
Is the user supposed to believe (or suspend his or her disbelief) that they are interacting with a human or cartoon-like character?
YES
NO
Does the application use agents in a "simulation" where the agents are used as actors, designed to respond in a realistic manner to certain events in the environment.
YES
NO
The AI Approach
STOP
FILTER 2
Is the user aware that the application is agent-based?
NO
YES
Is there any interaction between the end-user and the agent application?
NO
YES
The DSS Approach
STOP
The CS/S Approach
STOP

Classifying Agents by Approach – A User's Prespective

Instructions for Phase 2

As discussed, the instructions for Phase 2 now reflect a prototypical or exemplar approach to the classification task, rather than a classical (rules-based) approach.

The listed characteristics are common to agents within the AI, CS/S and DSS categories. None of the characteristics are meant to be necessary or sufficient for categorization. You should place the application in the category where the listed characteristics are most similar to the characteristics of the application described in the article. Exemplars from Phase 1 of the Approaches to Agents study are listed for each category.

After you review each of the journal articles in Phase 2 of the study, please record which category best describes the application(s) discussed in the article on the attached sheet.

The AI Approach

CHARACTERISTICS:

- The agent application attempts to simulate "realistic" or "believable" human behaviour.
- The user is encouraged to believe that he or she is interacting with a human or cartoon-like character.
- The agent possesses anthropomorphic characteristics; Agents have "personalities" and/or display "emotions".
- The application uses agents in a "simulation": Agents are used as actors, designed to respond in a realistic manner to certain events in the environment.

EXEMPLARS OF THE **AI APPROACH** (from Phase 1)

1. **Interactive Characters**, (Hayes-Roth, Johnson et al)
2. **SIM AGENT (Tank Battle Simulation)**, Baxter and Hepplewhite
3. **The Synthetic Economy for Analysis and Simultation (SEAS)**, Chaturvedi & Mehta

The CS/S Approach

CHARACTERISTICS:

- There is no interaction between the end-user and the agent application; The agent application is described as "transparent" or "invisible" to end-users.
- The agent's knowledge base is programmed by the systems designers during design and modified only by systems personnel once implemented.
- The end user is *not aware* or does *not need to be aware* that the application is agent-based.
- Agents are used for one or more of the following reasons:
    - To facilitate decentralized or modular system design.
    - To facilitate distributed systems architecture and/or operation.
    - To reduce network loads or latency.
    - As "wrappers" to translate requests and responses from legacy systems.
    - To employ distributed problem-solving algorithms or concurrent processing.

EXEMPLARS OF THE **CS/S APPROACH** (from Phase 1)

1. **NetChaser**, DiStephano & Santoro
2. **ISES Load Balancing**, Gustavsson (1)
3. **Lycos**, Green and Pant
4. **Domain Name Exchange (DNX)**, Gannoun, Francioli et al

The DSS Approach

CHARACTERISTICS:

- End users are aware that they are delegating some part of a decision-making or problem-solving task to a software agent.
- Agents can provide support for any of the following:
    - Search activities
    - Choice activities
    - Dialogue/interaction between the user and the system

- End users have some level of interaction with the agent; This interaction can include:
    - Providing initial information or parameters for a task
    - Observing the agents' actions and intervening if desired.
    - Notification of the agents' actions or proposed actions.
    - Receiving exception reports from the agent.
    - Providing feedback to the agent
- The end user is not encouraged to believe that the software agent has human-like characteristics.

EXEMPLARS OF THE **DSS APPROACH** (from Phase 1)

1. **Bounded Information Gathering (BIG)**, Lesser, Horling et al
2. **Nomad**, Sandholm & Huai
3. **ISES Smart Building**, Gustavsson (2)
4. **Agents that Buy and Sell**, Meas, Guttman et al
5. **Socialware**, Hattori, Ohguro et al
6. **Karma-Teamcore**, Tambe, Pynadath et al
7. **Sci-Agents**, Drashansky, Houstis et al
8. **Virtual Enterprise**, Jain, Aparicio IV et al

Articles used for classification of agent applications

PHASE 1	
1	[Chaturvedi et al. 1999]
2	[Baxter et al. 1999]
3	[Hayes-Roth et al. 1999]
4	[Di Stephano et al. 2000]
5	[(1) Gustavsson 1999]
6	[Green et al. 1999]
7	[Lesser et al. 2000]
8	[Gannoun et al. 2000]
9	[Sandholm et al. 2000]
10	[(2) Gustavsson 1999]
11	[Maes et al. 1999]
12	[Hattori et al. 1999]
13	[Tambe et al. 2000]
14	[Drashansky et al. 1999]
15	[Jain et al. 1999]
PHASE 2	
1	[Chau et al. 2002]
2	[Wang et al. 2002]
3	[Menczer 2002]
4	[Blum et al. 2002]
5	[Turowski 2002]
6	[West et al. 2002]
7	[Miranda et al. 2001]
8	[Hornby et al. 2001]
9	[Karacapilidis et al. 2001]
10	[Muller et al. 2001]
11	[Nelson 2001]
12	[Tewari et al. 2002]
13	[Delicato et al. 2001]
14	[Arcelli et al. 2002]
15	[Benyoucef et al. 2001]
16	[Camacho et al. 2001]
17	[Jonker et al. 2001]
18	[Kim et al. 2002]
19	[Nissen 2001]
20	[Torrens et al. 2002]

(See next three pages for full references.)

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Baxter, J. and R. Hepplewhite (1999). "Agents in Tank Battle Simulation." *Communications of the ACM* 42(3): 74-75 March, 1999.

Benyoucef, M., H. Alj, M. Vezeau and R. U. Keller (2001). "Combined Negotiations in E-Commerce: Concepts and Architecture." *Electronic Commerce Research* 1: 277-299

Blum, J. and A. Eskandarian (2002). "Enhancng intelligent agent collaboration for flow optimization of railroad traffic." *Transportation Research* Article in Press Accepted December 4.

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Di Stephano, A. and C. Santoro (2000). "NetChaser: Agent Support for Personal Mobility." *IEEE Internet Computing* 4(4): 74-79 March - April, 2000.

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Gannoun, L., J. Francioli, S. Chachkov, F. Schutz, J. Hulaas and J. Harms (2000). "Domain Name eXchange: A Mobile-Agent-Based Shared Registry system." *IEEE Internet Computing* 4(2): 59-64 March - April, 2000.

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Jonker, C. M. and J. Treur (2001). "Agent-based Simulaltion of Animal Behaviour." *Applied Intelligence* 15: 83-115

Karacapilidis, N. and P. Moraitis (2001). "Building and agent-mediated electronic commerce system with decision analysis features." *Decision Support Systems* 32: 53-69

Kim, B.-i., R. J. Graves, S. Heragu and A. St.Onge (2002). "Intelligent agent modeling of an industrial warehousing problem." *IIE transactions* 34: 601-612

Lesser, V., B. Horling, A. Raja, X. Zhang and T. Wagner (2000). "Resource-Bounded Searches in an Information Marketplace." *IEEE Internet Computing* 4(2): 49-58 March - April, 2000.

Maes, P., R. H. Guttman and A. G. Moukas (1999). "Agents that Buy and Sell." *Communications of the ACM* 42(3): 81-91 March, 1999.

Menczer, F. (2002). "Complementing search engines with onlin web mining agents." *Decision Support Systems* Article in Press

Miranda, F. R., J. E. Kogler, E. D. M. Hernandez and M. L. Netto (2001). "An artificial life approach for the animation of cognitive characters." *Computers and Graphics* 25: 955-964

Muller, W., U. Spierling, M. Alexa and T. Rieger (2001). "Face-to-face with your assistant. Realization issues of animated user interface agents for home appliances." *Computers and Graphics* 25: 593-600

Nelson, M. (2001). "Buckets: A new digital library tecnology for preserving NASA research." *Journal of Government Information* 28: 369-394

Nissen, M. E. (2001). "Agent-based Supply Chain Integration." *Information Technology and Management* 2: 289-312

Sandholm, T. and Q. Huai (2000). "Nomad: Mobile Agent System for an Internet-Based Auction House." *IEEE Internet Computing* 4(2): 80-86 March - April, 2000.

Tambe, M., D. V. Pynadath and N. Chauvat (2000). "Building Dynamic Agent Organizations in Cyberspace." *IEEE Internet Computing* 4(2): 65-73 March - April, 2000.

Tewari, G., J. Youll and P. Maes (2002). "Personalized location-based brokering using an agent-based intermediary architecture." *Decision Support Systems* Article in Press

Torrens, M., B. Faltings and P. Pu (2002). "SmartClients: Constraint Satisfaction as a Paradigm for Scaleable Intelligent Information Systems." *Constraints* 7: 49-69

Turowski, K. (2002). "Agent-based e-commerce in case of mass customization." *International Journal of Production Economics* 75: 69-81

Wang, H., S. Liao and L. Liao (2002). "Modeling constraint-based negotiating agents." *Decision Support Systems* 33: 201-217

West, L. A., Jr. and T. J. Hess (2002). "Metadata as a knowledge management tool: supporting intelligent agent and end user access to spatial data." *Decision Support Systems* 32: 247-264

Krippendorff's Reliability for Content Analysis

---

r = number of articles

m = number of coders

alpha = 1 – (Do/Dc)

where

Do = observed disagreement

Dc = expected disagreement

The computational form of this equation is:

Alpha = 1 – ((rm-1)/(m-1))(numerator/denominator)

numerator = $\sum_i \sum_b \sum_{c>b} n_{bi} n_{ci} d_{bc}$

denominator = $\sum_b \sum_{c>b} n_b n_c d_{bc}$

where b and c are possible values of the categories variable

Krippendorff, K.(1980) Content Analysis. Beverly Hills, Sage Publications.

Phase 1

Article number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Author	AI	AI	AI	CS	CS	CS	DS	DS	DS	DS	DS	DS	DS	DS	DS		
Coder 1	AI	AI	AI	CS	CS	CS	DS	CS	DS	CS	DS	DS	DS	CS	DS		
Coder 2	DS	AI	AI	CS	CS	CS	DS	CS	DS	DS	DS	AI	CS	CS	DS		denominator
n1i	2	3	3									1				n1=9	9x15
n2i				3	3	3		2		1			1	2		n2=15	9x21
n3i	1							1	3	2	3	2	2	1	3	n3=21	15x21
																	=639
numerator	2							2		2		2	2	2		=12	

r = 15 and m=3

numerator = 2+2+2+2+2+2 = 12

denominator = (9*15) + (9*21) +(15*21) = 639

Alpha = 0.59

Phase 2

Article number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Author	DS	DS	DS	DS	CS	CS	AI	AI	DS	AI	CS	DS	DS	CS	DS	DS	AI	CS	DS	DS		
Coder 1	DS	DS	DS	CS	CS	CS	AI	AI	DS	AI	CS	DS	DS	CS	DS	DS	AI	CS	DS	DS		
Coder 2	CS	DS	DS	DS	CS	CS	AI	AI	DS	AI	CS	CS	DS	CS	DS	DS	AI	CS	DS	CS		Denominator
n1i							3	3		3							3				n1=12	12x19
n2i	1			1	3	3					3	1		3				3		1	n2=19	12x29
n3i	2	3	3	2					3			2	3		3	3			3	2	n3=29	19x29
																						1127
numerator	2			2								2								2	8	

r = 20 and m=3

numerator = 2+2+2+2+2+2 = 8

denominator = (12*17) +(12*31) +(17*31) = 1127

Alpha = 0.79

Appendix II

Exhibits for Chapter 5

Pre-Purchase Online Information Seeking:

Search versus Browse

Product-Related Coding Categories

Retailer-Related Coding Categories

Interface-Related Coding Categories

Product-Related Coding Categories

Level 1	Level 2	Level 3	Description
PRODUCT			Pertains to information displayed about a product
	AESTHETICS		Information about what the product looks like
		PICTURE	About seeing pictures/images of the product
		COLOUR	About viewing products in its various colours
		SIZE	About the physical size of the product
		OTHER	Other Aesthetics
	DESCRIPTION		A written description of the product
		GOOD	+ve aspects about the product description
		POOR	-ve aspects about the product description
		NAME	Brand or product names explicitly mentioned
		OTHER	Other Description
	MANUFACTURER		Information about who makes the product
		NAME	Mention of the manufacturer's name
		REPUTATION	About the manufacturer's reputation
		OTHER	Other Manufacturer information
	PRICE		Any mention of product price, discounts, rebates
		AMOUNT	A specific dollar amount displayed for a product
		RANGE	A dollar value range displayed for a product
		COMPLETE	About seeing all or complete product pricing info
		DISCOUNT	About product discount or sale information
		REBATE	About product rebate information
		GOOD	About the price being good (cheap, reasonable)
		POOR	About the price being poor (high, expensive)
		OTHER	Other Price
	QUALITY		Information about product quality
		GOOD	+ve aspects of product quality
		POOR	-ve aspects of product quality
		OTHER	Other Quality
	RELIABILITY		Information about product reliability & warranties
		GOOD	+ve aspects about product warranty
		POOR	-ve aspects about product warranty
		OTHER	Other Reliability
	SPECS	SPECS	Product specifications (features & performance)

Retailer-Related Coding Categories

Level 1	Level 2	Level 3	Description
RETAILER			Pertains to information displayed about a retailer
	ADVICE		About info the retailer to assist decision-making
		GUIDES	Buying guides (wizards)
		REVIEWS	Consumer or expert reviews/ratings
		FAQS	Frequently-asked questions
		HELP	About needing help or explanations of terminology
		COMPARISONS	Product comparisons
		RECOMMENDATIONS	Includes gift ideas, suggestions, recommendations
		OTHER	Other Advice
	AVAILABILITY	AVAILABILITY	About the retailer having the product in stock
	DELIVERY		Information about the delivery of online purchases
		COST	About costs pertaining to shipping/delivery
		TIME	About time delivery windows for product shipping
		METHOD	About how shipping process works
		OTHER	Other Delivery
	POLICY	POLICY	About the retailer's policies (returns, privacy, etc.)
	REPUTATION	REPUTATION	About the retailer's reputation.
	SELECTION		Information about the variety of products available
		CANNOT-FIND	Cannot find the specific product desired
		OFFERS	Offers or does not offer the desired product
		GOOD	+ve aspects of the variety or # of products to choose
		POOR	-ve aspects of the variety or # of products to choose
		OTHER	Other Selection
	SERVICES		Info about the services offered by the retailer
		GIFTWRAP	Giftwrap
		CUSTOMER	Customer service/support or technical support
		OTHER	Other Service

Interface-Related Coding Categories

Level 1	Level 2	Level 3	Description
INTERFACE			How information on the Web site is displayed
	CONTEXT		Refers to a site's general functionality and form
		ORGANIZATION	Organization of information and product offerings
		NAVIGATION	About navigation of the Web site
		SPEED	Speed at which the Web site loads
		AESTHETICS	Site aesthetics (e.g., colour scheme, clutter, font)
		OTHER	Other Context
	CONTENT	CONTENT	About the quality of information displayed
	COMMERCE		Ability of the site to handle aspects of eCommerce
		SECURITY	Security
		PRIVACY	Privacy
		PAYMENTS	Credit card transactions
		ORDER-FULFILLMENT	Order fulfillment
		TRUST	Trust
		OTHER	Other Commerce

Appendix III

Exhibits for Chapter 7

Shopbot use and Consumer Behaviour

Online Stores used in Shopbot Experiment

Training Presentation on Copernic Shopper

Questionnaire 1

Questionnaire 2

Supplementary Questionnaire

Samples of Agent Results and Subject Logs

Behavioural Observations

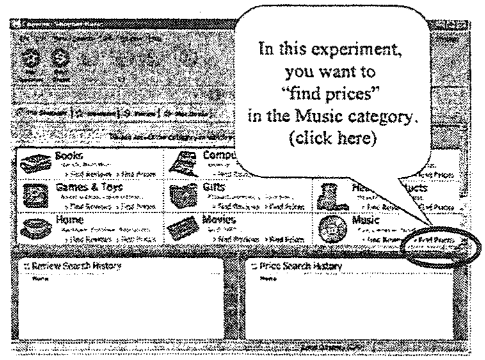
Online Stores used in Shopbot Experiment

Country	Code	Store	URL
CA	ABSO	A&B Sound	http://www.absound.ca/
US	ALLE	Allegro Music	http://www.allegro-music.com/
CA	AMCA	Amazon.ca	http://www.amazon.ca/
US	AMCO	Amazon.com	http://www.amazon.com/
CA	ARCH	Archambault	http://www.archambault.ca/store/default.asp
US	BARN	Barnes and Noble	http://bn.bfast.com/
US	CDCO	CD Connection	http://www.cdconnection.com/
CA	CDPL	CD Plus	http://www.cdplus.com/
US	CDUN	CD Universe	http://www.cduniverse.com/
US	CHEA	Cheap CDs	http://cheap-cds.com/
US	CYBE	Cybermusic	http://www.cybermusicsurplus.com/
US	DUFF	Dufflebag	http://www.duffelbag.com/
CA	FUTU	Future Shop	http://www.futureshop.ca/
CA	HMV	HMV	http://www.hmv.com/
CA	MUSI	Music Selection	http://www.musicselection.com/
CA	MYMU	My Music	http://www.mymusic.com/
US	SPUN	Spun	http://www.spun.com/

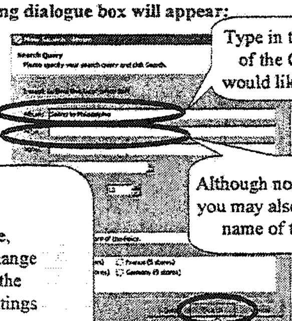
Introduction to Copernic Shopper™

Susan Sproule
Fall, 2002

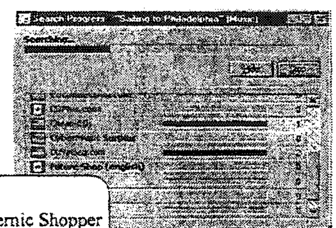
Copernic Shopper will search for many different types of products



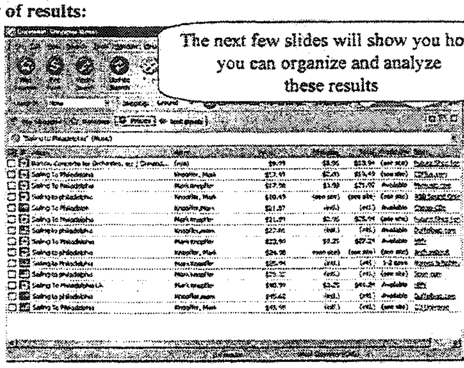
The following dialogue box will appear:



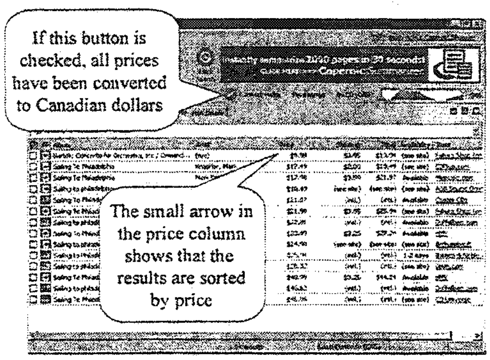
You will see a new window that shows the progress of the search as Copernic Shopper checks on-line music stores and builds its list of results:



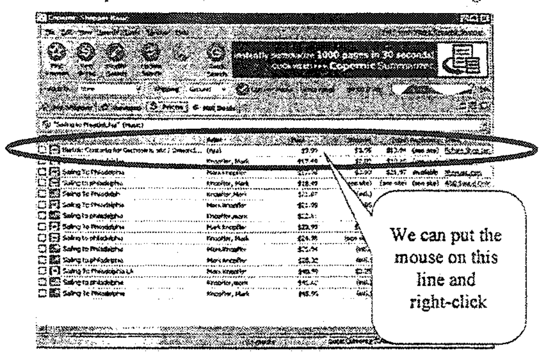
When Copernic Shopper has completed its search, you will see a list of results:

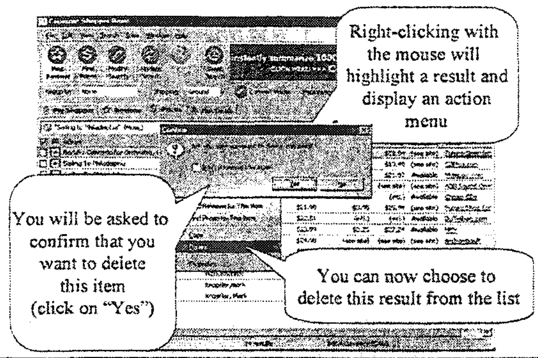


Copernic Shopper has already done some work for you:

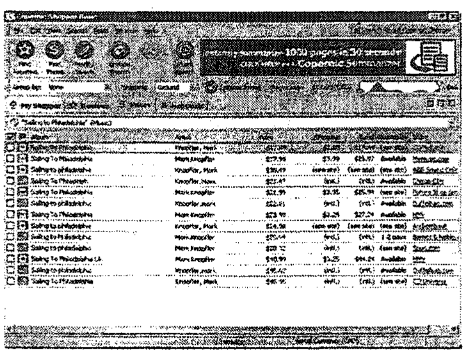


You may want to get rid of results that are not relevant.
In this example the first result is not the CD we are looking for:

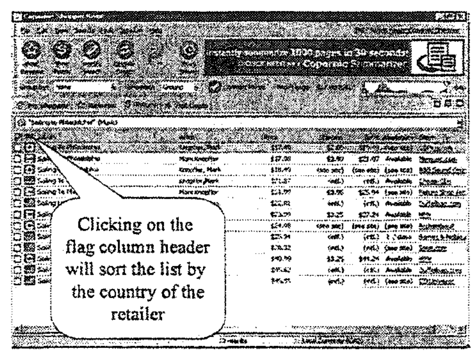




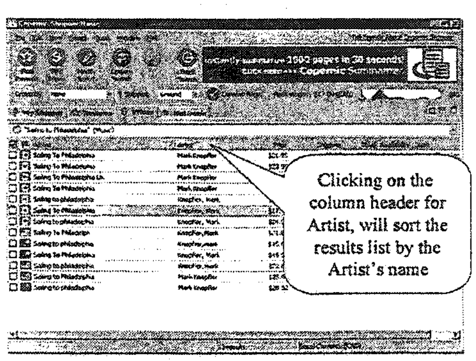
This item has now been removed from the list.



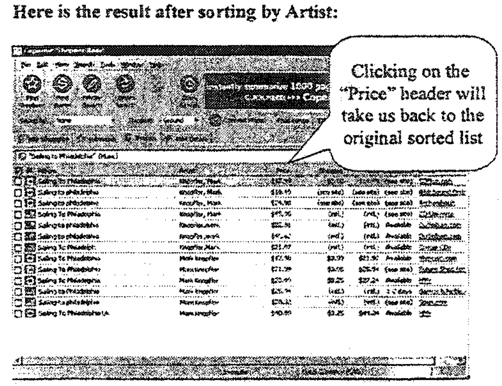
We can also sort by any of the other column titles:



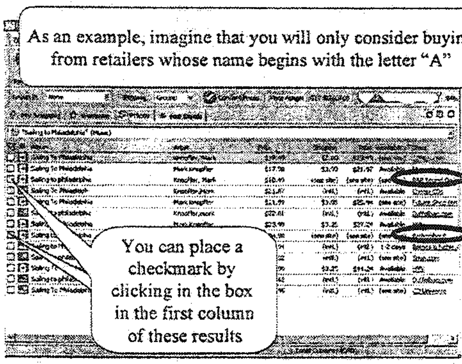
Here is the result after sorting by country:

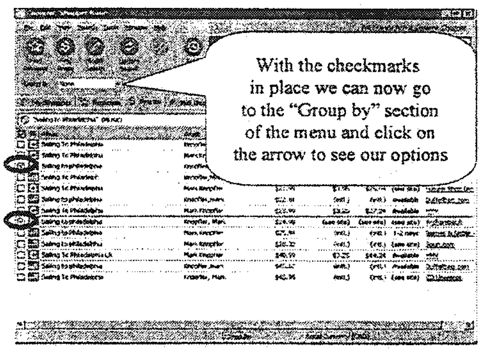


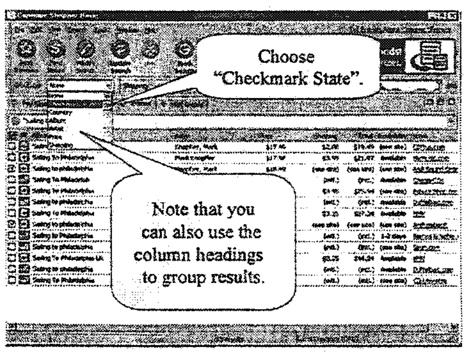
Here is the result after sorting by Artist:



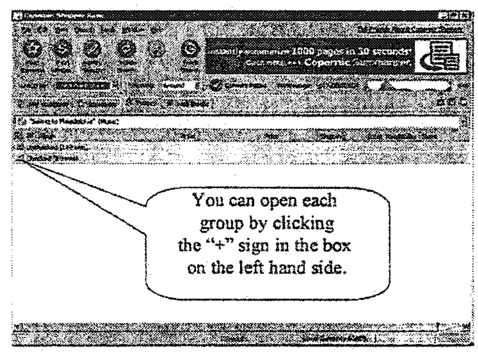
Results can be grouped by using the checkboxes:



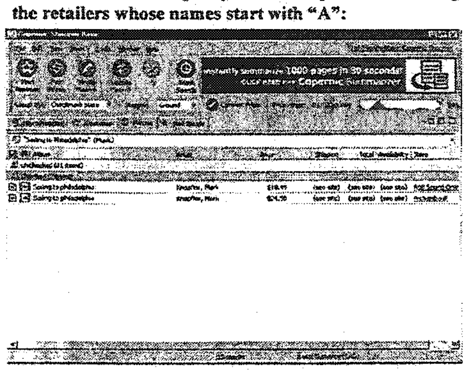




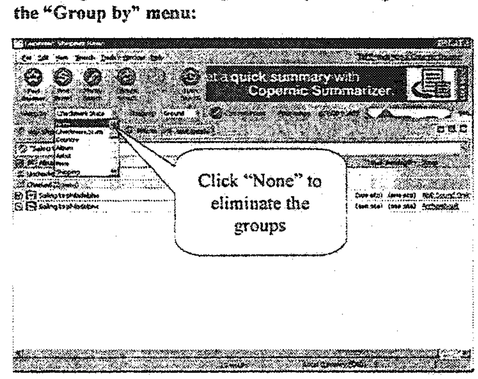
The results list now contains two groups of results (checked and unchecked).



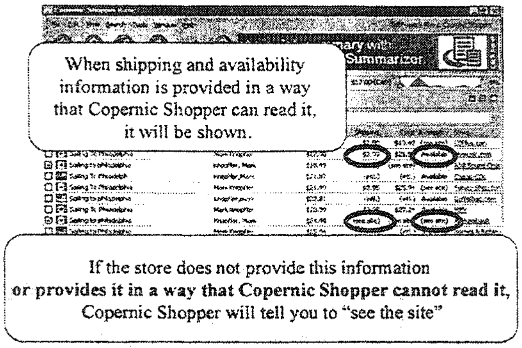
Here the "Checked" group has been opened, containing only the retailers whose names start with "A":

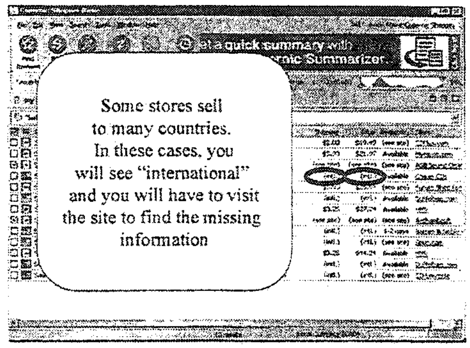


We can go back to the original list by choosing "None" from the "Group by" menu:

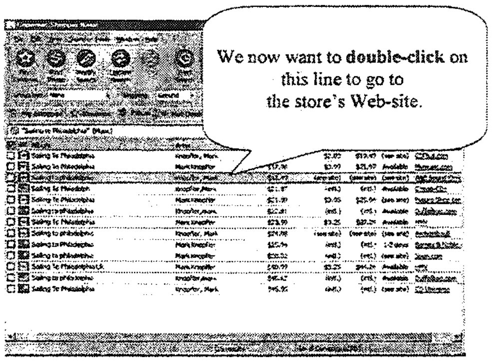


We are now ready to find out more information about our purchase options.

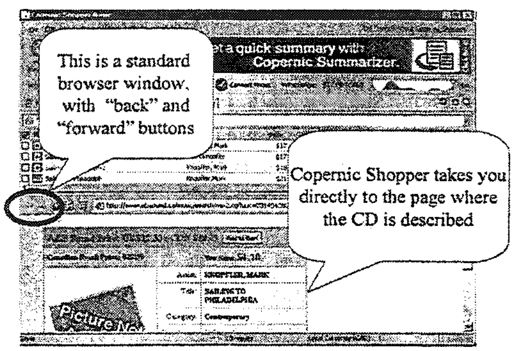




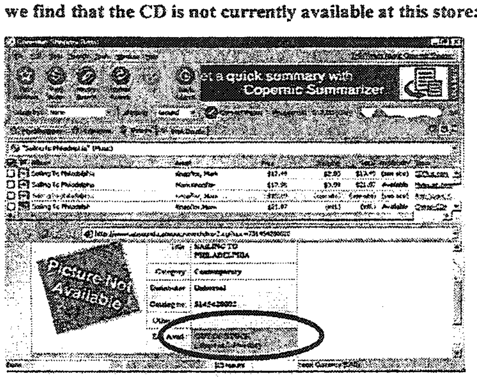
Single-clicking on a line of the results will highlight that result:



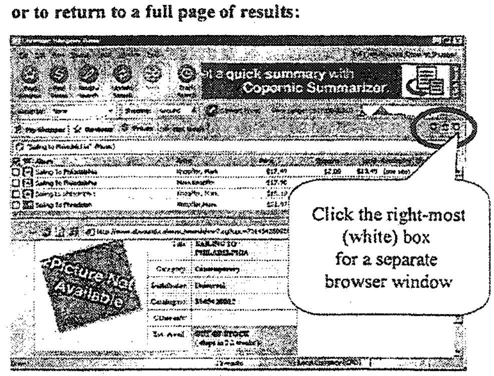
A new window is opened at the bottom of the page:



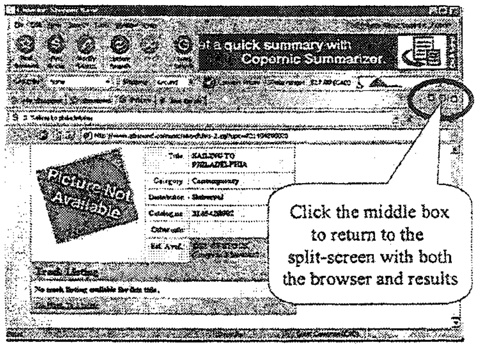
When we scroll down to see the rest of the page, we find that the CD is not currently available at this store:



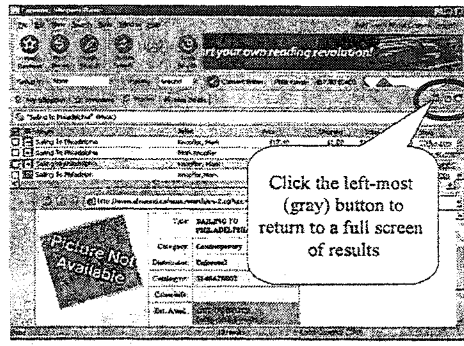
You can choose to view the browser in a separate window, or to return to a full page of results:



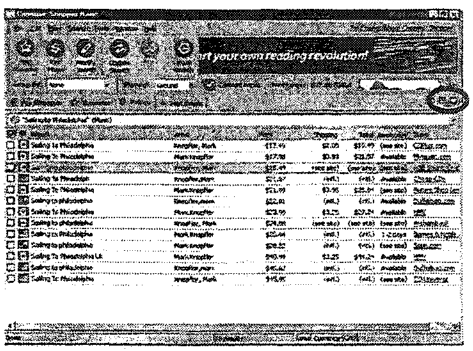
This is what you will see:



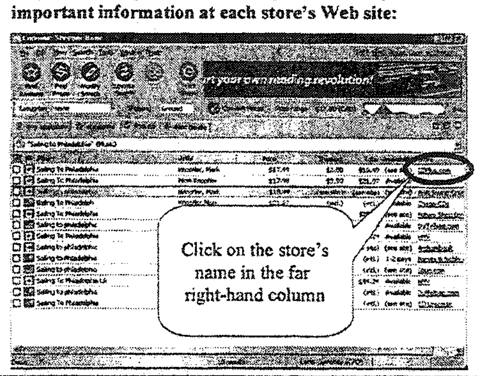
This is what you will see:



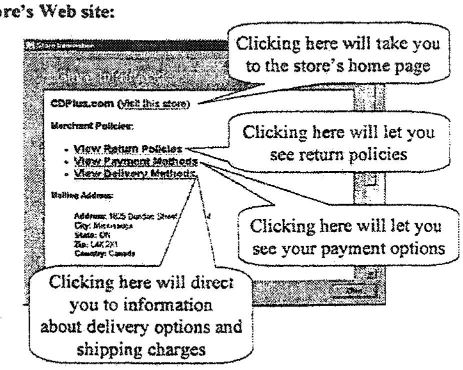
You can return to the browser window by clicking the full screen or split screen buttons.



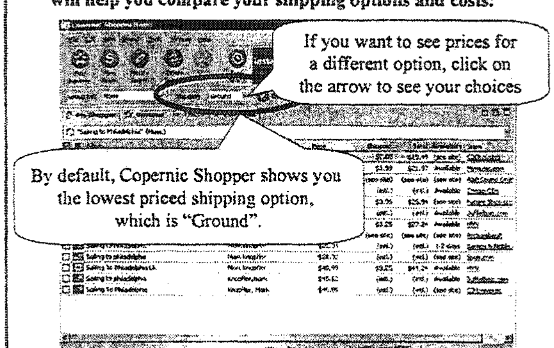
Copernic Shopper will also take you to directly to other important information at each store's Web site:

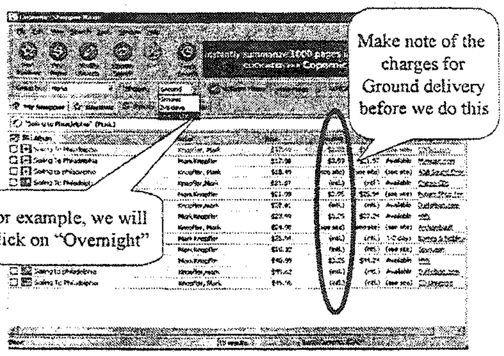


A new window will appear with 4 direct links to the store's Web site:

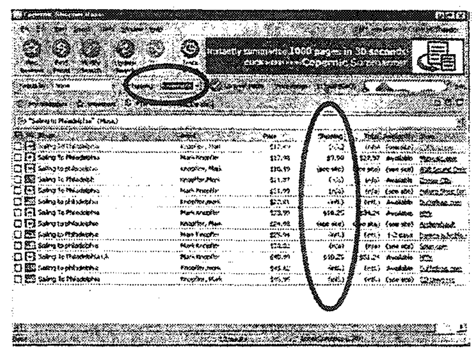


While we are on the subject of delivery, Copernic Shopper will help you compare your shipping options and costs:

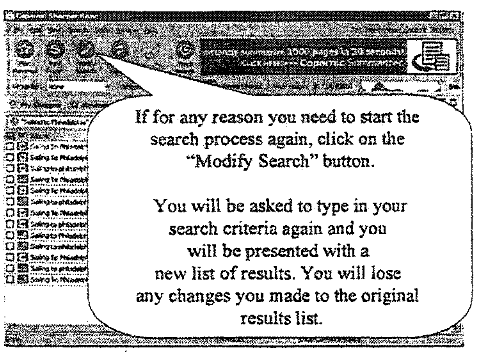




Copernic Shopper is now showing charges for overnight delivery:



This completes the introduction to Copernic Shopper:



Thank you and enjoy shopping!

QUESTIONNAIRE 1

1. **What music CD would you like to purchase?**

Name of the album? ______________________________

If known, name of artist or group? ______________________________

2. **What price range do you expect to find in your on-line search...**

a) for the CD?

Lowest price? _________$CDN

Highest price? _________$CDN

Average price? _________$CDN

b) for the CD plus shipping (total)?

Lowest price? _________$CDN

Highest price? _________$CDN

Average price? _________$CDN

3. **Gender**

❐ Male

❐ Female

4. **Age**

❐ under 18

❐ 18-25

❐ 26-30

❐ 30-50

❐ over 50

5. **University association**

❐ undergraduate student

❐ MBA student

❐ Other graduate student

❐ Staff or faculty member

❐ Other/none

6. **Have you looked for information on music CDs on-line before?**

❐ Never

❐ Once

❐ 2-5 times

❐ More than 5 times

7. **Have you purchased a music CD on-line before?**

❐ Never

❐ Once

❐ 2-5 times

❐ More than 5 times

QUESTIONNAIRE 2

Please indicate your agreement with the following statements:

	Strongly Disagree						Strongly Agree
This was a good way to make my purchase decision.	☐	☐	☐	☐	☐	☐	☐
I would use this same process again to buy a music CD on-line.	☐	☐	☐	☐	☐	☐	☐
The time and effort I used to make my decision were well spent.	☐	☐	☐	☐	☐	☐	☐
If my friend wanted to buy a music CD, I would be likely to recommend this process.	☐	☐	☐	☐	☐	☐	☐
This process was useful in helping me to make the best purchase decision.	☐	☐	☐	☐	☐	☐	☐
This process took too much time to reach a decision.	☐	☐	☐	☐	☐	☐	☐
I feel I have made a good purchase decision.	☐	☐	☐	☐	☐	☐	☐
There are probably other alternatives that I should have examined.	☐	☐	☐	☐	☐	☐	☐
I feel comfortable purchasing this CD from this retailer.	☐	☐	☐	☐	☐	☐	☐
This is clearly the best purchase decision in this situation	☐	☐	☐	☐	☐	☐	☐
I would make this same decision if I had to make the decision again.	☐	☐	☐	☐	☐	☐	☐
I am not sure that I should make this purchase.	☐	☐	☐	☐	☐	☐	☐

SUPPLEMENTARY QUESTIONS

Please indicate your agreement with the following statements:

	Strongly Disagree						Strongly Agree
This would have been a good way to make my purchase decision.	❑	❑	❑	❑	❑	❑	❑
I would use this process the next time I wanted to buy a music CD on-line.	❑	❑	❑	❑	❑	❑	❑
This process would make better use of my time and effort.	❑	❑	❑	❑	❑	❑	❑
If my friend wanted to buy a music CD, I would be likely to recommend this process.	❑	❑	❑	❑	❑	❑	❑
This process would have helped me to make the best purchase decision.	❑	❑	❑	❑	❑	❑	❑
This process would take too much time to reach a decision.	❑	❑	❑	❑	❑	❑	❑

Sample of Agent Results (Group 1)

		Item price	Shipping price	Total price (from agent)	Total price	Availability (from agent)	Store
Descriptive Statistics							
COUNT		7	7	2	7		
AVERAGE		$19.99	$5.11		$25.10		
MIN		$14.99	$2.00		$18.49		
MAX		$28.04	$7.03		$35.07		
STDEV		$4.31	$1.65		$5.43		
Agent Results							
A Rush of Blood to the Head	Coldplay	$14.99	$4.94	$19.93	$19.93	1-2 days	Amazon.ca
A Rush Of Blood To The Head	Coldplay	$16.49	$2.00	$18.49	$18.49	(see site)	CDPlus.com
A Rush of Blood to the Head	Coldplay	$17.74	$6.20 (intl.)		$23.94	1-2 days	Barnes & Noble.com
Rush of blood to the head, a	Coldplay	$19.99	$4.74 (see site)		$24.73	(see site)	Archambault
A Rush Of Blood To The Head	Coldplay	$20.72	$6.25 (intl.)		$26.97	3-7 days	GoHastings.com
Rush of blood to the head	Coldplay	$21.98	$4.60 (see site)		$26.58	(see site)	CDconnection.com
Rush of blood to the head	Coldplay	$28.04	$7.03 (intl.)		$35.07	(see site)	Spun.com

Sample of Subject Log (Group 1)

STORE	COUNTRY	FOUND BY AGENT			dominated	EXAMINED			OTHER RETAILER INFO		
		album	ship	avail	(Y/N)	album	ship	avail	returns	payment	other
ABSO	CA										
ALLE	US										
AMCA	CA	1	1	1	N						
AMCO	US										
ARCH	CA	1	0	0	Y						
BARN	US	1	0	1	N						
CDCO	US	1	0	0	Y						
CDPL	CA	1	1	0	BEST	1		1			
CDUN	US										
CHEA	US										
CYBE	US										
DUFF	US										
FUTU	CA										
GOHA	US	1	0	1	Y						
HMV	CA										
MUSI	CA										
MYMU	CA										
SPUN	US	1	0	0	Y						
TOTALS	**sum**	7	2	3		1	0	1			
	count	7	7	7		1	0	1			

- indicates chosen alternative

Sample of Agent Results (Group 2)

		Item price	Shipping price	Total price (from agent)	Total price	Availability (from agent)	Store
Descriptive Statistics							
COUNT		12	12	4	12		
AVERAGE		$15.36	$4.88		$20.25		
MIN		$10.90	$2.00		$13.26		
MAX		$17.98	$7.83		$24.11		
STDEV		$2.30	$1.79		$3.29		
Agent Results							
Starry Night	Iglesias,Julio	$10.90	$2.36 (intl.)		$13.26	Available	Cheap-CDs
Starry Night	Iglesias, Julio	$12.49	$2.00	$14.49	$14.49	(see site)	CDPlus.com
Starry night	Iglesias, Julio	$13.49	$6.95 (see site)		$20.44	(see site)	A&B Sound Online
Starry Night	Iglesias, Julio	$14.17	$7.83 (intl.)		$22.00	(see site)	CD Universe
Starry Night	Julio Iglesias	$14.99	$4.94	$20.89	$19.93	1-2 days	Amazon.ca
Starry night	Julio Iglesias	$15.14	$4.60 (see site)		$19.74	(see site)	CDconnection.com
Starry Night	Julio Iglesias	$15.40	$6.25 (intl.)		$21.65	3-7 days	GoHastings.com
Starry Night	Julio Iglesias	$16.98	$3.99	$20.97	$20.97	Available	Mymusic.com
Starry Night	Julio Iglesias	$16.99	$3.25	$20.24	$20.24	(see site)	HMV
Starry night	Iglesias,julio	$17.91	$5.48 (intl.)		$23.39	Available	Duffelbag.com
Starry Night	Julio Iglesias	$17.91	$6.20 (intl.)		$24.11	1-2 days	Barnes & Noble.com
Starry night	Iglesias,julio	$17.98	$4.74 (see site)		$22.72	(see site)	Archambault

Sample of Subject Log (Group 2)

STORE	COUNTRY	LOOKED	FOUND			OTHER RETAILER INFO			AGENT	dominated
		1=Yes	album	ship	avail	returns	payment	other	FOUND	(Y/N)
ABSO	CA								1	N
ALLE	US	1								
AMCA	CA	1	1		1				1	Y
AMCO	US	1	1							
ARCH	CA								1	Y
BARN	US								1	Y
CDCO	US	1							1	Y
CDPL	CA	1	1						1	BEST
CDUN	US								1	N
CHEA	US								1	N
CYBE	US	1								
DUFF	US	1							1	Y
FUTU	CA									
GOHA	US								1	Y
HMV	CA	1	1						1	Y
MUSI	CA	1	1	1						
MYMU	CA	1	1						1	Y
SPUN	US									
TOTALS	**sum**	10	6	1	1	0	0	0	12	
	count	10	6	1	1	0	0	0	12	

- Indicates chosen alternative

Behavioural Observations

GROUP ONE	GROUP TWO
◆ Time from query submission to return of results set ◆ Number of relevant results returned ◆ Restructuring activities performed (Sort, Group, Delete, Calculate, Use of blank sheet) ◆ Alternatives (presented by the agent) investigated ◆ Number of "price dominated" alternatives searched for additional information ◆ Total number of pages viewed ◆ Number of unique pages viewed ◆ Found the least cost provider (Y/N) ◆ Chose the least cost provider (Y/N)	◆ Restructuring activities performed (Calculate, Use of blank sheet) ◆ Number of stores visited ◆ Number of pages viewed ◆ Number of unique pages viewed ◆ Found the least cost provider (Y/N) (determined after the researcher conducted a search using the agent) ◆ Chose the least cost provider of those found (Y/N)