

# Development of Geospatial Dashboard with Analytic Hierarchy Processing for the Expansion of Branch Office Location

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**Abstract.** One of the considered business opportunities that exploit the geographical aspect is the branch office expansion. However, this activity still has some problems to learn various location criteria, either in quantitative or qualitative form. Moreover, there is a need to analyze those criteria quickly to get a proper location priority that will be expanded. Therefore, this research develops a semantic technology of the form geospatial dashboard using analytic hierarchy processing (AHP) method that can display the distribution of location and its criteria in a map. Furthermore, it recommends the list of top priority locations will be expanded implicitly from the various kinds of data. This research takes a case study in one local company in Indonesia. At the end, this research shows that geospatial dashboard using AHP method is considered capable of producing accurate solution up to 90.48% to determine the priority order of locations to be expanded.

**Keyword:** analytic hierarchy processing, geospatial dashboard, business intelligence, geographic information system, expansion of branch office location

## 1 Introduction

Ventana [13] mentioned that the current business object that can be a valuable asset in business analysis activities is the location. Companies can use it to determine the distribution of location data customer, partner, or distribution of such products more widely and deeply. The existence of this location analytics also increases the role of business intelligence (BI) in analytics technology that combines some aspects of geographic information system (GIS). Eckerson [3] on the BI Delivery Framework 2020 stated that the future of technology intelligence is needed in terms of changing the data and information into knowledge and potential business opportunities. Even, Halper [5] created a survey which was published in The Data Warehouse Institute (TDWI) report that stated that there was a result of big data technology trends that will emerge since 2014

which is a technology with the analytics types such as visualization tools (96% respondents), predictive analytics (88% of respondents), and geospatial analytics (70% of respondents).

Based on this survey result, we note that more users need technology that can support their location analytic skills in the form of geographic information and equipped by predictive analytic capability to predict which business steps that must be executed further and gives the semantic of given variety of data. This kind of technology brings us to the conclusion that the needs of an enterprise to look the appropriate data in the various type, such as qualitative and quantitative, and then process them into an obvious visualization are the sort of challenges that always be faced to the capability of BI and GIS technology.

The output of this research is geospatial dashboard as the form of visualization and geospatial analytics which uses Analytic Hierarchy Processing (AHP) to strengthen aspects of predictive analytics to determine the location of branch offices to be built first. This research takes a case study at Rekan Usaha Mikro Anda (RUMA) Company <sup>3</sup>, which is one of the Microfinance Company that has some various types of product and some branch office locations in Indonesia. This company is feasible for a case study due to its main condition is fit to the challenge of BI and GIS technology that is mentioned above. Their problem in terms of analyzing location data to expand their branch office was divided into two aspects, which are business and technology. In business aspect, they do not find such a method that can calculate qualitative and quantitative data based on many criteria and some location alternatives. In technology aspect, they still try to look for the technology that can give recommendations to expand their branch office in the priority order of location. In following, this paper will use the involvement of Zone Expansion Manager (ZEM) of RUMA as a division that takes care to the management of branch office expansion in RUMA.

This paper is written and arranged to focus on the use of AHP to solve the problem of branch office expansion. The notion of geospatial dashboard will be introduced only as a tool which support the decision making process. This paper initially introduces the theoretical background of geospatial dashboard and AHP in section 2. Then, in section 3 we explain the methodology of this research, meanwhile in section 4 we provide the evaluation on the AHP method. At the end, we put the conclusion and future work of this research in the last section.

## 2 Preliminaries

Here we introduce the theoretical background of geospatial dashboard and AHP. Since the main subject of these two terminologies are business intelligence, then the detailed explanation about business intelligence can be read in [12].

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<sup>3</sup> [www.ruma.co.id](http://www.ruma.co.id)

## 2.1 Geospatial Dashboard

One thing that is currently needed for the non-technical user to understand the data into the form of information, decision, and action is the translation of data into a form of visualization. Technology that covers that needs is called *data visualization*. According to [11], the data visualization is a gathering of various domains of science, such as information technology, cognitive science, as well as the graphical interface which aims to enrich the interpretation and the exchange of the information of users.

According to [2], basically geospatial dashboard is a combination of BI and GIS application on a single architecture that combines spatial analysis and visualization maps with a BI tool that is expected to assist companies in making decisions related to the analysis of location data.

To develop the architecture of geospatial dashboard, we can start from the point of view of BI architecture [8]. Then, to integrate it with the GIS technology, [2] state that spatial capabilities are needed to be injected into the structure of BI architecture. These capabilities include reading and writing GIS file formats, performing coordinate transformations, and other spatial reference system.

## 2.2 Analytic Hierarchy Processing

According to [10], AHP is a theory that measures assessment of any expert or executive in making decisions through pairwise comparison method with the use of scales of priority. Pairwise comparison is a comparison between two alternative decision-making based on the specific criteria. Each criterion will also be compared in pairs. This comparison is done to look at the interest rate of one element with another element. Results produced on this comparison was obtained from qualitative assessment conducted by the experts who have the knowledge to the problems of making the decision. This assessment could indeed be relative or inconsistent, but that is the focus of the use of AHP. AHP is expected to solve that inconsistency problem of the form of mathematical modeling. The scales of priority range from 1 to 9 which means that the bigger the priority, the more important that criterion or alternative to the others. In addition, AHP is not only used for qualitative assessment. The quantitative criteria can also be involved in this method [6].

The paper [10] states that there are steps that can be followed to carry out this AHP method as follows:

1. State the objective of the decision making, define the criteria, and pick the alternatives. We turn these three components into an *AHP Tree Structure*.
2. Construct the pairwise comparison matrix for the criteria and then turn the matrices into a ranking priorities of criteria by using the *eigenvector* [9] calculation.
3. Construct the pairwise comparison matrix for every alternative based on a certain criterion and then also turn it into a ranking priorities of alternatives based on the chosen criterion by using the *eigenvector* calculation.

4. If the criterion is quantitative, then we only need to do a normalization on the alternatives' value based on that criterion. Otherwise, do the step 3.
5. Combine the ranking priority value for each alternative based on a criterion into a matrix and then multiply that matrix by the criteria ranking we obtained in step 2.

Every computed eigenvector gives us the relative ranking for our criteria or alternatives. The eigenvector calculation is computed by running this algorithm.

1. Raise the pairwise matrix to powers that are successively squared each time.
2. Calculate the row sums and the normalize it.
3. The computation is stop to iterate when the difference between the normalized row sums in two consecutive calculations is smaller than an assigned value.

**Example 1:**

We want to choose which city that will be expanded based on the given criteria and the assigned objective. By following the previous explained steps to do the AHP calculation, first we need to define the objective, criteria, and cities. To make it general, we state that we have criteria  $C_1$ ,  $C_2$ , and  $C_3$ . Here we treat the criterion  $C_3$  as a quantitative criterion. Then, we have cities which are  $A_1$ ,  $A_2$ , and  $A_3$ . We construct these components into AHP tree structure which is depicted in Figure 1.

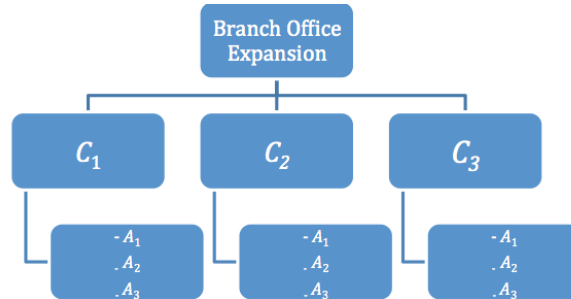


Fig. 1: Example of AHP Tree Structure

Next, we do the second step by constructing pairwise comparison matrix and turn it a criteria ranking by *eigenvector* computation. The values in this matrix are obtained by the agreement between the domain experts.

$$\begin{matrix} & C_1 & C_2 & C_3 \\ C_1 & \begin{pmatrix} 1 & 0.33 & 2.00 \\ 3.00 & 1 & 0.25 \\ 0.50 & 4.00 & 1 \end{pmatrix} & & \\ C_2 & & & \\ C_3 & & & \end{matrix} \implies \begin{matrix} & \text{Criteria's Priority Value} \\ C_1 & \begin{pmatrix} 0.287 \\ 0.299 \\ 0.414 \end{pmatrix} \\ C_2 & \\ C_3 & \end{matrix}$$

These values state that criterion  $C_3$  is the most important criterion. Similar to

obtain the criteria ranking, we obtain the alternative ranking by running the third step. First, we compute the alternative ranking based on criterion  $C_1$ .

$$\begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{ccc} A_1 & A_2 & A_3 \\ \left( \begin{array}{ccc} 1 & 4.00 & 0.11 \\ 0.25 & 1 & 5.00 \\ 9.00 & 0.20 & 1 \end{array} \right) & \Rightarrow & \begin{array}{c} C_1 \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \left( \begin{array}{c} 0.250 \\ 0.352 \\ 0.398 \end{array} \right) \end{array}$$

Next, we compute the alternative ranking based on criterion  $C_2$ .

$$\begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{ccc} A_1 & A_2 & A_3 \\ \left( \begin{array}{ccc} 1 & 0.33 & 0.33 \\ 3.00 & 1 & 0.25 \\ 3.00 & 4.00 & 1 \end{array} \right) & \Rightarrow & \begin{array}{c} C_2 \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \left( \begin{array}{c} 0.131 \\ 0.247 \\ 0.622 \end{array} \right) \end{array}$$

Since, the criterion  $C_3$  is quantitative, then we only do the fourth step which is normalizing the alternatives value based on  $C_3$ .

$$\begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} C_3 \\ \left( \begin{array}{c} 30 \\ 10 \\ 20 \end{array} \right) \end{array} = \begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} C_3 \\ \left( \begin{array}{c} 0.287 \\ 0.299 \\ 0.414 \end{array} \right) \end{array}$$

Last, we compute the final alternatives ranking priority by combining all the alternatives ranking priority into a matrix and then multiply it by the criteria ranking.

$$\begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{ccc} C_1 & C_2 & C_3 \\ \left( \begin{array}{ccc} 0.250 & 0.131 & 0.500 \\ 0.352 & 0.247 & 0.167 \\ 0.398 & 0.622 & 0.333 \end{array} \right) \end{array} * \begin{array}{c} C_1 \\ C_2 \\ C_3 \end{array} \begin{array}{c} \text{Criteria's Priority Value} \\ \left( \begin{array}{c} 0.131 \\ 0.247 \\ 0.622 \end{array} \right) \end{array} = \begin{array}{c} A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \text{Alternatives' Priority Value} \\ \left( \begin{array}{c} 0.376 \\ 0.211 \\ 0.413 \end{array} \right) \end{array}$$

Therefore, we conclude that alternative  $A_3$  has the greatest value as the most important city to be expanded first.

### 3 Research Method

The methodology of this research is adopted based on the stages in the development of geographic information system project ([1], [7]). It consists of five stages. The first stage is named as the *initiation stage*. It aims to determine the problems and case studies will be discussed on this research. The second stage, which is the *requirement analysis stage*, purposes to identify which requirements must be used to support this research and how to gather the data from the data source. The next stage is how to *design the geospatial dashboard*, especially in

terms of its architecture. The fourth stage is to *implement the geospatial dashboard and AHP* from the design sketch in previous stage that will be integrated with the AHP algorithm. Finally, the last stage is how to *evaluate the result* from the implementation. The explanation of this research method is depicted in the following Figure 2. The analysis to model this case study into AHP tree structure as well as the implementation of geospatial dashboard and AHP will be explained more detail in the following subsections.



Fig. 2: Research Methodology

### 3.1 AHP Component Analysis

Here, we analyze the needs of some components of AHP model, which are, objective, criteria and alternatives. We take the case study of looking for the order of priority of branch office locations that will be expanded as the objective of AHP model. To analyze the criteria of decision making for the expansion of branch office location, we adopt the structure of the criteria based on [4] about the common criteria to determine the location that will be expanded by geospatial analytic techniques. The criteria cover some factors which are target market, competitors in the area around the site, operational considerations, and changes. The determination of these criteria was also supported by the recommendation from RUMA's stakeholders.

First, the type of *target market* criteria which is owned by RUMA was the data of amount of stalls and population density in a region. Next, the *competitive* aspect that is used to learn the competitors in the area around the site was the price of a competitor's product. Then, many types of *operational activity* of RUMA make us to focus on the number of criteria used, such that the top operational consideration taken for this research is the regional minimum wage. The criterion based on *change* factor is determined by some changes that will occur in an area, both physical and non-physical, which can affect the increase of the number of potential customers for the company. In terms of RUMA's case study, we use the population of its business centers of Bank XYZ who had cooperation with RUMA in terms of financial transactions for micro-enterprises. In addition to the above four types of criteria, we also take a more qualitative criterion. That criterion is the potential PT. RUMA to recruit the number of stalls as customers in a region.

Then, this research exploits the alternative component of AHP method by taking some cities/counties that were the current branch office location up to February 2014 which is the period when this research began first time. There

are 22 cities/counties taken into this research which were Bandung, Bogor, Bekasi, Ciamis, Canjur, Cilegon, Cirebon, Garut, Indramayu, Jakarta, Kendal, Klaten, Lebak, Majelengka, Semarang, Serang, Sukabumi, Sumedang, Tabanan, Tangerang, Tasikmalaya, and Yogyakarta. Last, all these components of AHP are structured into AHP tree (Figure 3).



Fig. 3: AHP Tree Structure

### 3.2 Implementation of Geospatial Dashboard and AHP

The name of this geospatial dashboard is “*Sistem Ekspansi Lokasi Kantor Cabang PT. RUMA*” (System of Expansion of Branch Office Area at RUMA). Geospatial Dashboard has some features that are useful to facilitate RUMA, especially ZEM team to know the priority of branch office locations that are first to be built using AHP approach. Some features of geospatial dashboard are described as follows:

1. Selecting the decision making criteria
2. Selecting the city that will be expanded
3. Running the calculations of AHP
4. Showing the distribution of each locations in a form of map After the user runs the AHP, the application will display a map with the position of the selected location. Each location will have a different colour marker which indicates the priority of that location to be expanded. There are three kinds of priority order. The first priority which is indicated by red colour means a high priority. The second priority is interpreted with a yellow one means a medium priority, while the third priority indicates a low priority for a city with a green marker colour. Users can view detailed information of a city / county on the map by selecting the corresponding marker.
5. Showing the order of priority value of each branch office locations in the form of table.

## 4 Evaluation on the AHP Method

The main purpose of this evaluation is to measure the accuracy of AHP method used in geospatial dashboard. This evaluation compares the resulted priority order of city from geospatial dashboard with the data of order of all branch office location of RUMA based on the level of profit per transaction of product. This data was produced in the February 2014. For the simplicity, we name this ordered data as a *targeted list* for the further experiment. We take this data with a reason that the resulted list from geospatial dashboard is the order of city/county with the profit expectation from the top to the bottom based on the criteria that we analyzed before. This comparison technique directly looks into a correlation between two difference lists of order, such that this technique require such a statistic method that is so-called *Spearman Rho* [14].

The next step is how to determine the chosen criteria and city during the evaluation. We make two group of experiments that have different format of chosen criteria and city. Every group had 3 experiments. The first group will use the chosen criteria based on some recommendations from having focus group discussion with ZEM of RUMA. The other group of experiments use criteria which is obtained by conducting a little experiment aided by spearman rho.

In this evaluation, every criterion would be divided into two groups that are basic criteria and non-basic criteria. Basic criteria are criteria that always become top consideration for ZEM of RUMA once analyzing a location to be expanded, while non-basic criteria are only supporting criteria. Therefore, every two groups of experiment will have different basic and non-basic criteria. According to focus group discussion with ZEM of RUMA, we have some basic criteria that are density of population (DP), density of stalls (DS), and price of competitor's product (P), while the non-basic criteria are regional minimum wage (RW), population of business center (PB), and potency of RUMA to recruit stalls (PR). Moreover, for another group of experiment we have some following steps to choose criteria based on the spearman rho method, which are:

- Run 6 little experiments that only use one criterion in each of them. Recall that we only have 6 criteria in this research. For every experiment, choose all 22 cities and run the geospatial dashboard.
- Once obtaining the result, compare it to the list of order of cites/counties based on the level of profit per product transaction. In other words, we compare the rank of each city in these two lists.
- Calculate this comparison by using spearman rho and in the end every little experiment will have an accuracy value. This accuracy value directly become a value for the used criterion in this little experiment.
- From these little experiments, we have the basic criteria which are price of competitor's product (P), regional minimum wage (RW), and population of business centre (PB), while the non basic criteria are the rest.

For every group of experiments, we will do 8 sub-experiments in which the number 8 is obtained as the combination of three basic criteria and all subsets of non-basic criteria. We name the experiments in the first group as A, B, and



C, while in the second group we have D, E, and F. All sub-experiments will be treated by running geospatial dashboard, choosing all 22 cities, and use one of the chosen criteria.

However, there are different ways of comparing the resulted ordered list with the targeted list. For experiments A and D, we compare the similarity of rank of 22 cities between these lists. For experiment B and E we only choose first 8 cities from the resulted ordered list of geospatial dashboard to be compared with their rank in the targeted list as a consideration that 8 cities are the first priority of cities to be expanded in the middle term planning. For experiment C and F, similar to experiment B and E, but we only chose first 4 cities because among 8 cities as the first priority, there were only 4 cities to be observed first in the short term planning of ZEM.

Table 1: Result of Evaluation of AHP Method in 1st Experiment Group

1 <sup>st</sup> Experiment Group				
Procedure	Experiments			
	Chosen Criteria	A	B	C
1	DP+DS+P	0.28%	38.10%	80.95%
2	DP+DS+P+RW	12.59%	9.52%	40.00%
3	DP+DS+P+PB	5.48%	23.81%	40.00%
4	DP+DS+P+PR	4.23%	19.05%	40.00%
5	DP+DS+P+RW+PB	13.16%	9.52%	40.00%
6	DP+DS+P+RW+PR	10.78%	9.52%	40.00%
7	DP+DS+P+PB+PR	1.19%	19.05%	40.00%
8	All Criteria	11.80%	4.76%	40.00%
Accuracy Value of AHP Method		7.44%	16.67%	45.12%

Table 1 and table 2 show the result of this evaluation with the information of accuracy value with some chosen criteria. Based on table 1, we can conclude that in 1st experiment group which used the chosen criteria from having focus group discussion with ZEM, we can get at most **80.95%** accuracy which only uses the first 4 cities from the resulted list of geospatial dashboard for the comparison and the criteria used are density of population, density of stalls, and price of competitor's product. On the other hand, table 2 shows that we can get at most **90.48%** accuracy which only uses the first 8 cities from the resulted list of geospatial dashboard for the comparison and the criteria used are price of competitor's product, density of population, and density of stalls.

Table 2: Result of Evaluation of AHP Method in 2nd Experiment Group

2 <sup>nd</sup> Experiment Group				
Procedure	Experiments			
	Chosen Criteria	D	E	F
1	P+RW+PB	31.11%	90.48%	40%
2	P+RW+PB+DP	35.29%	76.19%	20%
3	P+RW+PB+DS	24.34%	76.19%	80%
4	P+RW+PB+PR	23.49%	22.02%	40%
5	P+RW+PB+DP+DS	13.16%	9.52%	40%
6	P+RW+PB+DP+PR	14.74%	2.38%	20%
7	P+RW+PB+DS+PR	7.99%	26.19%	40%
8	All Criteria	11.80%	4.76%	40%
Accuracy Value of AHP Method		20.24%	38.47%	40%

## 5 Conclusion

Here we develop the geospatial dashboard based on analytic hierarchy processing technique for the expansion of branch office location by using a case study of Rekan Usaha Mikro Anda Company. First, we show how to analyze the component of AHP, such as objective, criteria, and alternatives. Then, we construct them into an AHP tree structure. Next, we implement the geospatial dashboard by introducing its features. Using the evaluation in terms of the accuracy of AHP method, we can get at most 80.95% of accuracy by using chosen criteria from focus group discussion with ZEM of RUMA and at most 90.48% of accuracy by using the criteria that are determined from spearman rho calculation.

Other research that can be developed from this research is the development of data warehouse or online analytical processing (OLAP) for the utilization of geospatial dashboard. With the similar situation in case study, this technology can provide data which is multidimensional, historic, or even real-time, so the decision maker viewpoint to a location data can be wide and varied. Some machine learning techniques to read and process the variety of data can be injected further into this application for the improvement process of decision making.

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