Web-based Decision Support System with Group Buying using Analytic Hierarchy Process

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Abstract

In electronic market places, group buying is seen as an effective form of electronic commerce. When buyers cooperate with each other, a seller can discount the price of a good. In existing group buying sites, each buyer preference may not be reflected effectively. This system implements a decision support system (DSS) for group buying based on buyer's preferences. DSS is an interactive system that provides the user with easy access to decision models and data in order to support semi-structure and/or unstructured decision making task. This system is intended to develop a computerized system for some functions of house trading. The aim of this paper is to develop the web-based decisions support system for house selection using Analytical Hierarchical Process (AHP). The AHP appears to be a flexible decision making tool for multi-criteria problems such as selection of the best house.

1. Introduction

A decision support system (DSS) is an integrated set of computer tools that allows a decision maker to interact directly with computers to create information useful in making unanticipated semi-structured and unstructured decisions. Decision Support System is an information system that assists users to make a decision by providing information, models and analysis tools [3].

AHP was developed based on mathematics and psychology. AHP first decompose their decision problem into a hierarchy. The elements of the hierarchy can relate to any aspect of the decision problem such as tangible or intangible, carefully measured or roughly estimated, well- or poorly-understood [8]. Decision Support System for group buying can be developed based on buyer's multi-attribute preferences.

Group buying is a model in which multiple buyers cooperate and buy a good/service at a discount price. When buyers can cooperate with each other, a seller can discount the price of a good. Multiple buyers can form coalitions with each other on the World Wide Web. Existing group buying sites have a problem. Buyers need to compromise in their preferences on the quality of a good in order to buy the good at a discount price. Thus, each buyer in a group cannot purchase a good that satisfies his/her preferences. Proposed Decision Support System for group buying can solve this problem. Our system can support group buying in which the user' preferences are reflected when effectively trading [5].

2. Related Work

J.Mustajoki and R.P.Hamalainen propse Web-HIPRE (Hierarchical PREference analysis on the World Wide Web) is WWW software for multicriteria decision analysis based on the well-known decision support software. It provides an implementation of multiattribute value theory (MAVT) and the analytic hierarchy process (AHP) to support the different phases of decision analysis [2]. The focus of this article is upon the AHP as a means for assisting in the plan selection process [1]. Related to this group decision-making about a meeting schedule is supported by using AHP [4].

3. Theory Background

Decision Support Systems are information systems that assist users to make a decision by providing information, models and analysis tools. A model is a representation of some aspect of the real world. A simulation is the use of that model. Interactivity allows the user to choose the sequence and content of the information to be displayed [6].

3.1 Multi-criteria Decision Making

The problem that the Multi-criteria Decision Making (MCDM) process aims to solve is evaluating a set of alternatives in terms of a number of criteria

which is conflicting in nature. The MCDM methods that authors have considered are Simple Multi-Attribute Rating Technique (SMART), Multiple Attribute Utility Theory (MAUT) and Analytical Hierarchy Process (AHP). There are three ways to solve multi-criteria decision problems. They are Goal Programming Scoring Models, and Analytical Hierarchy Process.

3.2 Analytical Hierarchy Process

The definition of Analytical Hierarchy Process is an approach to decision making that involves structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives [7].

AHP provides decision makers with a method to indicate his/her decision by weighting the evaluation criteria and making pair-wise judgments of a set of subset of alternatives. AHP is especially suitable for complex decisions which involve the comparison of decision elements which are difficult to quantify. AHP can also support a group of decision makers. Geometric means of individual judgments can be used to aggregate group preferences.

AHP can be used to priority requirements according to their complexity and sometimes according to the available techniques. AHP is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered.

3.3 Decision Support System for Group Buying

Group buying system based on buyer's preferences. A buyer's preference is shown as a utility function. A utility function consists of multiple independent attributes based on MAUT (Multi Attribute Utility Theory). In general, MAUT handles problem in which outcomes are characterized by two or more attributes.

For example, purchasing a new house requires consideration of the attributes such as location, size, price, design etc for the alternative house. In MAUT, for an alternative C_1, there exists the attributes $X_1, X_2, \ldots, X_n$ and their values $x_1(C_i), x_2(C_i), \ldots, x_n(C_i)$. We can represent the utility $u(C_i)$ for the alternative C1 as:

$$u(C_i)=f(f_1(x_1(C_i)), f_2(x_2(C_i)), \ldots, f_n(x_n(C_i)))$$

where f is a certain function.

We can select several options with respect to f according to the application area. In this system, we select the AHP method for calculating a users' utility. Based on the above utility, each agent has preference. We can define the agent's preferences as follows:

$C_i \succ C_j \Leftrightarrow u(C_i) > u(C_j)$ and

$C_i \sim C_j \Leftrightarrow u(C_i)=u(C_j)$

$C_i \succ C_j$ means that the agent prefers C_i to C_j

$C_i \sim C_j$ means that the agent has no preference for C_i or C_j.

A users' preference is quantified into a multi attribute utility by using MAUT [5].

4. System Architecture

The main aim of the system is for group buying in which multiple buyers cooperate and buy good/services at a discount price. Further more to support group buying in which user' preferences are reflected when effectively trading. The other objectives of the system are to provide information and decision support techniques to confront specific problems, to realize trading that reflects buyer's multi-attribute preferences and to handle complex situations within a multiple criteria decision problem using AHP.

4.1 System Design

This web-based house selecting system is designed to use as a deciding aid for the customer to buy a house.

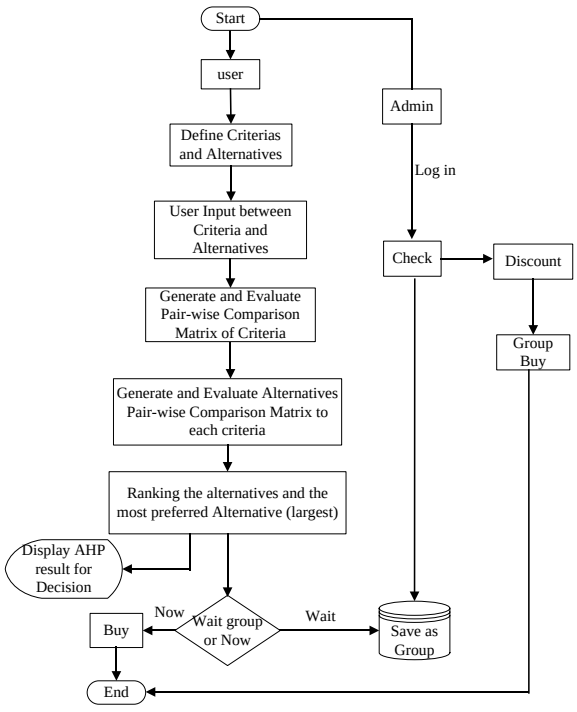

Figure 1 . System flow diagram

This system includes three main parts, which are making comparison with AHP based on the user's preferences, displays the best alternative for the users and grouping to reply discount information by administrator. In this system each user can select the preferred method and how much more important for each criteria. When establish priority vector for alternatives, the user's selected attributes are used to compare the alternatives by the system rather than to select preference for alternative by users. Using AHP of Expert Judgments, the system provides the result by displaying house in their priority. If user get house discount with group, user confirm at form with email. The user will seen how much get discount after typing the email in the site for one month.

4.2 Algorithm for Grouping the Suitable house using AHP

Begin

Accept alternative name from user;

Accept Important-criteria from user;

Made Comparison;

Display decision results;

If (user wait group)

Add all information about user to database depend on the type of flat.

If (Group buy)

Count each database for discount and save these discount.

If (user check his/her email in this Web Site)

Inform discount to user's email in Site

4.3 Algorithm for Making Comparison

Begin

Calculate Priorities According to User's Choice;

Perform Synthesization to Get Approximation

Result;

Display the Suitable house to Buy;

End;

4.4 Algorithm for Analytic Hierarchical Process

Begin

Accept n (number of thing);

Begin

For (i = 1; i <= n (n-1) / 2; i++)

For (j = 1; j <= n (n-1) / 2; j++)

If i = j , a_{ij} = 1; // a_{ij} is the element of row i column j of the matrix

Else $a_{ij} = 1/a_{ij}$;

End if;

End

Normalize it

Calculate alternatives and overall scores

Compare alternatives

Calculate the best one

End;

5. System Implementation

In an AHP hierarchy of the case study of buying a house, the goal might be to choose the best house for buyer.

The following are the steps in AHP method for decision making.

1. Building the hierarchy
2. Pair-wise comparison
3. Establishing priority vector
4. Obtaining the overall ranking

5.1 Building the hierarchy

In the Figure 2, the alternatives are the lowest level of the hierarchy Level zero refers to the overall goal, i.e., selection of house, level one is composed of ten criteria and level two is formed by ten alternatives.

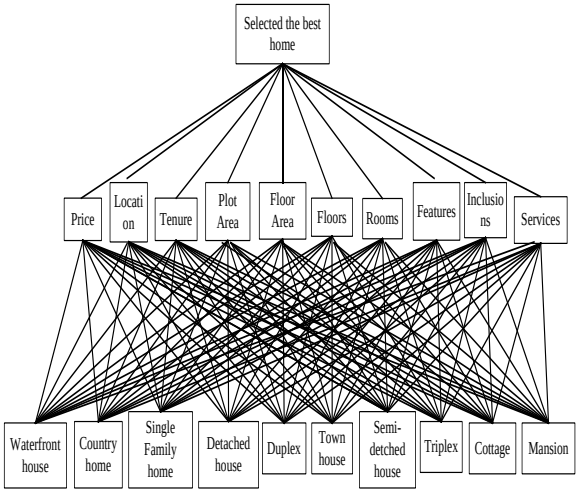

Figure 2. Hierarchy for house selection

5.2 Pair-wise comparison

We construct the pair-wise matrices for the criteria and alternatives on each of the criteria. All criteria are compared with each other to determine the relative importance of each factor in the accomplishing the overall goal.

In the pair-wise comparison step, N (N-1)/2 pair of comparison are required. N is the total number of criteria (or) the total number of alternatives.

Table 1.Fundamental scale for pair-wise comparison

Intensity of relative Importance	Definition
1	Object i and j are equal importance.
3	Object i is weakly important than of j.
5	Object i is strongly important than j.
7	Object i is very strongly more important than j.
9	Object i is absolutely more important than j.
2,4,6,8	Intermediate values between

5.3 Establishing priority vector

AHP uses the synthesization procedure for criteria and alternatives on each criterion that provided the priority vectors. Synthesization procedure includes three steps.

1. Sum the values in each column of the pair -wise comparison matrix.
2. Divide each element in the pair-wise comparison matrix by its column total.
3. Compute the average of the elements in each row of the matrix that provides the priorities for the criteria.

5.3.1 Establishing priority vector for criteria

We calculate the three steps of synthesization procedure to get the local priority matrix for criteria.

The following Figure 2 shows the sum of each column according to the step 1 calculation of synthesization procedure.

	Price	Location	Tenure	Plot Area	Floor Area	Floors	Rooms	Features	Inclusions	Services
Price	1	2	5	7	5	7	2	9	5	2
Location	1/2	1	5	3	5	7	2	5	7	5
Tenure	1/5	1/5	1	7	2	5	7	9	5	7
Plot Area	1/7	1/3	1/7	1	3	2	5	7	2	5
Floor Area	1/5	1/5	'2	1/3	1	3	5	7	5	2
Floors	1/7	1/7	1/5	1/2	1/3	1	2	9	5	2
Rooms	1/2	1/2	1/7	1/5	1/5	1/2	1	5	7	5
Features	1/9	1/5	1/9	1/7	1/7	1/9	1/5	1	2	7
Inclusions	1/5	1/7	1/5	1/2	1/5	1/5	1/7	1/2	1	2
Services	1/2	1/5	1/7	1/5	1/2	1/2	1/5	1/7	1/2	1
Total	2203 /630	1033 /210	7747 /630	2087 /105	3649 /210	1184 /45	859/ 35	61/ 14	79/2	38

Figure 3.Pairwise comparison matrix for criteria

The following figure 6 shows that each column is divided by the total sum of each column according to the step 2 calculation of synthesization procedure.

	Price	Location	Tenure	Plot Area	Floor Area	Floors	Rooms	Features	Inclusions	Services
Price	630/2203	420/1033	3150/7837	735/2087	1050/3687	315/1184	70/859	126/737	10/79	2/38
Location	315/2203	1210/1033	3150/7837	315/2087	1050/3649	315/1184	70/859	70/737	17/79	5/38
Tenure	126/2203	42/1033	630/7837	735/2087	420/3649	225/1184	245/859	126/737	10/79	7/38
Plot Area	90/2203	70/1033	90/7837	105/2087	630/3649	90/1184	175/859	98/737	4/79	5/38
Floor Area	126/2203	42/1033	315/7837	35/2087	210/3649	135/1184	175/859	98/737	10/79	2/38
Floors	90/2203	30/1033	126/7837	52.5/2087	70/3649	45/1184	70/859	126/737	10/79	2/38
Rooms	315/2203	105/1033	90/7837	21/2087	42/3649	22.5/1184	35/859	70/737	14/79	5/38
Features	70/2203	42/1033	70/7837	15/2087	30/3649	5/1184	7/859	14/737	14/79	7/38
Inclusions	126/2203	30/1033	126/7837	52.5/2087	42/3649	5/1184	5/859	7/737	2/79	2/38
Services	315/2203	42/1033	90/7837	21/2087	105/30649	22.5/1184	7/859	2/737	1/79	1/38
Total	1	1	1	1	1	1	1	1	1	1

Figure 4. Normalized matrix of a pair-wise comparison for house selection for criteria

The following Figure 3 shows the local priority of criteria. According to the step 3 of synthesization procedure, we sum each row and then divided by the total number of criteria.

	Priority
Price	0.2432
Location	0.1938
Tenure	0.1603
Plot Area	0.0938
Floor Area	0.0842
Floors	0.0600
Rooms	0.0741
Features	0.0363
Inclusions	0.0240
Services	0.0303

Figure 5. Local priority matrix for criteria

5.3.2 Establishing priority vector for alternatives

The calculation steps of local priority of the alternatives are the same way as the calculation of local priority criteria. Then we got the local priority matrix for house selection base on the ten criteria.

	Price	Location	Tenure	Plot Area	Floor Area	Floors	Rooms	Features	Inclusions	Services
Waterfront	0.2300	0.2505	0.2341	0.2554	0.2647	0.2647	0.2749	0.2829	0.2516	0.2405
Country	0.1896	0.1908	0.1993	0.1953	0.2070	0.2070	0.2053	0.2063	0.2191	0.2220
Single Family	0.1389	0.1377	0.1459	0.1238	0.1272	0.1324	0.1263	0.1271	0.1402	0.1404
Detached	0.1131	0.1051	0.0964	0.0964	0.0850	0.0751	0.0714	0.0749	0.0820	0.0862
Duplex	0.0797	0.0803	0.0950	0.0980	0.0921	0.0927	0.0932	0.0927	0.0934	0.0923
Town	0.075	0.0713	0.0720	0.0744	0.0728	0.0771	0.0789	0.0681	0.0666	0.0652
Semi-detached	0.060	0.0587	0.0534	0.0530	0.0521	0.0516	0.0485	0.0487	0.0482	0.0461
Triplex	0.0459	0.0461	0.0486	0.0479	0.0415	0.0413	0.0425	0.0386	0.0410	0.0497
Cottage	0.0419	0.0337	0.0291	0.029	0.0304	0.0308	0.0316	0.0329	0.0319	0.0314
Mansion	0.0242	0.0258	0.0263	0.0268	0.0271	0.027	0.0274	0.0278	0.0262	0.0261
Total	1	1	1	1	1	1	1	1	1	1

Figure 6. Local priority matrix for house selection based on the criteria

5.4 Obtaining the overall ranking

The last step in AHP is to obtain the overall ranking of the two alternatives. This system calculated to multiply the local priorities matrix for house selection from Figure 6 and local priority matrix for criteria from the Figure 5 to get their ranks of alternatives and highest priority is the suitable house for user as shown Figure 7.

	Priority
Waterfront	0.4971
Country	0.3960
Single Family	0.2716
Detached	0.1939
Duplex	0.1759
Town	0.1452
Semi-detached	0.1102
Triplex	0.0904
Cottage	0.0677
Mansion	0.0520

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Figure 7.Priorities for house selection

5.5 Group Buying for house selection

DSS for group buying support effective decision for buyers. Each buyer can select attributes of each good as they want and make preferred value for each criterion.

Table 2. Discount for group buying

In proposed system, many buyers are cooperating and goods are sold at a discount price. When buyers can cooperate with each other, a seller can discount the price of a good. (eg: one good is sold for $50, two goods is sold for $90, and four goods is sold for $160).

6. Implementation Result

Pairwise Comparison for Alternatives on each of the Criteria

	Price	Location	Tenure	Plot Area	Floor Area	Floors	Rooms	Features	Inclusions	Services	Result
Waterfront House	0.2300	0.2505	0.2341	0.2554	0.2647	0.2647	0.2829	0.2829	0.2516	0.2405	0.4971
Country Home	0.1896	0.1908	0.1993	0.1953	0.2070	0.2070	0.2063	0.2063	0.2191	0.2220	0.3960
Single Family Home	0.1389	0.1377	0.1459	0.1238	0.1272	0.1324	0.1271	0.1271	0.1402	0.1404	0.2716
Detached House	0.1131	0.1051	0.0964	0.0964	0.0850	0.0751	0.0749	0.0749	0.0820	0.0862	0.1939
Duplex	0.0797	0.0803	0.0950	0.0980	0.0921	0.0927	0.0927	0.0927	0.0934	0.0923	0.1759
Town House	0.0757	0.0713	0.0720	0.0744	0.0728	0.0771	0.0681	0.0681	0.0666	0.0652	0.1452
Semi-Detached House	0.0609	0.0587	0.0534	0.0530	0.0521	0.0516	0.0487	0.0487	0.0482	0.0461	0.1102
Triplex	0.0459	0.0461	0.0486	0.0479	0.0415	0.0413	0.0386	0.0386	0.0410	0.0497	0.0904
Cottage	0.0419	0.0337	0.0291	0.0291	0.0304	0.0308	0.0329	0.0329	0.0319	0.0314	0.0677
Mansion	0.0242	0.0258	0.0263	0.0268	0.0271	0.0272	0.0278	0.0278	0.0262	0.0261	0.0520

Figure 8. Result priority vector of house alternatives

Sales by Email

Email: nangkhamsoe86@gmail.com Search

Invoices:

Invoice Number	Email	Date
Select 4	nangkhamsoe86@gmail.com	11/22/2009 12:00:00 AM

Invoice Details:

Alternative	Price	Qty
Waterfront House	10000000.00	3

Alternative	Selling Price	Total Qty	Discount Rate
Duplex	6000000.00	2	5% each
Waterfront House	10000000.00	3	5% each

Figure 9. Group buying discount result for buyer.

7. Conclusion

Group buying n (number of house)	Discount information
1>n≤5	5%
5>n≤10	8%
n>10	10%

In the system, buyer's utilities are shown based on a multi-attribute utility theory using the AHP. Existing group buying systems have a problem in that each buyer's preference is not reflected effectively enough when trading. To solve this problem we use AHP to quantify user's preference.

Advantages of our system are as follows.

1. It realizes trading that reflects buyer's multi-attribute preferences.
2. Each buyer can purchase a good at a lower price.
3. A buyer's payment amount is decided based on compromise value.
4. Successful sellers can trade with more buyers.

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