A Web-Based Consumer-Oriented Intelligent Decision Support System for Personalized E-Services

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ABSTRACT
Due to the rapid advancement of electronic commerce and web technologies in recent years, the concepts and applications of decision support systems have been significantly extended. One quickly emerging research topic is the consumer-oriented decision support system that provides functional supports to consumers for efficiently and effectively making personalized decisions. In this paper we present an integrated framework for developing web-based consumer-oriented intelligent decision support systems to facilitate all phases of consumer decision-making process in business-to-consumer e-services applications. Major application functional modules comprised in the system framework include consumer and personalized management, navigation and search, evaluation and selection, planning and design, community and collaboration management, auction and negotiation, transactions and payments, quality and feedback control, as well as communications and information distributions. System design and implementation methods will be illustrated using an example. Also explored are various potential e-services application domains including e-tourism and e-investment.

Categories and Subject Descriptors
H.4.2 [**Information Systems Applications**]: Types of Systems – decision support.

General Terms
Management, Design.

Keywords
Intelligent decision support system, Decision making process, Personalization, E-services.

1. INTRODUCTION
Among many early views of Decision Support System (DSS), one popular definition given by Sprague and Carlson [17] identifies a DSS as an interactive computer-based system that assists managerial decision makers utilizing data and models to solve semi-structured and unstructured organizational problems. The system framework of a DSS consists of three main functional components, namely the Dialog Generation and Management System (DGMS), the Data Base Management System (DBMS), and the Model Base Management System (MBMS). Three technical levels for the DSS implementation are Specific DSS (SDSS), DSS Generator (DSSG), and DSS Tool (DSST). DSS technologies have been widely used to help managers making better decisions in various business domains such as marketing, advertising, manufacturing, financial management, human resources management, as well as supply chain management. By integrating with artificial intelligence (AI) and expert system (ES) techniques, an expert support system (ESS), a knowledge-based DSS, or an intelligent DSS (IDSS) can be created to support decision-making with expert-level qualities [4,10,11,19,23].

The rapid advancement of Internet and Web technologies and the fast growth of electronic commerce (EC) applications in recent years have brought strong impacts on the strategies and processes of business conductions. Many innovative business models have emerged in the EC environment such as market-oriented E-Shop, E-Procurement, E-Auction, E-Mall, Third Party Marketplace, Virtual Communities, Value Chain Service Provider, Value Chain Integrator, Collaboration Platforms, Information Brokers, and Trust Service Provider [18]. Major identified EC characteristics include global markets, virtual organizations, 24/7 operations, quick responses, competitive pricing, secure transactions, multimedia and hypermedia documents, interactive processes, personalized and customized services, value-added information, innovative products and services, etc. The growing Business-to-Consumer (B2C) applications and increasing market competition have stimulated the needs for more information-intensive and decision-oriented online consumer-support systems and services that could incorporate personalized needs and interests in all searching, deciding, and purchasing processes. For instance, Konana et al. (2000) pointed out the need of a system to support do-it-yourself investors in e-brokerage selections [7]. Wells and Wolfers (2000) addressed the same need of financial services with a personalized touch and expected a properly engineered computer system to be developed to capture the demanded information processing capabilities [20]. Puhretmair et al. (2002) indicated an inevitable trend of tourism information systems to offer extended decision-making support in tourist travel planning [13]. It is obvious that the desired EC-oriented consumer decision and transaction process is relatively more complex than the traditional buying process, since it may contain online activities such as product search and discovery, product and vendor evaluation, price and contract negotiation, transaction and payments, post-purchase services and dispute resolution. Moreover, when planning and transaction services for consumer groups or communities are concerned, extended group decision

ICEC'04, Sixth International Conference on Electronic Commerce
Edited by: Marijn Janssen, Henk G. Sol, and René W. Wagenaar

support capabilities should be developed and provided [22]. Therefore, how to applied innovative EC-related models and technologies to facilitate the web-based consumer decision and transaction process that supports individual and group decision-making with expert-level qualities becomes critical for sustaining e-business competitiveness [1,2,3,5,6,9,14,21]. As a result, more sophisticated concepts and advanced technologies for designing the consumer-oriented intelligent decision support system (CIDSS) need to be developed to meet the increasing market demands. A CIDSS can be generally identified as a web-based IDSS 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 through all phases of the decision and transaction process. Potential business applications of the CIDSS range from online customized shopping, personalized insurance planning, personal financial and investment portfolio management, to individual or group travel planning.

2. LITERATURE REVIEW

In the research literature, most of the previous DSS research focused on enterprise-level decision support rather than on consumer support with regard to personalized preferences. Even for those works mentioning consumer or customer-focused EC and DSS applications were eventually focusing on supporting business organizations to make management decisions related to relationship marketing or product development [8,10]. Among very few research efforts, O'Keefe and Mceachern (1998) considered the role of customer DSS in web-based marketing and proposed a framework that comprised system functions including agents and event notification, visual catalog and search facilities, samples and evaluation models, pointers to existing customers, payment facilities, and email and newsgroup supports [12]. Saatcioglu et al. (2001) outlined 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 [16]. Ricci et al. (2002) presented a case-based reasoning (CBR) approach for a web-based intelligent travel recommender system to support users in travel-related information filtering and product bundling [15]. Generally speaking, the scopes and functions presented in the existing CIDSS related researches are limited to specific domains and tasks, only partial problems and issues of the CIDSS have been addressed. A broadened and integrated view of CIDSS is still in need to take into account all service requirements including full functional support of consumer decision making and transaction process, best match of personalized or community preferences, expert-level decision processing, dynamic pricing and quality control, as well as a generalized framework in support of diversified specific application domains.

As for commercial web sites, some efforts to assist customers in searching and selecting products and services have been reported. For example, General Electric Plastics (www.geplastics.com) provides datasheets, engineering calculator, and material selection tools on the company web site to help customers in analyzing product needs and getting an effective material solution. 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 (www.wallstreetcity.com) help investors simulate performances of their current investment portfolios and make suggestions for improvement. Although the needs to offer more powerful capabilities for consumer decision support on the web sites are widely recognized, the facilities already provided to the consumers are still limited to specific products and tasks and thus unable to support full-stage and high-quality decisions.

As can be seen, the lack of CIDSS regarding to personalized and community needs is significant in both research and practice sectors. To fill the gap, the CIDSS research topics in all the architecture, development and application aspects deserve extensive research efforts and in-depth explorations. The goals of this paper are firstly to propose a system framework of the information-intensive, model-based and knowledge-based CIDSS for supporting all-stage, high-quality, and personalized consumer decision-making process, and then to illustrate design and implementation methods for directing system development, and finally to explore potential applications in various e-services domains for capturing consumer values. In the following sections, system architecture with application-level functional modules and base management subsystems of the CIDSS are presented in section 2. Design and implementation methods of databases, model bases, and knowledge bases are illustrated in section 3. Extended CIDSS applications in business domains such as e-tourism and e-investment are discussed in section 4, followed by a conclusion.

3. THE CIDSS ARCHITECTURE

By integrating previous views of decision-making process from the DSS and consumer purchasing behaviors [12,17], we classify the complete consumer decision-making process as a process encompassing identification, intelligence, design, choice, implementation, and control stages. Main tasks in each of the six stages respectively are 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. A comprehensive CIDSS is expected to offer full support to consumers through the complete decision-making process. As a result, an ideal CIDSS should be capable of providing extensive functions and capabilities to support (1) all phases of consumer decision making process, (2) effective decision making regarding individual and community preferences, (3) intensive information search, (4) complex decision model computation and knowledge inference, (5) do-it-yourself and self-defined decision planning, (6) group and community decision making, (7) negotiation and auction activities, (8) transaction and payment processes, (9) dynamic quality control, and (10) problem resolution and feedback control. In other words, a consumer is able to access CIDSS functional supports for (1) searching, evaluating and selecting products and services to match his personal needs and preferences, (2) designing personalized decision plan with products and services bundles, (3) forming a

group decision plan if necessary using community mechanisms, (4) initiating an auctioning session for gathering product and service providers to bid on the decision plan and then evaluating and selecting the one with the best bid, (5) activating online transaction, contracting, and payment processes, (6) controlling qualities of implemented decision plan using real time communication facilities, and (7) providing feedbacks, comments, and suggestions.

Taking into account all the required decision support and system management functions, the CIDSS architecture contains three functional levels, namely, the visualized user interfaces (VUI), the generic application functional modules (GAF), and the base management subsystems (BMS). Figure 1 depicts the CIDSS architecture with all the structural functions and components.

3.1 The Visualized User Interfaces

The visualized user interfaces allow users to generate and submit requests of information and decisions, to browse the contents of retrieved information and the computational results of decision models, to revise inputs of decision procedures and activate what-if analysis, to give feedbacks with respect to system outcomes and performances, to select and execute applications and functions, to login and logout the application systems. This component also provides the usual DSS DGMS functions to interact with consumers for activating desired application functions, decision procedures, information retrieval and model/knowledge computational processes.

3.2 The Generic Application Functions

Focusing on full decision support to various specific application domains, major generic application functional modules comprised in our CIDSS architecture include consumer and personalized management, search and browsing, evaluation and selection, planning and design, community and collaboration management, auction and negotiation, transaction and payments, quality and feedback control, as well as communications and information distribution.

Consumer and Personalized Management Module. By using this module, consumers can create and modify their own profiles including basic personal information, personalized preferences, and evaluation criteria for selecting products, services, and vendors. They can edit their own web pages with frequently used information and decision directories, as well as add personal annotations, place bookmarks, and create hyperlinks to specific information and websites.

Navigation and Search Module. In this module, consumers can use navigational facilities such as subject directories and guide tours, as well as search functions to retrieve and browse relevant information, documents, cases, and decision procedures.

Evaluation and Selection Module. This module is responsible for carrying out decision procedures that integrate model and knowledge computing processes to evaluate decision alternatives and to select the best solution while taking into account consumers' pre-specified personalized preferences and evaluation criteria.

Planning and Design Module. This module is responsible for helping consumers to plan and design their customized decision plans. The interactive process includes steps to pick attractive

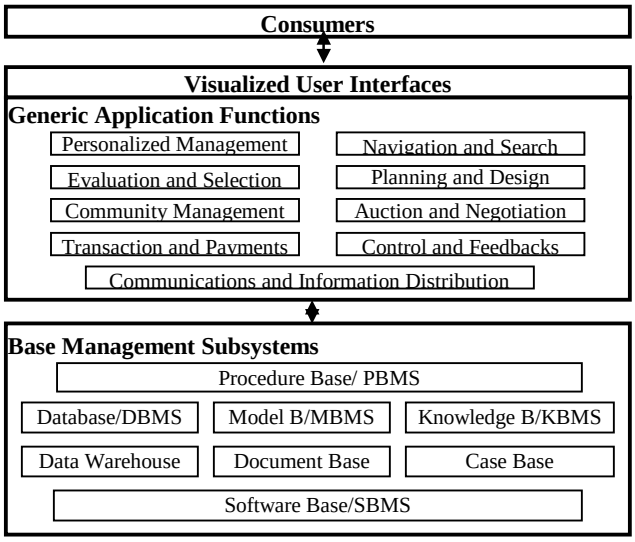

Figure 1. The CIDSS Architecture.

products and services, and to design decision plans that bundle these chosen products and services for future evaluation and implementation.

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

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

Transaction and Payments Module. This module is responsible for allowing consumers to issue orders and payments for implementing decision plans or simply purchasing products and services.

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

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

Through the use of these generic application functions, all stages of the consumer decision-making process concerning personalized and group demands can be fully supported. Figure 2 illustrates the

consumer decision-making process supported by the CIDSS application functions.

3.3 The Base Management Subsystems

In order for facilitating system management and ensuring full decision support in various specific application 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 related 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 decision procedure, such as trip package selection procedure and stock portfolio selection procedure in tourism and financial services domains respectively, is defined as a complete operating process for solving a specific decision problem. In a 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. A functional procedure can be specified as a specific process to carry out specific application functions such as group voting, auctioning, and negotiation. All procedures and associated metadata and control programs are stored in a procedure base and recorded in a procedure directory.

The Data Base Management System. The DBMS manages all different kinds of databases with diverse data models and data types for satisfying 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.

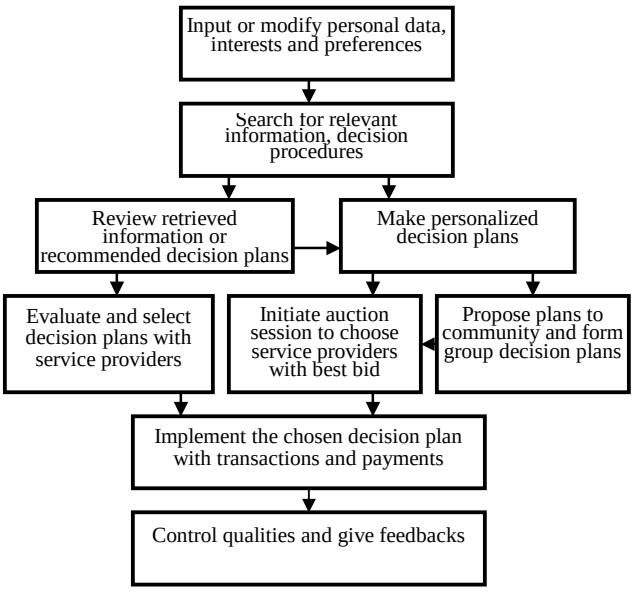

Figure 2. The CIDSS consumer decision-making process.

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 product evaluation, trip package selection, 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. For example, the trip package selection model is a multi-criteria decision model that computes and compares the scores of matchability between consumer preferences and trip package characteristics.

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 the trip package selection procedure is a rule set for identifying matchability scores of every criteria element and for performing initial screening of trip packages. 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 system manages tool level components of the CIDSS including 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 component.

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 types and logical links of hypermedia documents relevant to decision and information needs. The case base collects and maintains past cases with case characteristics related to the application domains. Past cases with similar characteristics are helpful for consumer references and for supporting case-based reasoning to assist consumers in designing better decision plans to meet their needs. A document management system and a case base management system can also be added for better document and case maintenance.

In this proposed conceptual CIDSS architecture, various technical levels of the traditional DSS such as SDSS (including VUI, GAF, PBMS and domain-specific databases, model bases, and knowledge bases), DSSG (including VUI, PBMS, DBMS, MBMS, and KBMS), and DSST (including SBMS and associated software) can all be expressed in this framework, which is adaptable, evolvable, and operable. The process model for system operations follows the same concepts of distinguished technical levels. In the application level, consumers can directly use a SDSS to select and execute a specific decision procedure listed in an application functional menu or shown as a function button for solving their problem, or interact with the embedded ES to help identifying problem, analyzing data, and recommending proper decisions for their evaluation. In the system development level, system managers can create the consumer demanded decision procedures with relevant data, models, and knowledge using DSSG functions when notified from consumer feedbacks that indicate the need of new decision procedures. And in the tool level of DSST, system

users can pick and utilize particular software for specific purposes such as creating application programs, and can install and characterize a newly purchased software tool for future usage.

4. THE DEVELOPMENT OF CIDSS

For efficiently and effectively constructing the CIDSS for specific applications, an Object-Oriented conceptual modeling approach is used for uniformly representing classes and relationships of consumers, vendors, products, services, decision procedures, as well as data, models, and knowledge. A multi-tier Client-Intermediary-Server network structure, and a software integration approach are adopted for facilitating system implementation and operation.

4.1 Conceptual Modeling and System Design

Main tasks in the analysis stage are to identify information, decision, function and process requirements for specific application domains. In general, the most frequently demanded information categories are products and services, functions and features, vendors and service providers. Decisions demanded for supporting include optimal product and vendor selection, plan scheduling, and cost allocation, etc. Functions demanded include browse, search, evaluation, selection, negotiation, auction, payment, etc as stated in the previous section of generic application functions. Taking the tourism domain as an example, one kind of decision for a traveler to make is to choose a trip package that matches his preferences. Associated application functions include search, evaluation, and selection of trip packages and travel agencies. The related decision procedure is then a trip package evaluation and selection process, and major associating information classes include the consumer-related objects such as consumer and preference, the decision-related objects such as decision procedure, decision model, decision knowledge, as well as input, process, and output objects for model and knowledge computations, and the product-related objects such as trip package, destinations, prices, accommodations, schedules, features, and tourism service providers.

In the conceptual design stage, an object-oriented conceptual model is created to represent the integrated database, model base and knowledge base structures of the application decisions and functions. Figure 3 shows an integrated relationship structure of these identified objects. When a decision procedure is activated, data, models, and knowledge related to this specific decision procedure are retrieved, integrated, and computed to generate matched results. In the trip package example, the preference input by the consumer at a particular instance contains six criteria elements, namely, trip destinations, trip length, trip price, accommodation rank, departure date, trip features, and associated weights for each input elements. The corresponding output for the particular instance lists trip package related elements including trip title, trip destinations, trip length, trip price, accommodation rank, departure date, trip features, trip schedule, and travel agency, as well as the trip package's total matchability score obtained from running the decision procedure. The decision procedure of trip package selection consists of one multi-criteria decision model and one associated decision knowledge represented as a rule set as shown in Figure 4. Only information of those trip packages with the total matchability score being greater than or equal to a pre-specified level are retrieved and presented in a recommendation list to the consumer for future investigation.

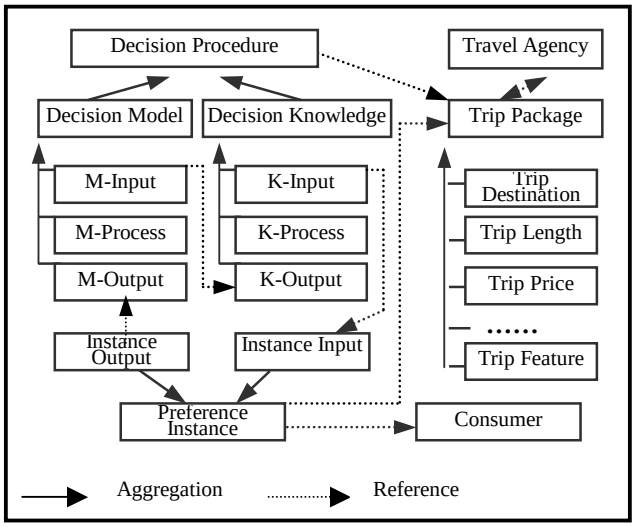

Figure 3. An OO model for trip package selection.

SET T = Sum(T1*W1,…,T6*W6)
Subject to Sum(W1,..,W6) = 1
where T = total score of matchability,
Ti and Wi are value and weight of the ith evaluation criteria, i = 1,…, 6

If Trip destination set B belong to the Input destination set A then T1 = "100"
else T1 = (100-10*(Count(A-B))
If Trip length in days l is within the Input days interval (l1, l2) then T2 = "100"
else if if l < l1 then T2 = 100 – 20*(l1 – l)
or if l > l2 then T2 = 100 – 20*(l – l2)
If Trip price c is within the Input price interval (c1, c2)
then T3 = "100"
else if c < c1 then T3 = 100 – 10*(c1 – c)/5000
or if c > c2 then T3 = 100 – 20*(c – c2)/5000
IF Accommodation rank a is >= Input accomm. rank a1
then T4 = "100"
else T4 = 100 – 20*(a1 – a)
If Departure date d is within the Input date interval (d1, d2)
then T5 = "100"
else if if d < d1 then T5 = 100 – 20*(d1 – d)/3
or if d > d2 then T5 = 100 – 20*(d – d2)/3
If Trip feature set F contains Input feature set F1
then T6 = "100"
else T6 = 100 – 100*Count(F1-F)/Count(F1)

Figure 4. The model and rules for trip package selection.

4.2 Implementation and Operation

In the physical implementation stage, there are several feasible approaches that can be used to implement the computational relationships. The first approach is to use application link with external computation programs created by some programming language such as ASP (Active Server Page) and scripting language such as Java to create the system embedded model and

knowledge computation programs. The second approach is to use CGI (Common Gateway Interface) protocol to 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, necessary continuing tasks are undertaken, and the final outcomes are presented to the users.

The CIDSS can be operated in a client-intermediary-server environment. Participating roles in the system environment include consumers, vendors, intermediary service providers, as well as web resources repositories and computing servers. Intermediary services providers can be categorized into several groups including (1) the information brokers that provide product catalogs, subject directories and search engines, (2) the community managers that provide public platforms for special interest groups to share experiences, knowledge, and cases, (3) the market-making agent systems that provide auction, bidding, negotiation, and matching services, (4) the recommender systems that provide planning, counseling, filtering, and recommendation services, and (5) the commerce support systems that provide payments, certifications, and clearing services. For simplicity, all functions and services of these intermediary services providers can be integrated into a single intermediary CIDSS application server. To implement the CIDSS using an alternative agent-based system approach, three groups of interoperable agents are identified as follows: (1) search agents, decision agents, community agents, auction agents, transaction agents, and payment agents for performing application-oriented functions, (2) collaboration agents, solver agents for dealing with procedure control and model/knowledge computations, as well as (3) collection agents for collecting and maintaining various application-related information, models, knowledge, documents, cases, and software.

5. POTENTIAL CIDSS APPLICATIONS

Among the broad range of potential CIDSS application domains, we only discuss in this section extensive applications in the e-tourism and e-investment domains.

5.1 The Tourism Application Domain

According to reports released from several public and private organizations such as the World Trade Organization (WTO) (www.world-tourism.org), World Travel and Tourism Council (WTTC) (www.wttc.org), Forrester Research Group (www.forrester.com), the tourism sector is one of the largest revenue-generated industry in the world that accounted for 10% of the global GDP with 4.3 trillion US dollars in 1999. In the US, the total revenue of online tourism services was 12.5 billion dollars in 2000 and is expected to reach 30.4 billion dollars by 2004. Although there are great opportunities for tourism services providers to generate significant profits in the EC environment, current tourism information systems and websites such as Expedia (www.expedia.com), Travelocity (www.travelocity.com), Lastminute (www.lastminute.com), and Taiwan-based ezfly (www.ezfly.com.tw), Liontravel (www.liontravel.com.tw), etc mainly provide static tourism products such as package tours and booking services just like what traditional travel agencies offered. The slow adaptation to EC innovations leads to high product similarities and severe price competitions among web site operators, as well as low total tourism market share. It has been signified that a more consumer-oriented web-based tourism information system to support users in travel-related information search, product bundling, and travel planning, and so on is strongly desired.

Applying CIDSS to the tourism domain, consumers are potential travelers and tourists who are interested in looking for existing tourism products and services provided in the tourism value chain to meet their demands, or in planning their personal trips and looking for suitable trip operators. These consumers are provided by the CIDSS with application functions that help them performing the following tourism-associated tasks: (1) to search and browse tourism-related information such as destinations, scenic views, cultural events, accommodations, trip packages, tourism vendors by regions and amenities, (2) to input and maintain personalized travel objectives and preferences, (3) to set up evaluation criteria and activate the product search and selection procedure for selecting suitable trip packages and vendors, (4) to design personalized travel plans when no existing trip packages meet their needs, (5) to organize consumers of similar interests to exchange ideas and form a community groups with commonly accepted trip plans, (6) to initiate auctioning events for inviting tourism vendors and services providers to bid on the group trip plans, (7) to negotiate terms and contracts with chosen travel agents and operators, (8) to implement the contracted trip plans, (9) to control the qualities during the trips, as well as (10) to send feedbacks during and/or after trip operations. To this extent, all stages of the consumers' decision-making process about tourism and travel matters can be fully supported with personalization and customization concerns incorporated.

5.2 The Financial Application Domain

The financial services industry is a marketplace with a significant demand of advanced consumer decision support. As mentioned in the introduction and literature review sections, financial portals and information systems equipped with financial instruments and services for selecting and managing personalized/customized investment portfolios and for selecting proper brokers have been pointed out as urgent market needs. Current financial web sites such as Yahoo!.Finance (biz.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 Money (moneycentral.msn.com), E*Trade (www.etrade.com), Vanguard (www.vanguard.com) etc provide specific information and functions about stock indices and trading mechanisms but are still lack of full investment planning and decision supports to investors. Considering the provision of a CIDSS in the consumer-oriented financial application domain, target consumers are individual or small group investors who are trying to select and invest their money in specific financial products and instruments such as stocks, options, bonds, mutual funds, and foreign currencies. The goal is to match their personalized investment objectives and risk attitudes while attaining the highest rate of returns. With the assistance of a CIDSS, investors are able to activate the following investment-related tasks: (1) to 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, (4) to obtain recommendations of asset allocations, (5) to finalize and implement personal asset allocation plans, (6) to obtain recommendations of investment portfolios for various selected financial products, (7) to finalize and implement personal portfolio plans, (8) to select e-brokers and trading systems for executing and managing the trading processes, (9) to form special interest investment groups such as mutual fund families, (10) to initiate auction sessions for choosing agents or brokers with the best bids, (11) to negotiate with selected financial service providers about terms and contracts, as well as (12) to rebalance the asset allocation and portfolio plans to accommodate dynamic market changes. Similarly, the entire personal and community investment decision and transaction processes can be performed efficiently and effectively in terms of great user satisfactions, quick responses, and low operating costs.

5.3 A Prototype CIDSS

Prototype systems have been developed for both the e-tourism and e-investment applications using the proposed CIDSS framework and design methodologies. Figure 5 to Figure 9 demonstrate a series of web pages of the personalized e-tourism services provided by the specific tourism CIDSS. Figure 5 is a destination page when choosing New Zealand as an area for further navigation. Users can pick a specific city or national park from the list menu or the map, and then search and navigate information about feature attractions, restaurants, accommodations, and tours related to the chosen destination via the vertical menu in the left hand side of the page. Major application functions such as navigation and search, planning and design, personalized management etc are packed and shown as a horizontal menu bar that remains on the upper frame of every page for easy access. Figure 6 is a page for evaluating package tours in which consumers select their preferences and weights about destination region, trip length, price, accommodation rank, departure date, and features, as well as specify the level of matchability. Users can then submit the request to get a list of matched tour packages for their inspection. Figure 7 is a page for designing personalized tour plan in which consumers can design their own trip plan by selecting and bundling destinations, hotels, and restaurants in daily basis. The left hand frame is a working place for bundling destinations, hotels, and restaurants of a single day, while the right hand frame shows the resulting trip plan in consecutive days. Figure 8 is a page of community voting that allow community members to vote on original and alternative trip plans. Before they make the vote, users can check the content of each trip plan. After inserting a new vote by someone, new vote counts of all trip plans appear on the "number of votes" column. And Figure 9 is a page of tour plan bidding session that allows travel agencies to bid on posted group trip plans. The time interval for submitting a bid, the current lowest bid, and the name of the associated bidder are also shown in this page. Figure 10 and Figure 11 illustrate views drawn from operating the specific investment CIDSS. Figure 10 is a view showing the system recommended personalized asset allocation plan as well as the consumer finalized implementation plan. Names and associated investment ratios/amounts of chosen financial products including stocks, bonds, mutual funds, foreign currencies, and insurance in both the recommended and implementation plans are presented in this page. Figure 11 illustrates a continuing recommended personal insurance portfolio plan in which insurance types, principal, duration, and premium are shown in response to a consumer's need and preferences.

Figure 5. A destination navigation page.

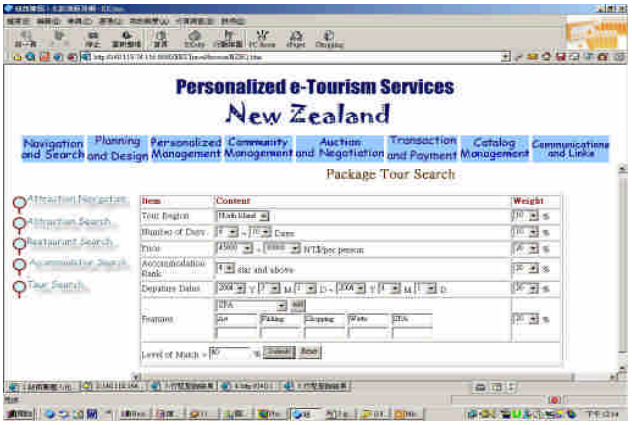

Figure 6. A page for evaluating package tours.

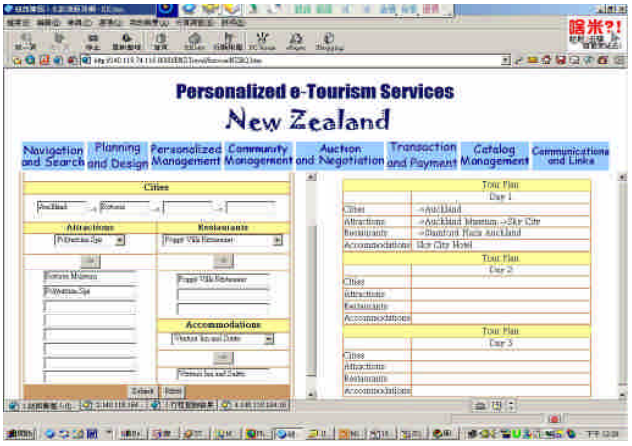

Figure 7. A page for designing personalized tour plan.

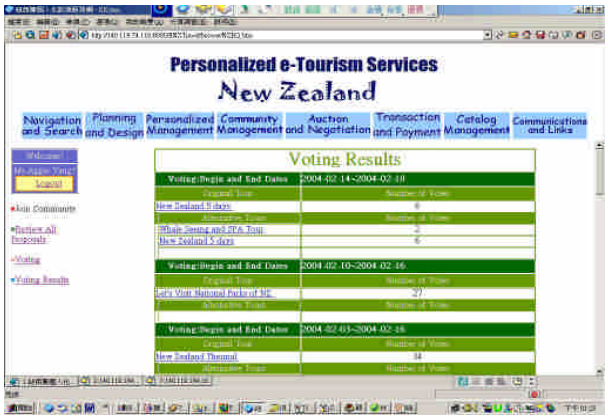

Figure 8. A page of community voting .

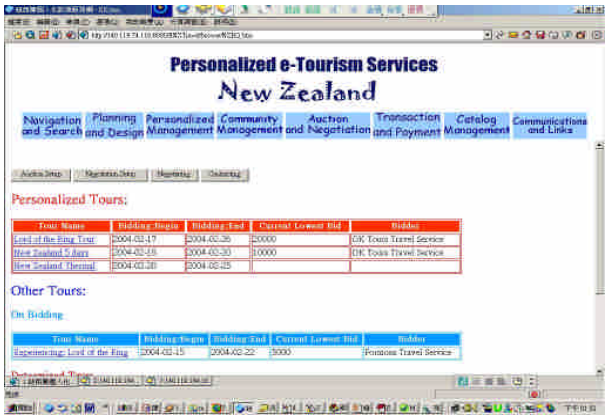

Figure 9. A page of tour plan bidding session.

Figure 10. A view of personalized asset allocation plan .

Figure 11. A view of recommended insurance plan.

6. CONCLUSION

In this paper we present a system architecture, design and implementation methods for developing consumer-oriented intelligent decision support systems and discuss how the CIDSS approach can be applied to support personalized decision making process in various e-services application domains. Major system components encompass the visualized user interfaces (VUI), the generic application functions (GAF), and the base management subsystems. We believe that this is the first comprehensive CIDSS architecture presented in detail. Through using the CIDSS, all phases of the consumer decision-making process can be supported, in addition, by serving consumers with great satisfaction may eventually lead to continuing consumer relationships as well as add values and assets to the entire value chain. Comparing either the e-tourism or e-investment prototype systems to current domain-specific web sites, the CIDSS prototypes are the only systems that are capable of supporting consumers fully in selecting, designing, and implementing personalized decision plans. These two CIDSS prototypes have also been presented to several travel operators and financial brokers respectively, and have received well acclaim as a better solution to the demand of customer decision support. However, an empirical study regarding the validation of the proposed CIDSS architecture and functional requirements is still needed. Future research directions include the validation and verification studies of the CIDSS approach to web-based tourism services, personal investment services and other application domains, as well as the performance evaluation studies related to system operation and control, system effectiveness and consumer satisfaction.

7. ACKNOWLEDGMENTS

This research was supported in part by National Science Council under Project NSC 92-2416-H004-019.

8. REFERENCES

[1] Abernethy, N. F. et. Al. Sophia: A Flexible, Web-Based Knowledge Server. *IEEE Intelligent Systems*, 14, 4 (1999), 79-85.

[2] Bhargava, H., Krishnan, R., and Mueller, R. Decision Support on Demand: On Emerging Electronic Markets for Decision Technologies. *Decision Support Systems*, 19, 3 (1997), 193-214.

[3] Bui, T. and Lee, J. An Agent-Based Framework for Building Decision Support Systems. *Decision Support Systems*, 25, 3 (1999), 225-237.

[4] El-Najdawi, M. K. and Stylianou, A. C. Expert Support Systems: Integrating AI Technologies. *Communications of the ACM*, 36, 12 (1993), 55-65.

[5] Gellersen, H.-W. and Gaedke, M. Object-Oriented Web Application Development. *IEEE Internet Computing*, 3, 1 (1999), 60-68.

[6] Kobayashi, M. and Takeda, K. Information Retrieval on the Web. *ACM Computing Surveys*, 32, 2 (2000), 144-173.

[7] Konana, P., Menon, N. M., and Balasubramanian, S. The Implications of Online Investing. *Communications of the ACM*, 43, 1 (2000), 35-41.

[8] Levin, N.; Zahavi, J., and Olitsky, M. AMOS - A Probability-Driven, Customer-Oriented Decision Support System for Target Marketing of Solo Mailings. *European Journal of Operational Research*, 87, 3 (1995), 708-721.

[9] Liao, Z. and Cheung, M. T. Internet-Based e-Shopping and Consumer Attitudes: An Empirical Study. *Information & Management*, 38, 5 (2001), 299-306.

[10] Liberatore, M. J. and Stylianou, A. C. Toward a Framework for Developing Knowledge-Based Decision Support Systems for Customer Satisfaction Assessment: An Application in New Product Development. *Expert Systems with Applications*, 8, 1 (1995), 213-228.

[11] Matsatsinis, N. F. and Siskos, Y. MARKEX: An Intelligent Decision Support System for Product Development Decisions. *European Journal of Operational Research*, 113, 2 (1999), 336-354.

[12] O'Keefe, R. M. and Mceachern, T: Web-Based Customer Decision Support Systems. *Communications of the ACM*, 41, 3 (1998), 71-78.

[13] Puhretmair, F., Rumetshofer, H., and Schaumlechner, E. Extended Decision Making in Tourism Information Systems. *Lecture Note in Computer Science*, Vol. 2455, Springer-Verlag, (2002), 57-66.

[14] Resnick, P. and Varian, H. R. Recommender Systems. *Communications of the ACM*, 40, 3 (1997), 56-58.

[15] Ricci, F., Arslan, B., Mirzadeh, N., and Venturini, A. ITR: A Case-Based Travel Advisory System. *Lecture Note in Artificial Intelligence*, Vol. 2416, Springer-Verlag, (2002), 613-627.

[16] Saatcioglu, K., Stallaert, J., and Whinston, A. B. Design of a Financial Portal. *Communications of the ACM*, 44, 6 (2001), 33-38.

[17] Sprague, R. H. and Carlson, E. D. *Building Effective Decision Support Systems*, Prentice-Hall, 1982.

[18] Timmers, P. Business Models for Electronic Markets. *Electronic Markets*, 8, 2 (1998), 3-8.

[19] Turban, E. and Watkins, P.R. Integrating Expert Systems and Decision Support Systems. *MIS Quarterly*, 10, 2 (1986), 121-136.

[20] Wells, N. and Wolfers, J. Finance with a Personalized Touch. *Communications of the ACM*, 43, 8 (2000), 31-34.

[21] Yu, C. C. Designing a Web-Based Consumer Decision Support Systems for Tourism Services. In *Proceedings of the 4th International Conference on Electronic Commerce (ICEC'02)* (Hong Kong, October 23-25, 2002).

[22] Zahir, S. and Dobing, B. Designing a Web-Based Multi-Criteria Group Support System (MCGSS). *Journal of Computer Information Systems*, 42, 4 (2002), 50-60.

[23] Zopounidis, C., Doumpos, M., and Matsatsinis, N. F. On The Use of Knowledge-Based Decision Support Systems in Financial Management: A Survey. *Decision Support Systems*, 20, 3 (1997), 259-277.