Marketplace Seller Recommender with User-Based Multi Criteria Decision Making

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Abstract—***This research develops a recommender system for seller selection of several online marketplace in Indonesia. Since users are provided with too many merchants with various offers regarding a product, it then creates such difficulty and longer time for them to decide which merchant they should choose to get the efficcient effort but optimum results.***

Case studies in several of the most popular online shops were adopted: Tokopedia, Shopee and Bukalapak., where respondents make online transaction the most. Criteria stated are product price, seller location, seller reputation, the number of sold products and expedition support. This study applied a method of Fuzzy Simple Additive Weighting to normalize by using weight authorized from user preference. The experiment applied a user-based method of testing due to each preference and method to place the rankings. At the end, a merchant with the highest point placed as the top rank and displayed as the recommendation

Keywords— recommender system, e-commerce, marketplace, MCDMc

I. INTRODUCTION (*HEADING 1*)

Although there are some issues that report Indonesia's sluggish economic conditions, the reality of Indonesia's economy continues to grow, when viewed from the data recapitulated by the World Bank. According to the report from The World Bank about Indonesia Economic Quarterly in 2017 as referred in [1], Indonesia's economic growth expanded for the first time in the past five years, rising to 5.0 percent in 2016 from 4.9 percent in 2015, although global policy uncertainty remains high. E-commerce become the one which plays significant role upon the growth of economy. An innovation of marketplace can be the opportunity for people to promote any products, including the new or second one. [ref] clarifies that the most popular online shop dominating the online transaction in Indonesia are firmly hold mostly by Tokopedia, Lazada, Shopee and Bukalapak.

Within those marketplaces, people can look for any products with a very good response from the system. Currently there are at least 2.6 million merchants is selling products on Tokopedia in year 2017, and this number will keep increasing forward. Internet users most often access online stores from their smartphones, which when compared to a smartphone PC computer platform has a smaller screen width, so that information obtained by users in a certain amount of time will tend to be less than desktop platforms. Users need more time to access the online shop from smartphones with more scrolling pages by paying attention to the information attached to the product. In general, buyers have the motivation to get the best product with a minimum price but maximum service. To find optimal results from this principle, users need a lot of effort and time to do research on products sold by many merchants individually. This study seeks to make a recommendation system that can make the user effort more effective and the results (information or specific product) obtained become more optimal. With a recommendation system, users can get information about merchants / sellers that best suit their preferences regarding the attributes of a merchant. The features currently available at each online shop only filter and sift the search results separately, so the recommendation system developed in this study is a system that can integrate the filter and sort processes and store them according to the user session. This recommendation system covers 3 online shops which are reviewed most popular in the community, seen from the intensity of promotions conducted in electronic media and based on surveys conducted by millennials.

II. STUDY LITERATURES

This study involves several research theories related to MCDM approaches which one of them had been observed in [2] and also a brief explanation about today's e-commerce trends in Indonesia and its implication which related to visualizing products of each online shop.

The purpose of the Decision Support System (DSS) is to be able to provide a decision support to the actors in the system against a decision-making process regarding specific issues that occur. With the existence of DSS, the hope of making decisions becomes faster, optimal and comprehensive; can be assessed as a whole from all the criteria of the compiler.

Based on what is described in [3] DSS are generally divided into several categories, including model-driven DSS, Data-driven DSS, Communication-driven DSS, Document-driven DSS, Knowledge-driven DSS, and Web-driven DSS. According to this research, two types of DSS will be emphasized more: Model-driven and Data-driven DSS.

Model-driven DSS is a DSS based on a simple quantitative model. This DSS uses a limited amount of data and emphasizes financial model engineering. A model-driven DSS is commonly used in planning, managing, and scheduling production. This type of DSS provides the most functionality for manufacturing / manufacturing problems.

Data-driven DSS emphasizes access and engineering of data that has been processed for specific problems using

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common tools. This DSS can also provide basic functionality for business coverage, which has a very strong base on time-series data (changes over time). Data-driven DSS able to provide decision support for a specific time period.

W.Ho et al. (2009) in their research [4] compared several methods involving multi-criterion models in building decision support systems, including Analytic Hierarchy Process (AHP), Case Based Reasoning (CBR), Fuzzy Set Theory and Genetic Algorithm (GA). They take case studies of supplier and supplier selection and evaluation. This study discusses other studies that compare several methods for determining supplier cases such as AHP, ANN, CBR, GA, DEA and SMART. The results of the research stated that each method has equally good capabilities, but individually, the DEA algorithm tends to produce better accuracy, because the price criteria are not the most crucial determinant to find the most optimal supplier.

R. Atmojo, A. Cahyani, B. Abbas et al. (2014) revealed in [5] proposed a model for DSS applications based on Fuzzy Simple Additive Weighting algorithm. This DSS aims to facilitate customers in narrowing the alternative choices of smartphone products into several recommendations.

Mohanty and Gupta (2015) in their research [6] suggested the aim of their research was to help managers in Iranian companies to be active in the tourism industry so that they are familiar with the most important factors that influence the shopping behavior of foreign tourism. To do this, these factors were identified and ranked in rank using the SAW, TOPSIS, ELECTRE and LINMAP methods. Realizing that the results of implementing these methods are not appropriate for some cases, a method called COPLAND is then used to achieve optimal results.

Fu, Zeng, Lao et al. (2017) stated in his research [7] proposed a systematic approach consisting of three types of fuzzy systems to build intelligent decision support systems for the case of price negotiation. The three systems include a standard fuzzy system, which consists of many inputs and an output that formulates mathematical mapping; second is SFS-SISOM, which is a linear fuzzy inference model with a single input and an output; and the third is a fuzzy hierarchy system, which consists of several fuzzy systems arranged hierarchically to run fuzzy decisions.

Wang (2015) in his research [3] proposed a fuzzy model with Multi-Criteria Decision Making that combines SAW with relative preference relations / relationships to solve multi-criteria-based problems. This FMCDM model is recognized as a generalization of Fuzzy from SAW. In practice, this method has sufficient level of difficulty due to the Fuzzy multiplication, aggregation and ranking.

The Multi Criteria Decision Making Model with the Fuzzy method - Simple Additive Weighting will process each attribute / criterion and each candidate in several stages. Each attribute must be given weight first which is 0 to 1. Each customer may give different weight for each attribute. After that, the mapping of the seller candidate data has been completed with alternative values according to the attributes or criteria specified in the matrix. Each attribute is then grouped into two parts, namely the benefit attribute and cost attribute. Benefit attributes mean beneficial attributes, where the greater the value means the better. While the cost attribute means an adverse attribute, where the smaller the value the better. The next calculation is to normalize the matrix so that all its value components change to the same scale as the weighting scale, which is 0 to 1. After the normalized matrix will be multiplied by the weight matrix, which will produce a recommendation value matrix, where the highest value is the suggested recommendation.

III. METHODOLOGY

In this study, the recommendation discovery process will be carried out by combining Fuzzy with the Simple Additive Weighting method that processes the multi-criteria attributes with many inputs to achieve an output. The main process that is carried out is to process the recommendation results in the form of support for the decision to choose a seller / shop whose features best suit customer preferences. Criteria for seller selection: product's price, seller location, seller reputation, the number of sold products, and the number of expedition support.

A. Data Acquisition

This study employs data from Tokopedia, Shopee and Bukalapak online shops about products, sellers and attributes chosen from respondents' user experience. There are 50 samples of data of products and 120 rank combination orders of respondent data taken from each marketplace. The data sample divided into data training and data testing with the ratio 4:1 respectively.

Due to the user-based technique of recommendation, the recommended system developed is a personal recommender system, each user might give a different order of ranking preferences, so the recommendations can also be different.

There are five criteria defined as the weighted attributes:

1. Products price, identified by the nominal in Rupiah currency.
2. Distance of seller location to the user's location, identified by the information of city or district from the merchant's page.
3. Sellers reputation, identified by how many star(s) collected by merchant through users' feedback.
4. The number of products sold by seller, identified by how many product(s) a merchant had been sold.
5. Number of delivery supports, identified by how many expedition company are supporting the users' destination area.

This criterion was surveyed based on information through interviews of a number of sample respondents who were actively transacting on e-commerce about what was most often seen when shopping for products online in the marketplace. This study only adopted five attributes with the highest likelihood of relativity, although there were several other factors that also supported the decision making of users on the selection of merchants for a product. Other factors that can be identified, for example, how long the seller repays the chat/message sent by users and how many reviews buyers give into a product.

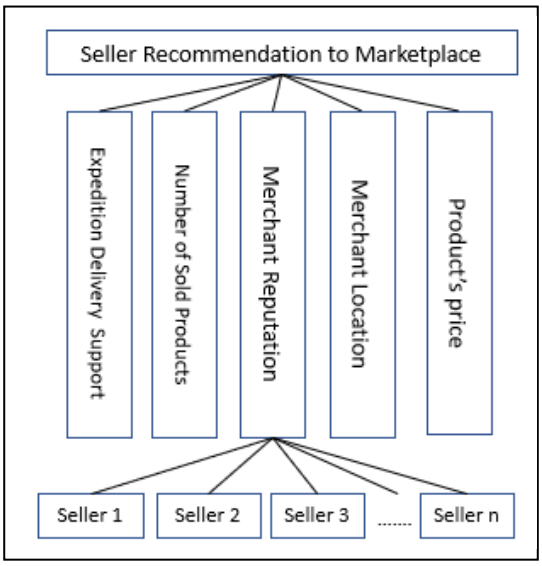

Fig 1. Framework Method of Seller Recommendation in Marketplace with SAW

These criteria are also popular as the most evaluating criterion as identified in [4] which investigated the supplier selection, in [8] of evaluating carbon performance, and also in [9] for implementing a personal recommender for price aware in eBay.

B. *Simple Additive Weighting*

As adopted from what is studied in [10], the working concepts of the Fuzzy-SAW algorithm in this study is to create an effective effort of filtering and sorting activities done by user while they are looking into a product within a marketplace. Users do not need to do a double check in every filter and sorting action because Fuzzy-SAW will cover both actions at a time. The system will issue recommendations by translating the user's desire for the search results of a product through a weighting system against the criteria inherent as product metadata and merchant. The description below will explain in more detail about the flow steps of Fuzzy SAW, which is also illustrated through Fig. 2.

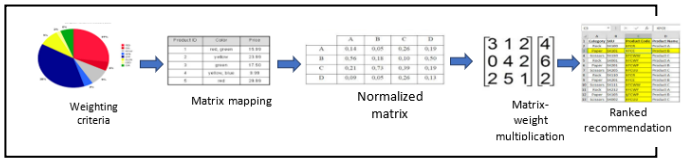

Fig 2. Workflow of Fuzzy-SAW Methodology

The first stage of Fuzzy-SAW is defining each attribute into cost and benefit attributes. Cost attribute means the best value is the minimum value, while the benefit attribute means the best value is the maximum value. Each criterion must be classified into one of the two types of attributes. By these five attributes, number (1) and (2) are considered as the attributes of cost; while attribute number (3), (4), and (5) are the benefit attributes.

The weighting part is done by giving a value of a scale of 0-1. After that, in the matrix mapping stage, the data of sellers is sold that sell similar products along with the value of the attributes of each alternative matrix and attributes. The second stage is the stage of normalization of the matrix. Each alternative seller/merchant candidate calculated the normalization value per attribute, adjusted for the type of attribute.

An example of normalization calculation for alternative i to attribute (1) is the division of the minimum value of all alternatives to the attribute (1) divided by the alternative value i to the attribute (1). Then for the calculation of alternative normalization I to attribute (4) is the division of the alternative value i to the attribute (4) divided by the maximum value of all alternatives to the attribute (4). The final result is a dimensionless matrix [number of alternatives x number of attributes] with a range between 0-1.

The normalized result matrix is then multiplied by a dimensioned weight matrix so that it will produce a recommendation weight matrix with dimensions. Alternatives that have a higher recommendation weight value will be more likely to be recommended. Alternative sellers that have the highest recommendation weight value are stated as the result of the final decision. The seller recommendation results can be applied as a feature in the online shopping application system and the selection of the most favorite sellers.

This study will focus on two parts: scenario to evaluate user performance and scenario to evaluate user experience. Where in the user experience scenario, we will focus on the activity of measure the completion time of participants to solve a task/command. Contribution given through this research are: a); b) implementation of the prototype; c) evaluation of the order rank for the results of seller recommendation.

IV. Result and Analysis

A. *Implementation Phase*

After accomplishing data pre-processing and implementation, Fig. 3 presents the interface of the personal recommender system.

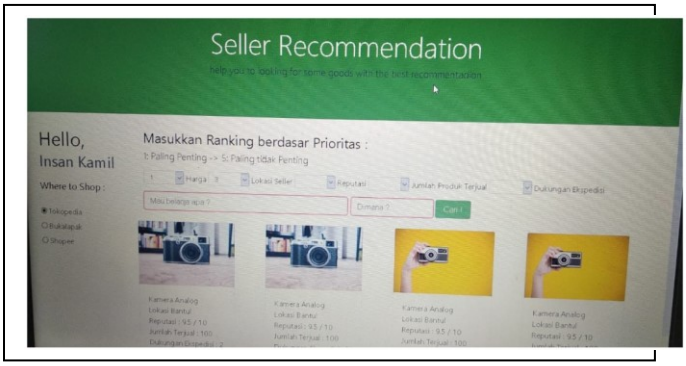

Fig 3. Recommender System Prototype Interface

In this system, the user will be given a path to find seller recommendations for the product they are looking for by first entering the online shop option where the product can be purchased, Tokopedia, Shopee or Bukalapak. Next, the user will be asked to determine the ranking for each attribute, product price, merchant location, merchant reputation, the number of sold products and the number of expedition

delivery support. Users are only allowed to rank 1-5 and there are no criteria with the same ranking. The next input is the product name search box and user location. Product recommendations will appear at the bottom of the search box. The system will display the 3-4 results of the initial recommendations with the top ranking. If the user wants the results of other recommendations, the system will display other merchants who have the next ranking order.

TABLE I. RAW MATRIX OF ALTERNATIVES

Alternative/Criteria	C1	C2	C3	C4	C5
A1	9000	713	4.6	701	1
A2	29000	394	3.9	0	1
A3	12000	370	4.6	646	3
A4	12000	403	4.7	26	2
A5	11000	258	4.5	342	3
A6	29200	390	4	0	1
A7	10282	208	4.6	71	3
A8	9300	399	4.5	304	2
A9	7900	713	4.5	2030	1
A10	13000	238	4.6	391	1

Table I illustrates the mapping of marketplace data into a matrix of alternatives. Tokopedia, Shopee and Bukalapak have differences in labelling their merchant reputation, where the different level scaling causes raw data to be normalized. Normalization is done by equalizing the level referred to the process of calculating the seller's reputation.

The seller's reputation represents the number of products that have been sold and at the same time the quality of service/customer satisfaction provided by the seller. The seller's quality includes, among others, rating the products sold, how long it takes the seller to respond to user questions, the quality of the products that have been purchased, and the quality of the information displayed by the seller in the product window.

Some factors can be calculated quantitatively, and the rest are qualitative, very dependent on user perception.

TABLE II. RESULTS OF MATRIX NORMALIZATION AFTER COST AND BENEFIT CALCULATION

	C1	C2	C3	C4	C5
A1	0.877778	0.29173	0.978723	0.34532	0.3333333
A2	0.272414	0.52792	0.829787	0	0.3333333
A3	0.658333	0.56216	0.978723	0.318227	1
A4	0.658333	0.51613	1	0.012808	0.6666667
A5	0.718182	0.8062	0.957447	0.168473	1
A6	0.270548	0.53333	0.851064	0	0.3333333
A7	0.768333	1	0.978723	0.034975	1
A8	0.849462	0.5213	0.957447	0.149754	0.6666667
A9	1	0.29173	0.957447	1	0.3333333
A10	0.607692	0.87395	0.978723	0.192611	0.3333333

Table II illustrates the normalized value matrix toward a Laundry Basket product at Shopee. There are at least ten sellers who sell the product with the same visual (type, brand and size) which will be processed by the Fuzzy-SAW method. Table II also shows the raw data taken from one of Shopee marketplaces, where the normalization results are shown as in the data in Table II. The normalized result table is then multiplied by the weighting number. Out of the 120 types of ranking methods, we can take an example of the 1-2-3-4-5 ranking sequence for price attributes-location-reputation-sold product-support expeditions. The results obtained are the 1 column matrix value shown by Fig. 4. Three consecutive sellers who get the highest score are A7-A9-A5.

$$\begin{bmatrix} 0.877778 & \cdots & 0.3333 \\ \vdots & \ddots & \vdots \\ 0.607692 & \cdots & 0.3333 \end{bmatrix} x \begin{bmatrix} 0.5 \\ 0.3 \\ 0.15 \\ 0.1 \\ 0.05 \end{bmatrix} = \begin{bmatrix} 0.7244 \\ 0.4357 \\ 0.7264 \\ 0.6686 \\ 0.8114 \\ 0.4396 \\ 0.8844 \\ 0.7730 \\ 0.8478 \\ 0.7487 \end{bmatrix}$$

Fig. 4. Alternative Matrix Calculation Results with 1Weight Matrix.

B. *Accuracy Evaluation*

This study employs an accuracy of the rank result calculation method. The accuracy is calculated based on the recommendations given by the system to data compared to the data given by respondents which is divided into data training to find the most optimum weight; and data testing in ratio of 4:1. In the data testing, a random sample of products with various combination of attributes rank order is applied. Accuracy value of each product search result is defined if a target seller is found as the first recommendation result.

TABLE III. SAMPLE OF DATA TESTING

Product	Attribute Rank	Seller Target	Seller Result
Aceh Arabica Coffee	1-5-2-3-4	Kopi Tubruk Indonesia	Kopi Tubruk Indonesia
	1-2-3-4-5	Q House of Coffee	Kopi Tubruk Indonesia
	2-1-3-4-5	Boenboen Coffee	Boenboen Coffee
	3-1-2-4-5	Kopi Tubruk Indonesia	Kopi Tubruk Indonesia
Zara Floral	1-3-4-2-5	Kimi Kimi Shop	Kimi Kimi Shop
	2-4-1-5-3	Kimi Kimi Shop	Value Bags
	3-1-5-4-2	Kimi Kimi Shop	Kimi Kimi Shop
Simbadda Music Player	4-1-5-2-3	Travarillo	Travarillo
	1-2-3-4-5	IT Shop Online	Simbadda Official
	2-1-5-4-3	IT Shop Online	IT Shop Online

Table III shows a sample of data testing that compares seller target to output from system. From the table, the accuracy of the correct amount of data can be calculated compared to the number of data testing, the pattern of which is represented as

in Table III. Attribute rank show the user preference respectively for price, location, number of sold product, seller reputation, and the number of expedition provider support. The accuracy generated by Fuzzy-SAW in this personal recommender system is 75%.

V. Conclusion

This paper has presented an experiment of seller selection with the case study of three marketplace in Indonesia, Tokopedia, Shopee and Bukalapak. Users can search recommendation results through this personal recommendation system by entering their preferences regarding the order of the product and seller criteria. From the results of accuracy and data from respondents, the price attribute becomes the attribute that respondents were being considered the most, since it originally belongs to a product, while the other attributes belong to each merchant. Some criteria ranking combinations produce the same sellers who are always ranked in the top-4 recommendations, one of the trigger factors because the values in almost all attributes are the most optimum number of each attribute type.

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