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IMPROVING KPI WEIGHTS OF EQUIPMENT SUPPLIERS IN MOBILE NETWORK OPERATORS USING QFD METHOD

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Abstract. *This paper focuses on improving the Key Performance Indicator (KPI) weights used by Mobile Network Operator (MNO) for measuring their Telecommunication Equipment Supplier (TEM) performance. The intention of measuring KPI is to monitor supplier performance based on purchasing agreement and renewal purchasing decision at the end of the contract. A survey was conducted among network leaders who worked in one leading Indonesian MNO. The company used existing KPI since 2016 without updating both the elements and weights afterward. There are no significant weights differences among existing group KPI (Capability, Performance, Resource and Support) which calculated with Analytic Hierarchy Process (AHP) Method. This study used Quality Function Deployment (QFD) to find new weights and used the AHP method for getting a relative weight of customer requirements as part of QFD's component. The result shows group KPI between existing and study are different significantly for both element ranking and weight, also the new weight better reflects the current situation. The process of this study could be proposed to another telecommunication firm in order to evaluate their supplier's KPI. The proposed method enables the decision-maker can easily assign his priority degrees and calculate the original KPI indices for their equipment supplier.*
Keywords: Telecommunication, Mobile network, Key performance indicator, Quality function deployment, GSM

1. **Introduction.** Globally the mobile telecommunication industry is known as one of the most dynamic industries and having fierce competition among the firms; they also compete with new players of OTT (Over-The-Top) services providing communication and media services in the context of mobile communications [1]. This industry has special characteristics that are technology, capital and regulatory intensive as well. From the end-users perspective, they have a high demand for affordable costs with various services and consistent Quality of Experience (QoE). Through rapid technological development, increasing market dynamics and deregulation in many countries, the complexity in the telecommunication industry continues to increase [2].

According to a statistic by GSM Association [3], the global Mobile Network Operator (MNO) revenue was $1,051 billion in 2017 and spending 17.07% of revenue for Capital Expenditure in Q32018 [4]. One of key item Capital Expenditure for MNO is hardware and software, for example in Base Transceiver Station (BTS), the equipment has a very critical function to make BTS can serve to bridge the user equipment with networks to other networks. The optimum performance of BTS is extremely critical for MNO. The failure function on BTS leads to the loss of potential revenue and customer loyalty accordingly. In order to meet customer expectations, MNO must always keep the reliability of telecommunication equipment on the BTS [5].

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Normally hardware and software are sourced from the third party called TEM. The TEM's role is not limited to supply and install the equipment only, but they are responsible to maintain it as well to ensure the Quality of Service (QoS) in the agreement is met during the contract time.

Considering expenditure value and vital function of telecommunication equipment in order staying competitive across telecommunication firms, it is essential that MNO identifies and measures TEM's performance. Performance Measurement is defined as "a systematic process of measuring the effectiveness and efficiency of supply chain operations" [6]. In this case, using KPI is very useful to monitor QoS systematically.

Although the existing literature investigated the RAN KPI by using surveys and statistical data, it is all related with assessment, measuring, analysis and improvement, optimization equipment performance [7-10], these studies were more technical matter (QoS). Another RAN KPI literature is performed at the end-users side, the empirical study to measure the overall acceptability of an application or service (QoE) as perceived subjectively by the end-user [11].

The authors found the literature of the weights KPI in other industries such as in shipping industries [12], palm oil industry [13] and airport industry [14] which measure performance and efficiency with criteria weights and value scales derived from expert's judgments. Therefore, this study intended to find better weight factors for existing RAN KPI from Voice of Customer perspective (Network Leaders) by utilizing QFD and discussing the differences between the improving factors and the existing factors afterward.

The major contribution and significance of this research is the first time studying the weights KPI of TEMs in MNO and it provides a guideline for other operators. The result obtained from this study is that KPIs must be reviewed regularly for both criteria and weights. For optimum results, the company's experts across the department must be getting involved during the review process. In this paper, Section 2 explains the research methodology, Section 3 explains results and discussion and Section 4 concludes the study.

2. **Research Methodology.** This study is conducted in one MNO company which is a pioneer and a leading in Indonesian mobile telecoms industry (further called "The Company"). "The Company" has an experience of more than 20 years and has a coverage network for almost all Indonesian territory. Since the beginning, there are many TEM companies with various technologies already selected as equipment suppliers from Europe and the Asian continent.

In order to evaluate their network performance and equipment vendor as well, since 2016 "The Company" used existing RAN KPI (Table 1) and calculated the weight/priorities degree using AHP approached and divided into two hierarchies as the following; 4 Group and 14 Criteria.

Figure 1 illustrates the flowchart of how the study is conducted and the summary of technique and method utilized.

Identified there are fifteen Leaders of Network Division in "The Company" who involved on TEM vendor selection. They are being involved in 3 times survey as respondent and Table 2 illustrated what survey and number and purchase role of respondent.

Quality Function Deployment (QFD) is a tool that offers many facets with an end goal of ensuring that customer requirements are satisfied. Therefore, the phrase "voice of customer" is normally associated with the term QFD [15], the main function of QFD is to translate Voice of Customers (requirements) into Technical Measures (TMs) by using the House of Quality (HoQ) matrix.

The traditional HoQ matrix consists of seven major components: 1) Customer Requirements (CRs), 2) The priority degree of requirements, 3) Technical Measures (TMs), 4) The Correlation Matrix (CMs), 5) Relationship matrix (between TMs and CRs), 6) Some

TABLE 1. List of RAN KPI's (group/criteria) and weighting

Group	Weight Group	Criteria	Weight Criteria
Capability	**22%**	Feature	37%
		DB Param Handling	32%
		Formula Counter	32%
Performance	**28%**	User Experience	36%
		KPI	18%
		QC New Site	18%
		Productivity	27%
Resource	**24%**	Manpower	53%
		Number	47%
Support	**26%**	Knowledge Sharing	21%
		Support Handling	21%
		Tool	18%
		Reporting	18%
		Complaint Handling	21%

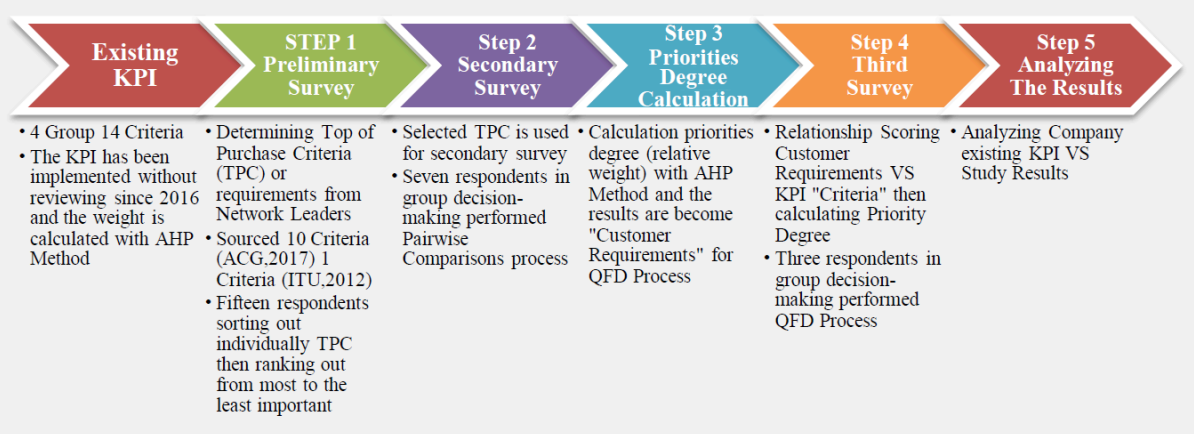

FIGURE 1. The study process for improving KPIs weighting

TABLE 2. Survey type, respondent's purchase role and number involved

Survey	Decision Type	Respondent's Purchase Role	Respondent's Number
Preliminary	Individual decision	Influencer	1
		Decision	4
		Evaluators	11
Second	Group decision-making (consensus)	Influencer	1
		Decision	2
		Evaluators	4
Third	Group decision-making (consensus)	Decision	1
		Evaluators	2

products of priority degrees and relationship degrees (w_j), 7) The priority degree of TMs, w_j^n (See Figure 2).

The priority degree of TMs can be derived by the sum product of the relative weight of a CR and its corresponding relationship degree with intended technical measures. A normalized value of the result will present the relative weight (priority degree) of technical measure for satisfying the customer. The correlation matrix is particularly useful for

developing strategies to improve a technical measure. In some cases, a technical measure has a positive or negative correlation and an improvement may contribute to another or deteriorate it. For assessment of the balance of improvements, the correlation matrix indicates such interactions. However, this paper deals with the priority degree of TMs, w_j^n, and the correlation matrix of TMs is out of the scope of this paper.

In the study, CRs are derived from a preliminary survey with Network Leaders in "The Company". Priority degrees, d_i, of CRs are based on the AHP processed, TMs are based on the criteria of RAN KPI. The priority degrees, w_j^n, of TMs will define the importance degree of each criterion among KPI.

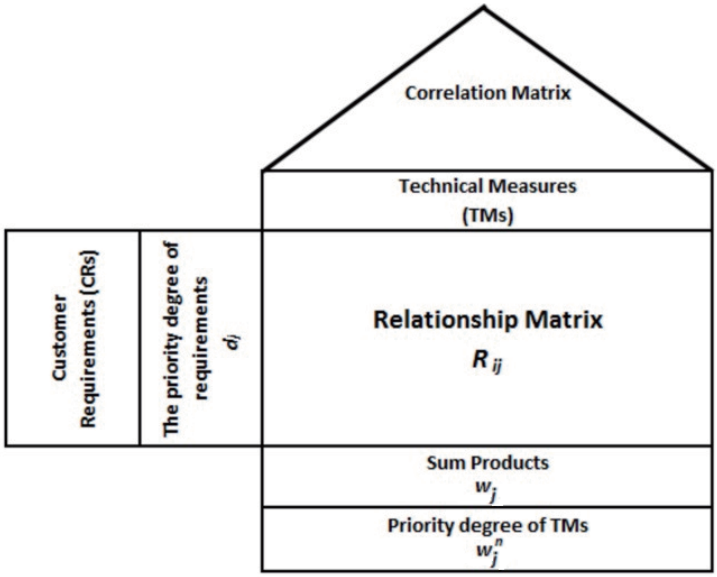

FIGURE 2. The house of quality matrix and components

The numerical process for assignment of priority degree of TMs is as follows.

1) Let m customer requirements be indicated by CR_i, $(i = 1, 2, \ldots, m)$ and n technical measures indicated by TM_i $(i = 1, 2, \ldots, n)$.
2) Let d_i $(i = 1, 2, \ldots, m)$ be the priority degree of the ith CR_i among the whole set of CRs, whereas w_j $(j = 1, 2, \ldots, n)$ denoting the relative weight of importance of the jth TM, is determined from the relationship between CRs and TMs.
3) Let R be the relationship matrix between CRs and TMs, the element R_{ij} indicates the level of impact of the jth TM on satisfaction of the ith CR. The value of R_{ij} is assigned by an indicator: 0 (No relationship), 1 (Low relationship), 5 (Moderate relationship), 9 (Strong relationship).

The sum product of the priority degree, d_i of the ith CR_i and R_{ij} is calculated as follows:

$$W_j = \sum_{t=1}^{m} d_i R_{ij}, \quad j = 1, 2, \ldots, n$$

j is the normalized value of w_j which indicates the priority degree of the jth TM for customer satisfaction. The priority degree of the CRs, d_i, is defined by an initial AHP process through the pairwise comparisons survey and the following section discusses the AHP. In Steps 2 and 3, performed pairwise comparisons with using AHP approached. The objective of this step is to calculate priorities degree (relative weight) of selected TPC which is become "Customer Requirements" for QFD Process on the next step.

AHP is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales. It is a robust multi-criteria decision-making

method that has been applied in analyzing complex and unstructured problems in various decisionmaking situations [16].

It needs a scale of numbers indicating how many times more important one criterion is over other criteria with respect to the property with respect to which they are compared, see Table 3.

Table 3. The fundamental scale of absolute numbers

Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption

Use the eigenvalue method to estimate the relative weights of each element. The $\lambda_{\max}$ value is an important validation parameter in AHP, which is usually used as a reference index for filtering information by calculating the consistency ratio CR, of the estimation vector to validate whether the pairwise comparison matrix provides a complete consistency of evaluation as following steps [17]. First, calculate the eigenvectors or relative weights and for each matrix of n. Second, enter the consistency index for each matrix of n with the formula:

$$\mathrm{CI} = (\lambda_{\max} - n)/(n-1) \tag{1}$$

CI's calculations are intended to determine the consistency of answers that will affect the validity of the results. And the consistency ratio is calculated using the formula:

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI} \tag{2}$$

The RI value is a random index value issued by Oarkridge Laboratory in the form of Table 4.

Table 4. Average random index (RI) based on matrix size

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Consistency Ratio (CR) is one parameter used to measure whether pairwise comparisons have been done consistently or not. The acceptable CR range varies according to the size of the matrix, i.e., 0.05 for a 3 by 3 matrix, 0.08 for a 4 by 4 matrix and 0.1 for all larger matrices, $n \geq 5$. Making paired comparisons displayed at a known level, the matrix is created by placing the results of the pairwise comparison of element i with the j element in the a_{ij} position as the following.

$$\mathbf{A} = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & C_4 - C_n \end{array} \\ \begin{bmatrix} 1 & a_{12} & a_{13} & a_{14} - a_{1n} \\ a_{21} & 1 & a_{23} & a_{24} - a_{2n} \\ a_{31} & a_{32} & 1 & a_{34} - a_{3n} \\ a_{41} & a_{42} & a_{43} & 1 - a_{4n} \\ a_{n1} & a_{n2} & a_{n3} & a_{n4} - 1 \end{bmatrix} \end{array}$$

n = number of criteria to be evaluated
$C_i = i$, criteria
a_{ij} = importance of i criteria according to j criteria

3. **Result and Discussion.** Top of Purchase Criteria (TPC) which is a result of a preliminary survey, the criteria list are compiled from the literature of ACG Research [18] and International Telecommunication Union [19]. This study used an electronic survey and asked the respondents to sort those 11 requirements from the most important to the least important one and the results are shown as Figure 3.

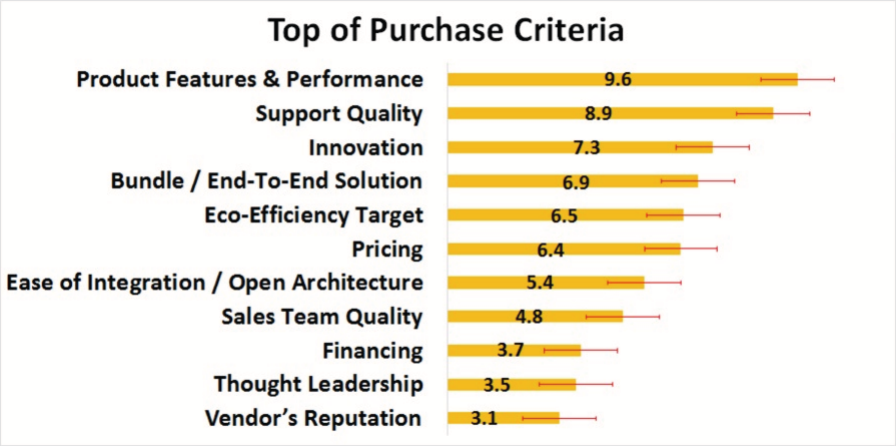

FIGURE 3. Top purchase drivers (requirement) of network leaders and error bar from each criterion

For pairwise comparisons purposed, selected requirements with the score more than 6.0 are the following: Product Feature & Performance, Support Quality, Innovation, Bundle/End-To-End Solution, Eco-Efficiency, Pricing.

Base on calculation, relative weights from pairwise process are as the following: Product Features & Performance (0.28), Support Quality (0.06), Innovation (0.19), Bundle/End-To-End Solution (0.33), Eco-Efficiency (0.07), Pricing (0.07).

After QFD processed Table 5, Table 6 shows the comparison of the weight between existing and study KPI results for "Group" and "Criteria". Study weight group is totally summed of criteria under that particular group. For example, the resource group is 8%, it is summed of manpower (5%) and number (3%). The weight group between existing and study is as the following: Performance (28% to 39%), Capability (22% to 31%), Support (26% to 22%) and Resources (24% to 8%).

Based on the interview with the respondents, it is confirmed that weight from the study is more reflected in the current condition. For respondent performance and capability are two key factors while support and resource are considered as supporting elements. From the study, performance and capability weight increased by 11% and 9% and has a 70% share of total Group KPI.

Table 5. House of quality matrix for new calculation

			Capability			Performance				Resource		Support				
Max Value in Row	Relative Weight		Feature	DB Param Handling	Formula Counter	User Experience	KPI	QC New Site	Productivity	Manpower	Number	Knowledge Sharing	Support Handling	Tool	Reporting	Complaint Handling
9	0.28	Product Features & Performance	9	9	9	5	9	5	5			1	1	1	1	1
9	0.06	Support Quality	5	5	5	5	5	1	5	9	9	1	5	5	5	5
9	0.19	Innovation	1	1	1	5	5	1	5	5	1	9	5	1	1	1
9	0.33	Bundle/End-To-End Solution	1	1	1	1	1	1	1			1	1	1	1	1
9	0.07	Eco-Efficiency Target	5	1	1	5	5	1	1			1			1	
9	0.07	Pricing	5	5	5	5	1	1	1	5	5	1	1	1	1	1
		Max Value in Column	9	9	9	5	9	5	5	5	5	9	5	5	5	5
		Sum Product	4.04	3.76	3.76	3.68	4.52	2.12	3.12	1.84	1.08	2.52	1.93	1.17	1.24	1.17
		Relative Weight	0.11	0.10	0.10	0.11	0.13	0.06	0.09	0.05	0.03	0.08	0.05	0.03	0.03	0.03

Table 6. Group and criteria weighting (existing and study)

Group			Criteria		
Group	**Existing Weight**	**Study Weight**	**Criteria**	**Existing Weight**	**Study Weight**
Capability	**22%**	**31%**	**Feature**	**37%**	**11%**
			DB Param Handling	**32%**	**10%**
			Formula Counter	**32%**	**10%**
Performance	**28%**	**39%**	**User Experience**	**36%**	**11%**
			KPI	**18%**	**13%**
			QC New Site	**18%**	**6%**
			Productivity	**27%**	**9%**
Resource	**24%**	**8%**	**Manpower**	**53%**	**5%**
			Number	**47%**	**3%**
Support	**26%**	**22%**	**Knowledge Sharing**	**21%**	**8%**
			Support Handling	**21%**	**5%**
			Tool	**18%**	**3%**
			Reporting	**18%**	**3%**
			Complaint Handling	**21%**	**3%**

4. **Conclusion.** In this paper, there is a significantly different result between existing RAN KPI with the study. Previously "The Company" used AHP method for each hierarchy, here this study used QFD with Relative Weight getting from AHP process. In Group KPI level shows different rankings: existing (1. Performance, 2. Support, 3. Resource, 4. Capability) and the study (1. Performance, 2. Capability, 3. Support, 4. Resource). The weight between existing and study has been changed also significantly and it is more reflected to the current situation.

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