

Research Horizon

Vol. 1, no. 6, (2021), 237-243

Website: <http://journal.publindoakademika.com/index.php/RH>

Determination of Network Technology of Fixed Broadband with Fuzzy Multiple Criteria for Decision Making Method

Juanda Wijaya^{1,*}

¹ Mercu Buana, Jakarta, Indonesia

* Corresponding author:

Email:

Received : Aug 19, 2021

Revised : Nov 26, 2021

Accepted : Dec 14, 2021

Abstract

To get the concept of developing an effective and efficient fixed broadband network, it is necessary to standardize fixed broadband access network technology. This standardization will facilitate in determining the design and development costs of the overall access network. In this paper, the process of determining the standardization of access networks is discussed through the Fuzzy SWOT MCDM (Multiple Criteria Decision Making) method. The process that is made is by establishing the SWOT access network technology that is available then the ranking process is carried out with fuzzy MCDM algorithm from the results of the questionnaire provided by network experts at PT. Indosat, one of the telecommunications network and service providers in Indonesia.

Keywords

Fixed broadband network, fuzzy MCDM, SWOT

1. Introduction

PT. Indosat is currently planning to develop fixed broadband services in several locations in Indonesia. This is related to the vision of PT Indosat to become a leading company in the Data network. Furthermore, currently PT. Indosat has started a fixed broadband network with limited coverage, namely in several locations of buildings or partnership areas, with diverse local network technology concepts, namely ADSL (Asynchronous Digital Subscriber Line) through copper cable (twisted pair), HFC (Hybrid Fiber Coaxial) and FTTH (Fiber To The Home) as shown in Table I.1.

Determination of network standardization is done by using SWOT Fuzzy Analysis (Strength Weakness Opportunity Threat) and MCDM (Multi Criteria Decision Maker) for three types of fixed broadband access network technologies, namely ADSL, HFC and FTTH / C. Strength Analysis, Weakness, Opportunity, Threat (SWOT) is a method which is often used to formulate operational strategies and also important tools in decision making (Hill & Westbrook, 1997).

According to Chang & Huang (2006) in a study in some of the old SWOT literature revealed that the main criteria were not measurable to present the impact of each criterion on the main strategy. In other words, in accordance with Kurttila et al. (2000), SWOT analysis cannot present a good analysis for presenting performance ratings and the weight of each SWOT factor. Therefore a SWOT analysis is not able to assess the feasibility of alternative decisions based on existing factors. So that to get a more measurable and easier result to get a clear assessment parameter, fuzzy MCDM methodology is currently used. Especially in the last few years the application of the MCDM method has been expanded since the rapid development of computer development.

2. Research Method

In this paper, the results of the determination of fixed broadband access network are the SWOT MCDM fuzzy method. Where the process of determining the results is obtained based on the process of determining SWOT analysis for fixed broadband access networks obtained based on references from BT Exact in Telecommunication Series 47 IET, coming white paper (WP6321) and FTTH Council Europe with the title Broadband Access Technology seen in table I. 2. Then made a fuzzy MCDM analysis method approach so that it can be generated a ranking of the existing alternative access networks (Anisseh et al., 2009). To get a decision with the fuzzy MCDM methodology, decision makers must first be determined (Ding & Chou, 2012). In this paper the determination of decision makers is experts or experts in the field of access technology at PT. Indosat. In this case to facilitate calculation, the decision makers can be notified with DM (Decision Maker). Furthermore, to get a decision from a number of alternative choices, access technology for fixed broadband networks can be determined by the process detailed in the next part..

2.1 Fuzzy SWOT MCDM Process

The process or stages taken to obtain the results of a decision that refers to the α -cut concept as developed in the journal Ding & Chou (2012) are as follows:

Determination of SWOT criteria for Internal and External factors in this case fixed broadband services of PT. Indosat. Determination of several objects of access network technology as an alternative to support fixed broadband services of PT. Indosat. Assessment of the weight of each criteria and sub-criteria in SWOT is based on the determination of several decision makers. Aggregation assessment of the results of the assessment of all sub-criteria with known weights. Lastly, ranking of all available alternatives in accordance with the aggregation results of the existing subcriteria.

2.2 Fuzzy MCDM

The ranking process with the α -cut calculation used can be taken with the concept of integral assessment and α -cut (Liou & Wang, 1994; Yager, 2017; Liu, 1998). For ratings obtained from inversions of each function. Based on the reference to the previous fuzzy formula above, the left and right functions of f_A^{Ki} and f_A^{Ka} can be a form of inversion with the determination of the y axis and denoted as a function l_A^{Ki} and l_A^{Ka} .

So that the fuzzy numerical value of the A value for the left side can be formulated into an integral $g^{Ki}(A) = \int_0^1 l_A^{Ki}(y) dy$. (2.1), while for the left side is $g^{Ka}(A) = \int_0^1 l_A^{Ka}(y) dy$. (2.2).

If $\alpha_j, j = 0, 1, \dots, n$, and $0 = \alpha_0 < \alpha_1 < \dots < \alpha_j < \dots < \alpha_n = 1$ then according to the trapezoidal rules (Gerald & Wheatley, 1990), the left-sided integral value of fuzzy A can be obtained based on the equation $g^{Ki}(A) = \frac{1}{2} \lim_{k \rightarrow \infty} \{ \sum_{j=1}^k [l_A^{Ki}(\alpha_j) + l_A^{Ki}(\alpha_{j-1})] \Delta\alpha_j \} \dots$ (2.3).

The right side is obtained based on the equation $g^{Ka}(A) = \frac{1}{2} \lim_{k \rightarrow \infty} \{ \sum_{j=1}^k [l_A^{Ka}(\alpha_j) + l_A^{Ka}(\alpha_{j-1})] \Delta\alpha_j \} \dots$ (2.4) where $\Delta\alpha_j = \alpha_j - \alpha_{j-1}$.

Furthermore, according to Dong & Shah (1987), for the R (A) rating assessment of the fuzzy value A can be written with the equation $R(A) = \beta g^{Ka}(A) + (1 - \beta)g^{Ki}(A), 0 \leq \beta \leq 1$. (2.5).

In this formula the coefficient of β is the reference value of the risk index of the establishment / attitude of the decision makers. Based on Chang & Chen (1994), to get a rational β value is determined based on the evaluation of the decision maker like the $\beta =$ equation

$$\frac{\sum_{t=1}^k \left(\frac{a_t - c_t}{b_t - c_t} \right) + \sum_{t=1}^k \sum_{j=1}^{n_i} \left(\frac{a_{tj} - c_{tj}}{b_{tj} - c_{tj}} \right) + \sum_{i=1}^m \sum_{t=1}^k \sum_{j=1}^{n_i} \left(\frac{a_{itj} - c_{itj}}{b_{itj} - c_{itj}} \right)}{k + \sum_{t=1}^k n_t + m \times \sum_{t=1}^k n_t} \dots (2.6..(2.6))$$

So that the ranking process of alternatives made according to the values of Ai and Aj will refer to the following equation:

- a. $A_i > A_j \iff R(A_i) > R(A_j)$
- b. $A_i < A_j \iff R(A_i) < R(A_j)$
- c. $A_i = A_j \iff R(A_i) = R(A_j)$

If Ai for $i = 1, 2, \dots, n$ is a fuzzy value, then according to equation (2.3), (2.4) and (2.5) there will be a rating of the value of R (Ai) which refers to the value of Ai.

2.3 SWOT Criteria for network technology

From the SWOT table assessment results on the background and references to the Broadband Strategies Handbook issued by the World Bank, the findings of customer needs for fixed broadband services are obtained, including, Internet connectivity speed, Quality of Service, Network Availability, Network provision fees. This reference will be a criterion or factor of the assessment that will be weighted by each team of decision makers later.

2.3.1 Alternative

Alternatives (Objects) are values that refer to objects that will be compared in this case access technology (ADSL, HFC and FTTH / C). To simplify the calculation in a number variable, all alternatives are encoded into A_i where A_1 is the code for ADSL, A_2 for HFC and A_3 for FTTH / C.

2.3.2 Criteria

Criteria (Factors) is the value that refers to the key factors of internal and external assessment (SWOT). Where these factors include Internal factors (Internet Access Speed, Quality of access network), and External factors (Support device availability and capacity, Cost of providing access network).

2.3.3 Determination of weighting

Weights are assessments that are relatively measurable from criteria. Selection of evaluation measures for weighting and alternative feasibility of sub-criteria in this thesis evaluation evaluation is weighted in 5 levels, namely very unimportant = 1, not important = 2, do not know = 3, important = 4, very important = 5. As for assessment the criteria and sub criteria are set in 5 levels, namely very cannot = 1, can not = 2, can not be = 3, can be = 4, very possible = 5.

To calculate the subjective weight of all criteria and sub-criteria in a triangular fuzzy (Dubois & Prade, 1978), it can be formulated by operating the minimum, maximum and geometric mean values. In this paper, every time we are notated with K_i , for sub-criteria can be specified in SK_{ij} .

Criteria are made into 4 assessment criteria so that if notated to be K_1, K_2, K_3, K_4 . In this paper K_1 is the speed of access to the internet has 5 sub criteria with code $SK_{11} - SK_{15}$, K_2 is a quality access network that has 5 sub-criteria with code $SK_{21} - SK_{25}$, K_3 is support for availability of devices and capacity which has 4 sub-criteria with code $SK_{31} - SK_{34}$ while K_4 is the cost of providing an access network that has 4 sub-criteria with code $SK_{41} - SK_{44}$.

So the weight of each criterion is written with the notation BK_t . with a formula $BK_t = (p_t, q_t, s_t)$ in which $t = 1, 2, \dots, k$. Value of $p_t = \min \{x_{t1}, x_{t2}, \dots, x_{tn}\} \dots (2.7)$, value q_t is obtained from *geometric mean*, $q_t = (\prod_{d=1}^n x_{td})^{1/n} \dots (2.8)$ and value $s_t = \max \{x_{t1}, x_{t2}, \dots, x_{tn}\} \dots (2.9)$. Then the weight of the sub-criteria will be obtained from the formula y_{tjd} , $d = 1, 2, \dots, n$. So the weights formula for sub-criteria can be grouped by formula $BSK_{tj} = (p_{tj}, q_{tj}, s_{tj})$, in which $t = 1, 2, \dots, k$. and $j = 1, 2, \dots, n_t$. Value $p_{tj} = \min \{y_{tj1}, y_{tj2}, \dots, y_{tjn}\} \dots (2.10)$, value q_{tj} is obtained from *geometric mean* with a formula $q_{tj} = (\prod_{d=1}^n y_{tjd})^{1/n} \dots (2.11)$ and value from $s_{tj} = \max \{y_{tj1}, y_{tj2}, \dots, y_{tjn}\} \dots (2.12)$.

If the ranking of all alternatives with sub-criteria is written with z_{itjd} in which $d = 1, 2, \dots, n$. So that for fuzzy rank values can be written with $BA_{itj} = (p_{itj}, q_{itj}, s_{itj})$ where $i = 1, 2, \dots, m$; where the alternative consists of 3, alternative A_i ($m=3$); $t = 1, 2, \dots, k$ in this case the number of criteria K is 4 ($k=4$); $j = 1, 2, \dots, n_t$ dwith a value of $p_{itj} = \min \{z_{itj1}, z_{itj2}, \dots, z_{itjn}\} \dots (2.13)$, value q_{itj} is obtained from *geometric mean* with a formula $q_{itj} = (\prod_{d=1}^n z_{itjd})^{1/n} \dots (2.14)$, in which $s_{itj} = \max \{z_{itj1}, z_{itj2}, \dots, z_{itjn}\} \dots (2.15)$.

2.2.4 Aggregation

In the determination of aggregation or performance can be obtained from the value of the object compared in the evaluation of all the key factors with existing alternatives. And we can get this from the assessment of the weight of all criteria and sub criteria with the results of evaluation of criteria and alternatives. If the concept of α -cut is obtained from BK_t^α , BSK_{tj}^α and BA_{itj}^α . It is formulated with BK_t^α , BSK_{tj}^α dan BA_{itj}^α with the following formula:

$$R_{it}^\alpha = \frac{1}{n_t} [(BA_{it1}^\alpha \cdot BSK_{t1}^\alpha) + (BA_{it2}^\alpha \cdot BSK_{t2}^\alpha) + \dots + (BA_{itj}^\alpha \cdot BSK_{tj}^\alpha) + \dots + (BA_{itn_t}^\alpha \cdot BSK_{tn_t}^\alpha)] \dots (2.16),$$

In which $i = 1, 2, \dots, m$; $t = 1, 2, \dots, k$; $j = 1, 2, \dots, n_t$. Furthermore, the final assessment of the aggregation of several existing alternatives can be formulated:

$$F_i^\alpha = \frac{1}{k} [(R_{i1}^\alpha \cdot BK_1^\alpha) + (R_{i2}^\alpha \cdot BK_2^\alpha) + \dots + (R_{ik}^\alpha \cdot BK_k^\alpha)] \dots (2.17).$$

2.2.5 Ranking

For ranking or ranking of a fuzzy triangular A value with (p, q, s) is obtained by equation (2.5) and (2.6).

3. Methods

The data analysis used is the result of a fixed broadband online survey from the <https://www.surveymonkey.com/s/DevFixedBroadband> website which is filled by several technical experts at PT. Indosat. The data is used as a reference to get the ranking that has been formulated in equation 3. Where the results obtained are as below.

3.1 Weighting Calculations

Based on the data and the results of interviews conducted to the experts who have responded to the survey above. In this paper the weighting is made into 5 levels: 1 = very unimportant, 2 = not important, 3 = not knowing, 4 = important, 5 = very important. So if we enter in the weighting equation in equation (2.7) and (2.8) we will get the results as in table III.1. While the results of the assessment of each alternative obtained from the results of an online survey if compiled with equation (2.9)

3.2. Results of calculation of aggregation level

Furthermore, based on existing data, the process of determining the suitability value of the criteria for each alternative is available for the lowest value and highest value. Where the lowest value and highest value is obtained by the formula in equation (2.10) with α -cut cutting sampling as much as 7 levels, starting from values 0, 0.2, 0.4, 0.5, 0.6, 0.8 and 1. So that the results are obtained as in table III. 3. In the formula it is necessary to link weighting of all criteria and assessments of each sub-criterion in each alternative. Where aggregation is the process of determining the magnitude of each intersection of the y axis for values between 0 and 1. So that

the degree of intersection between each assessment can be determined between the weights with all existing criteria of each alternative. Furthermore, from the aggregation determination process obtained then proceed with the process of determining the side end of each alternative by using the formula in equation (2.11). The final aggregation determination is made to get the ranking of each alternative that is compared again with the weight of a number of existing criteria.

3.3 Alternative ranking results

Ranking of alternatives is obtained by using the formula in equation (2.5) which is the result of combining each value sampled with weight and delta between the highest values in equation (2.4) and the lowest value in equation (2.3) and multiplied by the confidence level index that is with the symbol β with equation (2.6).

Index values can be obtained using the method developed by Chang & Chen (1994) obtained by using the formula (2.13) in Chapter II. So that the value of $\beta = 0.574$ is obtained.

3.4 Results Analysis

Based on the data and analysis obtained in the discussion of the results above, it is known that where the highest final value is occupied by the third alternative (A3), namely FTTH / C. Where based on the previous theoretical basis that this FTTH / C technology already uses fiber optic media. So as to allow for greater application usage and higher speeds. Moreover, between rank 1 (FTTH / C) and 2 (HFC) is not too far away. This is due to the use of the same media for the backbone network of the two technologies, namely using fiber optic media as well. Whereas the two access network technologies themselves are commonly used by network operators with different customer segments. For FTTH / C technology, telecommunication operators are widely used, while HFC is widely used by television operators.

4. Conclusion

Based on the analysis results, it can be concluded that the appropriate access network technology for Indosat fixed broadband services is Fiber To The Home / Curb (FTTH / C).

And this is also in accordance with the data from the OECD in Figure IV.1 that in the developed countries of ASIA such as Korea and Japan the use of fiber optics as access network technology is more widely used as infrastructure for Fixed Broadband customers there. Meanwhile in the United States and Canada coaxial cable (HFC) is more dominant. The use of fiber optic networks with FTTH / C technology has been more dominant lately, along with the increasing need for speed and bandwidth of applications that are there. With references from several developed countries and the results of this study it is expected that PT. Indosat can synergize the development of the broadband network with the FTTH / C concept.

PT. Indosat itself in developing fixed broadband services can set the following standards. First, network technology used is FTTH / C (Fiber To The Home / Curb) so that it can meet all broadband needs of current and potential customers. Second, the development carried out should be referred to in a specific or selective area or area, considering the high and the amount of investment that needs to be issued for the construction of this fixed broadband network.

Third, there is a need for cooperation in the development of fixed broadband networks to increase the speed of penetration and provision of Indosat's fixed broadband services, because there are still weaknesses in service and provision of fixed broadband networks compared to existing competitors.

References

- Anisseh, M., Yusuff, RbM., Shakarami, A., (2009). Aggregating group MCDM problems using a fuzzy Delphi model for personnel performance appraisal. *Sci. Res. Essays*, 4(5), 381-391.
- Chang, H.H., & Huang, W.C., (2006). Application of a quantification SWOT analytical method. *Mathematical and Computer Modeling*, 43 (1), 158-169
- Chang, P. L., & Chen, Y. C. (1994). A fuzzy multi-criteria decision making method for technology transfer strategy selection in biotechnology. *Fuzzy Sets and Systems*, 63(2), 131-139.
- Ding, J. & Chou,C., (2012). A Fuzzy MCDM Model to Evaluate Investment Risk of Location Selection for Container Terminals. *Wseas Transaction on Information Science and Applications*. 10 (9).
- Dong, W., & Shah, H. C. (1987). Vertex method for computing functions of fuzzy variables. *Fuzzy sets and Systems*, 24(1), 65-78.
- Dubois, D., & Prade, H., (1978). Operations on Fuzzy Numbers. *The International Journal of Systems Science*. 9 (6), 613-626.
- Gerald, C. F, & Wheatley, P. O. (1990). *Applied Numerical Analysis*, 4th ed. New York: Addison-Wesley Publishing Company.
- Hill, T. & Westbrook, R. (1997). SWOT Analysis: It's Time for a Product Recall. *Long Range Planning*, 30 (1), 46-52.
- Kurttila, M., Pesonen, M., Kangas, J., Kajanus, M., (2000). Utilizing the analytic hierarchy process (AHP) in SWOT analysis—a hybrid method and its application to a forest-certification case. *Forest Policy and Economics*, 1 (1), 41-52.
- Liou, T. S., & Wang, M. J. J. (1994). Subjective assessment of mental workload—A fuzzy linguistic multi-criteria approach. *Fuzzy Sets and Systems*, 62(2), 155-165.
- Liu, A. F. (1998). *Structural life assessment methods*. ASM international.
- Yager, R. R. (2017). On using the shapley value to approximate the choquet integral in cases of uncertain arguments. *IEEE Transactions on Fuzzy Systems*, 26(3), 1303-1310.