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Development of a Web-service-agents-based Family Wealth Management System

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ABSTRACT

The roiling financial markets, constantly changing tax law and increasing complexity of planning transaction increase the demand of aggregated family wealth management (FWM) services. However, current trend of developing such advisory systems is mainly focusing on financial or investment side. In addition, these existing systems lack of flexibility and are hard to be integrated with other organizational information systems, such as CRM systems. In this paper, a novel architecture of Web-service-agents-based FWM systems has been proposed. Multiple intelligent agents are wrapped as Web services and can communicate with each other via Web service protocols. On the one hand, these agents can collaborate with each other and provide comprehensive FWM advices. On the other hand, each service can work independently to achieve its own tasks. A prototype system for supporting financial advice is also presented to demonstrate the advances of the proposed Web-service-agents-based FWM system architecture.

Keywords

Web-service agents, Intelligent agent, Web services, Family wealth management, Financial adviser.

1. INTRODUCTION

Recently, a joint research project between Bank of Communications (Hong Kong Branch) (BCOM) and City University of Hong Kong (CityU) has been started. The goal of this project is the long-term research and development of an investment advisor system. Up to now, the project is in the completion of the first phase, which involves first prototype building and testing. Financial Planner (FP), by its nature, is a kind of financial advisor system. It is a computer-based system that provides tailor-made financial and investment related advisory services to individuals. The objective of this joint research project is to apply innovative technology to help high-net-worth individuals to preserve and even to create wealth.

This project initiates our research in wealth management, more specifically, in family wealth management (FWM). According to Financial Advisor Pages (<http://www.fapages.com>), family wealth is the capital (intellectual, emotional, financial, or otherwise) it's used to secure a given quality of life for the whole family members. Given this definition, it makes sense that once an individual has that capital, he or she need to secure it. Traditionally, people who have accumulated a significant amount of wealth secure their wealth by consulting wealth management specialists. In this paper we focus on automating wealth specialist's role to achieve FWM.

The rest of paper is organized as follows. Section 2 briefly reviews the relevant literature on FWM, intelligent agents and Web-service issues, and describes our research motivation. Following the section, a Web-service-agents-based FWM system has been presented in Section 3. The implementation and operation of a prototype system is described in Section 4. Finally, Section 5 addresses our contribution as well as the future work.

2. BACKGROUND

2.1 Family Wealth Management (FWM)

Lifetime financial planning and management is a complex, challenging process (Tomecek, 2003). Families of great wealth have unique requirements and special responsibilities to themselves and to society as well (Grace, 2000). They concern not only the

wealth preservation, but also the wealth creation. Therefore, many wealthy families look for a vehicle that can address their fundamental needs in terms of investment management, tax and estate planning, insurance, accounting, legal services and administrative housekeeping. The business that specializes in these services is called Family Office (FO). According to the Family Office Exchange (FOX) in Oak Park, Ill., there are more than 3,500 family offices in the US and there are an estimated 4,000 more family offices overseas. FOX is a professional association that serves as an independent clearinghouse of global state-of-art best practices and leading-edge concepts within wealth management.

The multi-family office (MFO) has become one of the most sought-after platforms for serving ultra-affluent. FOX defines MFO as a multi-disciplined firm that offers integrated financial advice to its clients in eight or nine categories (Hamilton, 2002). MFO aggregates and focuses resources to facilitate a common interest in asset protection, cost control, financial education, family philanthropy and a host of other needs. Therefore, MFOs must provide services including integrated tax and estate plan, investment strategy, trusteeship, risk management, lifestyle management, record keeping and reporting, family continuity, and family philanthropy. The top 3 MFOs are Atlantic Trust Pell Rudman, Family Wealth Group (US Trust), and Rockefeller & Company (Hamilton, 2002).

Over the last few years, there has been an increasing interest in developing web-based FMO systems, called financial advisor, investment advisor, or financial planner systems. This kind of systems provides services as similar as FO or MFO does, but with narrow focusing on investment strategy and risk management services, such as asset allocation, portfolio management, monitoring and control and reporting services. The most famous financial advisor system is Financial Engines (www.financialengines.com), which is founded by Nobel Prize-winning economist William F. Sharpe. The Financial Engines is registered with the Securities and Exchange Commission (the SEC) as a financial advisor. It provides subscribers with specific buy-and-sell recommendations for managing tax-deferred and taxable investments. There are also some expert systems providing financial advisor services, such as Lymer and Richards' (1995) expert system for personal pension planning, Heuer et al.'s (1988) expert system for financial investment – INVEST, and Pickup's (1989) expert system for personal financial planning. In addition, some well-known banks developed their own on-line system for financial planning and investment advice, such as HSBC (www.hsbc.com), Bank of American (www.bankofamerican.com), Citibank (www.citibank.com), etc. Our research follows such contemporary trend in developing financial advisory system in a much more comprehensive way, as a Wealth Management System.

2.2 Motivation

Demands on family offices have been increasing due to the roiling financial markets, constantly changing tax law and increasing complexity of planning transactions (Martin, 2003). However, the current FOs and MFOs are founded on human specialists' teams, which accrue very high employment cost and in turn raise the service charges for the clients. According to McGould (1999), the dedication of technology can improve the efficiency of FOs business. For example, Asset Management Advisors Inc. ("AMA"), an MFO, uses the computing power and communication technology to expand its services while keeping the costs down. But, it uses technology only in the investment, operations and client services areas, which cover very little part of services provided by a typical MFO. Up to now, there is no one integrated comprehensive advisory system that can perform all MFO functionalities for wealthy people autonomously.

In addition, an estimated \$5 to \$10 trillion of intergenerational wealth will transfer hands over 20 years from 1998 to 2018 according to the statistics published by US Trust and Trusts & Estates. For the high-net-worth individuals, the integrated long-term planning and implementation are crucial to effective wealth management of their lives and their legacies. However, the most current MFO systems can only act as a financial or investment advisor providing customers with investment advices without the consideration of many other issues, such as cash flow management, legal issues, family philanthropy, education, etc. An ideal FWM will be the aggregation of those issues together. Moreover, these systems are lack of flexible, autonomous problem-solving behaviour, rich interactions, and pre-active and re-active features.

All the above mentioned problems motivate us to develop a FWM system, which is an integrated and comprehensive system imitating a real MFO. This FWM system will be able to represent specialists' roles and deliver advisory services that combine the expertise of FWM professionals with powerful technology in a cost-effective and efficient way.

2.3 Intelligent Agents

The concept of "agent" has become important in artificial intelligence, computer science, and e-commerce (Dugdale, 1996; Wang, 1997). Informally, intelligent agents can be seen as software agents with intelligent behavior. Formally, intelligent agents are used to denote a software-based computer system that is capable of autonomous action in order to meet its design objectives. They enjoy the following properties: (Woodridge, 1995)

- *Autonomy.* Agents operate without the direct intervention of humans. For example, agents in FWM systems can perform their own wealth management activities autonomously.
- *Co-operability.* Agents co-operate with other agents towards the achievement of certain objectives. For FWM system, different agents communicate with each other in order to reach their goals.
- *Reactivity.* Agents perceive their environment and respond in a timely fashion to changes that occur. For instance, if there is inflation in the financial market, some agents will response to such change immediately.
- *Pro-activity.* Agents do not simply act in response to their environment; they are able to exhibit goal-directed behaviors by taking the initiatives. For example, one agent in FWM system may take the initiatives to resolve the conflicts amongst agents.

According to Woodridge and Jennings (1995), a generic agent has a set of goals, certain capabilities to perform tasks, and some knowledge about its environment. To achieve its goals, an agent needs to use its knowledge to reason about its environment and the behaviors of other agents, to generate plans and to execute these plans. A multi-agent system consists of a group of agents, interacting with one another to collectively achieve their goals. By absorbing other agents' knowledge and capabilities, agents can overcome their inherent bounds of intelligence.

There has been a recent considerable growth of interest in the design of a distributed, intelligent society of agents capable of dealing with complex problems and vast amounts of information collaboratively. Since agent technology provides flexible, distributed, and intelligent solutions for business process management, researchers have proposed to design and develop numerous intelligent-agents based systems to support business processes management (Wang et al., 2002; Wang & Wang, 1997).

2.4 Distributed Problem Solving

Lifetime wealth management is a complex, challenging process (Tomecek, 2003). To preserve or even create wealth does not equal to save or earn money, it means to optimize financial management while taking one's other best interest into account. Due to an inherent distribution of intelligence among different FWM agents, any one agent is unable to accomplish this kind of wealth optimization alone. Therefore, distributed problem solving (DPS) is required.

According to Weiss (1999), DPS is the name applied to a subfield of distributed artificial intelligence in which the emphasis is on getting agents to work together well to solve problems that require collective effort. One class of DPS strategies is "result sharing", and the way to share the results is so-called functionally accurate cooperation, which is a style in which agents may only take their own interest into consideration when solving their tasks and need to engage in a cooperative iterative exchange of results to overcome their individual incomprehensiveness and coverage on an acceptable solution (Lesser and Corkill, 1981). Exchanging tentative partial solutions can improve group performance in combination of completeness, precision, and confidence.

In addition, to make the communication amongst different agents more efficient, negotiated search is introduced. Negotiated search is an approach in which multiple agents can propose partial or complete solutions, from which agents engage in iterative elaboration and critiquing (Lander and Lesser, 1993). For example, agents engaged in negotiated search have at their disposal a variety of operators for progressing the DPS effort: *initiate-solution* (propose a new starting point for solution); *extend-solution* (revise an already existing partial solution); and *critique-solution* (provide feedback on the viability of an already existing partial solution).

2.5 Web-services

Web Services is an emerging technology driven by the will to securely expose business logic beyond the firewall. Web services can be viewed as Internet-oriented and text-based integration adapters. Web services are self-contained and modular business process applications based on open standards; they enable integration models for facilitating program-to-program interactions. Through Web services companies can encapsulate existing business processes, publish them as services, search for and subscribe to other services, and exchange information throughout and beyond the enterprise. Web services will enable application-to-application e-marketplace interaction, removing the inefficiencies of human intervention.

A Web service is described by an XML-based service description that covers all the details necessary to interact with the services, including message formats, transport protocol, and location. A Web service interacts with its environment through a collection of operations that are network-accessible through standardized XML messaging. Web services offer a new model for deploying software as an Internet-based service, and they represent a new paradigm for distributed computing.

However, current Web services know only about themselves. That is, they are neither autonomous, nor are they designed to use ontologies; they are passive until invoked, and they do not provide for composing functionalities (Byung, 2003). Be aware of these, building a sophisticated Web service to contain these features and to utilize Web services on behalf of the user is required.

In this paper, we integrate agent technology with Web services in order to overcome limitations and complement each other. Our intelligent Web-services agents inherit properties from both intelligent agents and Web-services. This approach takes advantage of the flexibility, inter-operability and extensibility of Web services to illustrate feasibility in communicating with multiple legacy systems.

3. MULTI-AGENT FRAMEWORK FOR FAMILY WEALTH MANAGEMENT

In this section, the development of an agent-based FWM system is described.

3.1 Intelligent Agents in FWM

Before applying multi-agent technology into FWM process, it is need to decompose the process into several autonomous tasks. In these tasks, each agent is delegated a particular role to exhibit its goal-oriented and reactive behavior, and cooperate with others to pursue their goals. The FWM process is usually an iterant process. Each cycle consists of three key stages. First, the financial advisor will address an optimized asset allocation solution that maximizes the overall portfolio expected return. Second, the accounting and legal advisors will work out corresponding evaluation reports based on the investment advice. Third, any incompatibilities are highlighted as possible conflicts and actions will be taken place in an attempt to resolve the conflicts.

Based on such decomposed autonomous tasks of FWM process, multi-agents are applied to perform different FWM activities. An agent hierarchy for FWM is outlined in Figure 1, in which several intelligent agent classes are applied to provide a set of functionalities for FWM. The details of these agents are described below.

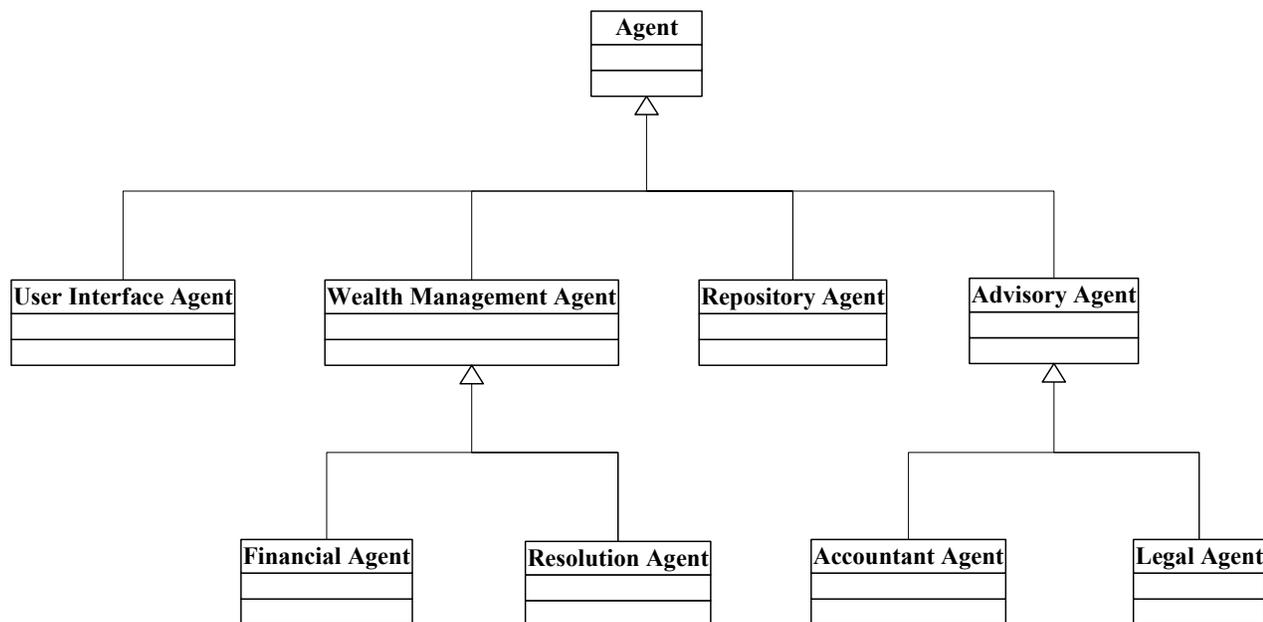


Figure 1. Agent Hierarchy for Family Wealth Management System

The **User Interface Agent** works as a bridge between FWM system and end user. It converts legacy user information into Web service messages and converts the Web service messages back into legacy messages when feeding back. Several kinds of user information related to FWM are required to be collected for advisory activities, such as user financial status, portfolio details, cash flow information, legal position, and so on. User interface agent can make the human-computer interface more intuitive and encourage types of interactions that might be difficult to evoke with a conventional interface.

Wealth management agents are the main parts of FWM system. **Financial Agent** plays a major role in the advisory process. It interacts with the user interface agent and produces investment advice independently. Financial agent analyzes the user personal information such as age, profession, income and so on to assess the user’s financial status, investment objectives, and risk tolerance level. Based on the risk tolerance level, user’s investment goal and specification, financial agent will come out with an optimized asset allocation solution. This solution will be sent to accountant agent and legal agent for evaluation. (Detailed process will be discussed in Section 4.1.)

Advisory agents consist of accountant agent and legal. **Accountant Agent** prepares a cash flow report on basis of the investment advice and other family revenues and expenses. Similarly, **Legal Agent** prepares the tax and estate planning report. Both agents will then compare their deliverables with the optimized asset allocation solution to see whether there is a conflict, such as insufficient available cash for investment and irrational high incurred tax investment. If any conflicts exist, a evaluation report will be produced.

Then, the optimized asset allocation solution, accounting and legal evaluation reports will all send to **Resolution Agent**, which will take some initiatives to resolve conflicts. If the conflict can be reconciled, a resolution report will be sent to financial agent. Financial agent will then revise the previous investment advice based on the resolution report and work out with a new investment advice. The advice will be evaluated by the accountant and legal agents again, so on and so forth. Such process will repeat again and again until there is no conflict at all.

The **Repository Agent** plays an important role of storing data in the system. Although there is no need for centralized storage of all knowledge regarding FWM process, there could be one consistent knowledge repository that maintains and integrates all information related to the advisory, monitoring and analysis tasks. In this way, the various agents in our system can exchange knowledge regarding entities involved and deal with conflicts in a collaborative manner. In our approach, the repository agent may contain and manage several kinds of information, e.g., optimized advisory solutions, evaluation reports, conflict resolution reports, etc. Such shared information about family wealth advices and conflicts may form an important base for agents’ collaboration in our FWM.

3.2 Multi-agent System Architecture

Our FWM system provides optimized long-term advices that maximize the family wealth, identify and subsequently resolve any possible conflicts amongst advices.

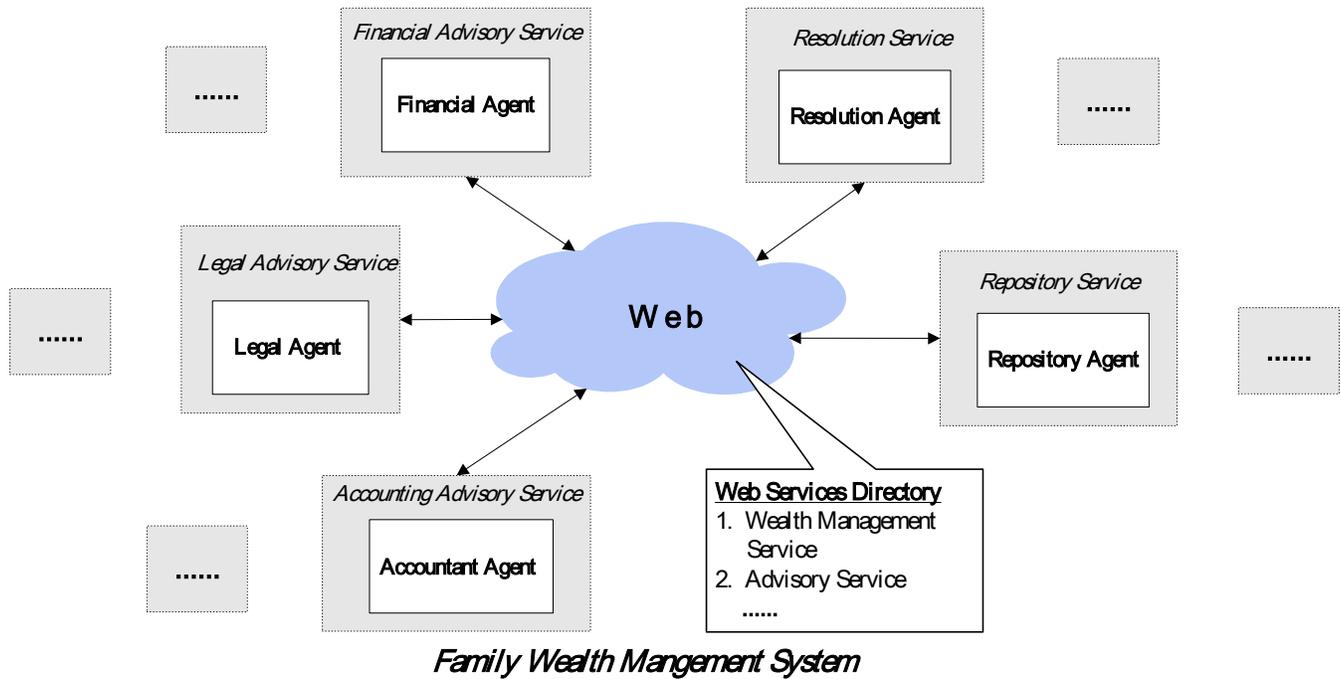


Figure 2. System Architecture

Based on the discussion of the deployment of intelligent agents in FWM in section 3.1, architecture of the Web-service-agent-based FWM system is presented in Figure 2. In this architecture, a society of intelligent agents wrapped as Web-services is proposed to provide a set of services for FWM. All these Web-service agents work autonomously and collaboratively via the Internet. Each agent focuses on its particular task such as optimization, solution evaluation, and resolution, without inventions from outside. Based on the optimized investment advice that the **Financial Service** produces, the **Accountant** and **Legal Advisory Services** produce the cash flow report, tax and estate planning report, respectively. When any advisory services capture a possible conflict, the evaluation report will be issued. Subsequently, reconciliation will be conducted by the **Resolution Service**.

4. PROTOTYPE DEVELOPMENT

4.1 Implementation

Up to now, our FWM system's analysis and architecture design have been completed; a Web-services based financial adviser agent prototype has been implemented; and others are still under development.

The current financial agent provides the following Web-services on the Internet:

- User investment objective assessment. To have a better understanding of user's financial status, the financial agent requires every user to fill out an on-line survey of Financial Foundation Report (Merrill Lynch). It is a specific form, which will be annually, indicating user's financial foundation and financial goals in actual data of monetary amount. In this report, the user is asked for his/her employment (e.g., salary), compensation plans (e.g., stock options), personal assets and liabilities (e.g., real estate information and mortgages), investment assets (e.g., current holdings of bonds, equities and insurance accounts) and income tax return. Assessing these information enables the agent to help the user identify both short- and long-term goals, such as reducing taxes, increasing retirement funds or developing an estate plan.
- User risk tolerance level analysis. In order to address each user an appropriate goal-specific portfolio, the agent also analyzes user's risk tolerance and investment preference. Users need to complete another set of on-line survey of Risk Tolerance Profile (Merrill Lynch). This is a multiple-choice questionnaire with each choice a predefined risk loading. This evaluation locates user's reaction to market volatility and weigh the relative importance of his/her financial goal. The questions regard user's preferences on expected return of the investment, time horizon of the portfolio, choice of portfolios with different risk and return. After adding up all risk loading scores, the agent will find an investor profile model (Merrill Lynch).
- Portfolio management. For different kinds of risk tolerance users, the system will generate different investment templates by some predefined criteria, such as the asset risk level, asset guarantor's credit rating, etc. Users can choose their favorite template as their portfolio. In addition, users can customize their portfolio (i.e., add/remove assets) by their preference.
- Asset risk level estimation. For each financial asset, the system will collect its 2 to 3 years' weekly price data; conduct simulations to estimate its risk level (Markowitz, Sharpe, and Miller, 1991).
- Asset allocation advice. According to the Merrill Lynch Asset Allocation Strategies, the financial agent will automatic provide an asset allocation recommendation to different investor profile models.
- Tailor-made optimization solution. According to user's collective investment goal and personalized specification, the agent will run a linear programming optimization model and work out an optimized investment solution. Figure 3 below shows the interface screen of an optimization solution together with a graphic demonstration.

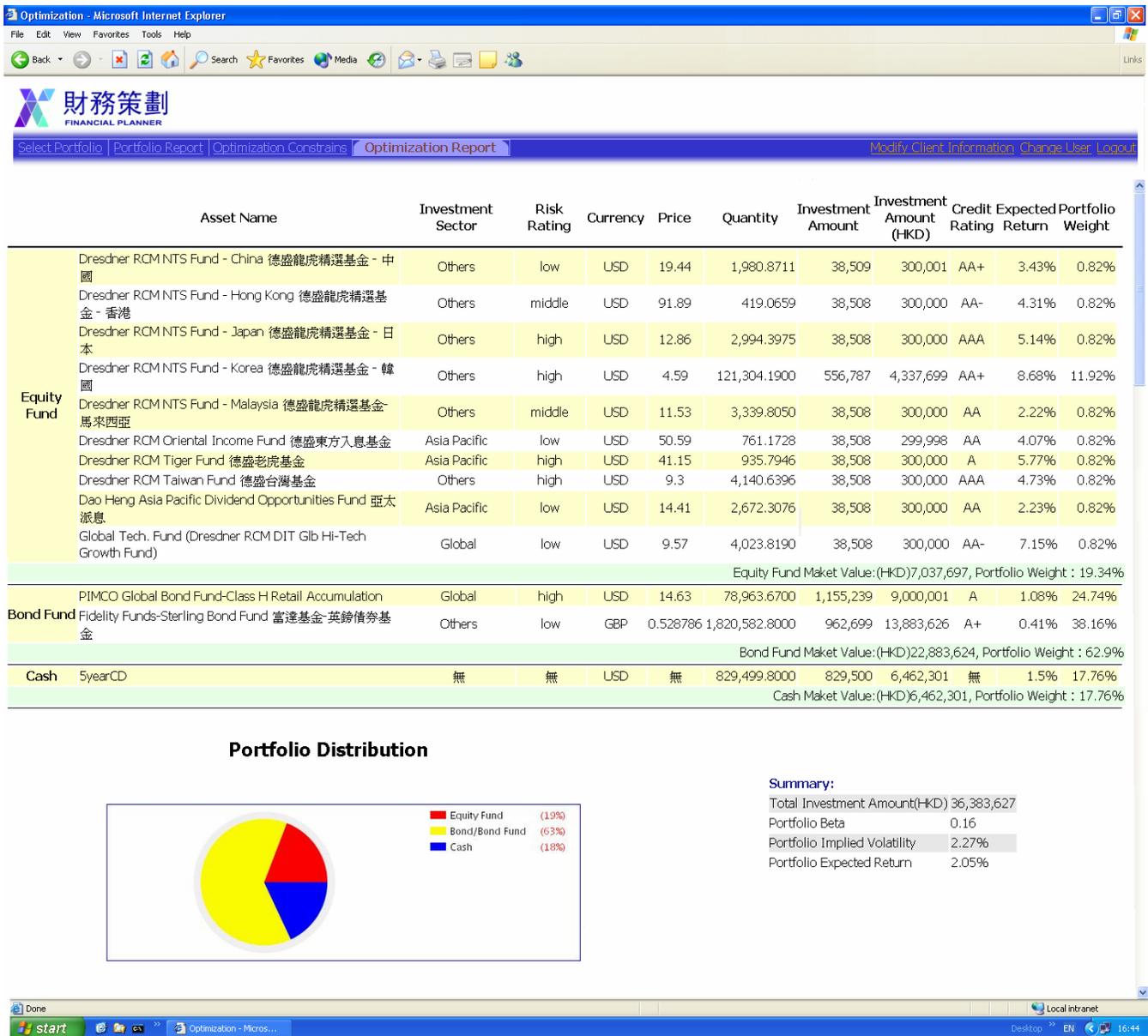


Figure 3. Financial Agent Prototype – Optimization Report

4.2 Operation

In order to demonstrate the effectiveness of our approach and illustrate how our Web-service agents work together to reach the family wealth maximize goal, the operation process of their collaboration is explained in the following example.

Assume that a user plans to buy a new-issued profitable asset. However, he does not know how much he should invest in this asset and how to adjust the other assets that are already in his portfolio. He wants our FWM system to give him advices. In addition, his family has ordered a new car, and requires him to pay the down payment this month.

Figure 4 shows the collaboration and interaction within the FWM Web-service agents. The details of message calls are described below.

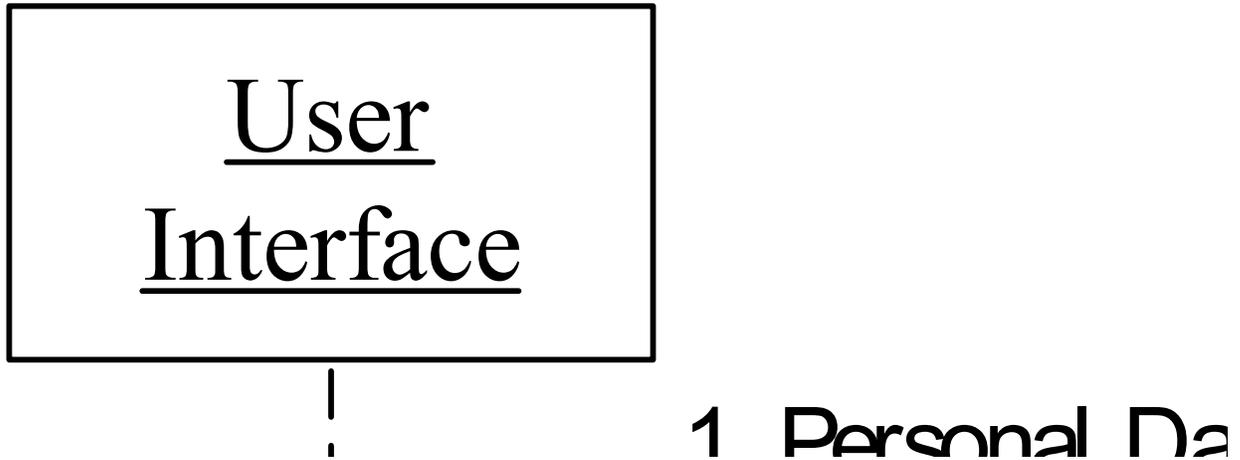


Figure 4. Collaboration and Interaction within FWM Web-service Agents

1. System receives user personal data, converts such data to the Web service messages and passes them to the **Financial Service** based on the UDDI.
2. **Financial Service** provides the user with risk tolerance level analysis report.
3. The user modifies his portfolio by adding the new-issued profitable asset and specifies his investment goal. His investment preference is sent to the **Financial Service** for advice.
4. **Financial Service** works out an initial optimized portfolio solution/advice. This investment solution is stored to **Repository Service** for future use.
5. The initial investment solution is sent to **Accountant Service** for evaluation.
6. The initial investment solution is sent to **Legal Service** for evaluation at the same time.
7. The initial investment solution is also sent to **Resolution Service** for future conflicts reconciliation.
8. To enable the **Accountant Service** to evaluate the investment solution, cash flow related information is retrieved from **Repository Service**.
9. Based on the investment solution and related information, **Accountant Service** works out with a cash flow report. Then, the cash balance result will compare with the investment solution to see whether there is a conflict. In this example, a short of cash is detected because of the extra investment in both asset and car in this month. An accounting evaluation report (indicating the conflict) will be produced as a result. Both reports will be stored in **Repository Service** for future use.
10. At the meantime, the cash flow report and accounting evaluation report are also sent to **Resolution Service** to activate its conflict reconciliation activities.
11. Parallel to the Accountant Service, the **Legal Service** retrieves the legal related information from **Repository Service**. In this case, the tax information of estate will be retrieved.
12. Based on the investment solution and related information, **Legal Service** works out with a tax and estate planning report. Then, the report will compare with the investment solution to see whether there is a conflict. In this example, a tax of estate is accrued because of the investment in car, which is unfavorable to the user. A legal evaluation report (indicating the conflict) will be produced as a result. Both reports will be stored in **Repository Service** for future use.
13. At the meanwhile, the tax and estate planning report and legal evaluation report are also sent to **Resolution Service** to activate its conflict reconciliation activities.
14. According to the initial investment solution and two evaluation reports, the **Resolution Service** may advise the user to sell some assets on-hand (that are less profitable) in order to afford the new car as well as to invest some in the new

profitable asset. In addition, in order to avoid the estate tax, the new car should under the name of the user's son. Such resolution report will be sent to **Repository Service** for future use.

15. The resolution report will also be sent to **Financial Service** to revise the previous investment advice.
16. **Financial Service** revised the current investment advice. The revised investment solution is sent to **Accountant** and **Legal Service** for further evaluation.
(Back to step 4, so on and so forth. The process will iterate until there is no further conflict.)
- n. If there is no conflict found by the **Accountant** and **Legal Service**, the final investment advice, cash flow report, tax and estate planning report, and evaluation reports will be sent to **Repository Service** for future use.
- n+1. The final investment advice, cash flow report, tax and estate planning report, and evaluation reports will finally be sent to end user.

This example above demonstrates the case of accountant service evaluating the investment solution. Similarly, the legal service can also evaluate the investment solution by tax and estate planning issues. Such evaluation will result in a tax-effective investment solution.

5. CONCLUSION

In this paper, a Web-Service-Agent supported Family Wealth Management System has been presented. The main contribution can be summarized as follows. From the technology perspective, we have designed a novel architecture for FWM. A number of different kinds of agents have been defined and wrapped as Web services. These different Web services can collaborate together to provide comprehensive FWM services as similar as MFOs provide. Or each Web service can be separated to function as a stand-alone system. This approach provides us with flexibility and reusability to a great extent.

On the other hand, from the business application perspective, most existing MFO systems focus on financial or investment aspects only and do not consider other important issues, such as legal issues, accounting issues, etc. In contrast, our system is able to deal with much wider aspects, including legal and accounting aspects. Therefore, our FWM system is able to provide more aggregative and comprehensive solutions to meet business needs.

By following the architecture, we will work on the remaining Web-service agents in our FWM system in the future. Further task analysis and knowledge acquisition will also be conducted. After the implementation, the system will be fully tested and evaluated. We will evaluate the effectiveness of the system. Necessary statistical analysis will be performed based on experiments.

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