DESIGN AND DEVELOPMENT OF A SITUATED DECISION SUPPORT SYSTEM FOR PERSONAL FINANCE MANAGEMENT

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Abstract

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With the rapid advancement of computer and Internet technology and availability of data and information, the need for decision support is continuously growing. In this context, a new vision of Decision Support Systems (DSSs) called situated DSS (SDSS) has been proposed. The key distinguishing features of SDSS include a tight connection with the problem environment, proactive decision supports, and decision implementation. In this work, a layered model of a SDSS is presented. The model includes three layers: the reactive layer, operational layer, and judgmental layer. Since the layered model is structurally different compared to the traditional type of DSS, a new method for designing and development is proposed. The model and method are illustrated through a personal finance management SDSS prototype. The results of the empirical test are presented and discussed.

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1. Introduction

The research of Decision Support Systems (DSSs) started around 30 years ago. Researchers have defined DSSs as interactive computer systems that help users make decisions using data and models (Keen and Morton 1978; Sprague and Carlson 1982). Initially, DSSs were only designed to assist managers to make decision in organizations (Turban and Aronson 2001). With the fast advancement of computer and Internet technology and the rapid growth of available information, DSSs have been introduced outside of business organizations and developed to satisfy individuals' needs for everyday decision making (Luo, Liu et al. 2002). However, many traditional DSSs offer passive types of decision support, where the decision making process is isolated from the environment and depends on the decision maker's initiative. In today's complex and dynamic environment, passive types of decision support are no longer sufficient to meet decision makers' needs. To meet the new challenges, a vision for a new type of DSS, named situated DSS (SDSS) has been recently introduced (Vahidov and Kersten 2003; Vahidov and Kersten 2004). SDSSs are systems that directly and actively connect with, evaluate and act upon the current problems in the environment.

While the original generic model of a SDSS seems to be able to facilitate research and development, it is important to further organize the components of the model into different levels of abstraction in order to provide structure to the characteristics and functionalities of the DSS components that would facilitate communication. Since the model of a SDSS is substantially different from the conventional DSS, in order to lay a solid scientific foundation for the researchers to work on its design and development, it is important to propose a development method to facilitate its construction for practical applications. After the conceptual model is further developed, it is important to illustrate the model using a functioning prototype in a specific problem domain. This procedure allows empirical investigation of the value of the concept, and its contribution towards improved performance by the decision makers.

The purpose of this work is to illustrate and investigate the effectiveness of the layered model of a situated DSS. Specifically, this work prepares (1) to present a layered model of SDSS; (2) to outline a method for the development of a situated DSS; (3) to illustrate the model and method proposed using the area of personal finance management; and (4) to empirically assess the effectiveness of a situated DSS and its value to the prospective adopters. Section 2 presents the theoretical background for the conceptual model of a situated DSS. It mainly builds upon the active DSS and real-time DSS paradigms and research in software agents. Section 3 presents the conceptual layered model of a SDSS. In section 4, we propose a new method for designing and developing a SDSS. Section 5 describes the research methodology of this study. It includes an illustration of the proposed approach using personal finance management DSS, the research hypotheses and measures, the design of the empirical experiment, and the results of statistical analysis. The thesis ends with the conclusions and the discussion of directions for future research.

2. Background

2.1 Decision Support Systems: Recent Developments

Decision support systems (DSS) was one of the most popular topic in information systems research (Brancheau and Wetherbe 1987; Claver, Gonzales et al. 2000). The development of the concept and the design of DSSs started in the seventies (Shim, Warkentin et al. 2002). Early decision support systems were computer programs that could be used to support managerial decision makers in solving semistructured and unstructured problems (Moore and Chang 1980; Sprague and Carlson 1982). A typical DSS application was composed of several subsystems which include a data management subsystem, a model management subsystem, a knowledge management subsystem and an user interface subsystem (Turban and Aronson 2001). In the early stage, development of DSSs emphasized data analysis support and decision modeling (Moore and Chang 1980). Early DSSs were human-machine problem solving applications in which the system dealt with the structural portion of a specific problem, while decision makers dealt with the unstructured part (Shim, Warkentin et al. 2002). Traditional types of DSSs support decision making passively, meaning that they utilize models for analyzing decision making situations through explicit commands and directions given by users (Rao, Sridhar et al. 1994).

Recently, the increases in information volume, the Internet, and the advent of improvements in communication technology led to a business environment that is more complex and connected (Shim, Warkentin et al. 2002; Vahidov and Kersten 2004). In this fast-changing and complex business environment, the need for decision support is expected to increase. At the same time, new technologies, such as the Internet, advanced database management tools, and software agents enable new types of DSSs to be developed to meet this need. Among all the DSSs extended from the conventional model, those that can actively support decision making in timely fashion attract the most attention from researchers (Silver 1990; Eom 1999).

One of the most significant changes in the business environment is the increase in the speed of market change. As market conditions change rapidly, quick decisions need to be made with the most up-to-date information. To fulfill this need, real-time decision support systems (RDSSs) have been developed. The aim of RDSSs is to provide up-to-date information, and "guarantee end-to-end response time" to decision makers (Delic, Douillet et al. 2001). RDSSs have several characteristics which distinguish them from traditional DSSs. RDSSs are characterized as continuously monitoring the environment, gathering timely data from managed systems, and quickly generating views appropriate and useful for decision makers to make timely decisions (Chaturvedi and Hutchinson 1993; Delic, Douillet et al. 2001; Filip, Donciulescu et al. 2002). RDSSs have been developed in several domains. Chaturvedi and Hutchinson (1993) developed FMS-DSS, an RDSS for flexible manufacturing system (FMS) scheduling and control. The FMS-DSS acquires knowledge from historical data, manages objectives and inaccurate data, and supports real-time decision making. Aronsky and Hang (1999) developed an RDSS for diagnosing and managing patients. This RDSS constantly monitors the emergency department to identify patients who have particular diseases, and are eligible for health care services. RDSSs are also used in traffic management in which timely decisions have to be made. Zografos, Androutsopoulos et al. (2002) developed an RDSS for roadway network incident response.

As mentioned, traditional DSSs offer passive decision support in which the process of decision making is controlled by the user's initiative (Rao, Sridhar et al. 1994). Active DSSs (ADSS) are developed to change the role of DSSs in decision making; it actively participates in the decision making process. The user is no longer the only party that takes initiative; the system would be able to perform certain actions on behalf of the user without getting specific commands (Raghavan 1991; Rao, Sridhar et al. 1994; Carlsson and Walden 1999). Raghavan (1991) designed JANUS, an active DSS which consists of four major functional components: knowledge bases; elicitation, which includes an agent for active suggestion making; analysis, which analyzes problems and critiques agents' suggestions; and user interface, which serves as the communication channel between the user and the system. Unlike JANUS, in which a central knowledge base and an intelligent agent are used, Rao, Sridhar et al. (1994) designed an active DSS in which decision making is distributed among several agents and each agent has its own knowledge base.

A more recent research stream in DSS is about combining the essential features of the real-time and active DSSs. This new type of DSS is closely connected to the environment (Vahidov and Kersten 2004), and responds to changes by automating much of the work (Hinkkanen, Kalakota et al. 1997). Vahidov and Kersten (2004) defined this type of DSS as "situated DSS". Besides the essential components of traditional DSSs, a situated DSS has sensors and effectors which closely and actively link the system to the problem environment. A situated DSS constantly senses the problem area, generates alerts, utilizes data, models and knowledge to provide decision support, implements decision on behalf of the user, and continuously monitors the user's activities (Vahidov and Kersten 2004). Two key characteristics distinguish situated DSSs from the previous types of DSSs: connectiveness and proactiveness. Connectiveness refers to the close links between the system and the problem environment. With the close links, a situated DSS can get information from the environment and react to the changes in a timely manner. Proactiveness refers to the capability of supporting decision and monitoring environment without getting direct commands from the user.

2.2 DSS and Software Agents

Software agent technology has been defined differently by different researchers. One often cited definition was given by Russel and Norvig (1995). They described an agent as "anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors" (Russel and Norvig 1995). This definition of software agent is used in this study because the concepts of sensors and effectors will be included in the design of our system. Agents have several characteristics that can distinguish themselves from other software programs. Agents are proactive; they sense the environment and act on changes proactively. Agents are autonomous; they act on behalf of the users automatically. Agents are intelligent; they can perform cognitive activities. Finally, agents are connected; they can communicate with other agent systems, other software applications and users (Wooldridge and Jennings 1995; Nwana 1996; Nwana and Ndumu 2000).

Traditional DSSs support decision making by providing user access to a data and models "toolbox". This passive type of decision support is considered less useful in today's dynamic business environment. Back in the late eighties, researchers started to advocate an active approach of decision making support (Manheim 1988). The improvement in computer technology and artificial intelligence in the later years made it feasible to incorporate software agents with DSSs. Software agent technology plays an innovative, active, and important role in the design and development of DSSs. With built in software agent technology, a DSS is no longer viewed as a tool, it is considered an active and autonomous decision making assistance to the users (Bui and Lee 1999).

Software Agent and ADSS. The software agent is the essential building block of active DSSs (ADSS). Being proactive, connective, and autonomous, agents can effectively facilitate active decision support. Balducelli, Costanzo et al. (2000) developed an agent-based ADSS to support planning in emergency management. The system includes three agents: a direct advisor agent, an automatic planner agent, and the info provider agent. The direct advisor agent is designed to interact with the user; the information provider agent accesses database to collect information; and the automatic planner agent is responsible for providing a recommendation of action. The use of agents allows the system to actively provide planning support for resource allocation to improve the efficiency of emergency actions.

Software Agents and RDSS. Software agents play a critical role in the success of a real-time decision support system (RDSS). Agents are built into RDSSs to enhance the ability of sensing the environment and reacting to changes. Agents can work in the back-end to support decision making in real-time. Lam, Cao et al. (2002) developed an RDSS to support airport gate assignment decision making. The intelligent agent was built into the system as a main module to determine the candidate gates for aircraft. Agents can also work in the front-end to sense the changes in environment in real-time. The stock market is one of the areas in which changes happen in real-time and updated information is a critical element of success. Luo, Liu et al. (2002) incorporated intelligent agents in their RDSS for stock trading. In their system, agents monitor the status of stocks continuously and communicate with users to collect requests and deliver results.

Software Agents and SDSS. Software agents make it feasible to create both connectiveness and activeness in traditional DSSs to build situated decision support systems (SDSS). Maes (1995) argued that intelligent systems which incorporate agent technology are situated in space and in time of the problem environment. An agent's capability of sensing can be used to monitor the problem domain in order to discover problems, and seek and collect information used in decision making (Vahidov, Chen et al. 2005). An agent's capability of reacting can be used to actively act on and react to the environment in the implementation stage after the decision is made. Furthermore, like traditional DSSs, SDSS can use data, models, and knowledge to support decision making. An agent-based distributed DSS for supply chain management was developed by Hinkkanen, Kalakota et al. (1997). This DSS comes close to the notion of a situated DSS. Three types of agents are included in this system: a raw materials inventory agent, a production agent, and a finished goods inventory agent. Every agent is specialized in one particular problem area and takes action to optimize operations. The agents obtain information electronically and implement decisions automatically by electronic channels such as EDI, electronic messages, etc. By using agents, this DSS is considered both active and situated.

2.3 DSS for Personal Finance Management

Personal finance is an area that has been largely neglected by DSS researchers.

There are many fields in personal finance management such as planning and budgeting, cash flow control, investment, taxation, and insurance (Kapoor, Dlabay et al. 2001). The decision process in the field of financial management involves the analysis of a large amount of data and performing calculations in real-time. The applicability of DSSs to these kinds of tasks has led researchers to the design and implementation of DSSs to fields of stock trading (Luo, Liu et al. 2002) and investment decision making (Palma-dos-Reis and Zahedi 1999; Vahidov and Fazlollahi 2004).

Unlike other fields in financial management, personal finance is about individuals. Individuals with different profiles need different levels of decision support. Palma-dos-Reis and Zahedi (1999) argued that DSSs for investment decision should be personalized in order to fit an individual investor's personal needs. They proposed a framework for personalized DSSs which includes four modules: a personalizing module, a meta-selection module, a selection methodologies module, and a database module. The personalizing module is used to learn a user's profile and customize decision rules accordingly. The meta-selection module is the "intelligent interface" which communicates with the user through a personalized interface. The selection methodologies module carries out the selected methodology for decision making, and the database module stores all the necessary data. The system that they developed builds a user profile base on age, gender, and attitude towards risk and uses this profile to make the best recommendation.

Due to the complexity in financial management, distributed problem solving is believed to be an effective way of providing real-time decision support to the user (Luo, Liu et al. 2002). In distributed problem solving, multiple and cooperative intelligent agents communicate with each other to solve problems in a specific domain. This complex architecture requires a more comprehensive design. Researchers therefore built a framework based upon the human decision process (Vahidov and Fazlollahi 2004). The design was implemented by a DSS that helps individual users make investment decisions. The design includes three groups of agents: the intelligent group, which collects information from sources; the design group, which generates proposals of sets of promising securities; and the choice group, which critiques the proposals generated by the design group based on several criteria which include the source of advice, investment returns, user preferences, and risk of the securities selected.

3. A Layered Model of Situated Decision Support System

3.1 Components of Situated Decision Support System

The generic architecture of a SDSS consists of four major components: sensors, effectors, a DSS kernel, and active interfaces (Vahidov and Kersten 2004). To sense the changes in the environment, sensors are designed as an important component in SDSSs. To act on those changes, effectors are built to send altering signals and implement decisions. Besides sensors and effectors, the DSS kernel in SDSSs contains the essential parts of a traditional DSS: data, models, and knowledge. The active component in the DSS kernel is the "DSS manager" (Vahidov and Kersten 2004). The DSS manager actively assesses the generated decisions according to the up-to-date situation, generates corrective actions if necessary, and keeps updating the information contained in the kernel. The last component included in a SDSS is the active user interfaces. The active interface connects users and the system. It gathers users' information, requirements, and decision activities; it also delivers altering signals, recommendations, and decisions generated by the system to users.

3.2 The Layered Model

Layered architecture was introduced by researchers of intelligent agents. They argued that agent systems are complex, especially multi-agents systems. Agents span several levels of abstraction and the operation of agents depends highly on the neighboring levels (Kendall, Krishna et al. 1998; Lemon, Cavedon et al. 2003). Layered architecture is a clear solution to organize agents in different levels of abstraction with control methodology (Fischer, Müller et al. 1995).

The layered model was first proposed by Müller and Pischel (1995). They developed inteRRaP, an application which incorporated the Hybrid agents. Hybrid agents are agents that combine aspects of reactive agents and deliberative agents. Reactive agents perform in the simplest sensing and reacting manner, they respond quickly to the sensed information, and they require little support infrastructure (Namee and Cunningham 2001). Deliberative agents are more sophisticated. They have built-in models and they utilize the models to propose plans in order to achieve goals. The inteRRaP application was integrated into a hybrid architecture which is a layered model. The model contains three layers: a layer for reactive action, a layer for deliberative actions, and a layer for cooperative actions. The authors argued that a layered model can make the multi-agent environment more structured and organized; it can also facilitate coherent action and interaction between agents.

It is useful to apply the layered model to the architecture of a SDSS because of the following reasons: 1) the active components in a SDSS are carried out by intelligent agents. Sensors, effectors, managers and active user interfaces are all active components in a SDSS; 2) the components in a SDSS have clear and distinct responsibilities and capabilities; 3) the operations of certain components such as the DSS kernel highly depend on the information provided by other components such as the sensors. Due to these reasons, we believe that a layered model is appropriate in representing the organizations and operations of a SDSS.

The components in a SDSS are separated into three layers: the reactive layer, which includes the sensors and effectors; the operational layer, which is the DSS kernel; and the judgmental layer, which includes the active user interface and the user. The layered model is illustrated in figure 1.

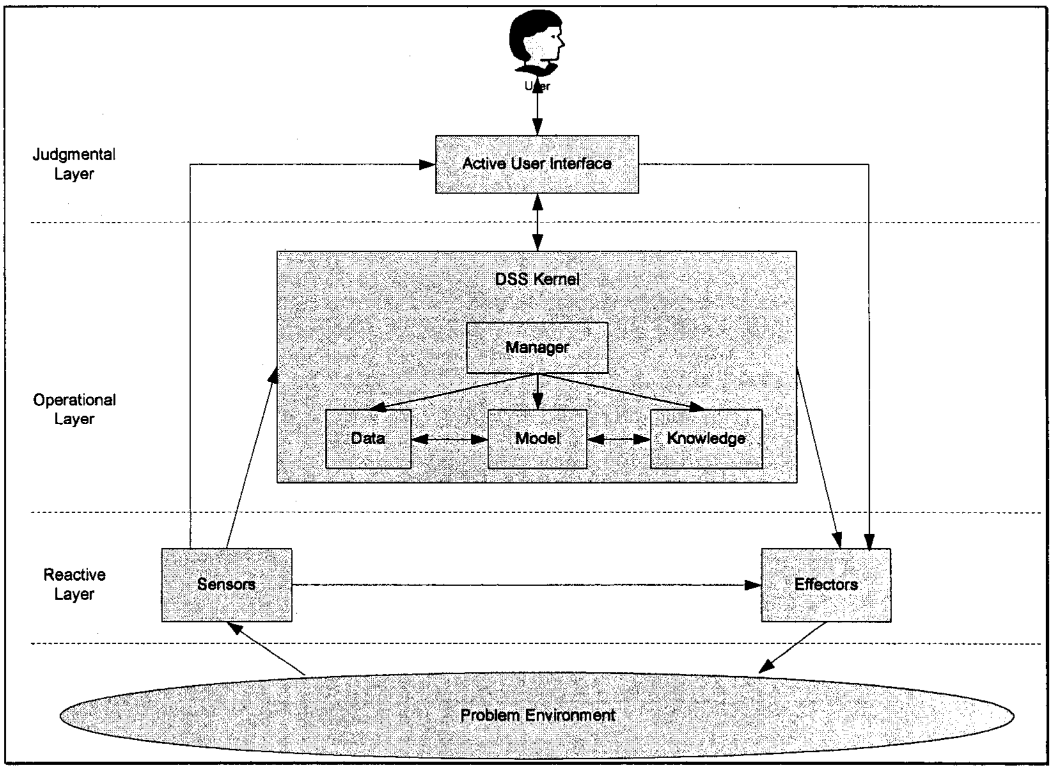


Figure 1. A layered model of SDSS

3.3 Reactive layer

The reactive layer contains the components that connect to the problem environment. It is the layer through which the system can sense changes in the environment and act on those changes. In SDSSs, sensors and effectors are the components included in the reactive layer. According to Vahidov and Kersten (2004), the capabilities of sensors include the ability to access information in the environment, process this information, generate alerts when immediate action is required, adapt itself to different environments, and make plans for the actions described above. The capabilities of effectors are similar to those of sensors, but function in the opposite direction. Effectors can connect to the environment to implement the decision generated by the system. They also query additional information from the environment when necessary, and adapt their abilities according to the changes in the environment. Similar to sensors, effectors are able to plan all the actions by themselves.

The idea of a reactive layer had originated from reactive agents. Reactive agents are able to respond to a stimulus in the environment (Kendall, Krishna et al. 1998); they can recognize emergency situations and deal with them directly (Fischer, Müller et al. 1995). Sensors in the reactive layer actively respond to stimuli in the environment. Once changes are sensed, they process the information and send it to the DSS kernel for further processing. If the user's judgment is required, sensors generate alerts and communicate with the user through the active interface. If immediate action is required, quick decisions can be made by sensors and implemented by effectors. However, not all decisions can be handled this way; only authorized situations are allowed.

3.4 Operational layer

The middle layer of the model is the operational layer. It contains the DSS kernel, which includes the traditional DSS components (data, models, and knowledge) and the DSS manager. Data, models, and knowledge are the passive elements of the DSS kernel, and the DSS manager is the active component (Vahidov and Kersten 2004). In the operational layer, data is stored, information is analyzed, alternative solutions are generated, and recommendations are made.

The component of data in the DSS kernel is responsible for storing relevant data of a certain domain and the data gathered by the sensors and the active user interface. The model component includes financial, mathematical, or other quantitative models that provide the kernel's analytical capabilities. The component of knowledge contains the relevant expert knowledge of the domain which provides intelligence to the decision making.

In addition to the above components, the DSS manager in the DSS kernel is what distinguishes SDSS from the traditional type of DSS. The DSS manager has a knowledge base which contains business and decision rules of the problem domain that enable it to control the operations of data, models, and knowledge. The DSS manager enables the analysis of the situation and provides decision support without the user's direct command. However, this capability is not applied in all situations. Only situations within the given authorization limits are allowed, otherwise, the user's judgment is needed from the active interface in the judgmental layer.

3.5 Judgmental layer

The judgmental layer is the topmost layer. It contains the active user interface and the user. It is called judgmental layer because in this layer, the user communicates with the active user interface to make judgments. The user's involvement is one of the major differences between DSSs and autonomous agents. In DSSs, the user is considered part of the system (Turban and Aronson 2001). The user's judgment is crucial for DSSs since the role of a DSS is not to replace the decision maker, but to assist decision making by providing recommendations. However, in the traditional type of DSS, the interaction between the decision maker and the system is intensive. The complexity of the DSS and its interface have become one of the major problems that prevent its effective use by decision makers (Vahidov 2005). To reduce this complexity, a recent stream of research is to design and develop intelligent and active user interfaces by using intelligent agents (Hejley and Murray 1993; Sproule and Archer 2000; Vahidov 2005).

The active user interface is an intermediary which connects the decision maker and the system. It transfers input from the user to the system and output from the system to the user. It generates alert signals to the user and queries for additional information if necessary. It maintains and updates the user's profile in order to personalize the communications and decision-making support. For example, if the active interface detects that the user spends most of his money on food every month, the interface may infer that the user is biased towards food purchases. This characteristic is considered in all the related analysis in the system.

4. A Design Method for Situated DSS

4.1 Design Method

When a new type of IT system is proposed, the question of how to effectively develop it is the next most important issue. If we don't have an appropriate method for design and development, the quality of system may be reduced. Since newly designed IT may not have architecture similar to that of older systems, the old type of design guidance may not be applicable anymore. Therefore, for new types of IT systems, we need a new kind of design method to guide the development.

A design method is a part of a design theory. "Design theory" is a concept proposed by Walls, Widmeyer et al. (1992) for information systems. According to Walls et al., design theory is an integration of user requirements, types of system, and methods for producing the system. Design theory is beneficial because it sets up the scope of a system within which structured and accurate design guidance is provided for system designers and developers. According to Walls et al., an effective design theory can improve system development quality and outcome.

Like other types of IT systems, DSSs have a development method that best fits their nature. This method is referred to as "iterative design" by Keen and Scott Morton (1978). Iterative design is also known as "prototyping" (Turban and Aronson 2001). In prototyping, a working prototype of the system is developed according to the very initial analysis, which may include a needs assessment, a system analysis, and a system design. Next, the analysis, design, and further development of the prototype are iteratively carried out until a fully functional system is developed. Prototyping is most beneficial when the problem and environment are less structured and when there is uncertainty about user requirements (Laudon, Laudon et al. 2002). The traditional type of DSS is developed to help managers solve semistructural and unstructual problems in organizations. Therefore most DSSs were developed through the prototyping process (Turban and Aronson 2001).

4.2 The Need for a New Design Method

Situated DSSs offer a new way to support decision making. It has a model that is different from other types of DSSs. Specifically, a situated DSS differs from other types of DSSs in terms of *structure* and *user*.

Structure

Situated DSSs have a layered model which organizes functional components in three levels of abstraction: judgmental layer, operational layer, and reactive layer. The layered model is inspired by the software agent architectures. It is totally different from the traditional "toolbox" DSSs. The essential components (data, models, and knowledge) in traditional DSSs become parts of the DSS kernel in the operational layer and they are controlled by an active component: the DSS manager.

Situated DSSs assist decision making actively with its active components. Active components (sensors, effectors, active UI, manager) are built by using agent technology. By incorporating agents in a DSS, we are able to make the SDSS situate in the problem environment, sense what is going on in real time, analyze and react to changes without direct command from the user. On the other hand, the traditional types of DSSs are "isolated" from the environment, therefore they cannot provide the user with the latest information, and the decision making process is totally dependent on the user's initiative.

User

The user's role in a SDSS is greatly different from the one in traditional types of DSSs. In traditional types of DSSs, the user's communication with the DSS is very complex and intensive. The user needs to have full knowledge about the problem, be able to input all the necessary information, read complex reports, and provide direct command for decision making. On the other hand, the complexity is reduced in SDSSs because in the judgmental layer, the user communicates with an active user interface. This interface provides simplified manners for data input, maintains a user's profile, generates signals, and transfers system output into a user-friendly format to reduce complexity. With the SDSS, the user is no longer required to have full knowledge with the latest information because sensors are there to provide this service. Moreover, the user is notified of changes in real-time since the system is situated in the environment. In SDSSs, the user is required to give judgment instead of direct command. SDSSs can process selected tasks without user initiative.

The type of user that SDSSs can serve is different from traditional types of DSSs. Traditional types of DSSs were designed to support managers who need to solve semistructural and unstructural problems in organization. However, since a SDSS does not require the user to have full knowledge and communication between user and system is much simpler, it can serve users with different knowledge and skill in many different fields, such as investment in securities and real estate, etc.

Due to all these differences between SDSSs and the old types of DSSs, the old design method may no longer be applicable and problems may arise if we apply the old method to the development of the new system. The first problem is that subtasks identified in the prototyping approach are not assigned to any layer. The layered model cannot be implemented without identifying subtasks that belong to each layer. Secondly, in the old design method, the prototype of a subtask is added to the other developed prototypes to form the final system. However in the layered model, rather than simply adding components together, the integration of the system requires communication between components within one layer and between neighboring layers to be well defined. The third problem is that a user of a SDSS does not necessarily have full knowledge about the domain. However, with the old design method, user knowledge is crucial. The user needs to have full knowledge in order to participate in the development process as well as to use the system. The fourth problem with the old design method is that it is not designed to provide the user with the latest information in real-time because the old design method is built for "toolbox" DSS, not for features like situatedness and activeness. The comparison between TDSS and SDSS, old design method, and problems encountered are summarized in table 1.

		TDSS	SDSS	Initial Design Method (prototyping)	Problems encountered when initial design method is applied in SDSS
Structure	Architecture	Data management, model management, knowledge-based management, and user interface subsystems are connected together.	Layered architecture which contains reactive layer (sensors and effectors), operational layer (DSS kernel), and judgmental layer (active UI and user).	The process starts with overall planning and analysis. Next, a subtask is selected. Then the analysis, design, and prototype implementation are iteratively performed until it is sufficiently developed. Then other subtasks are selected and developed as the first one and added to the deployed system. (Turban and Aronson 2001)	1). Subtask is not identified by using the layered approach. So we don't know which layer it belongs to. 2). The communication between subtask and other part of the SDSS is not defined
	Technology	DBMS, MBMS, organizational knowledge base.	Software agent and technology of the TDSS.		
	Relationship with the problem environment	Isolated. System cannot access to the latest information and cannot react to the changes in real-time.	Situated. System is situated in the problem environment, senses changes and reacts in real-time.		
User	Type	Managers	Many other types of individuals	User is required to have full knowledge about the problem domain. User participates in every stage of development to provide requirement and evaluation.	1). User does not necessary have full knowledge about the domain. 2). User does not necessary have the latest info about the environment.
	Required knowledge	Full knowledge of the domain	Knowledge to make judgment when it is necessary		

Table 1. Summary of the difference between TDSS and SDSS, the initial design method and problems

4.3 A New Design Method

Base on the analysis discussed above, in this section we will propose a new design method for the layered architecture of situated DSSs.

1. Define the scope of the decision problem.

The first step is to do an overall analysis in order to define the decision problem. In this step, we scan the environment to decide what major decision and implementation tasks need to be supported by the situated DSS.

2. Identify the task breakdown structure.

In this step, we break down the decision problem identified in the first step into subtasks. We produce a tree-like breakdown structure for the tasks, where the major problem is broken down into several subtasks, which in turn divide into smaller subtasks. We should break down subtasks until the subtasks are specific enough for implementation.

3. Assign the tasks to one of the three layers of the SDSS.

Tasks that have to do with the problem environment, such as sensing and reacting to the changes in the environment, should be assigned to the reactive layer. Tasks like analysis, computation, proposing alternatives, and generating reports, all of which involve the operation of the DSS kernel, should be assigned to the operational layer.

Tasks that involve the user and communication between the user and the system should be assigned to the judgmental layer.

4. For each task, define coordination requirements with other components.

Tasks are assigned to one of the three layers in the previous step, but they are not isolated from each other. Therefore, methods of communication, flows of information, and operations of coordination must be defined before development.

5. Design and implement the components.

Once the scope of the problem is identified, tasks are assigned to layers, and their coordination is defined, we are ready to move to the actual development of each component and implementing them as a whole system.

In the next section, the design method will be illustrated by using the development process of a prototypical SDSS for personal finance management.

4.4 Application of the Design Method to the Problem of Personal Finance Management

There are several reasons for choosing the problem of personal finance management as the application with which to illustrate our design method. 1) Personal finance management is an important domain largely overlooked by DSS researchers. As mentioned in section 2.3, very little DSS research has been done in the field of personal finance management. 2) In addition, there are alarming trends in personal finance management. For example, a recent report on family finance indicates that Canadian families' saving rate fell from 13% in 1989 to 2.1% in 2003, and the annual saving level in 2003 was only one quarter of the one in the early nineties (Sauve 2004). Also, according to Statistics Canada's newest report on economic indicators, personal saving rates fell down to 1.9% in the first quarter of 2006 (http://www40.statcan.ca/l01/cst01/indi02a.htm). In the United States, the situation is even worse. In the year 2005, the personal saving rate in the US sank to -0.5% (Waggoner 2006). According to economists, the situation of spending too much and saving too little will create difficulty for individuals and impact adversely to the nation's economy (Merrill 2006; Naroff 2006). 3) To stop spending too much and saving too little, we need to plan and budget effectively and control our spending accordingly. This is not as easy as it sounds. Without proper management, it is very difficult for individuals to adhere to a financial plan. Because of these reasons, software and tools are built to help people manage their personal finance. An application of "Personal Finance Course" was developed by Connaissance Technologies, a company which specializes in developing multimedia training applications. This application provides interactive instruction and practice which allow the users to learn the concepts of personal finance, and use the knowledge to develop financial plans. Popular commercial personal finance management software currently in the market includes Microsoft Money and Quicken. While these software programs are there to help people manage bills, organize taxes, and optimize investment portfolios, the situated DSS would aim to encourage users to set up realistic financial goals and budgets. Moreover, the situated DSS would prompt users with the latest changes and proactively guide them in the process of implementing the budget.

The scope of the system could include the major domain areas of personal finance management. These are financial planning, banking, investments, insurance, and taxation. These can be further broken down into more subtasks. Figure 2 shows the tree-like breakdown structure of personal finance management and its major aspects. Figure 3 shows the subtasks of each major aspect.

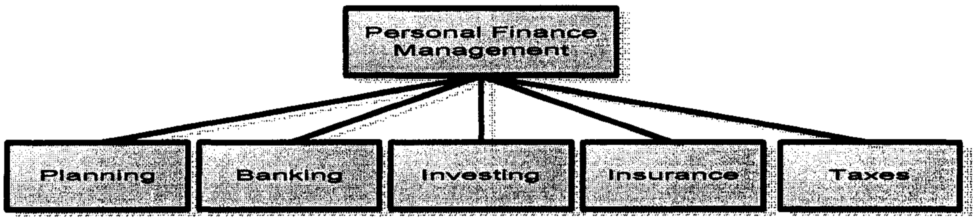


Figure 2. Breakdown structure of personal finance management and its main aspects

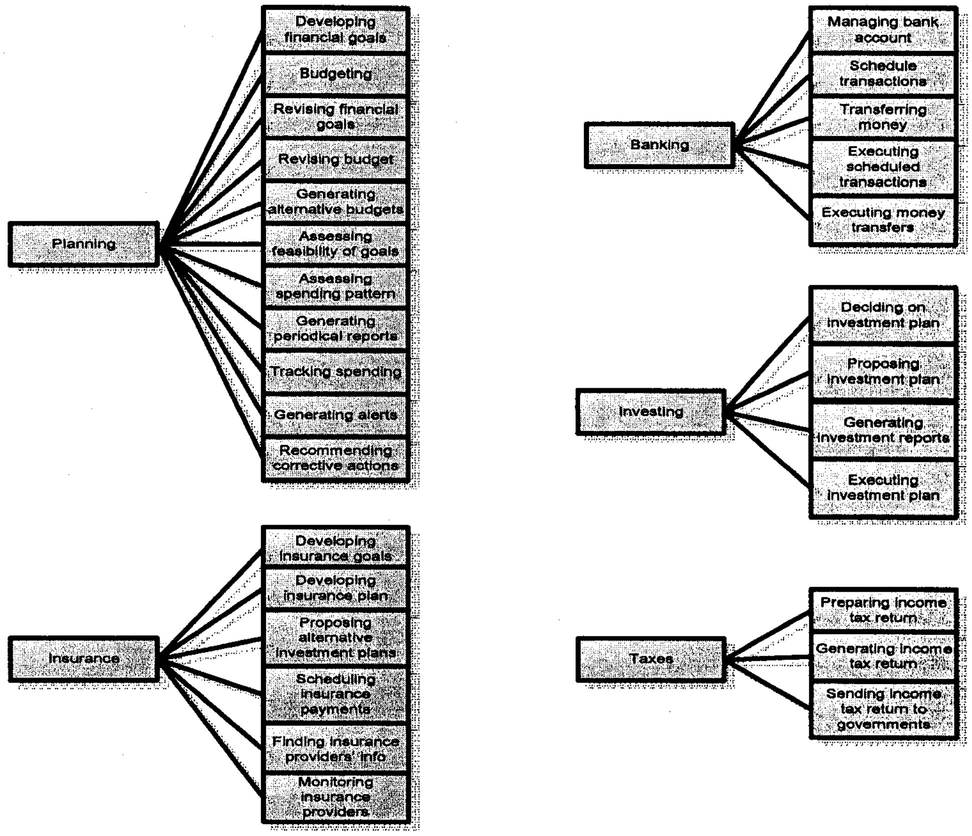


Figure 3. Breakdown structures of the main aspects

After the subtasks are identified, they are assigned to one of the three layers of the system. Table 2 shows the allocation. Budgeting, for example, is assigned to the judgmental layer. This implies that budgeting will be done by the user in collaboration with the active user interface. User judgment is necessary to this subtask. The task of generating alternative budgets is allocated to the operational layer because analysis and calculation are done by the DSS kernel to generate alternative solutions. Tracking spending is assigned to the reactive layer. The sensors in the reactive layer are responsible for this task. Sensors monitor the user's spending activities and generate alerts if necessary. The effectors are responsible for automatic money transfer.

Major Task	Judgmental	Operational	Reactive
Planning	Developing financial goals; Budgeting; Revising financial goals; Revising budget	Generating alternative budgets; Assessing feasibility of goals; Assessing spending pattern; Generating periodical reports	Tracking spending; Generating alerts; Recommending corrective actions
Banking	Managing bank accounts; Schedule transactions; Transferring money		Executing scheduled transactions; Executing money transfers
Investing	Deciding on investment plan	Proposing investment plan; Generating investment reports	Executing investment plan
Insurance	Developing insurance goals; Developing insurance plan	Proposing alternative investment plans	Scheduling insurance payments; Finding insurance providers' information; Monitoring insurance providers
Taxes	Preparing income tax return	Producing income tax return	Sending income tax return to governments

Table 2. Allocation of subtasks

Coordination here is achieved by assigning specific subtasks to different components and exchanging information between components. There are four types of information being exchanged within the system: 1) the information collected from the environment by the sensors; 2) the messages used to communicate with other components; 3) the information exchanged between the active user interface and the user; 4) and the information passed to the environment. Messages exchanged between components are the major method of coordination. Here, we adopt the communication protocol of agent systems. Karacapilidis and Moraitis (2001) built an agent-mediated e-commerce system with decision making features in which the agents communicated with each other by exchanging messages. In their system, each message type has a certain structure associated to a particular task. Messages exchanged between components in a SDSS also convey particular semantics associated to a particular task. In this way, once a component receives the message sent from another component, it immediately knows what procedure or operation should be performed. For example, for the subtask of financial planning, one type of messages exchanged between sensors and the active UI are the observations of abnormal spending. The structure of this type of message is presented in figure 4.


```
<msgID>infomsgA1</msgID>
<sender>sensor001</sender>
<receiver>UI001</receiver>
<infotype>
        <typ1 = obsv>
            <activity1>
                <name>overSpending</name>
                <category>c1</category>
                <amount>170</amount>
                <Date>04-21-2006</Date>
                <action>infoImme</action>
            </activity1>
        </typ1>
</infotype>
```


Figure 4. Message of abnormal observation

The first three lines in this message indicate the message ID, the sender, and the receiver. The <infotype> tag contains the body of the message. Tag <typ1> indicates the type of message, and in this case, the type is observation. The body of the <activity> tag is the content of the message. From the content, the active UI can recognize that this is a message about overspending. The category in which overspending happens is "c1". The amount of overspending is $170, and this event takes place on Apr 21, 2006. "<action>infoImme</action>" indicates that the active UI should inform the user immediately about this observation. This message is an example of the messages exchanged by components of the SDSS; the other messages contain similar structures.

Once the type and content of the communication are defined, we are ready to implement the design into working prototypes.

5. Research Methodology

5.1 SDSS prototype for personal finance management

To illustrate our approach and investigate the effectiveness of the model, we developed a web-based prototype SDSS for personal finance management using Coldfusion MX 7. The prototype was developed for one of the major areas in personal finance: planning. Financial planning is one of the most important keys to succeed in managing personal financial resources. Effective planning includes setting up realistic financial goals, building feasible financial budgets, and implementing the budgets accordingly in order to keep the goals reachable (Ahmad, 2000; Kapoor, Dlabay et al. 2001). The purpose of the prototype SDSS was to assist the user in setting up realistic financial plans and to guide him/her through the implementation process. A unified modeling language (UML) activity diagram that roughly presents the workings of the SDSS is shown in figure 5. The diagram outlines the operation of the prototype SDSS. The scenario begins with activities pertaining to the development of feasible financial goals and budgets. Then the implementation of the budget is monitored. The user is notified if significant variation is observed and periodical reports are generated. Detailed operation of the three layers is presented below.

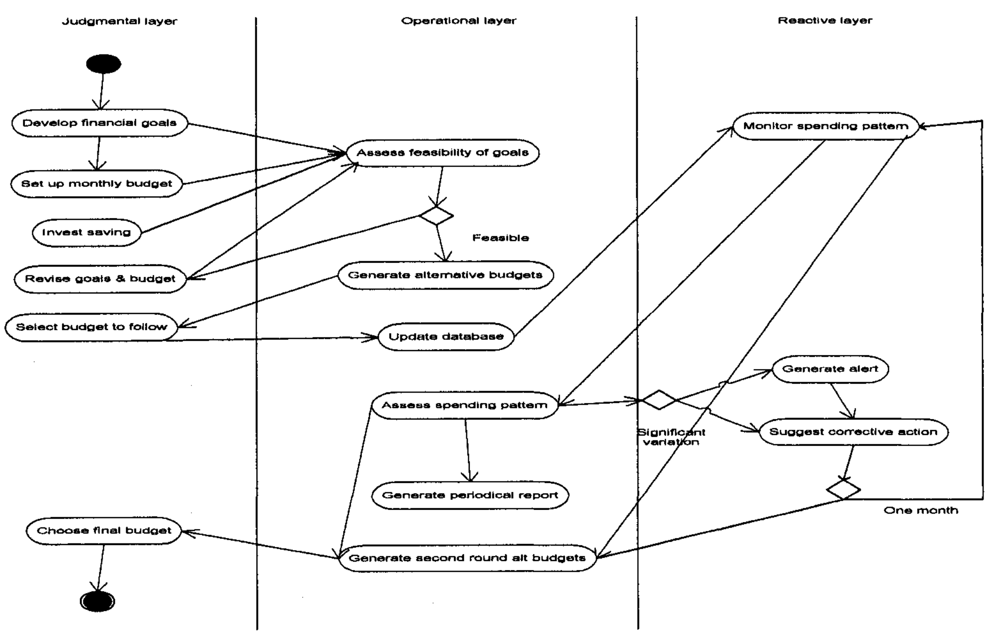


Figure 5. SDSS activity diagram

The active user interface works with the user to set up financial goals and a budget.

Here, to reduce the amount of input required from the user, an interface is provided with a list of the most common goals such as retirement, buying a car, etc. The interface is shown in figure 6. The user is asked to enter the year in which he/she would like to reach the goal and the amount of money. After the goals are developed, a similar interface with a list of budget categories, such as income, fixed expenses, and variable expenses, is provided to help the user set up a monthly budget. The interface for developing the budget is shown in figure 7. Next, the system provides the option of choosing to invest his saving to the user (figure 8). Three types of investments (stocks, bond, and GIC) are provided with detailed descriptions. After the user enters the amount of investment, the self-defined goals and budget are stored in the database for further analysis. An alert about the updated goals and budget is sent to the DS manager in the operational layer.

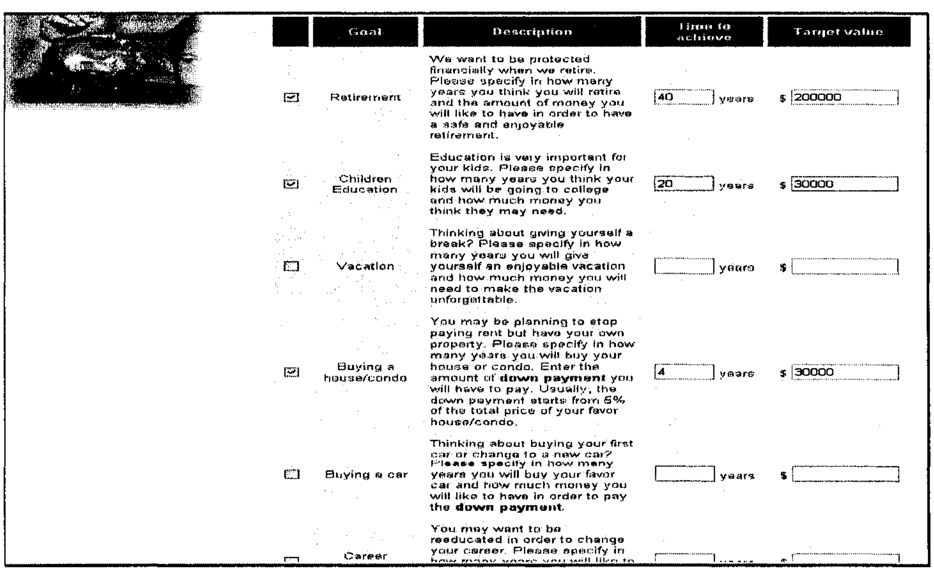


Figure 6. Developing goals

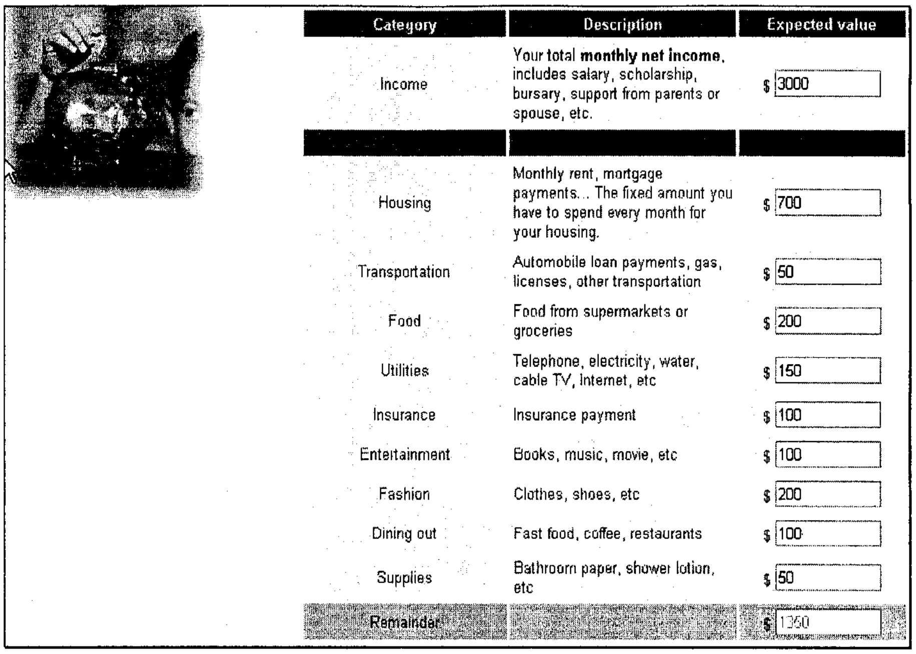


Figure 7. Developing a budget

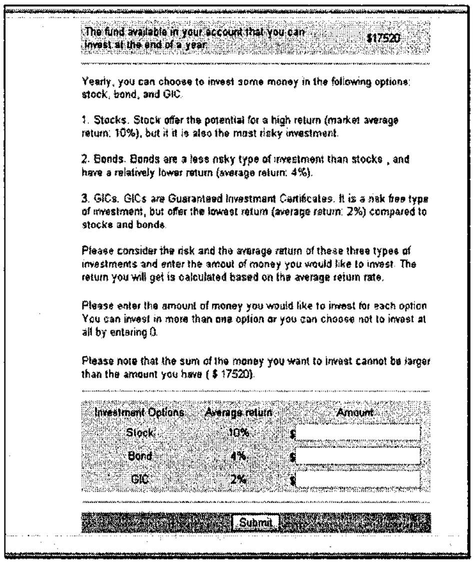


Figure 8. Investment

The feasibility of goals is assessed in the operational layer. The active interface's alert prompts the DS manager to control the DSS components to perform the calculation based on the data of goals and budget stored in the database. The purpose is to check if the user's goals can be achieved with the self-defined budget. If not all of the goals can be reached, the DSS kernel tries to generate a set of four alternative budgets which can make the goals feasible. If no alternative budget can be generated, that means that the user's financial goals are too unrealistic; in this case, an alert is sent to the judgmental layer where the user is asked to revise his/her goals and budget. If goals are feasible within the self-defined budget, while the user is given the option to keep his own budget, the system still proactively generate four alternative budgets for consideration. The purpose of generating alternative budgets is to allow users to explore other expenditure options and invest their money with different levels of risk and surplus, while keeping their goals reachable. The risk level is determined by the allocation of money invested in the categories of stock, bond, and GIC. Generally, stock is the most risky type of investment; bonds are less risky and GIC is the safest among the three (Kapoor, Dlabay et al. 2001). Therefore the more money invested in stock, the higher the level of risk. The return of investment is calculated based on the market's average return rate.

These four alternative budgets are generated based on three criteria: make sure the user can meet all the predefined goals; take the categories' flexibility into account; and let the user choose from budgets involving different risk and surplus levels. The list of the four alternative budgets is shown in figure 9. The amount of each category in budgets is calculated by using the formula:

$$A_i^p = A_i^s + F_i(SP_p - SP_s)$$

Where $SP_p = IC - SA(R_j, SP_j, PG)$

In the above expression, A_i is the amount of money that should be spent in the ith spending category. F_i is the flexibility ratio of the ith category. Each category of spending has a flexibility index. The index indicates how flexible the spending of this category is. For fixed expenses, such as rent, the flexibility index is 0. The flexibility ratio is the ratio of dividing a flexibility index by the sum of all the indices which are larger than 0. SP_p is the total flexible spending of the proposed budget. SP_s is the total flexible spending of the self-defined budget. Therefore $SP_p - SP_s$ is the adjustable amount between the two budgets. $F_i(SP_p - SP_s)$ is the adjustable amount in the ith category. A_i^s is the amount of self-defined spending in the ith category. By adding $F_i(SP_p - SP_s)$ to A_i^s, we get the proposed spending in the ith category, A_i^p. IC stands for monthly income. Finally, $S(R_j, SP_j, PG)$ means saving is a function of risk level, surplus level, and percentage of goals met in the jth alternative budget. Alternative budgets are found by using the optimization approach. As the model we use here is linear, an iterative improvement hill-climbing algorithm for searching is used (Renders and Bersini 1994; Han and Kamber 2001). The goal is to find the best solution in a certain range of risk and surplus level (R_j and SP_j), while making PG close to or equal to 1. The detailed alternative budget is shown in figure 10.

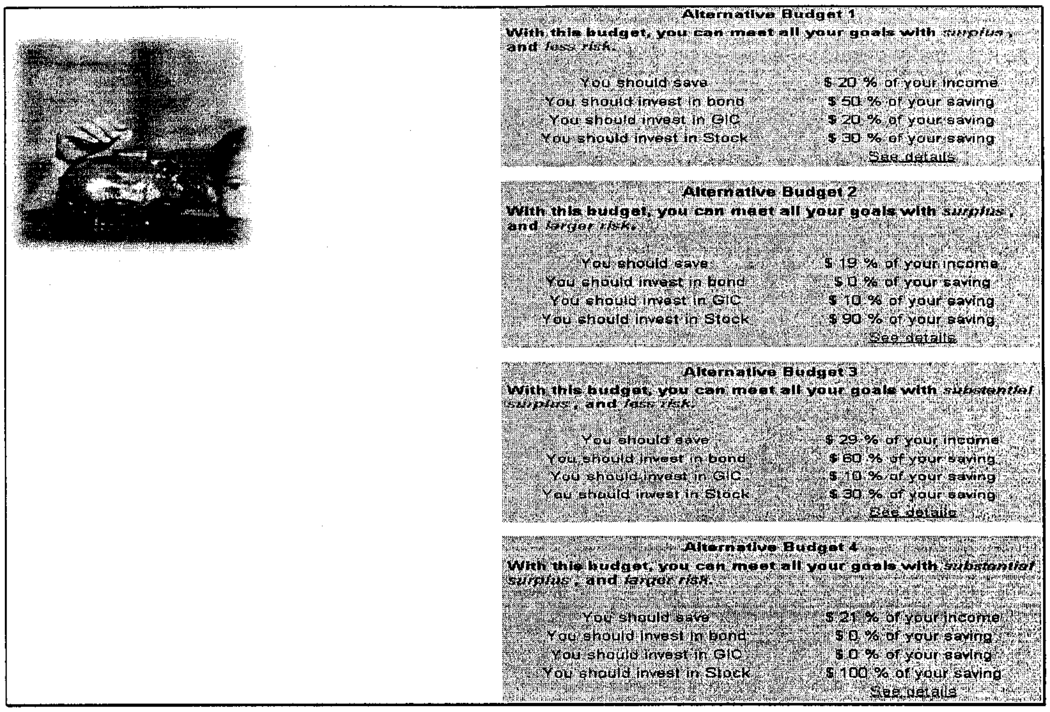
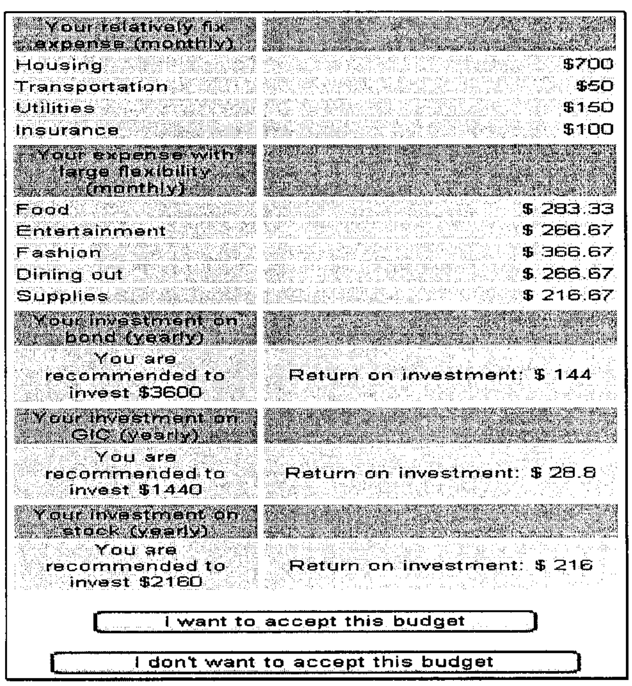


Figure 9. First around alternative budgets



Your relatively fix expense (monthly)	
Housing	$700
Transportation	$50
Utilities	$150
Insurance	$100
Your expense with large flexibility (monthly)	
Food	$ 283.33
Entertainment	$ 266.67
Fashion	$ 366.67
Dining out	$ 266.67
Supplies	$ 216.67
Your investment on bond (yearly)	
You are recommended to invest $3600	Return on investment: $ 144
Your investment on GIC (yearly)	
You are recommended to invest $1440	Return on investment: $ 28.8
Your investment on stock (yearly)	
You are recommended to invest $2160	Return on investment: $ 216

I want to accept this budget

I don't want to accept this budget

Figure 10. Detailed alternative budget

Once the four alternative budgets have been generated, they are displayed by the active UI to the user. The user can then choose the budget that fits his/her preference in terms of risk level, surplus level, and allocation of money in different spending categories. Once the budget is chosen, the database for the user's profile is updated.

During the normal spending period, the sensors in the reactive layer monitor the user's activities. The user's expenses are categorized by the spending categories in the budget and summed up in order to get the actual total spending of a particular category. The data of actual spending pattern is sent to the operational layer for assessment. If significant variation is observed, alerts will be sent to the user. Monthly, a report is generated by the DSS kernel in the operational layer. The report tells the user how well he/she followed the budget and if his/her goals are still feasible with the current spending pattern. The monthly report is shown in figure 11. While observing the user's spending, the DS manager processes the observation and updates the user's data in the database. Every three months a quarterly report (figure 12) is presented to the user. The quarterly report summarizes how well the budget is followed in these three moths. If the actual spending deviates significantly from the budgeted one, the DS manager will proactively generate another set of alternative budgets for the user to consider.

Monthly Report

Category	Your Budget	Your Actual Activities	The Difference	Judgement
Food	$ 280	$ 409	$ -129.00	You are spending somewhat more than your budget.
Entertainment	$ 260	$ 46	$ 214.00	You are spending too little compared to your budget, you can spend more in this category.
Fashion	$ 360	$ 377	$ -17.00	You are following your budget, you are on the right track.
Dining out	$ 260	$ 172	$ 88.00	You are spending too little compared to your budget, you can spend more in this category.
Supplies	$ 210	$ 55	$ 155.00	You are spending too little compared to your budget, you can spend more in this category.

Summary

The calculation based on your spending activities of this month indicates that you can meet all your financial goals by the time you target.

Figure 11. Monthly Report

Quarterly Report

Category	Your Budget	Your Actual Activities	The Difference	Judgment
Food	$ 280	$ 448.67	$ -168.67	You are spending somewhat more than your budget.
Entertainment	$ 260	$ 217.00	$ 43.00	You are spending somewhat less than your budget.
Fashion	$ 360	$ 294.67	$ 65.33	You are spending somewhat less than your budget.
Dining out	$ 260	$ 182.67	$ 77.33	You are spending somewhat less than your budget.
Supplies	$ 210	$ 91.67	$ 118.33	You are spending too little compared to your budget, you can spend more in this category.

Summary

You should be able to save $ 7560 after a year if you follow your planned budget.

With your actual activities, you are able to save $ 9184.

The calculation based on your spending activities in these three months indicates that you can meet all your goals by the time you have planned.

Figure 12. Quarterly Report

This set of alternative budgets is called the second round alternative budgets. These budgets are generated based on four criteria. The first three criteria are the same as the ones in the first set of alternative budgets (meet all the goals, consider the flexibility, and choose from different risk and surplus levels). The new criterion for this set of budgets is the consideration of the actual spending pattern observed.

$$SP_{t+1}^{f} = SP_{t}^{f} + \alpha(SP_{t}^{a} - SP_{t}^{f})$$

The expression above indicates how the actual spending pattern is taken into account. We use the method of exponential smoothing (Brown, Meyer et al. 1961) to calculate the spending in a certain category (SP_{t+1}^{f}). Exponential smoothing is the most common model-free forecasting method. An exponentially weighted moving average with a smoothing constant α is the most basic exponential smoother (Gijbels, Pope et al. 1999; Arsham 2006). In our case, we take $\alpha = 0.5$. This indicates that the considerations for the self-defined budget (SP_{t}^{f}) and the actual spending pattern (SP_{t}^{a}) are equal. The alternative budgets adapted from the actual spending pattern can better represent the habits and preferences of the user while keeping the spending under control. An example of the second round budget is shown in figure 13. In this example, the system detects that the user spends a lot on food and little on supplies as shown in figure 12. Therefore it adapts the budget to put more money in the category of food and less money in the category of supply.

Income	$3000
Housing	$ 700
Transportation	$ 50
Food	$ 391.66
Utilities	$ 150
Insurance	$ 100
Entertainment	$ 256.39
Fashion	$ 351.88
Dining out	$ 237.93
Supplies	$ 162.14
Remainder	$600
Investment at the end of a year	
Investment in stock	$ 1440
Investment in bond	$ 1440
Investment in GIC	$ 4320
With this budget, you can meet all your goals.	
Besides meeting all the goals, you can have an average surplus of 192% of the target value of your goals	

Figure 13. Budget adapted from actual spending

5.2 Research hypotheses

The situated DSS provides effective decision support by sensing what is going on in the problem environment, utilizing DSS facilities to generate alternatives, and undertaking implementation. In doing so, it offers active decision support to decision makers in real-time. It especially tunes in to the needs of decision makers who need to function in a constantly changing environment by monitoring activities and providing the most up-to-date information. Therefore, we believe that the SDSS is more effective in providing active and timely decision support to decision makers than traditional DSSs (TDSS).

The hypotheses of this study take "type of decision support system" (SDSS vs. TDSS) as an independent variable. The moderating variable is the user's "degree of activeness in financial planning". And the dependent variable is the "effectiveness of the decision support system".

The effectiveness of the decision support system is determined by the decision outcome and subjective perception. In the following H1 to H4, we hypothesize that the SDSS provides more effective decision outcomes than the TDSS.

H1: SDSS users will have greater achievement of goals than TDSS users. The achievement of financial goals is the number of goals a user can reach after implementing the budget. If a user overspends, not all of his financial goals will still be feasible. SDSS is an active decision support system that is situated in the environment. It prompts alerting signals to the user when abnormal spending is observed. Therefore, the user will be able to keep their goals reachable during the implementation process.

H2: SDSS users will have more improvement in achievement of goals than TDSS users. The improvement in achievement of goals is defined as the increase in the number of goals a user can reach during the implementation process. Individuals' spending activities change constantly. Without proper reviews of our activities, our financial goals may easily become unreachable. A SDSS not only helps the users to set up financial goals but also provides active and timely supports to help them keep their goals feasible. The system notifies the users once it detects that the users' goals are no longer reachable with the current spending. In this way, the users are aware with the situation and are able to improve their spending to increase the number of goals they can reach.

H3: The proportion of SDSS users who can achieve all of their financial goals is larger than the proportion of TDSS users. A user's ultimate objective is to be able to realize all the financial goals. A good system should be able to help the users to achieve this objective. If more users can reach all of their goals by using the system, the system is considered more helpful. The SDSS is expected to be more helpful than the TDSS.

H4: SDSS users will have more improvement in following a budget than TDSS users. The improvement in following a budget is defined as the increase of the consistency between the spending activities and the budget. Whether goals can be achieved highly depends on whether pre-defined budget is well followed. The SDSS encourages the users to set up realistic budget and guides them through the implementation process. With the proactive supports provided by the SDSS, users are expected to be able to adjust their activities to stay within budget. With the adjustment of spending activities, SDSS users are expected to improve in following their budgets over time.

In the hypotheses H5 to H7, we hypothesize that users of SDSS will perceive the system as being useful and will be satisfied with the decision process. We also expect that users of SDSS will not perceive the system as being difficult to use.

H5: The perceived usefulness of a SDSS is higher than that of a TDSS.

H6: The perceived ease of use of a SDSS is not lower than that of a TDSS.

H7: SDSS users will have more satisfaction with the decision process than TDSS users.

The main purpose of a SDSS is to assist users in finding the most feasible budget and implement it successfully. Users who are active in financial planning are more willing to plan for their goals and more likely to review the progress frequently. For users who are inactive in financial planning, the SDSS may provide active support to help them set up financial goals and a budget, and provide constant supports during the implementation process. For the active financial planners, the support provided by the system may be less significant. Therefore, in hypothesis H8, we hypothesize that the SDSS is more effective for users who are inactive in financial planning.

H8: A SDSS is more effective in supporting inactive financial planners than active

financial planners.

5.3 Measures

Objective measures. The achievement of goals was measured by the average percentage of goals achieved in the period of three months. The improvement of goal achievement was measured as the average difference of the percentage of goals achieved between months. The proportion of users who can achieve all the goals was measured by dividing the number of users who can achieve all the goals by the total number of users. Lastly, the improvement in following a budget was calculated in the following way. We first calculated the deviation of the actual spending and the budget for each month. Then we calculated the difference between these deviations. The value of improvement was attained by calculating the average of these differences.

Subjective measures. The subjective measures we used to gauge the effectiveness of the system are “perceived usefulness”, “perceived ease of use”, and “satisfaction with process”. Whether a system is effective or not depends on how people perceive the quality of the assistance or support that they have obtained from the system. To get this information, we used self-report measures because they collect people’s opinion directly.

The measures of "perceived usefulness" and "perceived ease of use" were adopted from Davis (1989). They are well-known measures used in assessing the effectiveness of information systems. The validity and reliability of these two measures have been proven in many other studies. We employed the following six items (seven-point likert scale from "strongly disagree" to "strongly agree") for the measure of "perceived usefulness":

1. Using the system would improve my performance on personal finance management.
2. Using the system would help me implement my financial plan.
3. Using the system would help me achieve my financial goals.
4. Using the system would help me follow my financial budget.
5. Using the system would enhance my effectiveness in managing my personal finance.
6. I find the system would be useful for managing my personal finance.

For the measure of "perceived ease of use", we included three items (seven-point likert scale from "strongly disagree" to "strongly agree"):

1. My interaction with the system will be clear and understandable.
2. Using the system will require little mental effort.

3. I find the system will be easy to use.

The measure of "satisfaction with process" was adopted from Paul, Seetharaman et al. (2004). In this study, three items are included (seven-point likert scale from "strongly disagree" to "strongly agree"):

1. I would be satisfied with the interaction with the system.
2. I would be satisfied with the guidance provided by the system.
3. I would be satisfied with the feedback provided by the system.

A new measure of "activeness of financial planning" was created by using two indicators of activeness of financial planning: the frequency of financial planning, and the frequency of evaluating financial plans. The frequency of financial planning was measured with self-reported frequency on a 4-point scale (labels: "never", "less than 1 time a year", "1 to 3 times a year", and "more than 3 times a year"). Similarly, the frequency of evaluating financial plans was measured with self-reported frequency of a 6-point scale (labels: "never", "less than 1 time a year", "1 to 5 times a year", "5 to 10 times a year", "1 time a month", and "more than 1 time a month").

5.4 Experiment

We performed experiments to investigate the effectiveness of the SDSS prototype empirically. We compared the performance and the user's experience of the SDSS with that of the traditional DSS (TDSS). The TDSS was a subset of the SDSS. It included data, models, and interface. The data in the TDSS included the user's financial goals, self-defined budget, and actual activities. The models in the TDSS allowed calculations used for the assessment of feasibility of financial goals based on the self-defined budget, and the difference between actual activities and the self-defined budget. The interfaces for developing financial goals and budgets were the same as the ones in the SDSS. The interfaces also allowed viewing of the assessment of goals and the difference between activities and budget.

For all the participants, the task in the experiment here involved selecting and implementing a feasible budget. Prior to the selection, participants were asked to set up their financial goals, monthly budget, and investment.

For the group of SDSS users, the system then evaluated the feasibility of goals based on the self-defined budget and proactively generated four alternative budgets. Once the participants chose a budget, they implemented the budget in a simulated environment (the simulation will be discussed in the next section). During the implementation, the system monitored the participants' activities and generated periodical reports. Once the implementation was finished, the system again proactively generated another set of alternative budgets which matched the spending pattern of the subjects. The participants then could select one of these budgets for future reference.

For the group of TDSS users, after goals, budget and investment were set up, the system evaluated the feasibility of the goals based on the budget. Then the participant implemented the budget in the simulated environment. After three months of implementation, the TDSS generated a detailed report which included the differences between the budget and the actual activities in these three months, and the evaluation of the activities based on the user's financial goals. The screen shots of the TDSS can be found in the instructions of TDSS, which is included in the appendix A.

The participants of this study included undergraduate and graduate students from Concordia University. Participants were randomly assigned to one of the two types of DSS (TDSS and SDSS). Before they started the experiment, a brief introduction was given by the experiment instructor. Detailed written instructions on how to use the system was also given to the participants, and they were required to read it carefully before they started the experiment. They were also given the procedural information for the questions on demographic information and the questionnaire about their perception of the system. The instructions are shown in the appendix A. Participants were asked to read and sign the consent form (Appendix B: Consent form) before they proceeded. Once they were ready to start, they log into the system by using the user name and password provided by the experiment instructor. After logging in, a page with the questionnaire for demographic information (Appendix C: Demographic questionnaire) was shown, and the participants were asked to fill it in before they could use the system. Once the participants started using the system, they followed a step-by-step wizard to complete the tasks as described above. After the final budget was chosen, a questionnaire was presented to the participants to measure their perception of the usefulness, ease of use, and satisfaction of the system (Appendix D: Perception questionnaire). Following completion of the questionnaire, a ten-dollar reward was given to each participant.

5.5 Simulation

To monitor a user's spending pattern, we created a simulation game which allowed participants to do their shopping activities in the lab environment. Simulation has been defined as a practice involving reality of function in a simulated environment (Jones 1981; Jones 1998). A well-developed simulation game combines lifelike experience in a controlled environment. Simulations can provide interactive, entertaining, and experiential environments. Computerized simulation provides the advantage of easy data collection because human errors can be eliminated (Noy and Ravid 2006).

Simulations have been used widely as tools that enhance learning (Thavikulwat

2004) . Simulations provide a dynamic environment for learners that can enhance their understanding of theories and concepts through active interaction in the artificial environment (Yeo and Tan 1999; Buchanan 2001). Simulations are also used in preparation for emergency situations. They offer opportunities for effective planning for fast response, evacuation, and casualty handling in case emergency events occur (Jain and McLean 2003). As tools, simulations have been suggested for research into behavioral science, professional training, business trading, information system analysis, and many other areas (Keys 1997; Yeo and Tan 1999; Noy and Ravid 2006).

One major concern about simulations is the validity of the method. Research has been done to investigate and assess the internal and external validity of this research tool. Researchers have found that generally, simulation as a research tool was considered as valid and reliable (Streufert, Pogash et al. 1988; Lamond, Crow et al. 1996; Devitt, Kurrek et al. 1998; Gaba, Howard et al. 1998; Jentsch and Bowers 1998; Devitt, Kurrek et al. 2001). According to the findings, the more accurately the simulation represents the reality, the greater the validity of the study (Adelman 1991). To increase accuracy, researchers suggest the following. 1) Use appropriate hardware and software to develop simulation. For PC-based simulation, interruption caused by hardware and software problems should be avoided during the simulation because interruptions may not occur in reality. 2) Add details to increase realism. For example, in a simulation of aircrew communication, use of headphones and background radio chatter would increase the sense of reality (Jentsch and Bowers

1998). 3) Present information in a form which subjects would normally use (Lamond, Crow et al. 1996).

The simulation game that we created was used to simulate twelve weeks of shopping activities. There were five categories of spending activities: food, dining out, entertainment, supplies, and fashion. The categories of food, supplies, and fashion contained the major shops that belong to these categories. The categories of dinning out and entertainment contained the major activities. For example, the category of entertainment included going to clubs, bars, and movie theatres. To increase the sense of reality, instead of the name, we used the store's logo to represent a store. Subjects who normally do shopping in these shops are very familiar with the logos. It was easier for them to associate the logos with the shopping activities they were asked to do in the instructions. The amount of money subjects spent in each shop was determined by the simulation game. The amount was calculated by the mean and standard deviation of the spending in a particular category and the six sigma rule was followed. A typical individual's spending was set as the mean, and such an individual's spending variation was set as the standard deviation.

The subjects were asked to read instructions about the experiment before they started, and the explanation of the simulation was placed in the "Caution" part at the beginning of the instructions in order to get subjects' attention. In the instructions, subjects were informed about the structure of the simulation, its purpose, its functionality, and the subject's role as a shopper. Before the simulation started, a brief instruction appeared again to remind the subjects about how the simulation worked. Subjects visited the stores by clicking on the logos. Once the logo was clicked, the amount of money spent was determined by the system and shown to the subject on the screen. As the subject visited more stores in the category, he/she would be informed of the total amount of money spent for that category. Figure 14 is a screen shot of the simulation interface.

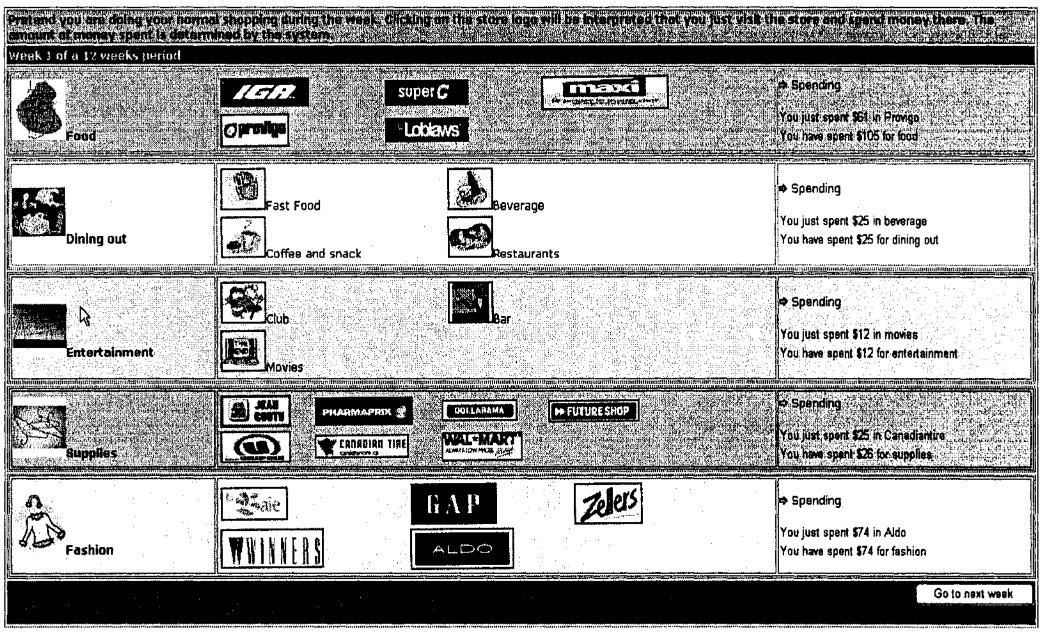


Figure 14. Simulation

5.6 Results

A total of 68 subjects participated in the experiment. Two of them did not complete the experimental task and were thus considered non-responses. The remaining 66 observations were retained for further analysis. Among these participants, 38 were male and 28 were female. The average age of the participants was 29 years. The average computer experience was 6.8 years. 70% of the participants reported having more than 6 years computer experience. The average Internet experience was 6.5 years. 58% of the participants stated having Internet experience for more than 6 years. This indicated that participants had no trouble in interpreting and following the simple step-by-step web-based wizard provided by the systems.

The subjects were randomly assigned to one of the two groups: SDSS as the treatment group, and TDSS as the control group. Out of the total of 66 subjects, exactly half (33) were assigned to the treatment group, and the rest were assigned to the control group.

Reliability and validity of the measures were tested. Reliability was measured by the Cronbach's alpha. As shown in the table 3, high reliability was found for the measure of perceived usefulness (PU: 0.93), perceived ease of use (PEU: 0.807), and satisfaction with process (SP: 0.874).

Construct	Cronbach's Alpha
PU	0.93
PEU	0.807
SP	0.874

Table 3. Cronbach's Alpha

Validity was tested by factor analysis. From the rotated component matrix (see table 4), we can see that the factor loadings with bold fonts are visibly correlated with each other, which is a strong proof for convergent validity. At the same time, the loadings on one construct are significantly higher than the loadings on the other constructs. This proves that the measures have strong discriminant validity.

Rotated Factor Matrix [a]

	Factor		
	1	2	3
PU1	**.822**	.421	.232
PU2	**.811**	.302	.305
PU3	**.651**	.378	.315
PU4	**.640**	.454	.095
PU5	**.609**	.343	.404
PU6	**.603**	.187	.491
PEU1	.462	.084	**.610**
PEU2	.096	.215	**.790**
PEU3	.326	.281	**.677**
SP1	.365	**.708**	.071
SP2	.280	**.749**	.345
SP3	.300	**.755**	.355

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Table 4. Factor analysis

Activeness of financial planning was calculated by standardizing and summing the two item discussed in section 5.2.2. The Conbrach's alpha for this measure is 0.61, which indicates an acceptable level of reliability. Participants were classified as either active or inactive based on a median split of the combined activeness scores. 33 out of 66 participants were classified as active financial planners and the other 33 were classified as inactive financial planners.

As discussed in section 5.2.2, the level of goal achievement was measured by the average percentage of goals achieved in the period of three months. To test hypothesis H1, we used the Mann-Whitney Test. The result (table 5 and table 6) shows that the level of goal achievement accomplished by SDSS users (group 1) is significantly higher than the TDSS users (group 0). The p-value of the test is 0.000. Therefore, hypothesis H1 is supported.

	Treatment	N	Mean Rank	Sum of Ranks
AVG	0	33	24.85	820.00
	1	33	42.15	1391.00
	Total	66		

Table 5. Mann-Whitney Test: Ranks

Test Statistics[a]

	AVG
Mann-Whitney U	259.000
Wilcoxon W	820.000
Z	-3.943
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Treatment

Table 6. Mann-Whitney Test: Test Statistics

The hypothesis H2 about the improvement of goal achievement was tested by using independent samples T test. The result suggests that the improvement achieved by the SDSS user is higher than the TDSS (0.0616 vs. 0.0212, see table 7). However, as shown in table 8, the result is not significant (p-value = 0.093). Therefore hypothesis H2 is not supported at 5% level of significance.

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
GoalImp	1	33	.0616	.15147	.02637
	0	33	.0212	.08367	.01457

Table 7. Mean comparison for goal improvement between SDSS users and TDSS users: Group Statistics

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
GoalImp	Equal variances assumed	5.150	.027	1.341	64	.185	.04040	.03012	-.01977	.10058
	Equal variances not assumed			1.341	49.867	.186	.04040	.03012	-.02010	.10091

Table 8. Mean comparison for goal improvement between SDSS users and TDSS users: Independent sample test

The hypothesis H3, which is about the proportion of users who can achieve all their financial goals after the implementation of budget, was tested by using z-score. After calculation, we obtained a z-score of 3.8082, and a p-value of 0.00007, which suggests that hypothesis H3 is supported.

Hypotheses H4 was tested by independent sample T test. The results are shown in table 9 and 10. Results indicate that H4 is supported (49.1152 vs. 31.1333, with p-value = 0.025).

	treatment	N	Mean	Std. Deviation	Std. Error Mean
AbsAvg	1	33	49.1152	46.59713	8.11152
	0	33	31.1333	22.40260	3.89979

Table 9. Mean comparison for the improvement in following a budget: Group statistics

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
AbsAvg	Equal variances assumed	8.730	.004	1.998	64	.050	17.98182	9.00028	.00168	35.96195
	Equal variances not assumed			1.998	46.043	.052	17.98182	9.00028	-.13436	36.09800

Table 10. Mean comparison for the improvement in following a budget: Independent sample test

The T test results in table 11 and 12 show that perceived usefulness (PU) for SDSS users is significantly higher than that for TDSS users (p-value=0.037). That means hypothesis H5 is supported. At the same time, perceived ease of use (PEU) for SDSS users is not significantly different from that for TDSS users (p-value=0.191). This means that hypothesis H6 is supported. Lastly, we did not find significant differences of the means in the construct of satisfaction with process, therefore H7 was not supported. These findings indicate that the SDSS users perceive the system is more useful than TDSS users, while both groups of users have indifferent perception concerning the ease of use and satisfaction with the process when using the systems.

	Treatment	N	Mean	Std. Deviation	Std. Error Mean
FSPU	1	33	.2201490	.88981794	.15489742
	0	33	-.2201490	1.06748008	.18582443
FSPEU	1	33	-.1085118	1.06252523	.18496190
	0	33	.1085118	.93701900	.16311407
FSSP	1	33	.0781322	.89139367	.15517172
	0	33	-.0781322	1.10637991	.19259602

Table 11. Mean comparison for subjective measures: Group statistics

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
FSPU	Equal variances assumed	3.337	.072	1.820	64	.073	.44029807	.24191720	-.042987	.92358323
	Equal variances not assumed			1.820	61.990	.074	.44029807	.24191720	-.043289	.92388517
FSPEU	Equal variances assumed	.689	.410	-.880	64	.382	-.21702357	.24661124	-.709686	.27563902
	Equal variances not assumed			-.880	63.015	.382	-.21702357	.24661124	-.709835	.27578742
FSSP	Equal variances assumed	1.801	.184	.632	64	.530	.15626434	.24732871	-.337832	.65036023
	Equal variances not assumed			.632	61.228	.530	.15626434	.24732871	-.338263	.65079136

Table 12. Mean comparison for subjective measures: Independent samples test

The results of the testing of hypothesis 8 (table 13 and 14) reveal that concerning both systems, the effects of activeness in financial planning on PU, PEU and SP systems are not significant. Further data analysis (table 15 and table 16: activeness effects on SDSS; table 17 and table 18: activeness effects on TDSS) shows that the insignificant effect occur within both participant groups (SDSS and TDSS groups). Therefore H8 is not supported.

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MPU	0	33	5.5253	1.14346	.19905	5.1198	5.9307	2.67	7.00
	1	33	5.2879	1.34969	.23495	4.8093	5.7665	1.67	7.00
	Total	66	5.4066	1.24692	.15349	5.1000	5.7131	1.67	7.00
MPEU	0	33	5.5152	1.00378	.17474	5.1592	5.8711	3.00	7.00
	1	33	5.5556	1.40353	.24432	5.0579	6.0532	1.00	7.00
	Total	66	5.5354	1.21089	.14905	5.2377	5.8330	1.00	7.00
MSP	0	33	5.2727	1.09435	.19050	4.8847	5.6608	2.00	6.67
	1	33	5.5354	1.34613	.23433	5.0580	6.0127	1.67	7.00
	Total	66	5.4040	1.22442	.15072	5.1030	5.7050	1.67	7.00

Table 13. Activeness in financial planning effects on both systems: Descriptives (0-inactive; 1-active)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MPU	Between Groups	.930	1	.930	.594	.444
	Within Groups	100.133	64	1.565		
	Total	101.063	65			
MPEU	Between Groups	.027	1	.027	.018	.893
	Within Groups	95.279	64	1.489		
	Total	95.306	65			
MSP	Between Groups	1.138	1	1.138	.756	.388
	Within Groups	96.310	64	1.505		
	Total	97.448	65			

Table 14. Activeness in financial planning effects on both systems: ANOVA

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MPU	0	19	5.8246	.94031	.21572	5.3713	6.2778	3.50	7.00
	1	14	5.3333	1.24379	.33242	4.6152	6.0515	2.00	6.83
	Total	33	5.6162	1.08931	.18963	5.2299	6.0024	2.00	7.00
MPEU	0	19	5.7544	.89472	.20526	5.3231	6.1856	3.67	7.00
	1	14	5.6429	1.29736	.34673	4.8938	6.3919	2.00	7.00
	Total	33	5.7071	1.06640	.18564	5.3289	6.0852	2.00	7.00
MSP	0	19	5.4211	.94177	.21606	4.9671	5.8750	3.00	6.67
	1	14	5.3095	1.59306	.42576	4.3897	6.2293	1.67	7.00
	Total	33	5.3737	1.23816	.21554	4.9347	5.8128	1.67	7.00

Table 15. Activeness in financial planning effects on SDSS: Descriptives (0-inactive; 1-active)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MPU	Between Groups	1.945	1	1.945	1.674	.205
	Within Groups	36.026	31	1.162		
	Total	37.971	32			
MPEU	Between Groups	.100	1	.100	.086	.772
	Within Groups	36.290	31	1.171		
	Total	36.391	32			
MSP	Between Groups	.100	1	.100	.063	.803
	Within Groups	48.957	31	1.579		
	Total	49.057	32			

Table 16. Activeness in financial planning effects on both systems: ANOVA

Descriptives

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
MPU	0	14	5.1190	1.29830	.34699	4.3694	5.8687	2.67	7.00
	1	19	5.2544	1.45548	.33391	4.5529	5.9559	1.67	7.00
	Total	33	5.1970	1.37149	.23875	4.7107	5.6833	1.67	7.00
MPEU	0	14	5.1905	1.08379	.28966	4.5647	5.8162	3.00	7.00
	1	19	5.4912	1.50869	.34612	4.7641	6.2184	1.00	7.00
	Total	33	5.3636	1.33428	.23227	4.8905	5.8368	1.00	7.00
MSP	0	14	5.0714	1.28222	.34269	4.3311	5.8118	2.00	6.67
	1	19	5.7018	1.14878	.26355	5.1481	6.2554	2.33	7.00
	Total	33	5.4343	1.22895	.21393	4.9986	5.8701	2.00	7.00

Table 17. Activeness in financial planning effects on TDSS: Descriptives (0-inactive; 1-active)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MPU	Between Groups	.148	1	.148	.076	.784
	Within Groups	60.044	31	1.937		
	Total	60.192	32			
MPEU	Between Groups	.729	1	.729	.402	.531
	Within Groups	56.241	31	1.814		
	Total	56.970	32			
MSP	Between Groups	3.203	1	3.203	2.200	.148
	Within Groups	45.127	31	1.456		
	Total	48.330	32			

Table 18. Activeness in financial planning effects onTDSS: ANOVA

In summary, 5 out of 8 hypotheses were confirmed at the 5% level of significance. Hypothesis 2 for the improvement of goal achievement was not confirmed. However, the goal achievement of SDSS users is significantly higher than that of TDSS users. This might be due to the fact that SDSS users set up feasible financial goals with the help of the system at the beginning. Therefore, even though the improvement in goal achievement is not significantly different from that for TDSS users, SDSS users can achieve most of their goals with a stable budget implementation process. Hypothesis 7 about satisfaction with process was not confirmed either. In addition, this study did not show a significant difference in the effect of activeness in financial planning on the effectiveness of the two types of systems. The reason of the insignificant effect of activeness may be due to fact that the simulation period included in this study was only three months. The period of three months is apparently too short to reflect activeness. For example, if a user reviews the progress of his retirement goal every year, he will be considered as an active planner. But this prototype system was not able to reflect a period of more than three months. Therefore in the future study, it will be very useful to include a longer period of simulation time in order to take a closer look at the effect of activeness. Although the above four hypotheses were not confirmed by the statistical test, the overall results are encouraging. The SDSS was proven to be more effective than the TDSS. The results of hypotheses testing are summarized in table 19.

Hypothesis	SDSS mean	TDSS mean	P-value	Confirm. (α=0.05)
H1 - goal achievement	42.150	24.850	0.000	Yes
H2 - improvement of goal achievement	0.062	0.021	0.093	No
H4 - budget improvement	49.115	31.133	0.026	Yes
H5 - perceived usefulness	0.220	-0.220	0.037	Yes
H6 - perceived ease of use	-0.109	0.109	0.191	Yes
H7 - process satisfaction	0.078	-0.078	0.265	No
H8 - effect of financial planning activeness	Active planner PU:5.2879 PEU: 5.556 SP:5.535	Inactive planner PU: 5.525 PEU: 5.515 SP: 5.273	PU: 0.222 PEU: 0.446 SP: 0.194	No
H3 - users proportion	z-score: 3.808		0.000	Yes

Table 19. Summary of hypotheses testing

6. Conclusions

In this study, we argued that the traditional type of DSS is no longer effective in providing decision support in a dynamic environment. The newly proposed situated DSS, on the other hand, is situated in the problem environment, and provides active and continuous support to decision makers in real time. We proposed a layered model of SDSS which contains three layers: a reactive layer, an operational layer, and a judgmental layer. The reactive layer contains sensors and effectors whose responsibilities are sensing what is going on in the environment and implementing decisions automatically. The operational layer includes the DSS kernel. The judgmental layer includes the active user interface, which communicates with the user and maintains the user's profile. To lay a solid scientific foundation in the development process, we proposed a new design method for developing SDSS. We also empirically tested the SDSS prototype for personal finance management based on the conceptual model. Overall, the results of the experiments confirmed our belief that the situated DSS would be more effective in providing decision support in a dynamic and constantly changing environment than the traditional passive DSS.

One implication of this work is the possibility of the use of agents and their layered architecture as tools for increasing the decision support effectiveness of DSSs. Research in DSSs may be advanced using agents to increase situatedness by sensing and reacting to changes in the problem environment in real-time. Situated DSSs can be applied to other areas of decision making. Their usefulness will be optimal in the areas 1) where changes happen continuously and in real-time, such as stock trading and investment portfolio management, and 2) where the decision making process is complex, such as strategic management. In strategic management, comprehensive plans have to be developed to cope with the complex business and organizational environment. In this situation, decision makers need to have superior knowledge about the changes in the environment. The SDSS empowers users by providing them with relevant information and responding to emerging situations.

For practitioners, the development of the SDSS for personal finance management in this work can be considered as a way to increase the functionality and effectiveness of the existing systems. For applications of online banking, it is useful to provide the SDSS as a "plug-in" service to customers. The SDSS can help them set up realistic financial plans and guide them through the implementation process. This service may encourage the use of online banking because it helps customers monitor their spending and track the process of goals realization. For existing personal finance management software packages (Microsoft Money), adding the SDSS as a feature may increase the effectiveness of these packages. Currently, these packages are "stand-alone" software; they have the tools to help users set up financial plans and budgets, but they don't actually guide users to implement them.

The main limitation of this study is the nature of the prototype systems. Due to time and resource constraints, we only implemented one aspect of personal finance management (financial planning) in the prototype systems. For future study and experiments, other aspects should be included to form a complete system. The prototype system was a simplified working version. There are many other considerations should be taken into account in the future development. These considerations are listed in details below:

- Financial goals should be categorized into short-term goals, intermediate goals and long-term goals. Long-term goals should be planned in coordination with the other two types of goals (Kapoor, Dlabay et al. 2001).

- Goal frequency is another important concept to be considered. For the goals like vacations, may be set in a yearly basic. While other goals, such as retirement, may be set less frequently (Kapoor, Dlabay et al. 2001).
- The interface for developing a budget can be further developed to support a more detailed categorization. For example, for the category of income, with the current version, the users were required to enter the sum of their net income from many different sources such as salary, scholarship and support from parents, etc. In the future development, we can layer this category to specify the breakdown. This has two advantages. (1) The users don't have to calculate the sum of income, they just need to enter the single amount for each category, and the program can calculate the sum for them, which will increase usability. (2) When problems occur during the implementation of budget, the users can find out the specific reason. For example, if a user overspends in the first month, and it indicates that the reason for overspending is because the salary is not high enough. In this way, it is easier for the user to figure out where the problem is and how it can be fixed.
- The calculation of risk and return of investment was based on general understanding and market average rate. More rigorous calculation should be designed and carried out carefully in the future development.
- The prototype system used in this study does not include the user's risk profile. Risk profile is important because it determines the user's risk tolerance which

influences the decision of investment. User's risk profile should be developed and maintained as part of the user's profile by the active UI.

- The level of situatedness can be increased by providing possibility of exploring the reasons of discrepancy between the actual activities and the budget. For example, a user may overspend on food in a month. This may due to different reasons such as not enough budget was planned for food or occasional events such as friends' visiting. The program can force the user to think about the reason. If it is because of the first reason, a revision of budget should be performed. If it is a second reason, a revision of budget may not be necessary.

In this study, we tested the effect of a user's activeness in financial planning on the effectiveness of the two types of systems. In the future study, it is useful to test the effect of experience in financial planning as well. The SDSS may provide significant helps to the users who are inexperienced in financial planning. For those users who are experienced or professional in financial planning, the assistance provided by the system may be less significant. It will be interesting to study this in order to find the right targeted users of the system.

Moreover, due to the limitation of a lab environment, we used simulation in the experiment. In future studies, tracking the user's activities in the real world will provide a set of more reliable data. Another limitation of this study is the relatively small set of samples. In the future, it would be good to involve more participants in order to produce more reliable statistical results. Finally, it will be necessary to include more constructs to measure the system's effectiveness. Prospective constructs would include confidence, trust, and intention to use.

A concern with the development of commercial systems based on our model of SDSS is the complexity of the system. It is true that developing a SDSS with layers and software agents requires more analysis and development effort than developing a traditional type of DSS. However, with the rapid advancement of computer and Internet technology, the problem of complexity is less and less threatening. Object-oriented programming brings reusable and maintainable objects which save a lot of effort in the development of software applications. New development techniques of web-application also make the implementation of SDSS more effortless. For example, ColdFusion MX introduced the ColdFusion components (CFCs), which combine key concepts from custom tags and user-defined functions into objects; these objects are reusable and extensible. Therefore, in our opinion, the SDSS is a promising direction of the research of decision support system.

7. References

Adelman, L. (1991). "Experiments, quasi-experiments, and case studies: a review of empirical methods for evaluating decision support systems." IEEE Transactions On Systems, Man, And Cybernetic **21**(2).

Ahmad, A. (2000). "Validating a theory-based design for online instruction: the integrated learning model." PhD dissertation, McGill University, Montreal, Quebec, Canada.

Aronsky, D. and P. J. Hang (1999). An integrated decision support system for diagnosing and managing patients with community-acquired pneumonia. Proc AMIA Symp.

Arsham, H. (2006) Forecasting by smoothing techniques. http://home.ubalt.edu/ntsbarsh/Business-stat/otherapplets/ForecaSmo.htm, last accessed at September 20, 2006

Balducelli, C., G. D. Costanzo, et al. (2000). A prototype of an active decision support system for automatic planning support in emergency management. Seventh Annual Conference of the International Emergency Management Society.

Brancheau, J. C. and J. C. Wetherbe (1987). "Key issues in information systems management." MIS Quarterly **11**(1): 23-45.

Brown, R. G., R. F. Meyer, et al. (1961). "The fundarmental theorem of exponential smoothing." Operations Research **9**(5): 673-687.

Buchanan, J. A. (2001). "Use of simulation technology in dental education." Journal of Dental Education **November**.

Bui, T. and J. Lee (1999). "An agent-based framework for building dcision support systems." Decision Support Systems **25**: 225-237.

Carlsson, C. and P. Walden (1999). "Intelligent systems and active dss", 32nd Hawaii International Conference on System Sciences.

Chaturvedi, A. R. and G. K. Hutchinson (1993). "Supporting complex real-time decision making through machine learning." Decision Support Systems **10**(2): 213-233.

Claver, E., R. Gonzales, et al. (2000). "An analysis of research in information system (1981-1997)." Information & Management **37**(4): 181-195.

Davis, FD. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology." MIS Quarterly 13(3): 319-340

Delic, K. A., L. Douillet, et al. (2001). "Towards an architecture for real-time decision support systems:challenges and solutions." Database Engineering & Applications: 303-311.

Devitt, J., M. Kurrek, et al. (1998). "Testing internal consistency and construct validity during evaluation of performance in a patient simulator." Anesthesia and analgesia.

Devitt, J. H., M. M. Kurrek, et al. (2001). "The validity of performance assessments using simulation." Anesthesiology **95**: 36-42.

Eom, S. B. (1999). "Decision support systems research: current state and trends." Industrial Management & Data Systems **99**(5): 213-220.

Filip, F. G, D. A. Donciulescu, et al. (2002). "Towards intelligent real-time decision support systems for industrial milieu." Studies in Informatics and Control **11**(4).

Fischer, K., J. P. Müller, et al. (1995). "Unifying control in a layered agent architecture." Agent Theory, Architecture and language Workshop.

Gaba, D. M., S. K. Howard, et al. (1998). "Assessment of clinical performance during simulated crises using both technical and behavioral ratings." Anesthesiology **89**(1): 8-18.

Gijbels, I., A. Pope, et al. (1999). "Understanding exponential smoothing vie kernel regression." Royal Statistical Society **61**(Series B): 39-50.

Han, J. and M. Kamber (2001). Data mining: concept and technique. San Francisco, Morgan Kaufman.

Hejley, W. E. and D. Murray (1993). Intelligent user interfaces. 1st International Conference on Intelligent User Interfaces.

Hinkkanen, A., R. Kalakota, et al. (1997). "Distributed decision support systems for real-time supply chain management using agent technologies." Readings in electronic commerce Addison-Wesley Longman Publishing Co., Inc: 275 - 291

Jain, S. and C. McLean (2003). A framework for modeling and simulation for emergency response. 2003 Winter Simulation Conference, New Orleans, Louisiana.

Jentsch, F. and C. A. Bowers (1998). "Evidence for the validity of pc-based simulations in studying aircrew coordination." The International Journal of Aviation Psychology **8**(3): 243-260.

Jones, K. (1981). "Who's who, who sits where?" Times Education Supplement **14**.

Jones, K. (1998). "Who's who, who sits where?" Simulation & Gaming **29**(3): 328-330.

Kapoor, J. R., L. R. Dlabay, et al. (2001). Personal Finance. McGraw-Hill Ryerson.

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

Keen, P. G. and M. ScottMorton (1978). Decision Support Systems: An Organizational Perspective, Addison-Wesley.

Keen, P. G. W. and M. S. S. Morton (1978). DSS: An Organizational Perspective. Reading, Addison-Wesley.

Kendall, E. A., P. V. M. Krishna, et al. (1998). Patterns of intelligent and mobile agents. The second international conference on Autonomous Agents.

Keys, J. B. (1997). "Strategic management games: A review." Simulation & Gaming **28**(4): 395-422.

Lam, S.-H., J.-M. Cao, et al. (2002). "Development of an intelligent agent for airport gate assignment." Journal of Air Transportation 7(2).

Lamond, D., R. Crow, et al. (1996). "Information sources used in decision making: considerations for simulation development." International Journal of Nursing Studies **33**(1): 47-57.

Laudon, K. C., J. P. Laudon, et al. (2002). Management Information Systems: Managing the Digital Firm, Prentice Hall.

Lemon, O., L. Cavedon, et al. (2003). "Managing dialogue interaction: a multi-layered approach." 4th SigDial Workshop on Discourse and Dialogue.

Luo, Y., K. Liu, et al. (2002). "A multi-agent decision support system for stock trading." IEEE Network **January/Februrary**.

Maes, P. (1995). "Modeling adaptive autonomous agents." Artificial Life (an overview), MIT Press: 135-162.

Manheim, M. L. (1988). "An architecture for active DSS." System Sciences **3**: 356-365.

Merrill, J. (2006). Is negative savings rate a problem? Bankrate.com. **March**.

Moore, J. H. and M. G. Chang (1980). "Design of decision support systems." Data Base **12**(1 and 2).

Namee, B. M. and P. Cunningham (2001). Proposal for an agent architecture for proactive persistent non player characters. Twelfth Irish Conference on Artificial Intelligence.

Naroff, J. (2006). "Is negative savings rate a problem?" http://bankrate.com. **March**, last accessed at September 20, 2006

Noy, A. and G. Ravid (2006). "Testing social theories in computer-mediated communication through gaming and simulation." Simulation & Gaming **37**(2): 174-194.

Nwana, H. and D. Ndumu (2000). "A perspective on software agents research." The Knowledge Engineering Review.

Nwana, H. S. (1996). "Software agents: an overview." Knowledge Engineering Review **11**(3): 1-40.

Palma-dos-Reis, A. and F. M. Zahedi (1999). "Designing personalized intelligent financial decision support system." Decision Support Systems **26**: 31-47.

Paul, S., P. Seetharaman, et al. (2004). User satisfaction with system, decision process and outcome in GDSS based meeting: an experimental investigation. Proceedings of the 37th Hawaii International Conference on System Sciences.

Raghavan, S. A. (1991). "JANUS A paradigm for active decision support." Decision Support Systems **7**: 379-395.

Rao, H. R., R. Sridhar, et al. (1994). "An active intelligent decision support system - Architecture and simulation." Decision Support Systems **12**: 79-91.

Renders, J.-M. and H. Bersini (1994). Hybridizing genetic algorithms with hill-climbing methods for global optimization: two possible ways. The 1st IEEE Conference on Evolutionary Computation.

Russel, S. and P. Norvig (1995). Intelligent Agents, Artificial Intelligence: A Modern Approach, Prentice-Hall.

Sauve, R. (2004). "The current state of Canadian family finances - 2003 report." Contemporary Family Trends. Ottawa, Ontario, Canada, The Vanier Institute of th eFamily.

Shim, J. P., M. Warkentin, et al. (2002). "Past, present, and future of decision support technology." Decision Support Systems **33**(2): 111-126.

Silver, M. S. (1990). "Decision support systems: directed and nondirected change." Information Systems Research **1**(1): 47-70.

Sprague, R. H. and E. D. Carlson (1982). Buiding Effective Decision Support Systems, Prentice-Hall.

Sproule, S. and N. Archer (2000). "A buyer behavior framework for the development and design of software agents in e-commerce." Internet Research **10**(5).

Streufert, S., R. Pogash, et al. (1988). "Simulation-based assessment of managerial competence: reliability and validity." Personnel Psychology; **41**(3).

Thavikulwat, P. (2004). "The architecture of computerized business gaming simulations." SIMULATION & GAMING **35**(2): 242-269.

Turban, E. and J. E. Aronson (2001). Decision Support Systems and Intelligent Systems, Prentice Hall.

Vahidov, R. (2005). "Intermediating user–dss interaction with autonomous agents." IEEE Transactions On Systems, Man, And Cybernetics—Part A: Systems And Humans **35**(6).

Vahidov, R., E. Chen, et al. (2005). Experimental evaluation of agent-supported e-negotiations. Group Decision and Negotiation Conference 2005, Vienna.

Vahidov, R. and B. Fazlollahi (2004). "Pluralistic multi-agent decision support system: a framework and an empirical test." Information & Management(41): 883-898.

Vahidov, R. and G. Kersten (2003). A framework for situated decision support systems. European Conference on Information Systems, Naples, Italy.

Vahidov, R. and G. E. Kersten (2004). "Decision station: situating decision support systems." Decision Support Systems **38**(2): 283-303.

Waggoner, J. (2006) "How long can households sustain negative savings?" USA Today **March**

Walls, J. G., G. R. Widmeyer, et al. (1992). "Building an information system design theory for vigilant eis." Information Systems Research **3**(1): 36-59.

Wooldridge, M. and N. Jennings (1995). "Intelligent agents: theory and practice." Knowledge Engineering Review **10**(2): 115-152.

Yeo, G. K. and S. T. Tan (1999). "Toward a multilingual, experiential environment for learning decision technology." Simulation & Gaming **30**(1): 70-82.

Zografos, K. G., K. N. Androutsopoulos, et al. (2002). "A real-time decision support system for roadway network incident response logistics." Transportation Research Part C **10**: 1-18.

Appendix A: Instruction

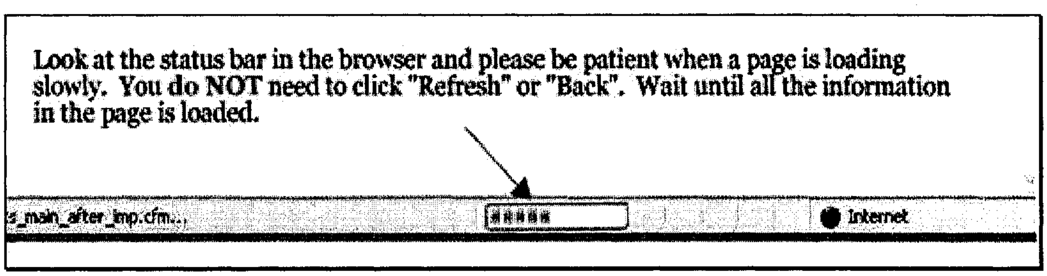
Instructions for the SDSS users

Decision Station, a prototype for Personal Finance Management -- Experiment Instruction

Decision station is a decision support system prototype that helps manage personal finance. It helps you set up financial goals and budget, and you can implement your budget through a twelve weeks simulation.

Caution: Please pay special attention to the following:

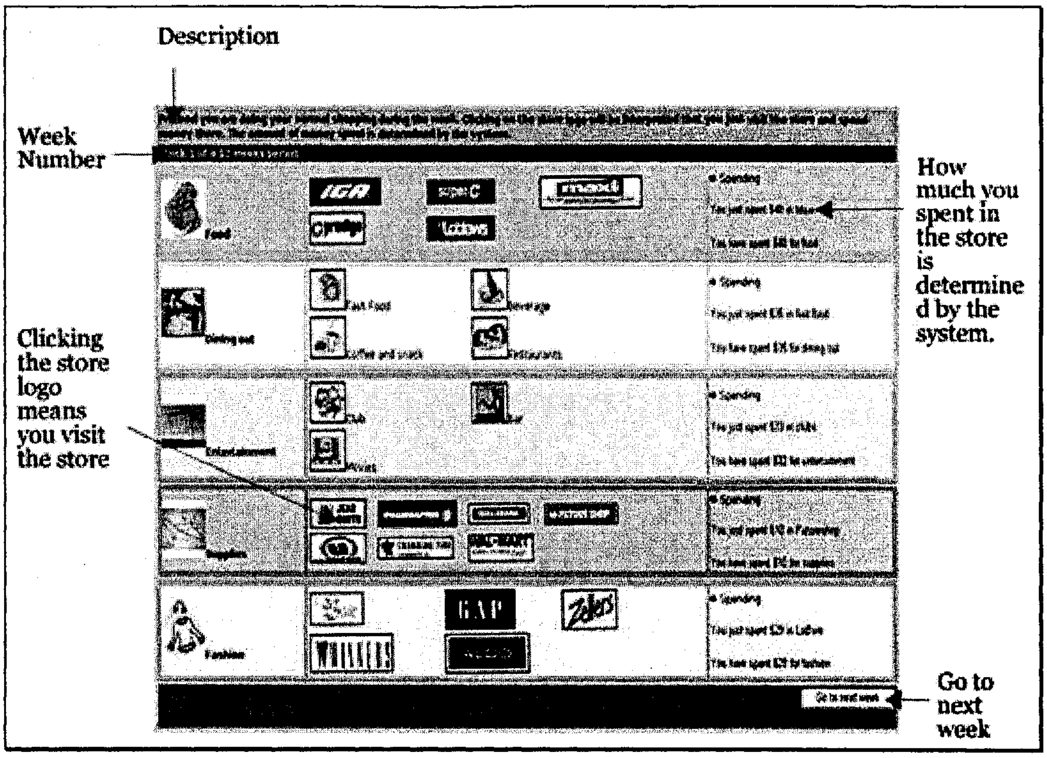
1. If you are in the middle of the experiment, a page is loading slowly, and you can see the progress in the status bar, please be patient and wait until the information is loaded completely.



2. Please read the following description of the weekly shopping simulation carefully.

- Imagining yourself is doing your normal weekly shopping.
- Clicking on a store logo is interpreted as you visit the store and spend money there.
- The amount of money is determined by the system. The amount is calculated base on the normal amount of money people tend to spend in this kind of store and the possible variation.

- Twelve weeks activities are simulated.



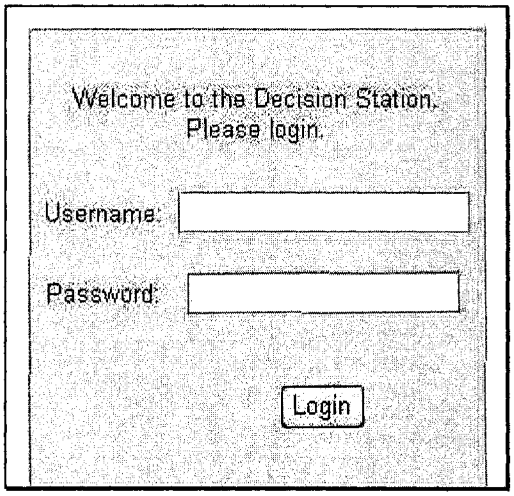
3. This is a preliminary version of the system, or, a prototype. When you fill out the questionnaire at the end, think about this prototype being further developed into a complete version. And instead of simulation, the complete system would be able to monitor one's actual spending activities and provide advice and feedback.

Steps:

Step 1: Login.
Step 2: Questionnaire
Step 3: Goals
Step 4: Budget
Step 5: Investment
Step 6: Evaluation of goals and budget
Step 7: Choose budget before simulation
Step 8: Simulation
Step 9: Choose budget after simulation
Step 10: Report

Step 1: Login.

Input the username and password provided in the corresponding boxes and click the button "Login".

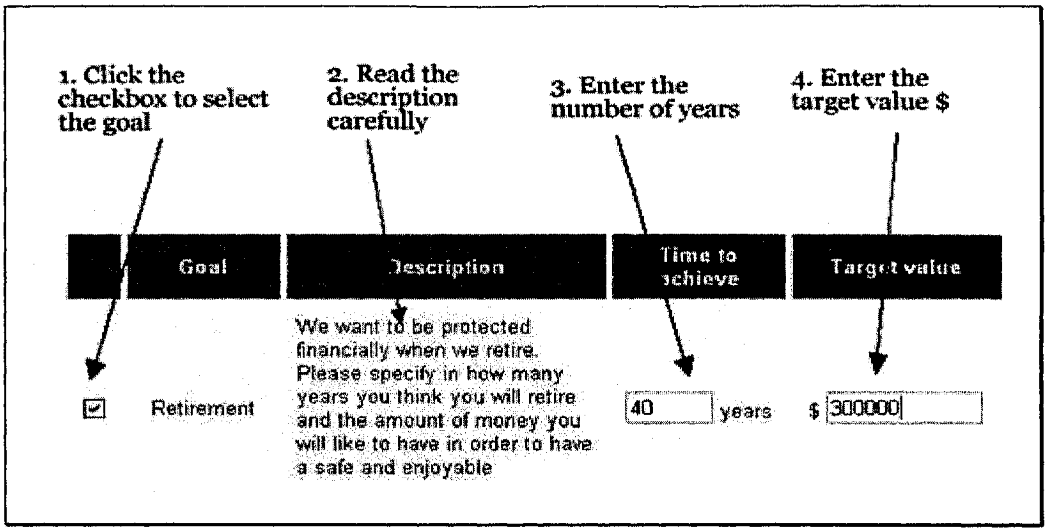


Step 2: Questionnaire

Please finish the questionnaire for collecting the demographic information

Step 3: Goals

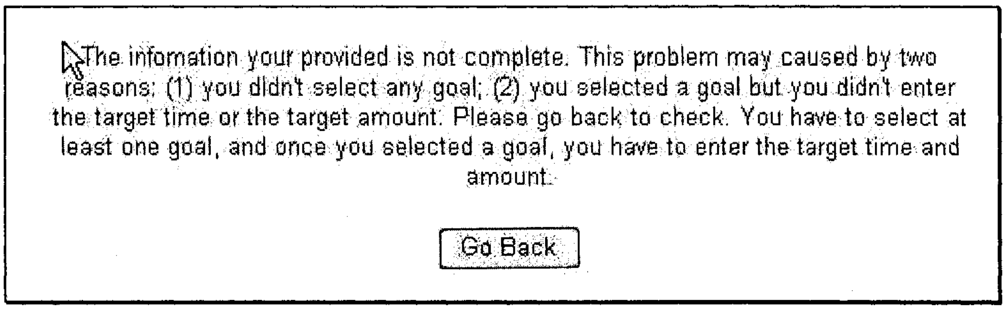
-- Select and specify your financial goals.



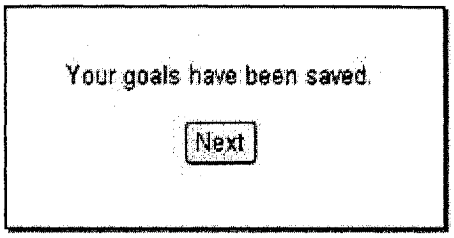
The number of years must be in a reasonable range which is between 1 to 50. The target value must be an amount larger than zero.

You can choose as many goals as you want. Click the button "Submit" after you finish.

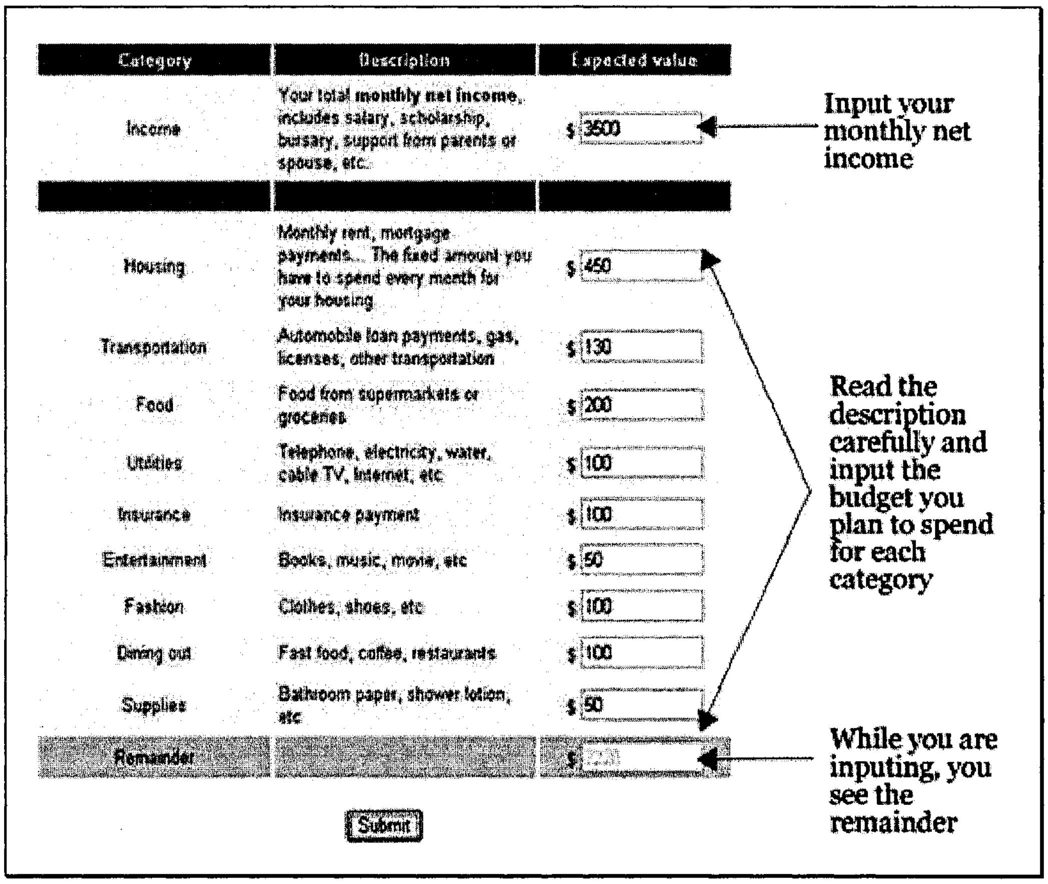
-- If this message appears after you click "Submit"in the goal page, you need to click "Go Back" button to fix the problems. It is possible that you didn't select any goals, or you selected goals but didn't enter the number of years or the target value.



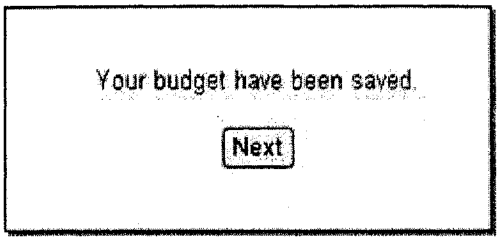
-- If your goals have been saved successfully, you will be notified that your goals have been saved. Click the button "Next" to continue



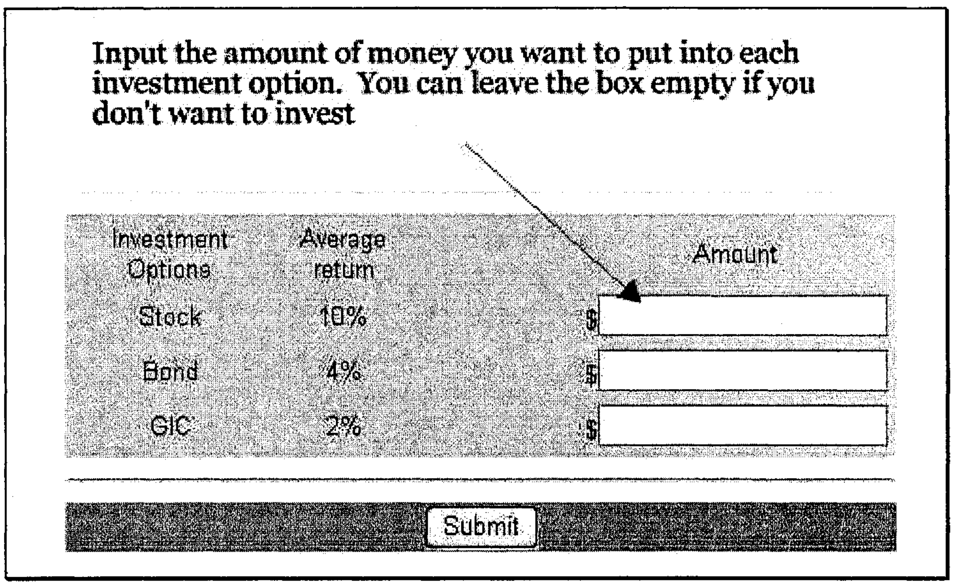
Step 4: Budget



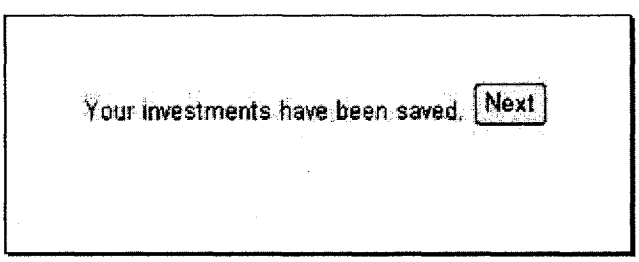
Once you finish setting up your budget, click "Submit" button and you will be notified that your budget has been saved. Click "Next" button to continue.



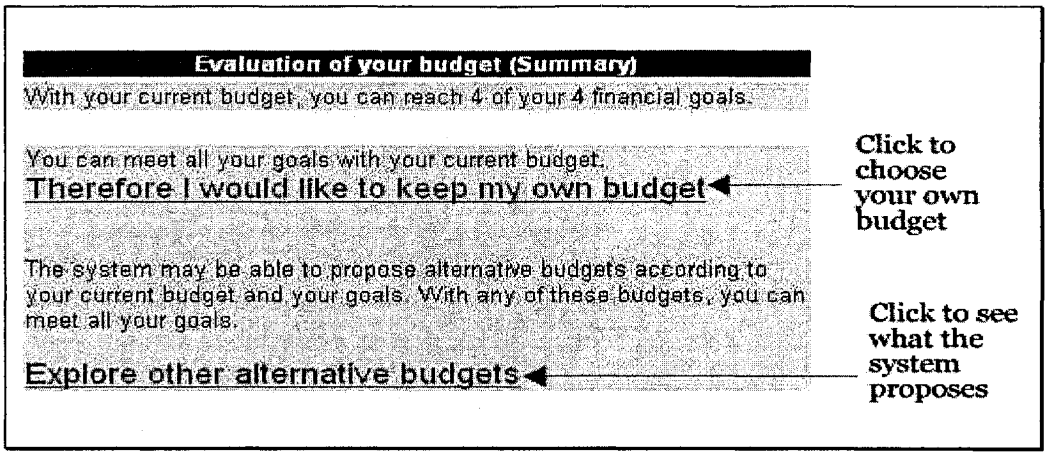
Step 5: Investment



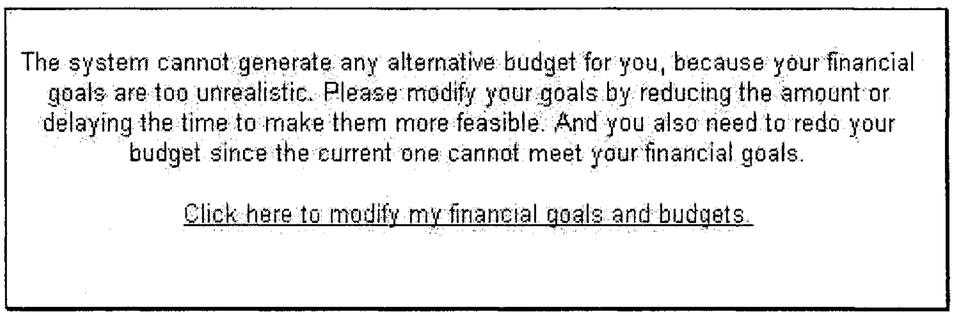
Once you finish entering your investment, click the "submit" button and you will be notified that your investments have been saved. Click "Next" to continue.



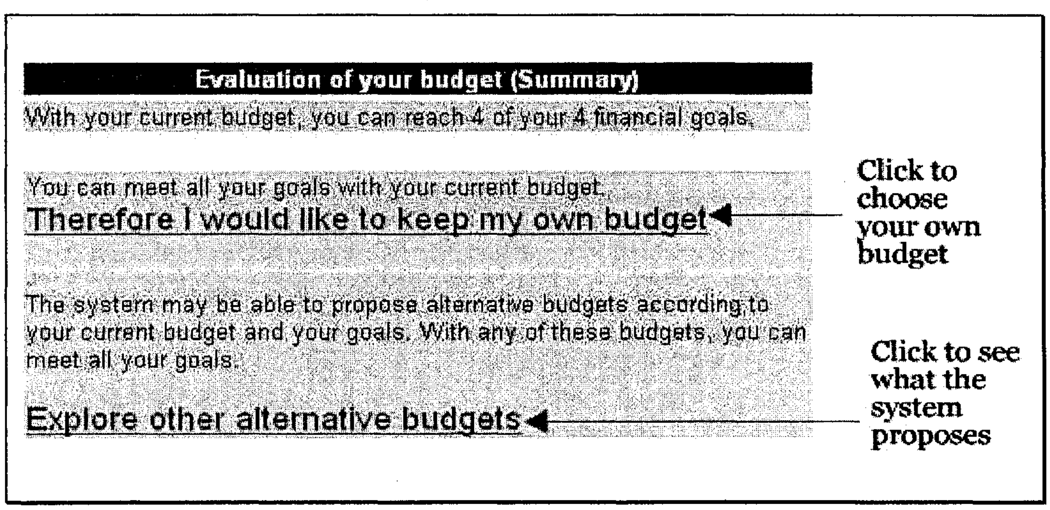
Step 6: Evaluation of goals and budget

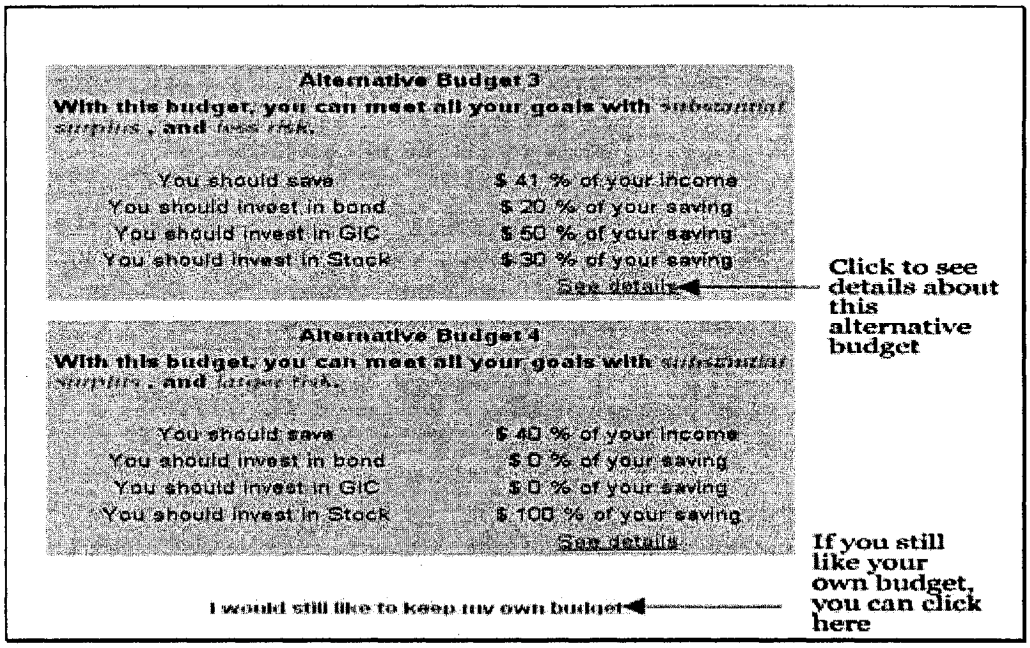


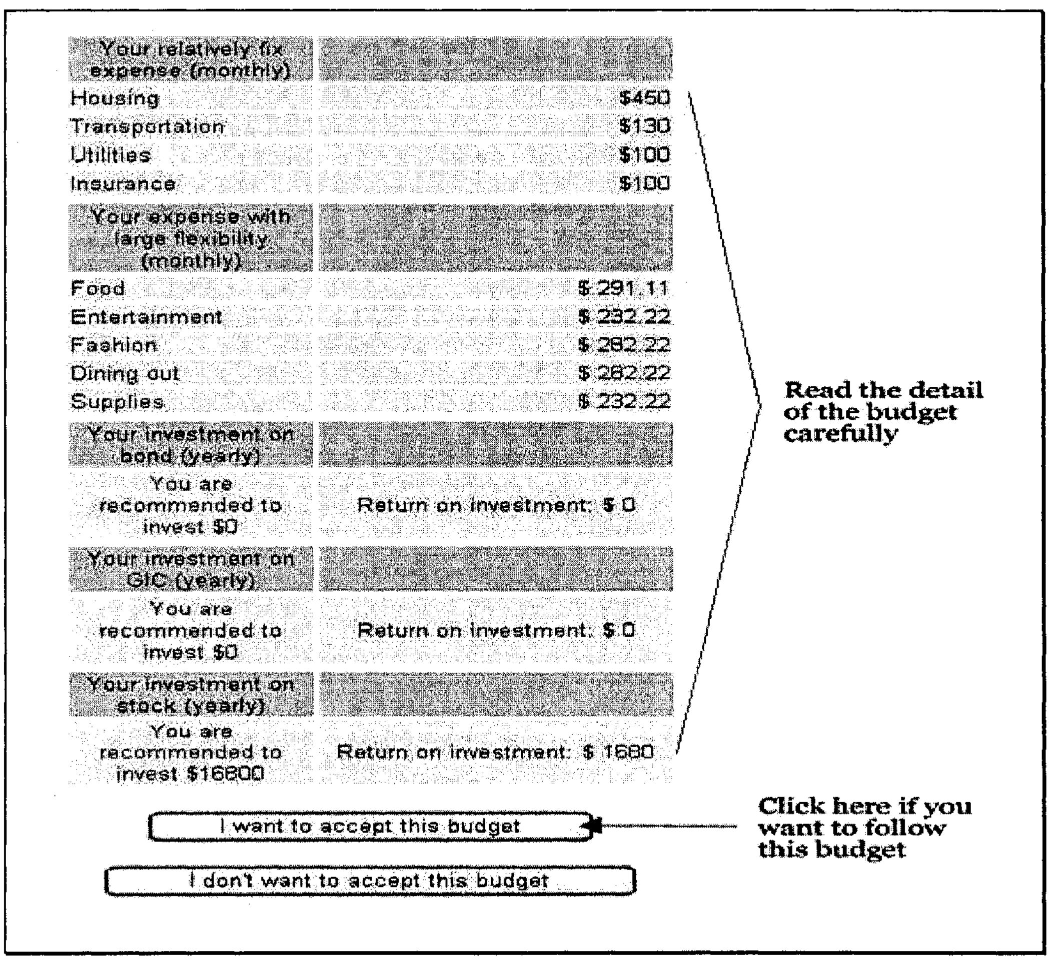
If your goals are too unrealistic base on your budget, the system cannot generate any alternatives, you will see this message, and you will have to input another set of goals and budgets.



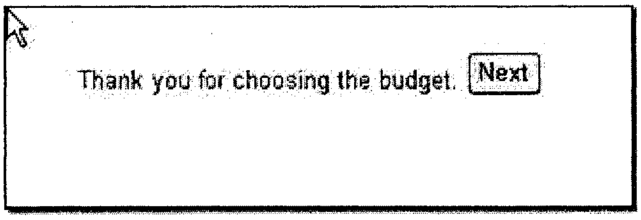
Step 7: Choose budget before simulation



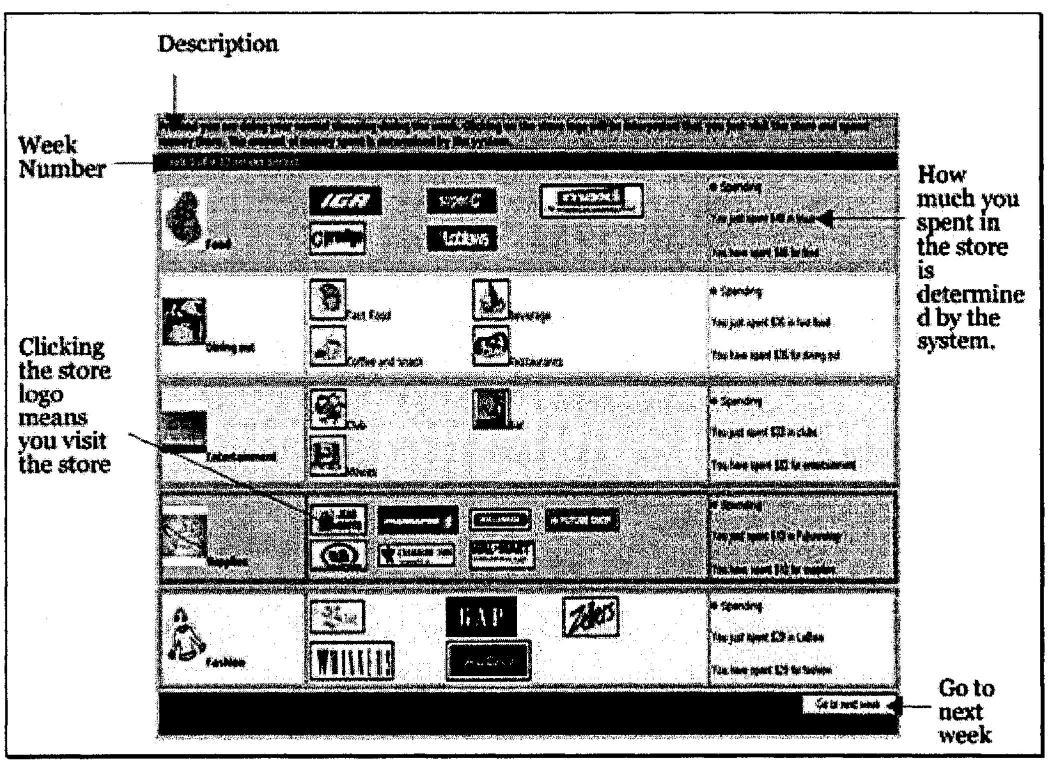

Alternative Budget 3
With this budget, you can meet all your goals with
, and
You should save
$ 41 % of your income
You should invest in bond
$ 20 % of your saving
You should invest in GIC
$ 50 % of your saving
You should invest in Stock
$ 30 % of your saving
See details
Click to see details about this alternative budget
Alternative Budget 4
With this budget, you can meet all your goals with
, and
You should save
$ 40 % of your income
You should invest in bond
$ 0 % of your saving
You should invest in GIC
$ 0 % of your saving
You should invest in Stock
$ 100 % of your saving
See details
I would still like to keep my own budget
If you still like your own budget, you can click here


Your relatively fix expense (monthly)
Housing
$450
Transportation
$130
Utilities
$100
Insurance
$100
Your expense with large flexibility (monthly)
Food
$ 291.11
Entertainment
$ 232.22
Fashion
$ 282.22
Dining out
$ 282.22
Supplies
$ 232.22
Your investment on bond (yearly)
You are recommended to invest $0
Return on investment: $ 0
Your investment on GIC (yearly)
You are recommended to invest $0
Return on investment: $ 0
Your investment on stock (yearly)
You are recommended to invest $16800
Return on investment: $ 1680
Read the detail of the budget carefully
I want to accept this budget
Click here if you want to follow this budget
I don't want to accept this budget

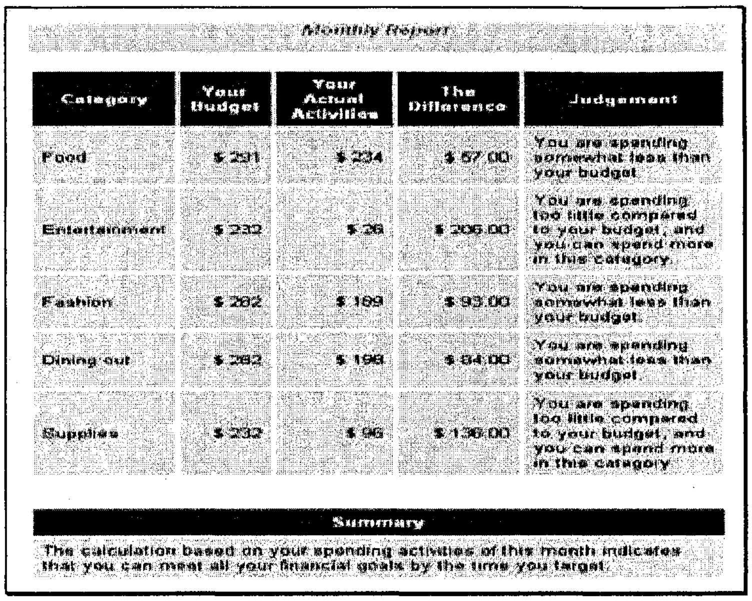
Once you select your budget, (your own one or the one proposed by the system) you will see this message. Click "Next" button to continue.



Step 8: Weekly Shopping Simulation



-- During the simulation, every four weeks, you will see a monthly report. And at the end of twelve weeks, you will see a quarterly report. Please read them carefully.



Monthly Report

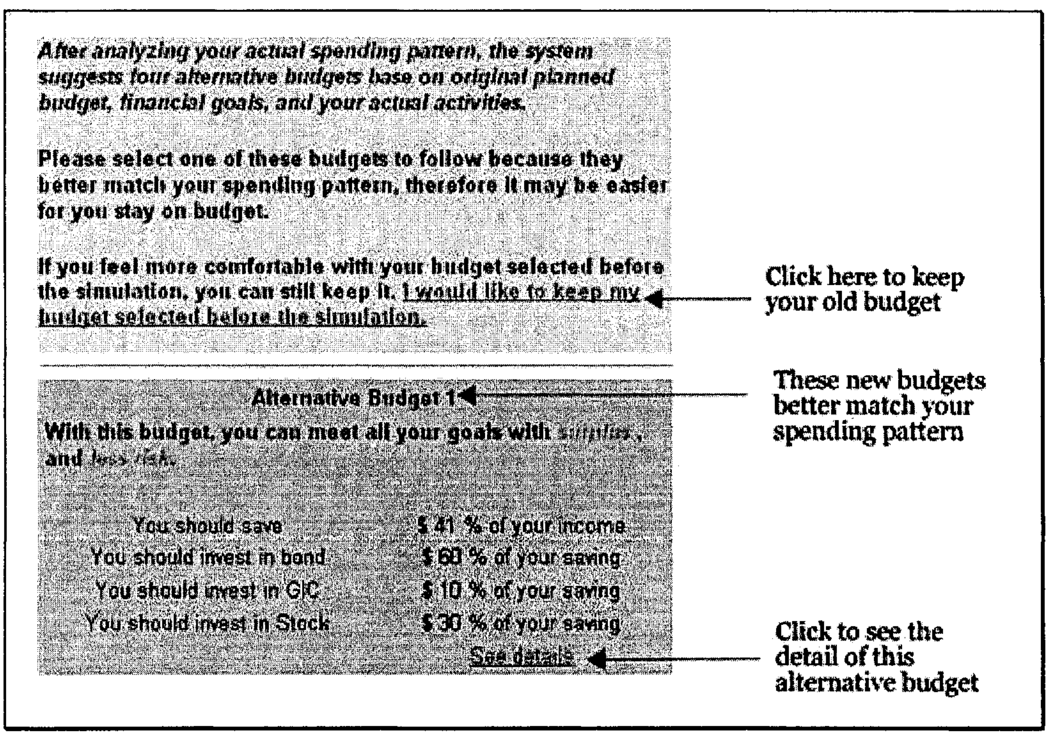
Category	Your Budget	Your Actual Activities	The Difference	Judgement
Food	$ 291	$ 234	$ 57.00	You are spending somewhat less than your budget
Entertainment	$ 232	$ 26	$ 206.00	You are spending too little compared to your budget, and you can spend more in this category.
Fashion	$ 282	$ 189	$ 93.00	You are spending somewhat less than your budget.
Dining out	$ 282	$ 198	$ 84.00	You are spending somewhat less than your budget.
Supplies	$ 232	$ 96	$ 136.00	You are spending too little compared to your budget, and you can spend more in this category.

Summary

The calculation based on your spending activities of this month indicates that you can meet all your financial goals by the time you target.

Step 9: Choose budget after simulation

After 12 weeks simulation, you will be provided with another set of alternative budgets. These budgets are generated by taking consideration of your spending pattern.



Step 10: Report

After choosing the budget, a final report will be presented. Please read it carefully. Click the link provided to finish the questionnaire.

Income	$3500
Housing	$ 450
Transportation	$ 130
Food	$ 356
Utilities	$ 100
Insurance	$ 100
Entertainment	$ 181
Fashion	$ 278
Dining out	$ 268
Supplies	$ 202
Remainder	$1435
Investment at the end of a year	
Investment in stock	$ 5166
Investment in bond	$ 10332
Investment in GIC	$ 1722
With this budget, you can meet all your goals.	
Besides meeting all the goals, you can have an average surplus of 500% of the target value of your goals	

Thank you for your participation.!

Please click here to finish the questionnaire.

Click the link below to finish the questionnaire.

Thank you for your participation.

Please click here to finish the questionnaire.

Instructions for TDSS users

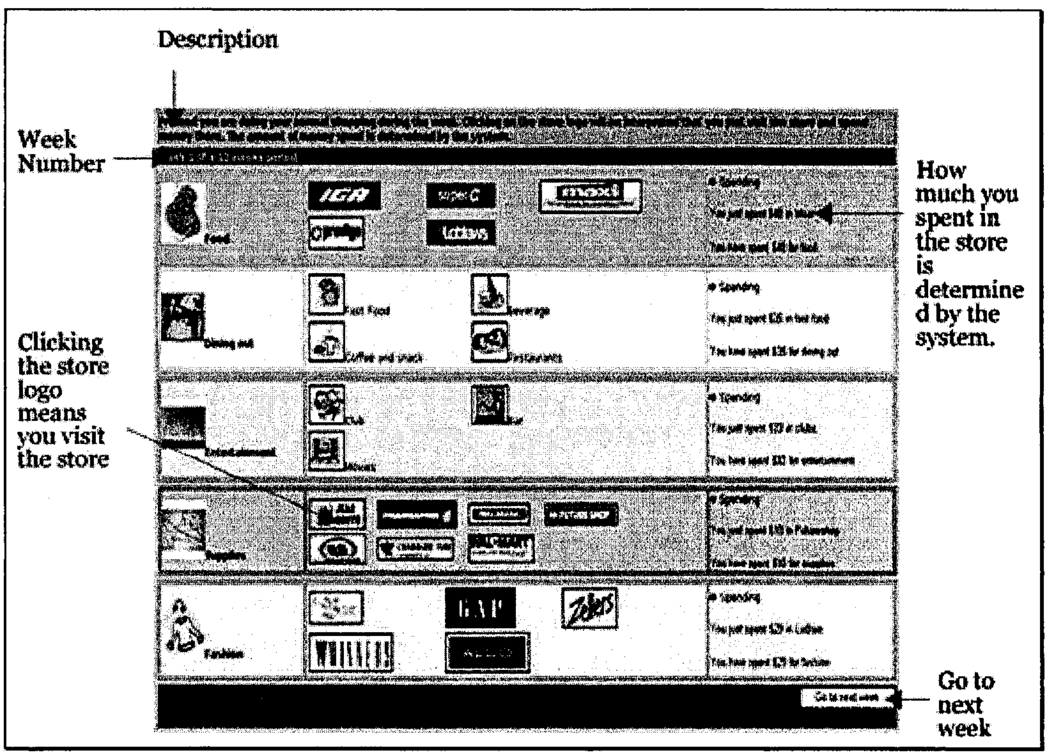
Decision Station, a prototype for Personal Finance Management -- Experiment Instruction

Decision station is a decision support system prototype that helps manage personal finance. It helps you set up financial goals and budget, and you can implement your budget through a twelve weeks simulation.

Caution: Please pay special attention to the following:

1. Please read the following description of the weekly shopping simulation carefully.

- Imagining yourself is doing your normal weekly shopping.
- Clicking on a store logo is interpreted as you visit the store and spend money there.
- The amount of money is determined by the system. The amount is calculated base on the normal amount of money people tend to spend in this kind of store and the possible variation.
- Twelve weeks activities are simulated.



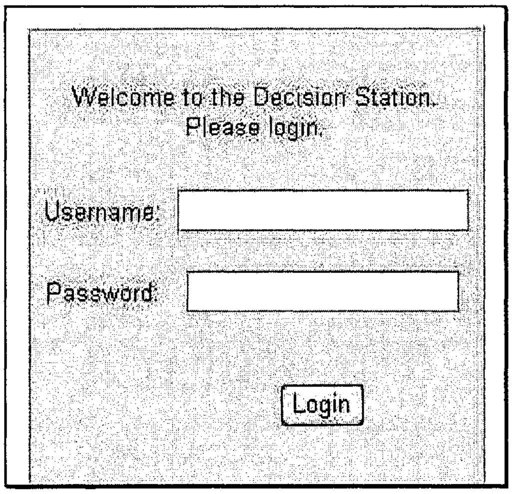
2. This is a preliminary version of the system, or, a prototype. When you fill out the questionnaire at the end, think about this prototype being further developed into a complete version. And instead of simulation, the complete system would be able to monitor one's actual spending activities and provide advice and feedback.

Steps:

Step 1: Login.
Step 2: Questionnaire
Step 3: Goals
Step 4: Budget
Step 5: Investment
Step 6: Evaluation of goals and budget
Step 7: Simulation
Step 8: Report

Step 1: Login.

Input the username and password provided in the corresponding boxes and click the button "Login".

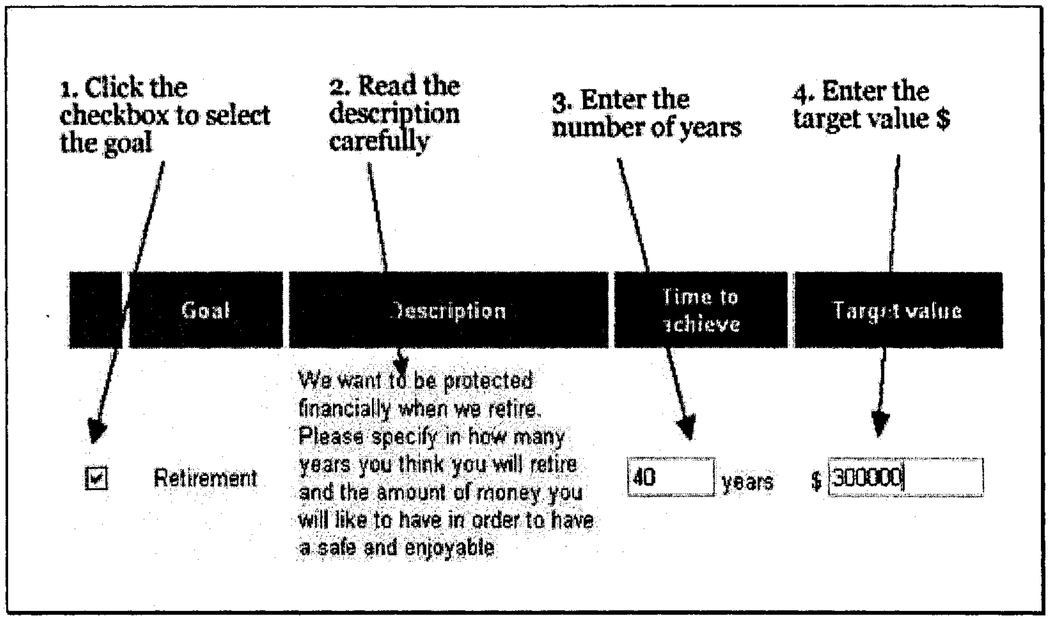


Step 2: Questionnaire

Please finish the questionnaire for collecting the demographic information

Step 3: Goals

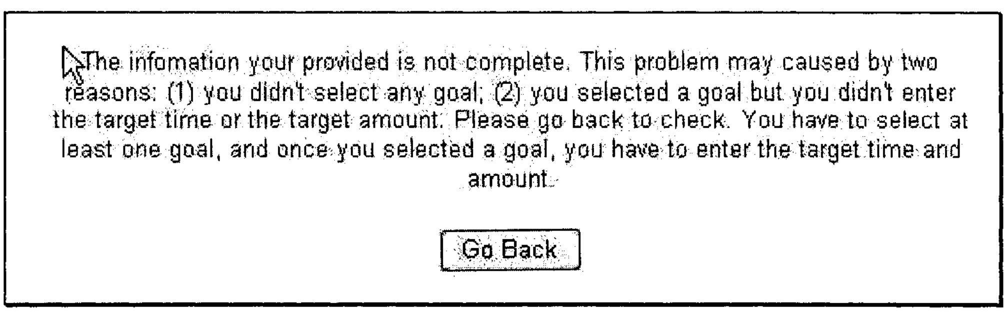
-- Select and specify your financial goals.



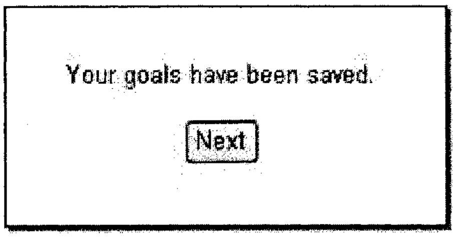
The number of years must be in a reasonable range which is between 1 to 50. The target value must be an amount larger than zero.

You can choose as many goals as you want. Click the button "Submit" after you finish.

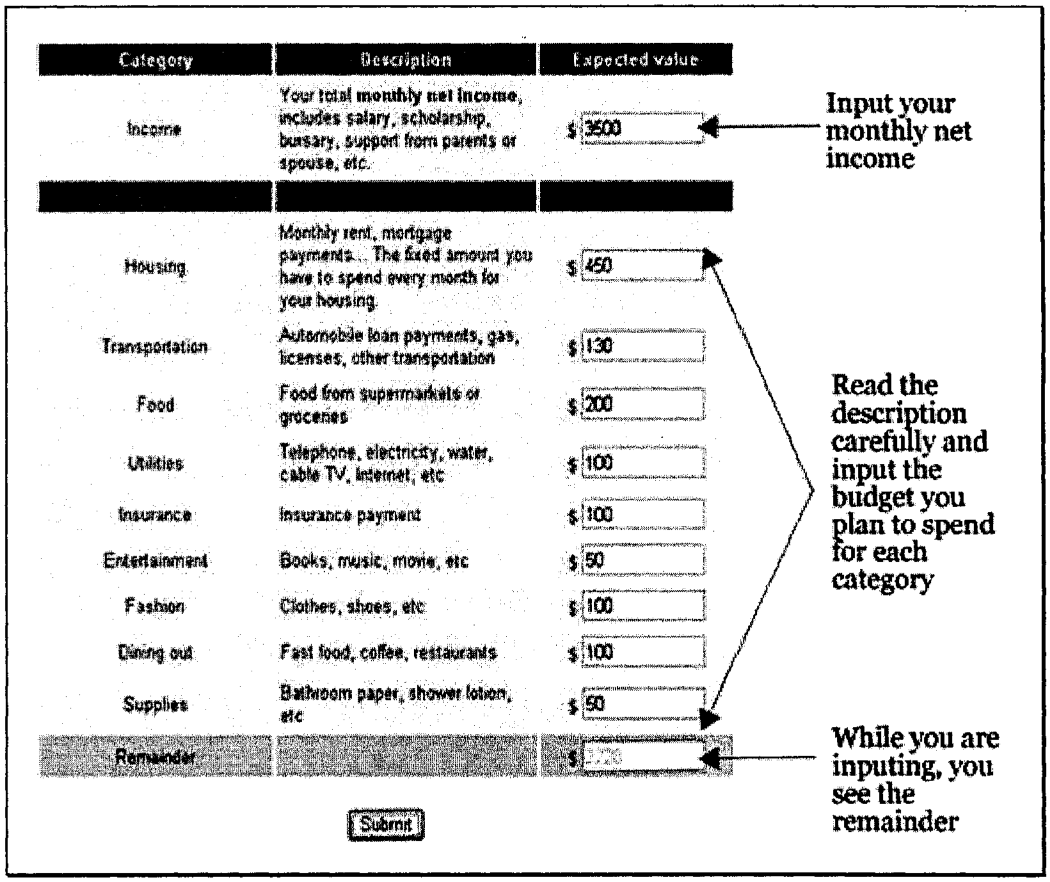
-- If this message appears after you click "Submit" in the goal page, you need to click "Go Back" button to fix the problems. It is possible that you didn't select any goals, or you selected goals but didn't enter the number of years or the target value.



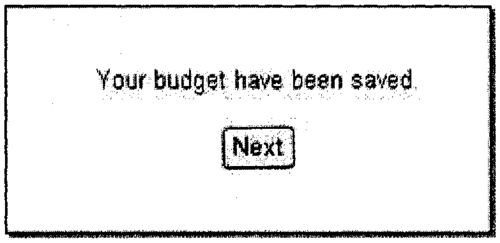
-- If your goals have been saved successfully, you will be notified that your goals have been saved. Click the button "Next" to continue



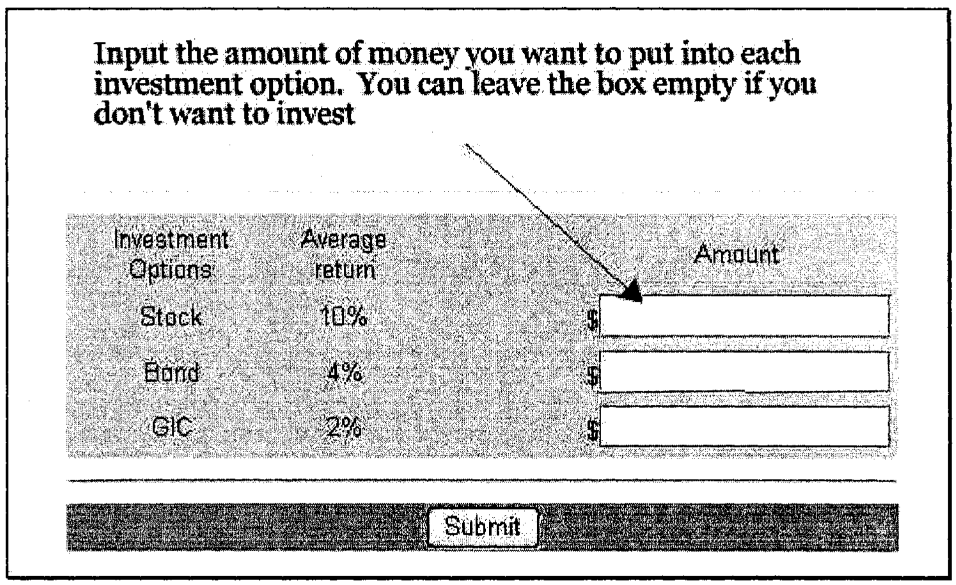
Step 4: Budget



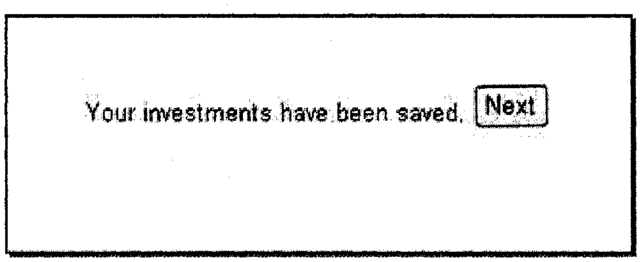
Once you finish setting up your budget, click "Submit" button and you will be notified that your budget has been saved. Click "Next" button to continue.



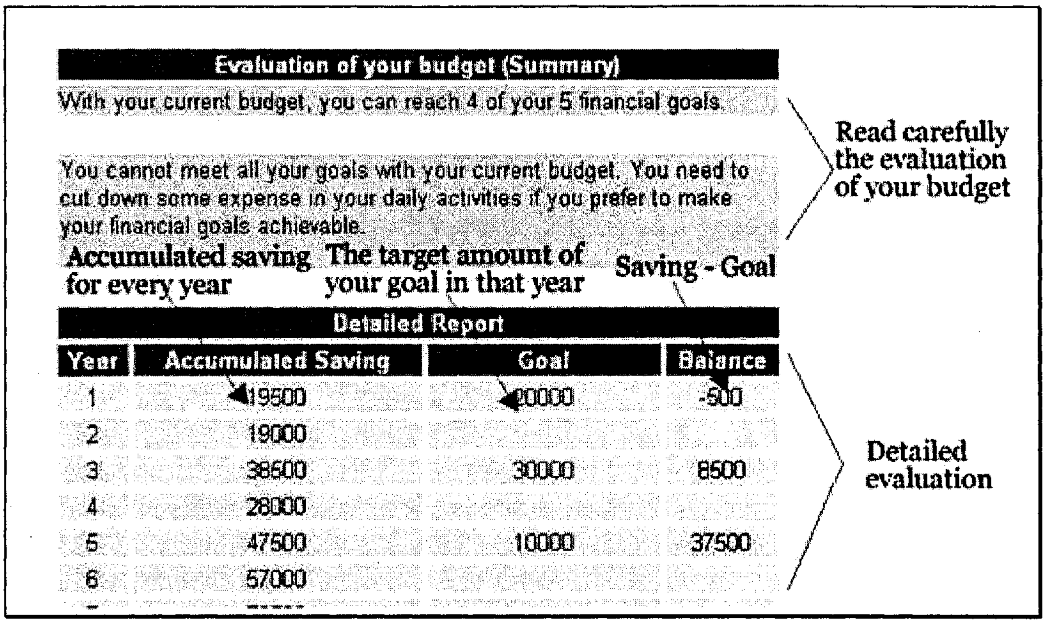
Step 5: Investment



Once you finish entering your investment, click the "submit" button and you will be notified that your investments have been saved. Click "Next" to continue.



Step 6: Evaluation of goals and budget



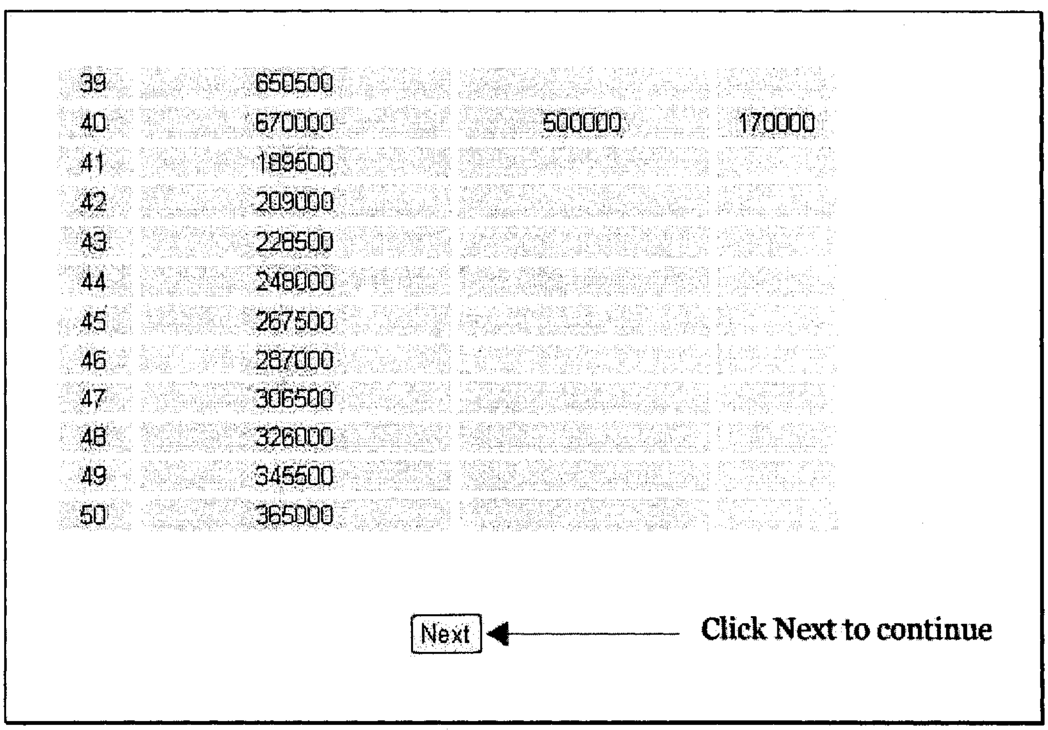
Evaluation of your budget (Summary)

With your current budget, you can reach 4 of your 5 financial goals.

You cannot meet all your goals with your current budget. You need to cut down some expense in your daily activities if you prefer to make your financial goals achievable.

Detailed Report

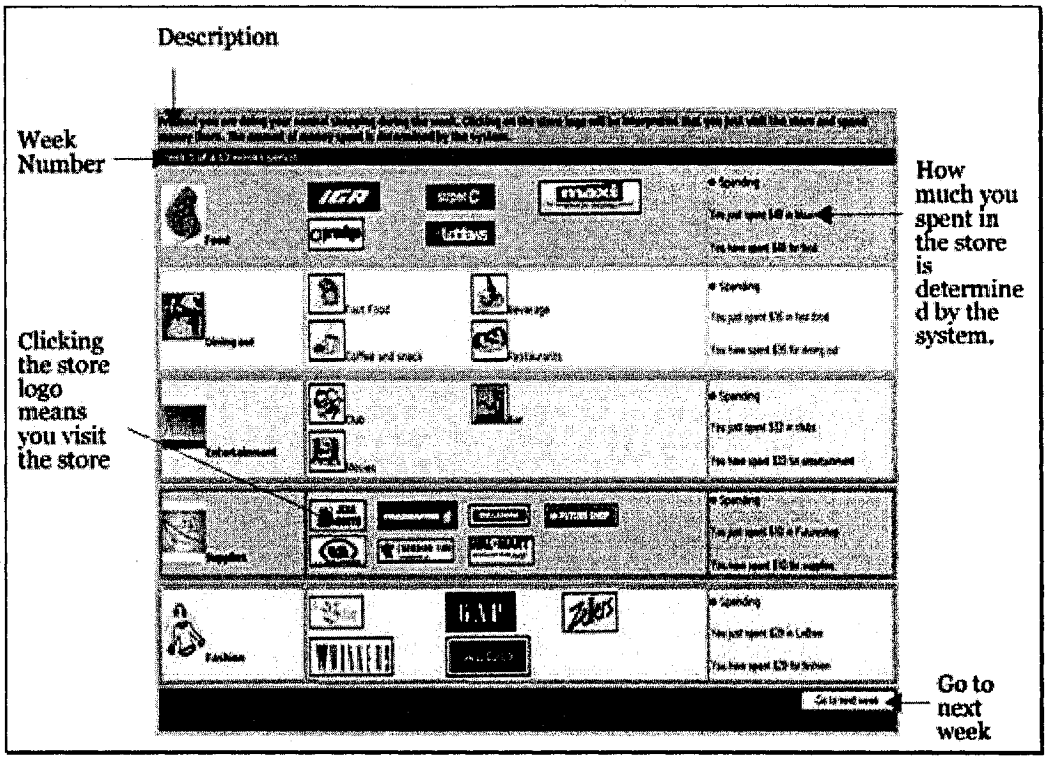
Year	Accumulated Saving	Goal	Balance
1	19500	20000	-500
2	19000		
3	38500	30000	8500
4	28000		
5	47500	10000	37500
6	57000		



39	650500		
40	670000	500000	170000
41	189500		
42	209000		
43	228500		
44	248000		
45	267500		
46	287000		
47	306500		
48	326000		
49	345500		
50	365000		

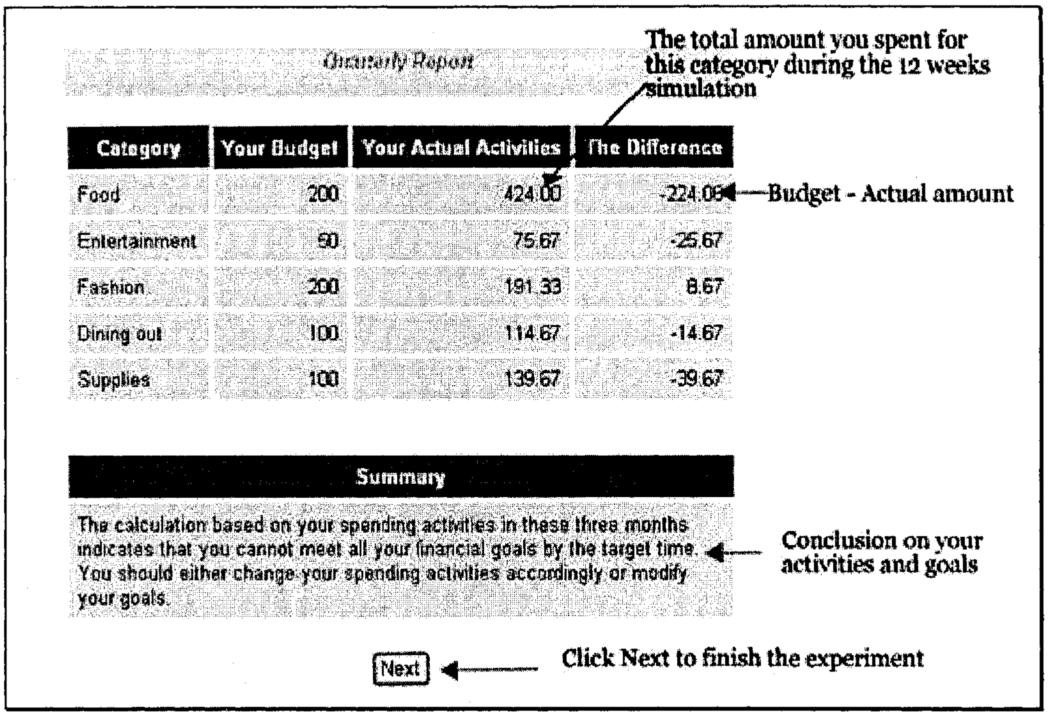
Next

Step 7: Weekly Shopping Simulation



Step 8: Report

-- At the end of twelve weeks, you will see a quarterly report. Please read them carefully.



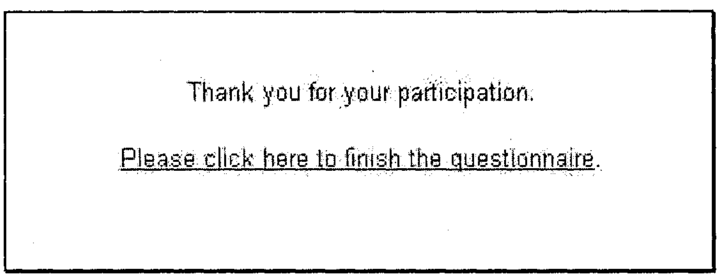
Quarterly Report

Category	Your Budget	Your Actual Activities	The Difference
Food	200	424.00	-224.00
Entertainment	50	75.67	-25.67
Fashion	200	191.33	8.67
Dining out	100	114.67	-14.67
Supplies	100	139.67	-39.67

Summary

The calculation based on your spending activities in these three months indicates that you cannot meet all your financial goals by the target time. You should either change your spending activities accordingly or modify your goals.

Click the link below to finish the questionnaire.



Appendix B: Consent Form

CONSENT FORM TO PARTICIPATE IN RESEARCH

This is to state that I agree to participate in a program of research being conducted by Xin He of Department of DS&MIS of Concordia University.

Contact Information:
Name: Xin He
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A. PURPOSE

I have been informed that the purpose of the research is as follows: to interact and evaluate a system for personal finance management.

B. PROCEDURES

The experiment will be conducted in a computer lab. Participants will be asked to fill in a short questionnaire in which their demographical information will be collected. Sample questions will be the following: what is your age group; did you take any personal finance course before. Then participants will be asked to interact with a system to do their financial planning and expense tracking in a simulated environment. After using the system, participants will be asked to fill in a questionnaire in which their opinion about the system will be asked. Sample questions will be the following: using the system would improve my performance on personal finance management, using the system would help me better implement my financial plan.

C. RISKS AND BENEFITS

Risk: The identity of the participant and the data collected are fully confidential. There will not be any potential risk involved in this study.
Benefits: Participants will better understand their financial goals, budget, and how they can manage their financial resources to reach their goals effectively. And $10 will be paid to participants at the end of the experiment for their participation.

D. CONDITIONS OF PARTICIPATION

- I understand that I am free to withdraw my consent and discontinue my participation at anytime without negative consequences.
- I understand that my participation in this study is CONFIDENTIAL (i.e., the

researcher will know, but will not disclose my identity)

- I understand that the data from this study may be published.

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

NAME (please print) ____

SIGNATURE ____

Appendix C: Demographic questionnaire

1. What is your gender?

O Male O Female

2. What education are you currently enrolled in?

O undergraduate O graduate O Ph.D O Other

3. What is your major?

O Finance O Accounting O MIS O Other business related major O Other non-business related major

4. How long have you been using personal computer?

O Less than 1 year O 1 to 3 years O 4 to 6 years O More than 6 years

5. How long have you been using the Internet?

O Less than 1 year O 1 to 3 years O 4 to 6 years O More than 6 years

6. What age group do you belong to? O under 18 O 18 - 25 O 26 - 30 O 31 - 40 O More than 40

7. Did you take any course or training in personal finance management?

O Yes O No

8. Did you take any finance-related course?

O Yes O No

9. How do you rate your knowledge of personal finance management?

O Very low O Low O Moderate O High O Very high

10. How frequently do you perform financial planning (such as setting financial goals, setting up budget) ?

O Never O Less than 1 time a year O 1 to 3 times a year O More than 3 times a year

11. How frequently do you evaluate the implementation of your financial plan?

O Never O Less than 1 time a year O 1 to 5 times a year O 5 to 10 times a year O I time a month O More than 1 time a month

12. How frequently do you check your account history? O Never O Only if necessary O Less than 1 time a month O More than 1 time a month

Appendix D: Perception questionnaire

1. Using the system would improve my performance on personal finance management.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

2. Using the system would help me implement my financial plan.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

3. Using the system would help me achieve my financial goals.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

4. Using the system would help me follow my financial budget.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

5. Using the system would enhance my effectiveness in managing my personal finance.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

6. I find the system would be useful for managing my personal finance.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

7. My interaction with the system will be clear and understandable.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

8. Using the system will require little mental effort.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

9. I find the system will be easy to use.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

10. I would be satisfied with the interaction with the system.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

11. I would be satisfied with the guidance provided by the system.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree

12. I would be satisfied with the feedback provided by the system.

Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree