Designing A Consumer-Oriented Intelligent Decision Support System For Personalized Financial Planning Services

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Abstract

The rapid advancement of the electronic commerce and web technologies in recent years has substantially changed the way of doing business in almost all domains including the financial services sector. How to provide web-based, personalized, and full-stage decision support services for facilitating individual and community-based group financial planning activities has quickly emerged as a critical issue for both the academics and professionals. With only narrow scopes and limited functions, existing online personal financial planning tools or service systems are incapable of taking into account the variations of individual financial status, needs and preferences for delivering complete and personalized financial management services such as asset allocation, insurance planning, and investment portfolio recommendations. The goal of this paper is to propose a system architecture for designing web-based consumer-oriented intelligent decision support systems to support personalized financial planning services. The system development approach will be discussed along with the illustration of a prototype to validate the feasibility and effectiveness of the proposed architecture and processes.

1. Introduction

For the past few years, the rapid advancement of Internet and Web technologies as well as the fast growth of electronic commerce (EC) and electronic business (EB) applications have strongly forced business companies in almost all domains to redesign their business models, processes, and information infrastructures in order to sustain competitive advantages. The ways of conducting business have changed substantially in the services industries such as information and communication services, tourism and hospitality services, as well as media and learning services. There is no exception for the financial services sector to confront the digital impacts and to fight for survival and success in the increasingly competitive market [11,23,24,29]. Inevitably, financial services providers need to adopt or develop new business strategies, models, processes, and information systems with an innovative thinking for successfully capturing customer values. Therefore, how to provide web-based, personalized, and complete decision support services for facilitating individual and group financial planning activities has quickly emerged as a critical issue for both the academics and professionals. For instance, Konana et

al. (2000) point out the need of a system to support do-it-yourself investors in e-brokerage selections [21]. Wells and Wolfers (2000) address the same need of financial services with a personalized touch and expect a properly engineered computer system to be developed for capturing the demanded information processing capabilities [35]. Poh (2000) also points out the need of an automated investment decision support system for investors. He provides an architecture and an example of a decision support system to support stock investment analysis [28]. Saatcioglu et al. (2001) outline a design model for a financial bundling portal that provides its individual and small-business customers with proprietary financial instruments for selecting and rebalancing customized optional portfolios based on Mean-Variance optimization and scenario analysis approaches [31]. Herbst (2001) indicate that Internet-based applications and innovations in finance include investment research, electronic banking, electronic stock exchange, electronic cash and smart cards. He also emphasize that using the Internet for allocating and rebalancing investment portfolios is among the research topics need to be addressed [18]. Homann, Rill, and Wimmer (2004) describe a web services oriented architecture for facilitating modular design of business functionalities in retail banking. The goal is to get more value out of existing assets. However, the support is focused on business instead of consumers [19]. Yu (2004) present an integrated framework of intelligent decision support systems for consumer-oriented e-services. The financial services industry has been point out as a potential application domain of consumer-oriented intelligent decision support systems [37].

Existing online financial planning systems and web sites such as Yahoo!.Finance (finance.yahoo.com), Quote.com (www.quote.com), Stock Smart (www.stocksmart.com), Quicken.com (www.quicken.com), Fidelity (www.fid.inv.com), FinanCenter (www.financenter.com), Financial Planning (financialplan.about.com), MSN Monev (moneycentral.msn.com), E*Trade (www.etrade.com), Vanguard (www.vanguard.com) etc provide only specific information and functions about stock indices and trading mechanisms. Currently, these limited financial support functions and services offered online are incapable of dealing with personalized and community-based group financial needs and preferences. The lack of full functional supports of investment planning, recommendation, decision making, and performance control to investors is significant. For examples, Quicken InsWeb (www.insweb.com) provides a Term Life Needs Analyzer that uses consumer input data and a simple model to roughly estimate consumer's coverage needs of life insurance. The personal financial planning services of Vanguard (flagship.vanguard.com) provides a Retirement Plan module to help customer estimating the amount of money needed to meet his objectives on retirement. The portfolio function module of Wall Street City (<u>www.wallstreetcity.com</u>) helps investors simulate performances of their current investment portfolios and make suggestions for improvement. It can be seen that although the needs for more powerful consumer-oriented financial decision support are widely recognized, the financial services already provided on web sites are still limited to specific product types and transactions. As a result, these web-based financial services systems can not deliver complete personalized financial planning services such as asset allocation, insurance planning, and investment portfolio recommendations, and thus are unable to support individual investors making high-quality financial decisions.

For meeting the demand of personalized financial decision support, the objective of this paper is to propose a architecture designing web-based system for consumer-oriented intelligent decision support systems (CIDSS) to facilitate personalized financial planning services. The system development approach will also be discussed with an illustration of a prototype to validate the feasibility and effectiveness of the proposed architecture and processes. The rest of this paper is organized as follows. In section 2, a system architecture with application-level functional modules and base management subsystems of the CIDSS is presented. Design and implementation considerations of the CIDSS are illustrated in section 3. A CIDSS application prototype in e-investment is discussed in section 4, followed by a conclusion.

2. The CIDSS Architecture For E-Investment

A CIDSS can be defined as a web-based DSS that provides generic and specific application functions, information resources, model and knowledge computing mechanisms, as well as communication facilities to efficiently and effectively assist consumers in making personalized and group decisions with expert-level qualities through all phases of the decision and transaction process. The complete consumer decision-making process encompasses identification, intelligence, design, choice, implementation, and control stages. Main tasks involved in these sequential decision phases respectively include identifying and specifying consumer requirements, searching relevant information and computing resources, designing feasible decision plans for individual or group consumers, evaluating and selecting the optimal or the most satisfactory decision plan, implementing the chosen decision plan, as well as controlling quality and providing

feedbacks during plan execution. Potential financial services of the CIDSS in e-investment include online customized mutual fund organization, personalized insurance planning, personalized asset allocation, and personalized investment portfolio management. Ideally, such a comprehensive CIDSS should be capable of providing extensive functions and capabilities to support (1) all phases of consumer decision making process for financial planning, (2) effective decision making regarding individual and community preferences of investment, (3) intensive search of financial information and products, (4) complex model computation and knowledge inference for investment planning and control, (5) do-it-yourself and self-defined financial planning and analysis, (6) group and community decision making for joint investment, (7) negotiation and auction activities for interacting with financial services providers, (8) transaction and payment processes for acquiring financial services, (9) dynamic quality control of investment plans, and (10) problem resolution and feedback control during the investment plan execution processes.

To design a CIDSS for supporting personalized financial planning activities, we adapt Yu's generic CIDSS architecture with functional extensions. Three functional levels identified are the visualized user interfaces (VUI), the specific financial functions (SFF), and the base management subsystems (BMS). Figure 1 depicts the financial CIDSS architecture with the major and supporting functions and subsystems.

2.1 The Visualized User Interfaces

The visualized user interfaces allow current and potential investors to generate and submit requests of financial information and decisions, to browse the contents of retrieved information and the computational results of personalized financial decision models, to revise inputs of personalized financial decision procedures and activate what-if performance analysis of investment plans, to give



Figure 1. The CIDSS architecure for financial services

feedbacks with respect to system recommendations and actual performances, to select and execute financial planning services and functions, to login and logout the financial application systems. This front-end component also provides the usual DSS dialog management functions to interact with consumers for activating desired financial applications and services, decision functions and procedures, as well as information retrieval and model/knowledge computational processes.

2.2 The Specific Financial Functions

Focusing on full personalized decision support to specific financial applications, major functional modules comprised in this CIDSS architecture include customer and personalized management, information search and browsing, plan evaluation and selection, do-it-yourself planning and design, community and collaboration management, auction and negotiation, transaction and payments, quality and feedback control, as well as communications and information distribution.

Customer and Personalized Management Functions. By using this module, customers of the financial services can create and modify their own profiles including basic personal information, personalized investment preferences, and evaluation criteria for selecting financial products, services, and vendors. They can edit their own personalized web pages with frequently used financial information and decision directories. They can also add personal annotations, place bookmarks, create reference links to specific financial web pages, and organize hyperlinks to relevant financial information repositories and websites.

Information Navigation and Search Functions. In this module, financial customers can use navigational facilities such as subject directories, guide tours, as well as search functions to retrieve and browse information, documents, cases, and decision procedures relevant to their financial planning problems.

Plan Evaluation and Selection Functions. This module is responsible for carrying out financial decision procedures that integrate model and knowledge computing processes to evaluate decision alternatives and select the best solution for implementation. Pre-specified personalized preferences and evaluation criteria are taken into account when selecting and bundling financial products or recommending investment plans.

Do-It-Yourself Planning and Design Functions. This module is responsible for helping customers to plan and design their customized financial decision plans. The interactive process includes steps to pick attractive financial products and services, and to design investment plans that bundle these chosen financial products and services for future evaluation and implementation.

Community and Collaboration Management Functions. This module allows customers to form special interest groups (SIG), to set up community forums and communication channels, to share experiences and resources, to exchange ideas and alternative financial product specifications, to vote and generate a commonly accepted group financial decision plan. Extended functions include recommendation mechanisms that suggest individual or group financial decision plans based on collaborative filtering or case based reasoning (CBR) techniques.

Auction and Negotiation Functions. This module offers a dynamic platform for customers to launch reverse auctioning sessions that call for financial vendors, brokers, and services providers in the financial supply chain to bid on posted personal or group financial decision plans, as well as to negotiate terms and contracts with the final picks.

Transaction and Payment Functions. This module is responsible for allowing customers to issue orders and payments for implementing financial decision plans or simply purchasing financial products and services.

Quality and Feedback Control Functions. This module provides mechanisms for customers to track situations during and after the financial plan execution stages, and to make necessary changes in financial decisions for controlling the qualities of financial services and decision plans. It also collects feedbacks and takes care of questions and complaints.

Communications and Information Distribution Functions. This module is responsible for delivering financial-related information such as news and reports, products and services, orders and contracts, distributions and payments, as well as decision plans to customers and associated trading parties via wired and wireless networks.

Through the use of these specific financial functions, all stages of the consumer-oriented decision-making process concerning personalized and group demands can be fully supported.

2.3 The Base Management Subsystems

In order to facilitate general system management and to ensure full decision support in specific financial applications as well as other potential business domains, base management subsystems in the CIDSS framework include the procedure base management system (PBMS), the database management system (DBMS), the model base management system (MBMS), the knowledge base management system (KBMS), the software base management system (SBMS), and other decision-centric data warehouses, document bases and case bases.

The Procedure Base Management System. The PBMS is a management system that provides functions for efficiently creating, storing, browsing, retrieving, executing, and controlling decision and functional procedures. A specific financial decision procedure, such as the asset allocation procedure or the stock portfolio selection procedure is defined as a complete operating

process for solving a specific financial decision problem. In a specific decision procedure, problem related data, models, and knowledge are arranged in a cross-referred sequence according to their interoperable relationships for obtaining the final solution. On the other hand, a functional procedure can be specified as a specific process that carries out specific application functions such as product and information search, group voting, auctioning, and negotiation. All procedures with execution programs and associated metadata are stored in a procedure base and recorded in a procedure directory. The PBMS directly supports all specific financial functions of the upper application level.

The Data Base Management System. The DBMS manages all different kinds of databases with diverse data models and data types to satisfy various decision and information needs of specific application domains. Entities in the databases include document files, relational tables, and multimedia objects. Also to be created and managed are local and distributed data directories, as well as a link database for maintaining the status of distributed web resources.

The Model Base Management System. The model base contains all needed decision models including general-purpose mathematical programming and statistical analysis models, as well as application-oriented models such as financial product evaluation, insurance coverage calculation, and asset allocation models. The MBMS creates and manages the model base and model directory, as well as the input, process, and output files for model computations.

The Knowledge Base Management System. The knowledge base contains all required knowledge to help making better decisions for specific application problems. For example, knowledge used in assessing level of risk aversion before doing the personalized asset allocation procedure is a rule set for classifying individual into risk-taking groups. The KBMS creates and manages knowledge base and knowledge directory, and input, process, and output files for knowledge inference.

The Software Base Management System. This subsystem manages tool level components of the CIDSS. System components and decision tools to be included are web servers, application servers, database servers, model and knowledge computing servers, multimedia data processing software, statistics and operations research software, application and scripting languages, as well as ES shells and DSS generators. Software and program directories, and operational guides are maintained and managed in this subsystem.

Other Decision-related Data Warehouse, Document Bases and Case Bases. When the OLAP and data mining functions are desired, a data warehouse and/or multiple single-subject data marts can be established as a separate subsystem to manage decision-oriented multi-dimensional databases. The document base stores physical files of various data and document types as well as logical links to relevant hypermedia documents that match the decision and information needs. The case base collects and maintains past cases with case characteristics related to the application domains. Past best cases derived from case-based reasoning with similar characteristics to investor's financial situation are helpful to assist them in developing better investment plans.

In this proposed conceptual CIDSS architecture, various technical levels of the traditional DSS such as the specific DSS (including VUI, GAF, PBMS and domain-specific databases, model bases, and knowledge bases), DSS generator (including VUI, PBMS, DBMS, MBMS, and KBMS), and DSS tools (including SBMS and associated software) can all be expressed in this framework, which is adaptable, evolvable, and operable.

2.4 Personalized Financial Planning Process

In the consumer-oriented financial application domain, consumers are focused on individual and small group investors. Most of this type of investors need assistance from the financial advisors or systems to recommend investment portfolios. They are expecting to gain high returns on portfolios through optimally selecting and bundling specific financial products such as stocks, options, bonds, mutual funds, and foreign currencies. Personalized investment decision making is subject to individual's financial situation, investment objectives, and risk attitude. With the functional support of the CIDSS, investors are capable of performing the following financial activities: (1) browse news, documents, regulations, reports, indices, and other information related to financial markets, institutions, and products, (2) to input and maintain personal financial data, investment objectives, and preferences, (3) to assess personal attitudes about risks and losses, (4) to obtain recommendations of asset allocations and to finalize personal asset allocation plans for implementation, (5) to obtain recommendations of investment portfolios for various selected financial products and to finalize personal portfolio plans for implementation, (6) to select e-brokers and trading systems for executing and managing the trading processes, (7) to design customized and personalized investment plans including asset allocation plan, insurance plan, and stock portfolio plan, (8) to form special-interest investment groups such as mutual fund families, and to collaboratively design a community-based group investment plan, (9) to negotiate with selected financial service providers about terms and contracts, or to initiate auction sessions for choosing agents or brokers with the best bids, as well as (10) to rebalance the asset allocation and portfolio plans to accommodate dynamic market changes. Figure 2 illustrates a customer's financial decision-making process supported by the CIDSS specific financial functions. The entire personal investment decision and transaction processes can then be supported with great satisfaction and low cost.



Figure 2. The consumer financial decision process.

3. The Design and Implementation of CIDSS

The CIDSS development methods, processes, and operating environment are presented in the following subsections respectively.

3.1 The Development Methodologies

For efficiently and effectively constructing the CIDSS for financial planning services, several system development methodologies as explained below are adopted and integrated.

(1) A layered system structure encompassing application layer, conceptual layer and physical layer is classified for guiding system analysis, design and implementation processes.

(2) Hypermedia techniques having characteristics such as interactive and visualized user interfaces, non-linear organization of hyperlinked objects and resources are applied for designing application procedures, user views and interfaces, and cross-referenced information content. (3) An Object-Oriented modeling approach is used for uniformly representing classes and relationships of actors, products, services, decisions, functions, documents, procedures, data, models, knowledge, user views and user interfaces.

(4) A multi-tier Client-Broker-Server network structure incorporating client browsers, web servers, application servers, community and communication servers, intermediate auction and negotiation servers, database and document servers, model base servers, knowledge base servers, etc is adopted for facilitating system implementation and operations.

(5) A software integration approach which takes into account open protocols and methods is used to link CIDSS related operational tools and computing software for building an inter-operable system.

3.2 The Development Process

In the application layer, the main tasks are to identify information and decision requirements, as well as functional and process requirements. Major information categories investors may be interested to search and navigate include financial products and news, company profile and stock performance, price quote and analyst recommendations, etc. The decisions for a personal investor to make include the total amount of investment money, the duration of the investment period, the types of financial products to invest, the portfolio selection of each financial product type, etc. Some commonly performed consumer-oriented financial decision procedures include personal budget planning for investment, personalized insurance planning, personalized asset allocation, personalized investment portfolio selection, e-broker selection, investment performance evaluation and change management, etc. The functions mostly required include search and navigation of financial products and vendors, do-it-yourself design of personal investment plan, recommendation of personalized asset and investment plans, community and communication support, auction and negotiation, etc.

In the conceptual layer, core objects identified for the portfolio selection problem include financial product, financial product vendor, financial market performance, price quote, return on investment, Analyst rating and option, personal financial status, personalized investment needs and preferences, decision procedure, portfolio selection model, model input, model output, model computation program, decision knowledge/rule, knowledge input, knowledge output, knowledge/rule inference program, consumer preference instance, instance input, instance output, and so on. When using a relational DBMS for database implementation, the conceptual object-oriented data model must be mapped into an internal relational data model first.

In the physical layer, there are several feasible approaches for implementing the computational relationships. The first approach is to use application programming language such as ASP (Active Server Page) and/or scripting language such as Java or VB script to write the system embedded model and knowledge computation programs. The second approach is to use CGI (Common Gateway Interface) protocol to link with external computational programs created by some procedural or nonprocedural programming languages for model and knowledge processing. The third approach is to use intelligent agents to search the web for appropriate model and knowledge servers, and then to edit and submit work files with proper formats to the linked servers for computational processing. The returning results are then integrated and continuing tasks are undertaken. The final outcomes are presented to the users for collecting feedback. When executing specific financial decision models and knowledge programs, users provide inputs to activate the computing process, and then receive and view the outputs. They can also modify the inputs, rerun the process and

compare the original and alternative results for what-if analysis.

3.3 The Operating Environment

The CIDSS can be operated in a client-broker-server environment. Participating roles in the system environment include consumers, financial product vendors, intermediary brokers and service providers, online trading and order management systems, as well as web-based financial resources repositories and computing servers. Intermediary financial services providers, on the other hand, can be categorized into several groups including (1) the information brokers that provide financial news, product catalogs, market performance data, subject directories and search engines, (2) the community managers that provide public platforms for special interest groups to share experiences, knowledge, and cases, and to form group financial plans, (3) the market-making agent systems that provide auction, bidding, negotiation, and matching services, (4) the recommender systems that provide financial planning, counseling, filtering, and recommendation services, and (5) the commerce support systems that provide payments, certifications, and clearing services. Web resources repositories and computing servers are websites that provide information. documents. as well as decision model and knowledge computational resources. In the networked operational environment of the CIDSS, there are application servers, database servers, model servers, knowledge servers, and web information and computing servers. The CIDSS personalized operational processes including the self-design of personalized financial products and services, the group negotiation of community-wide financial products and services specifications, as well as the launch of an auctioning session for selecting financial products and vendors.

4. A Prototype CIDSS for E-Investment

A prototyped personalized financial system (PFS) is developed for supporting personalized investment applications based on the proposed CIDSS framework and design methodologies. Figure 3 to Figure 7 illustrate a series of user views and interfaces. Consecutively, these views illustrate an entry point of the system portal, a page for assessing consumer's risk aversion index, a page of recommended personalized insurance plan, a page for showing the recommendation and implementation plans of personalized asset allocation, and a page for presenting the investment portfolio plan on stocks.

For validating our approach, the specific financial functions of the CIDSS are compared with financial services offered in the existing global and local financial web sites including Prudential, Wallstreet City, jfrich.com.tw, and money.udn.com. The CIDSS prototype for investment is the only attempt to incorporate full personalized and community-based decision support functions, while the other web sites can only provide 10% to 50% desired functionalities. In addition, the financial service framework and prototype system is presented to a group of 12 CEOs and CIOs who take a EMBA class related to innovative e-services. After three weeks of focused discussions, a survey is conducted regarding importance, feasibility, and potential effectiveness of the proposed financial services system. The survey outcome shows that both the financial service functions and the system are well received and highly anticipated. Scaring from 1 to 5 for the least to the most supported responses, the average scores for the importance, feasibility, and potential effectiveness are 4.5, 4.2, and 4.5 respectively.

5. Conclusion

In this paper we present a system architecture, design and implementation methods for developing a consumer-oriented intelligent decision support system to support personalized financial planning services. Major system components encompass the visualized user interfaces, the specific financial functions, and the base management subsystems. Through using the CIDSS, all phases of the personalized financial decision-making process can be supported. The results of functional comparisons and an extended focus group survey validate the importance and effectiveness of this CIDSS approach



Figure 3. The front page of the investment portal



Figure 4. The page of assessing risk aversion degrees

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Figure 5. The recommendation of an insurance plan

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Figure 6 A page of personalized asset allocation plan



Figure 7 A page of personalized stock portfolio plan

for personalized financial planning services. Future research directions include the field experiment of the CIDSS prototype to web-based financial consumers, and the performance evaluation related to investment planning and control, as well as the measurement of consumer satisfaction.

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