Ontology-based Decision Support System with Analytic Hierarchy Process for Tour Package Selection

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ABSTRACT

The popularity of Internet and growing B2C electronic commerce nowadays make product or service information easy to be acquired. However, making an optimal choice from the various alternative products becomes a laborious process. In this paper, an ontology-based Decision Support System (DSS) with Analytic Hierarchy Process (AHP) was proposed for the specific application of tour package selection. The system is composed of two subsystems, the product gatherer and the decision maker, which are used to find out right products and make an expected choice respectively. In the product gatherer subsystem, an ontology-based web service architecture with Web Ontology Language (OWL) was established for the semantic content processing of product information. The Simple Object Access Protocol (SOAP) is utilized to establish the communication interface and gather XML-based contents through Remote Procedure Calls (RPC) between the system and the database servers of travel agencies. In the decision maker subsystem, the Analytic Hierarchy Process is utilized to make an optimal decision for satisfying the requirement given by the consumer. The system aims to help consumers to avoid falling into decision-making hesitation and get an expected choice from various and similar products.

INTRODUCTION

The advance of Internet and WWW technologies has made a great impact on the human life and business. It has caused the electronic commerce applications to grow extraordinarily, especially for the business-to-consumer applications. However, the convenience also make various and similar products difficult to be chosen by consumers. Making decision with many tradeoff considerations among products is the major cause of such a hesitation. To solve the problem, it requires an intelligent decision-making process. This paper proposes an architecture and an intelligent Decision Support System (DSS)[1] to help consumers make the purchase...
decision by conducting the Web Service and Analytic Hierarchy Process (AHP)[2]. There are two fundamental components, the product gatherer and the decision maker, in the system. The first one is majorly responsible to complete tourist information aggregation from distributed database servers offered by the travel agencies. The other one acts as a decision-making assistant.

**SYSTEM ARCHITECTURE**

The proposed system is a 3-tier architecture, as shown in Fig. 1, which contains the front-end Client Tier (Web Browser), middle Application Tier (Web Application) and back-end Data Tier (Web Service). Consumers who want to take a tour could evaluate some tour packages before making the purchases. The system can help users to collect tour packages information from distributed database servers provided by different travel agencies and recommend an optimal one according to user preferences.

For the purpose of delivering data via a standard communication interface, the system utilizes Simple Object Access Protocol (SOAP)[3] for the data communication between middle tier and back-end tier. This will require the employ of database system which supports Web Service functionality. Microsoft SQL Server has built-in native XML Web Service features with SOAP in its engine and is utilized in the proposed system. On the other hand, data must be expressed in a structured and standard manner for interoperability; therefore the system uses Web Ontology Language (OWL)[4] to define the XML-based ontology about tour information. Tour package data will be stored and delivered in an XML formation.

**PRODUCT GATHERER SUBSYSTEM**

The product gatherer subsystem was divided into two parts: data requester and data provider. The data requester is responsible to request the data provider to deliver tour package data which satisfies the consumer’s preferences. The preference setting will be finished in the user interface. After receiving the request, data provider will query its database and return the results. Data requests and

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![Figure 1. System Architecture.](image-url)
responses operate under the Web Service-based environment; thus, data requester acquires required data via a Remote Procedure Call (RPC) to the data provider. To do this, the XML and HTTP-based SOAP standard protocol is used. User’s preference setting and returned tour package data should be encapsulated respectively in the SOAP network packets of request and response. The Ontology semantic technique[5] is also used in the encapsulation; thus, Ontology-based XML schema is used in the expression of preference setting and returned data. The OWL language was utilized to pre-define the travel ontology in the system implementation.

The used RPC performs the detail data query process. It is implemented by the database Stored Procedures which were created by the CREATE PROCEDURE statement and saved as a collection of Transact-SQL statements in the database system. Moreover, to set up the database engine as a Web Service provider that can listen for SOAP requests, it requires the creation of an HTTP Endpoint beforehand. An HTTP Endpoint is created for use with SQL Server to listen and receive requests on a TCP port (Ex: port 80) and to start up the execution of indicated stored procedures. The endpoint was created by the CREATE ENDPOINT statement in the database system.

An additional remark is that only one data requester component was built in the middle-tier AHP-DSS system, but a data provider component should exist in each system owned by every joined travel agency. In other words, AHP-DSS system can send SOAP requests to many HTTP Endpoints distributed in respective database servers that provided by the travel agencies and can get various tour packages data from these agencies for further tour package selection decision. In current stage of the proposed system, the list of joined agencies was recorded within a table in the AHP-DSS system. In the future work stage, the Web Service registration mechanism UDDI (Universal Description, Discovery and Integration)[6] will be conducted into the system.

DECISION MAKER SUBSYSTEM

Once the data of various tour packages has been acquired, the next step should help the user to make a preferred decision. Making decision by users with many tradeoff considerations is a hesitating process. Analytic Hierarchy Process is used in the system to solve such a problem. It is a structured technique for assisting people to make complex decisions and can be divided into five steps: (1) model the problem as a decision hierarchy; (2) calculate local weight vectors; (3) check consistency; (4) calculate global weight vector; and (5) make the decision.

The first step of AHP is to construct a decision hierarchy which the top level is the decision goal; the second level is the collection of consideration factors, and the third level is composed of different tour packages. Fig. 2 is an illustration of a constructed hierarchy.
The second step is to calculate local weight vectors, which are the weight vector of decision factors to the goal and the weight vector of products to each factor. Both of the weight vectors can be calculated with the same procedure. In this step, firstly it requires to make a pairwise comparison matrix through pairwise comparing each decision factor by using judgments to determine the relative importance of one factor over another. The pairwise comparisons should be judged by the user with scales 1 to 9. The matrix is shown in Equation (1), where $a_{ij}$ denotes the weight ratio of the $i^{th}$ factor to the $j^{th}$ factor, and $n$ is the number of factors. Equation (2) shows the local weight vector of decision factors to the goal, and an eigenvector $W$ can be obtained from the eigenvalue equation shown in Equation (3). The Average of Normalized Columns (ANC) method shown in Equation (4) also can be used to obtain an approximate value of the eigenvector $W$. This vector indicates the weights of each decision factor to the goal.

$$A = (a_{ij})_{n \times n} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix}$$ (1)

$$W = (w_k)_{n \times n} = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \vdots \\ w_n \end{bmatrix}, k = 1, 2, 3, \ldots, n$$ (2)

$$\sum_{j=k}^{n} a_{ij} w_k = \lambda_{\max} w_i, i = 1, 2, 3, \ldots, n$$ (3)

$$w_i = \frac{1}{n} \sum_{j=1}^{n} \left( a_{ij} / \sum_{k=1}^{n} a_{kj} \right), i = 1, 2, 3, \ldots, n$$ (4)

Since user’s judgments may cause to an inconsistent pairwise comparison matrix and a significant inconsistency will lead to an unacceptable decision result, the next step is to check the consistency of the matrix. If the matrix satisfies the following Equations (5) and (6), it is a consistency matrix.

$$a_{ij} = 1/a_{ji}$$ (5)

$$a_{ik} \cdot a_{kj} = a_{ij}$$ (6)
After the calculation of level-2 weight vector, the next step is to determine the level-3 weight vector, that is, the weight vector of products to each factor. The procedure is the same as described above. There will be seven pairwise comparison matrices in the case since there are seven factors considered. Finally, the global weight vector can be obtained by the Equation (7), where $t_i$ is the global weight of $i^{th}$ product, $b_{ij}$ is the local weight of $i^{th}$ product to $j^{th}$ factor, and $w_j$ is the local weight of $j^{th}$ factor. The product with largest value is the preferred and optimal choice for the decision. Fig. 3 shows the example that tour package E is the optimal choice.

$$t_i = \sum_{j=1}^{n}(b_{ij} \cdot w_j)$$

**Figure 3.** Decision result (an example).

**CONCLUSION**

This paper proposes an architecture that integrates ontology-based semantic web service with Analytic Hierarchy Process to provide consumers the decision support assistance and recommendation for tour package selection. Since making decision with many tradeoff considerations usually causes consumers falling into a hesitation, the proposed intelligent system that composed of subsystems of product gatherer and decision maker can help to solve this situation and offer a preferred and optimal choice to the consumer for further purchase. The system can be improved in the future by introducing UDDI service registration mechanism into data gatherer subsystem. This can improve the process flexibility for tourist data aggregation from travel agencies.

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**REFERENCES**