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Evaluation of MVNO model implementation in remote and border areas using the consistent fuzzy preference relations method

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Abstract — Law No. 36 of 1999 concerning Telecommunication has brought many changes, especially in Indonesia's telecommunications infrastructure development. However, the penetration of telecommunications services in the forefront, outermost, and backward regions are still relatively low. The government has made various efforts to minimize the gap in telecommunication services between urban and rural areas through various programs. However, acceleration is needed so that the service disparity can be immediately overcome. One of the telecommunications products that can overcome these barriers is the Mobile Virtual Network Operator (MVNO). This study evaluates the most appropriate type of MVNO model in Indonesia by implementing the Consistent Fuzzy Preference Relations (CFPR) method. This method can accommodate expert opinion through a series of scientific steps to produce weights for each alternative type of MVNO model. The results obtained are that the most appropriate model to be applied in Indonesia by taking into account the criteria given. The implementation of this model is expected to be able to encourage the optimization of BTS USO that the government has declared.

Keywords – Mobile Virtual Network Operator, BTS USO, CFPR, backward regions, Reseller MVNO

I. INTRODUCTION

One of the mandates contained in Law No. 36 of 1999 [1] is the obligation attached to telecommunications operators, both network operators and service providers, to provide 1.25% of their gross income to meet the needs of the community, especially in the forefront, outermost, backward and border areas, for telecommunications services. These obligations are regulated in more detail in Government Regulation No. 7 of 2009 concerning Non-Tax State Revenue in the Ministry of Communication and Informatics [2].

The 1.25% issued by all telecommunications operators is then utilized in a Universal Service Obligation (USO) program through the Ministry of Communication and Informatics. Some of the programs that have been implemented are the Ringing Village, the Services Center of Rural Telecommunications and Information, the Smart Village, the District Internet Service Center, and the Mobile District Internet Service Center. These programs can provide benefits, especially for people in the forefront, outermost, backward, and border areas. However, the availability of both telecommunication networks and services in urban areas is still lacking.

The disparity proves that the program still has many barriers, such as the lack of infrastructure such as the availability of electricity, roads, and buildings in the forefront, outermost, backward, and border areas. If the service disparity in urban areas and the forefront, outermost, backward regions are not immediately resolved, its telecom services' availability will be increasingly left behind.

One of the telecommunication products that can solve the problem of disparity in the availability of telecommunications services is the Mobile Virtual Network Operator (MVNO). MVNO is a company that does not have a communication frequency band license. Still, it sells communication services under its brand, using another network, the Mobile Network Operator (MNO) network [3]. Since it was first introduced in the United Kingdom in 1999, MVNO has been widely applied in other countries, especially

Europe and America [3]. However, it is difficult to provide telecommunications services in Indonesia, especially in terms of investment in the forefront, outermost, and backward regions because it requires high costs.

BTS USO is a government strategic program closely related to the distribution of telecommunications services in Indonesia. MVNO is one program that can be considered and used as a solution to optimize BTS USO. However, based on its distribution, MVNO has not been widely applied in Asian countries compared to European and American countries [4]. In addition, the existence of Law No.53 of 2000 concerning the Use of Radio Frequency Spectrums and Satellite Orbits has limited the application of MVNO. In general, there are three types of MVNO models [5][6]:

A. Reseller MVNO

This provider does not have its SIM card but can offer its own branded package. In addition, this provider depends on MNO in almost all aspects of service provision, core network, billing, and customer care.

B. Enhanced Service Provider

This provider can control several network elements and has its own SIM card. It means that it can own their own numbering range and operate their own Home Location Register (HLR) for network facilities, even though this provider does not offer or own network facilities. If it has bandwidth services, the Enhanced Service Provider will need a Network Service Provider (NSP) and mobile cellular services to provide public cellular services to customers.

C. Full MVNO

Unlike the Reseller and Enhanced Service Provider, Full MVNO can provide network facilities and services such as tower, MSC, HLR, and mobile cellular services. One of the differences between Full MVNO and other models is that this model can operate independently of MNO. The Full MVNO model can have its own numbering range, offer its own SIM card, and have full flexibility of service design and tariff. It only needs an individual license Network Facility Provider (NFP) and NSP for the network facilities.

The core concept of the MVNO model is the creation of infrastructure sharing that aims to positively influence customers and will have an impact on the spread of telecommunications services in border areas. This implementation can get many benefits from both MVNO and MNO [7]. MNOs or providers can exploit network capacity, Information Technology (IT) infrastructure, and product services to get underserved segments of society. MNO’s avenue will also increase from the wholesale business [8]. MVNO benefits derived from brand awareness, distribution channels, and customer base by services to its customers [9].

This research evaluates the most appropriate MVNO models to be applied in Indonesia. Based on the literature studies that have been carried out, four aspects affect the effectiveness of the application of MVNO models. These four aspects are the government (regulator) aspect, the network provider industry aspect, the consumer aspect, and the MVNO aspect. Furthermore, in this study, these criteria are broken down into sub-criteria, as shown in Table 1.

Table 1. Criteria and sub-criteria that influence the implementation of MVNO

Main Criteria	Sub Criteria
Government (A)	Equitable development of infrastructure in all regions of Indonesia (A1)
	Improved regional economy (A2)
	Increased employment (A3)
	Support for national medium and long term development plans (A4)
	Increased state and regional income (A5)
	Equitable ICT services (A6)
	Regulatory Support (A7)
Network Provider Industry (B)	Increased profits (B1)
	Increased business competition (B2)
	Investment (B3)
	Operational costs (B4)
	Service rates (B5)
	Capacity usage (B6)
	Market segmentation (B7)
	Network rent cost (B8)
Consumer (C)	Improved service quality (C1)
	Increased variety of services (C2)
	Price affordability (C3)
	Productivity (C4)
	Program socialization (C5)
	Impact on the people's economy (C6)
MVNO (D)	Earnings (D1)
	Business competition (D2)
	Investment (D3)
	Operational costs (D4)
	Service rates (D5)
	Capacity usage (D6)
	Market segmentation (D7)
	Network rent cost (D8)

As explained earlier, this research will evaluate or choose the most appropriate MVNO model to be applied in Indonesia. Table 2 shows a type of MVNO model. In general, there are three types of models that will be referred to as alternatives to be selected based on the criteria in Table 1.

In mathematics, choosing one option over many provided alternatives issue is considered a Multi-Criteria Decision Making (MCDM) problem. Many methods can be used to solve MCDM problems. One of the most frequently used methods is the Analytic Hierarchy Process (AHP), first introduced by Thomas L. in 1971. Until now, many studies have applied the AHP method [10]-[14].

This method has been widely used in various problems. For example, research [15] applied the CFPR method in solving supply chain problems, determining good e-learning [16], and other uses of this method often found in the literature. In terms of the magnitude of the benefits and convenience of this method compared to the usual AHP method, one of the CFPR method implementations is to determine the appropriate IP-based interconnection tariff model to be applied in Indonesia.

The AHP method models a problem in the form of a hierarchy then compares each criterion using human subjective judgments on the scale of 1 to 9.

Table 2. The alternative choice of MVNO

MVNO Model	Acronym	Notation
Reseller MVNO	RMVNO	M1
Enhanced Service Provider MVNO	EMVNO	M2
Full MVNO	FMVNO	M3

The problem with using the AHP method is when assessment involves inconsistent persons [17]-[21]. This inconsistency can be prevented, it will be carried out by an academic in telecommunications regulation. The Consistent Fuzzy Preference Relations (CFPR) method will be used. This method will minimize the number of assessments given by the decision-makers [16].

In the AHP method, the number of comparisons that must be given in the questionnaire to experts is:

$$C_2^n = n(n-1)/2 \tag{1}$$

Where n is the number of criteria to be compared to each comparison matrix. The results in matrix with a low level of consistency [22], so the results obtained are less valid [16]. Therefore, in the CFPR method, only (n-1) comparisons are needed for each comparison matrix. This comparison will minimize the inconsistency of the results of the expert's judgment.

II. RESEARCH METHODS

This study aims to evaluate the most appropriate MVNO model in Indonesia by applying the Consistent Fuzzy Preference Relations (CFPR) method. The basic method used in this study is the development of the AHP method. This method works by weighting a problem that has been formed into a hierarchy. The top hierarchy is a goal to be achieved in solving the problems. For example, if the main goal is to choose several alternatives, the alternatives are placed in the lower hierarchy. Then, these criteria are compared on the same level by using a scale from 1 to 9. The comparisons are made by experts or academics, or respondents who know telecommunication. However, the consideration or judgment in the comparison of the criteria made by experts is very subjective. Subjectivity improvement, fuzzy logic is implemented to replace the scale of 1 to 9 as a rating scale in the AHP method [16]. A triplet fuzzy number replaces the scale.

A. Triangular Fuzzy Number

If a, b, and c are the scale where each of the smallest values, the closest value, and the largest value indicate a fuzzy event, then the triangular fuzzy number can be expressed as a triplet fuzzy (a, b, c), where a < b < c [16]. The membership function of the triangular fuzzy number can be seen in (2):

$$\mu_N(x) = \begin{cases} \dfrac{x-a}{b-a}, & x \in [a,b] \\ \dfrac{c-x}{c-b}, & x \in [b,c] \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

Table 3. Triplet fuzzy linguistic scale

Triplet Fuzzy	Definition
(8, 9, 10)	Extreme Importance
(7, 8, 9)	
(6, 7, 8)	Very Strong Important
(5, 6, 7)	
(4, 5, 6)	Strong Importance
(3, 4, 5)	
(2, 3, 4)	Moderate Importance
(1, 2, 3)	
(1, 1, 1)	Equally Important

A triplet fuzzy number scale was used for evaluating the comparisons between criteria and sub-criteria. The use of a fuzzy triplet number is to reduce the subjectivity of the expert judgment. The scale can be seen in Table 3.

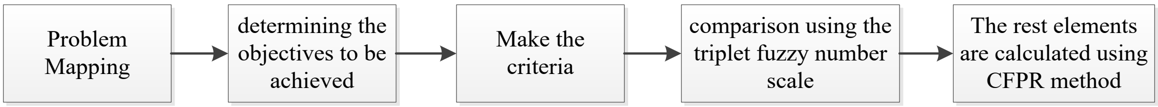

Fig 1. The research flowchart

The steps undertaken in this study are as follows:

a. The first step is to map the problem into a hierarchical form. This step begins by determining the objectives to be achieved, namely "Determining the most appropriate MVNO model to be applied in Indonesia". This step has presented the influence criteria that affect MVNO in Table 1. They are government criteria, industry network providers, consumers, and MVNO criteria. Next, these criteria are developed into more specific criteria, which are referred to as sub-criteria.
b. The second step is to compare by using the triplet fuzzy number scale (in Table 3) by experts or academics who know telecommunications, especially MVNO. The judgment given in this study was only carried out by an academic in the telecommunications field who understood MVNO because it is only a simulation. The more experts or academics involved and give consideration, the better research results obtained. These comparisons will then be elements of the comparison matrix (pairwise comparison matrix).
c. In part b, the comparison matrix has been filled with n-1 elements from the n2 supposed number of elements. Then, the rest elements are calculated using the CFPR method.

B. Preference Relations

Preference relations (PR) allow a decision-maker to give a value for a set of criteria or alternatives, where this value represents the importance of the first criteria compared to the second criteria, and so on. There are two types of PR: multiplicative preference and fuzzy preference relations [16].

C. Multiplicative preference

Multiplicative comparison R in terms of criteria X can be represented as a matrix $R.R$ obtained from $R \subseteq X \times X, R = (r_{ij}), \forall i, j \in \{1,...,n\}$, where r_{ij} the comparison scale is used. In this case, the scales in Table III are used, where $r_{ij}.r_{ji} = 1, \ \forall i, j \in \{1,...,n\}$.

D. Fuzzy preference relations

Fuzzy preference relations/the fuzzy comparison relationship P for the set of criteria X is the set of fuzzy numbers $X.X$ with a membership function $\mu_p : X \times X \to [0,1]$.

E. Preposition 1

Suppose that $X = \{x_1,...,x_n\}$ is a set of criteria that will be compared to the comparison of multiplication $A = (a_{ij})$, where $a_{ij} \in [1/9, 9]$. Then, the opposite fuzzy comparison relationship $P = (p_{ij})$, where $p_{ij} \in [0,1]$ related with A, is denoted as $P = g(A)$, is as follows

$$p_{ij} = g(a_{ij}) = \frac{1}{2}(1 + \log_9 a_{ij}), \quad (3)$$

where g is a transformation function. The base number 9 is used in the logarithmic term since the comparison scale a_{ij} is from 1/9 to 9.

F. Preposition 2

For reciprocal fuzzy preference relations of $P = g(A)$ where $P = (p_{ij})$, the following two statements are equivalent:

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \ \forall i, j, k, \quad (4)$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \ \forall i < j < k. \quad (5)$$

G. Preposition 3

For the opposite fuzzy comparison, $P = (p_{ij})$ the following two statements are equivalent:

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \ \forall i < j < k, \quad (6)$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + ... + p_{(i+k-1)(i+k)} + p_{(i+k)i} = \frac{k+1}{2}, \ \forall i < k. \quad (7)$$

Preposition 1 – 3 will be used for calculating the elements of the comparison matrix that have been previously obtained by the expert's judgment (*n-1* elements), then $n^2 - n + 1$ the remaining elements of the comparison matrix will be obtained.

d. After the elements of the comparison matrix are obtained, the score and weight can be calculated. Two formulas that will be employed in this step. The first formula is used to calculate scores. The formula is given in (8).

$$s_i = \frac{1}{n_c}\left(\sum_{j=1}^{n_c} p_{ij}\right), \quad (8)$$

where n_c is the number of criteria, p_{ij} is the value of the i-th row and j-th column of the comparison matrix. Then the second formula is used to calculate the weight by using (9):

$$w_i = \frac{s_i}{\sum_{i=1}^{n_c} s_i}. \tag{9}$$

Based on the weights and scores that have been calculated by (8) and (9), the results can be analyzed. The weights represent the priority of the MVNO model to be applied in Indonesia.

III. RESULTS AND DISCUSSION

Literature studies obtain models given in Table 2. Experts in the regulation of telecommunications have filled in the comparisons for each criteria and sub-criteria as well as alternatives. The assessment uses a scale provided in Table 3. CFPR method simplifies the questionnaires so that experts can fill in consistently.

The results of comparisons made by experts are then formed into a comparison matrix. Since the assessment uses triplet fuzzy numbers, the fuzzy numbers are defuzzified first, then the value of is calculated by (5) in Preposition 1.

The matrix elements whose value is unknown are then calculated using Preposition2, which is then used to calculate the weights for each criterion using (8) and (9). The next step is to calculate the final weights of each MVNO model. The final calculation is the same as when using the AHP method, starting from the lowest hierarchy. To make it easier, it will be made per criteria for alternatives that have been presented in Table 4 – Table 7 below (at the end of the paper).

Table 8 shows the final result. The weights indicate the priority level of the MVNO model. It can be seen that the greatest weight is the M1 model, which is the reseller model. The second recommendation is to use the enhanced service provider model, and the least recommendation is the full MVNO model.

Based on the fact that the MVNO is widely applied in other countries, MVNO has experienced rapid development. There are several generations of MVNO that exist today. However, in terms of implementing MVNO in Indonesia, it is necessary to pay attention to the current condition of the Indonesian telecommunication industry. The reseller model is in line with the spirit of the Indonesian government to spread the equitable distribution of telecommunications services. Based on 7 sub-criteria included in the government criteria, all the results are the reseller model as the most recommended model if it is viewed more deeply. This model can be concluded from the weights obtained in Table 8 below (at the end of the paper).

Meanwhile, from the network provider industry aspect, from 8 sub-criteria, 5 of them produced the reseller model as the most recommended model. The 3 others obtained the full MVNO model as the most recommended model. This model can be understood because the existing telecommunication operators certainly have concerns with the reseller model. The reseller model will disrupt the flow of profits that have been obtained. Besides, they are fear the model will disrupt the capacity that the customer has obtained. So, overall, the network provider industry aspect produces the reseller model as the most recommended model.

The last two aspects, namely the customer and MVNO aspects, have also generally produced the reseller model as a recommended model. There are only 3 sub-criteria in the customer criteria that show different results. The three sub-criteria are based on the results of expert evaluation recommending the full MVNO model. From 8 sub-criteria included in the MVNO criteria, there are only 3 sub-criteria that recommend the full MVNO model. Those criteria are profit, capacity use, and network rental costs, while the rest all recommend the reseller model.

In its implementation, MVNO resellers have an advantage compared to other MVNO types. MVNO resellers have lower investment costs, but the influence on the distribution of telecommunication services is significant. MVNO resellers can also enter niche market environments and adjust to various market segments in the remote and border areas. Besides that, MVNO reseller can provide many choices of services for the community. It is also able to encourage economic development. It is hoped that the implementation of the MVNO reseller will reduce the digital divide between the remote and the border areas with other regions in Indonesia. MVNO resellers can also use ICT services as a driver of productivity and economy in remote areas.

Other types of MVNO, such as enhanced MVNO and full MVNO, have greater control over customer traffic. However, the investment required is too large that it does not fit into the concept of equity in the remote and border areas. This environment is due to the difficulty of covering large investment costs. The concept of cooperation between MVNO and MNO network organizers must be reconsidered to get the optimal benefits. This condition is because customer traffic control depends a lot on MNO network operators.

The concept of cooperation and determination of network rental rates needs to be done fairly by promoting the principles of anti-discrimination, anti-monopoly and fair competition. The scope of cooperation between network organizers and MVNO must pay attention to all aspects of engineering and business and problem solving if a dispute occurs. Another challenge is how regulations can adjust to the implementation of MVNO in remote and border areas. The Government Regulation No.53 in 2000 does not allow the use of frequency spectrum outside the provider holding the license. So, it needs to be revised and adjusted as a whole.

IV. CONCLUSSION

The determination of the most appropriate MVNO model to be implemented in Indonesia is an important agenda that the government must support. Today's increasing critical customer characteristics require regulators and telecommunication operators to continuously improve services in urban areas and the remote and border areas. In addition, the application of MVNO can improve the investment climate so that equitable distribution of telecommunication services can be achieved. Telecommunication service users will certainly be a challenge to the MVNO model that can satisfy regulators and operators. Accommodating expert judgment into a CFPR method whose purpose is to determine the most recommended MVNO model has been carried out in this study. The results of this study will be better if many experts are involved. The results obtained in this study are expected to provide an overview of the right MVNO model if it is implemented someday.

APPENDIX

Table 4. The calculation of the weight of each alternative toward sub-criteria A

	A1	A2	A3	A4	A5	A6	A7	Total Weight
	0.136	0.156	0.147	0.121	0.164	0.173	0.104	
M1	0.349	0.349	0.349	0.349	0.349	0.349	0.349	**0.349**
M2	0.336	0.336	0.336	0.336	0.336	0.336	0.336	**0.336**
M3	0.316	0.316	0.316	0.316	0.316	0.316	0.316	**0.316**

Table 5. The calculation of the weight of each alternative toward sub-criteria B

	B1	B2	B3	B4	B5	B6	B7	B8	Total Weight
	0.143	0.151	0.158	0.136	0.126	0.076	0.098	0.113	
M1	0.316	0.349	0.349	0.349	0.349	0.316	0.349	0.316	**0.338**
M2	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	**0.336**
M3	0.349	0.316	0.316	0.316	0.316	0.349	0.316	0.349	**0.327**

Table 6. The calculation of the weight of each alternative toward sub-criteria C

	C1	C2	C3	C4	C5	C6	Total Weight
	0.151	0.134	0.184	0.174	0.164	0.194	
M1	0.316	0.349	0.349	0.316	0.349	0.316	**0.332**
M2	0.336	0.336	0.336	0.336	0.336	0.336	**0.336**
M3	0.349	0.316	0.316	0.349	0.316	0.349	**0.333**

Table 7. The calculation of the weight of each alternative toward sub-criteria D

	D1	D2	D3	D4	D5	D6	D7	D8	Total Weight
	0.151	0.113	0.126	0.143	0.098	0.076	0.158	0.136	
M1	0.316	0.349	0.349	0.349	0.349	0.316	0.349	0.316	**0.337**
M2	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	**0.336**
M3	0.349	0.316	0.316	0.316	0.316	0.349	0.316	0.349	**0.328**

Table 8. Final weights and ranking

	A	B	C	D	Weight	Ranking
	0.267	0.248	0.227	0.257		
M1	0.349	0.338	0.332	0.337	0.339	**1**
M2	0.336	0.336	0.336	0.336	0.336	**2**
M3	0.316	0.327	0.333	0.328	0.325	**3**

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