DEVELOPMENT OF IDEAL ANALYTIC HIERARCHY PROCESS DECISION SUPPORT FOR INVESTMENT

Buhm Lee*
Department of Electrical and Semiconductor Engineering, Chonnam National University
Yeosu, South Korea
E-mail: buhmlee@chonnam.ac.kr

Min-Suk Yoon
Department of Electronic Trade, Chonnam National University
Yeosu, South Korea
E-mail: msyoon@chonnam.ac.kr

Kyu-Seung Whang
Business School, Korea University
Seoul, South Korea
E-mail: kswhang@korea.ac.kr

ABSTRACT

This paper presents a new Ideal Analytic Hierarchy Process model which has three states: [Ideal] – [Actual] – [Possible] States. Ideal state reflects that customers feel ideal for its quality and Possible state reflects that customers feel as extremely challenging because of its quality. By setting of Actual state, competitiveness between Ideal and Possible state can be obtained. Merits of Ideal AHP are expression of absolute value of competitiveness and decomposition of competitiveness calculation. Instead Traditional AHP needs competitiveness calculation by using all Alternatives, Ideal AHP can calculate competitiveness individually and can obtain absolute competitiveness. By applying Ideal AHP to hamburger shops and actual electrical distribution system, the usefulness of this method has been verified.

Keywords: Ideal AHP, 3-states model, absolute competitiveness, decomposition, decision support

1. Introduction

AHP is widely used to evaluate competitiveness by using Alternatives and Criteria (Saaty, 1996). Because this model can obtain competitiveness among all alternatives, this model needs calculation with all alternatives. If an alternative is added to alternative group, evaluator needs re-calculation among all alternatives including new alternative. For example, if you evaluate competitiveness of a bank, you need build AHP model with all banks. If you evaluate a bank among 10000 banks, you have to build 10000 Alternative AHP model and to calculate for your selected bank. If one bank is newly added, you have to re-build 10001 AHP model and to re-calculate for your selected bank. Actual society, nobody re-calculate competitiveness with whole banks. Instead, they evaluate a bank as an absolute value, such as AAA, AA+, and BB. So, we need new evaluation tool which can evaluate as an absolute value.

This paper presents a new AHP model which has three states, and named Ideal AHP. This model has three states: [Ideal] – [Actual] – [Possible] States. Ideal state reflects that customers feel ideal for its quality and Possible state reflects that customers feel as extremely challenging because of its quality. By setting of Actual state, absolute competitiveness between Ideal and Possible state can be obtained. Instead Traditional AHP (Forman; Ilic, 1996) has n Alternatives, Ideal AHP has 3 States as Alternatives. By calculating Ideal AHP, evaluator can obtain absolute competitiveness.

* Corresponding author

This model has two merits. First merit is customer can obtain absolute competitiveness for an alternative. By calculating absolute competitiveness for each alternative, customers can feel its quality between Ideal and Possible state. For a given industrial system, this competitiveness can be used as Unified Index. Second merit is decomposition of calculation. AHP calculation is only one time for each alternative. It can reduce calculation load when alternatives are many and changing, such as small stores on the market. This paper shows example of Hamburger shop to explain the characteristics of Ideal AHP, and application of actual electric distribution system model to demonstrate the effectiveness.

2. Ideal AHP which has 3-states

This paper presents an Ideal AHP model which can evaluate an Alternative or a system.

2.1 Define 3-states

This paper proposes the use of three states, defined as [Ideal], [Actual], and [Possible] states in the AHP model. [Ideal] state is the ideal value that customers feel as ideal for its quality, [Possible] value is the possible value that customers feel as extremely challenging because of its quality, and [Actual] state is calculated or current value that reflects current states. (Lee, 2006)

2.2 Ideal AHP model

This paper proposes an Ideal AHP model, as shown at Figure 1. Instead traditional AHP model has n Alternatives, this model has only 3 states as alternatives. If you set Ideal value and Possible value, you can obtain absolute competiveness of Actual state by using m Criteria and 1:1 matrices. Calculation procedure of Ideal AHP is the same as traditional AHP model.

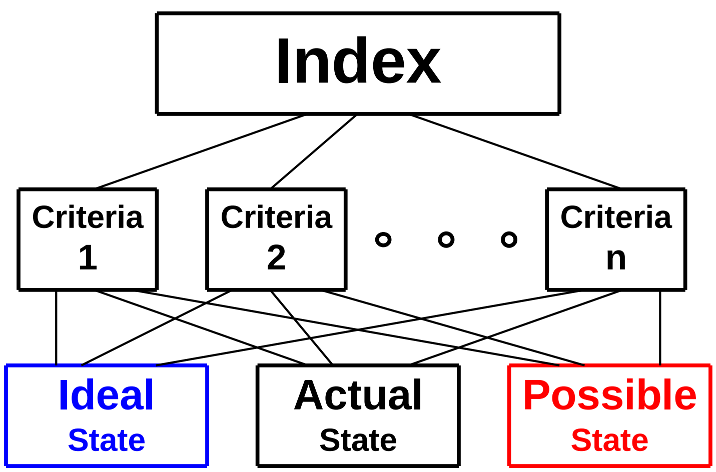

Figure 1. Ideal AHP model

2.3 Scaling for human sense

In spite of the above, [Actual] state of 3-State model can reflect the current state between [Ideal] and [Possible] states, but it does not reveal the proper scale to fit human judgment. This paper proposes a methodology that rescales [Actual] states, instead of employing one-to-one matrices. As a methodology, this paper normalizes [Actual] state between [Ideal] and [Possible] states to overcome different standards, and apply a new non-linear scale, as follows: (Lee, 2008)

$$y = x^a \qquad (1)$$

Where, x is one of measured [Actual] state, and y is human feeling reflects x.

3. Example of hamburger shop competitiveness

Example of Hamburger shop competitiveness which includes new hamburger shop is shown at Figure 2. Here, this model is an example only to explain the merit of Ideal AHP. So, values which used in here are no related to actual values.

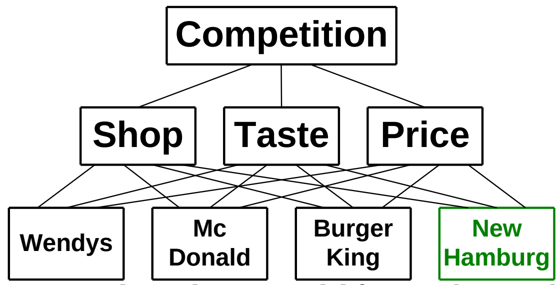

Figure 2. Traditional AHP model for Hamburger shops

Ideal AHP model can be decomposed as Figure 3.

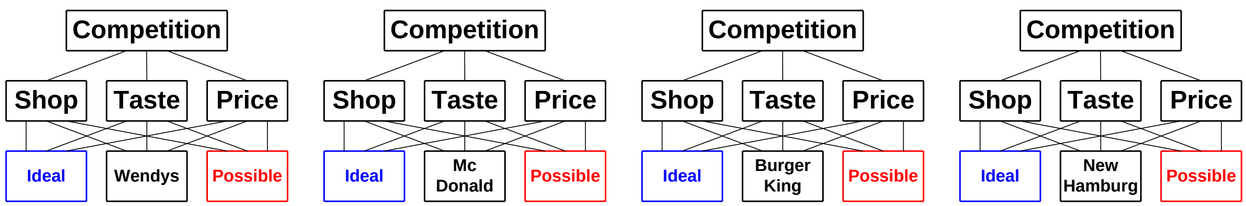

Figure 3. Ideal AHP models for Hamburger shops

From Figure 3, competitiveness can be obtained as Table 1, and eigenvalues reflect competitiveness. By comparing eigenvalues, customers can feel which shop is better than another shop.

Table 1. Competitiveness using Ideal AHP

Wendys	Shop	Taste	Price
Ideal	10	★★★★★	$0
Acutal	2	★★	$4
Possible	0	-	$20

⇒

Eigenvalue for Item		**Eigenvalue**
Shop	0.2	
Taste	0.4	**0.4904**
Price	0.8	

McDonald	Shop	Taste	Price
Ideal	10	★★★★★	$0
Acutal	3	★★★★	$5
Possible	0	-	$20

⇒

Eigenvalue for Item		**Eigenvalue**
Shop	0.3	
Taste	0.8	**0.6984**
Price	0.75	

Burger King	Shop	Taste	Price
Ideal	10	★★★★★	$0
Acutal	4	★★★	$7
Possible	0	-	$20

⇒

Eigenvalue for Item		**Eigenvalue**
Shop	0.4	
Taste	0.6	**0.5812**
Price	0.65	

New Hamburg	Shop	Taste	Price
Ideal	10	★★★★★	$0
Acutal	1	★★★★★	$3
Possible	0	-	$20

⇒

Eigenvalue for Item		**Eigenvalue**
Shop	0.1	
Taste	1.0	**0.7984**
Price	0.85	

4. Application of distribution system investment

4.1 Ideal AHP model for Unified Power Quality Index

This paper builds an Ideal AHP model to evaluate competitiveness of Power Quality for electric distribution system. Finally, this competitiveness can be used as Unified Power Quality Index, as shown at Figure 4.

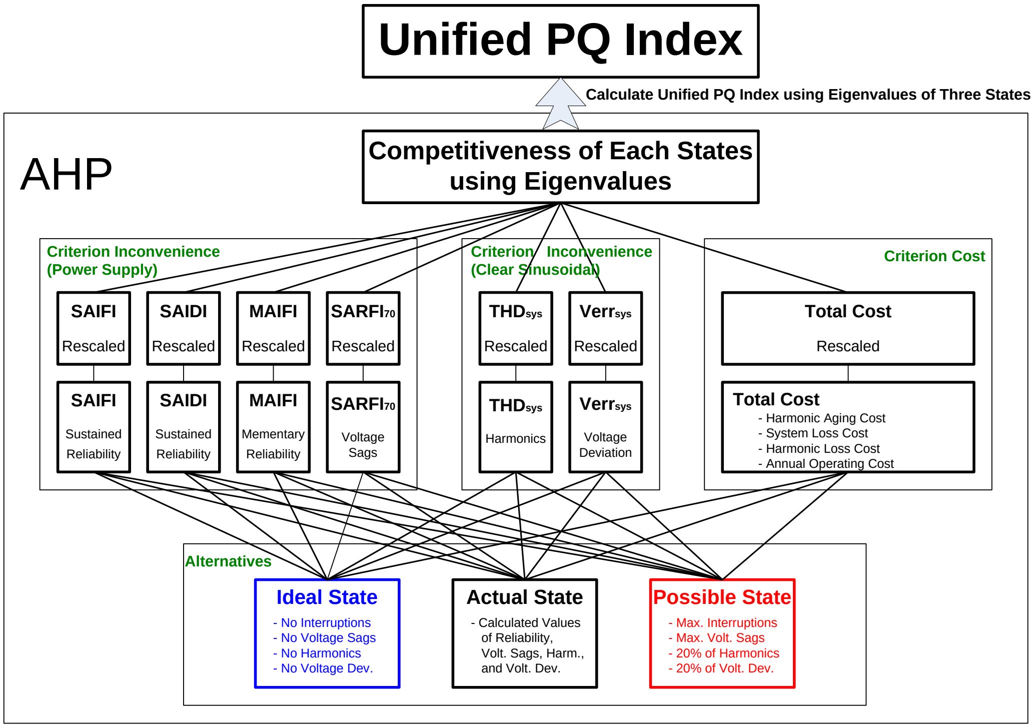

Figure 4. Ideal AHP model for Unified PQ index

4.2 Competitiveness of expansion for electric distribution system

Figure 5 is an actual system in South Korea. To expand electric distribution system, this paper proposes three alternatives. Alternative 1 uses existing substations A and B, with a new additional transformer extension to feed new loads. Alternative 2 and 3 are based on constructing of a new substation C, fed either by a single circuit (Alternative 2) or by two circuits (Alternative 3).

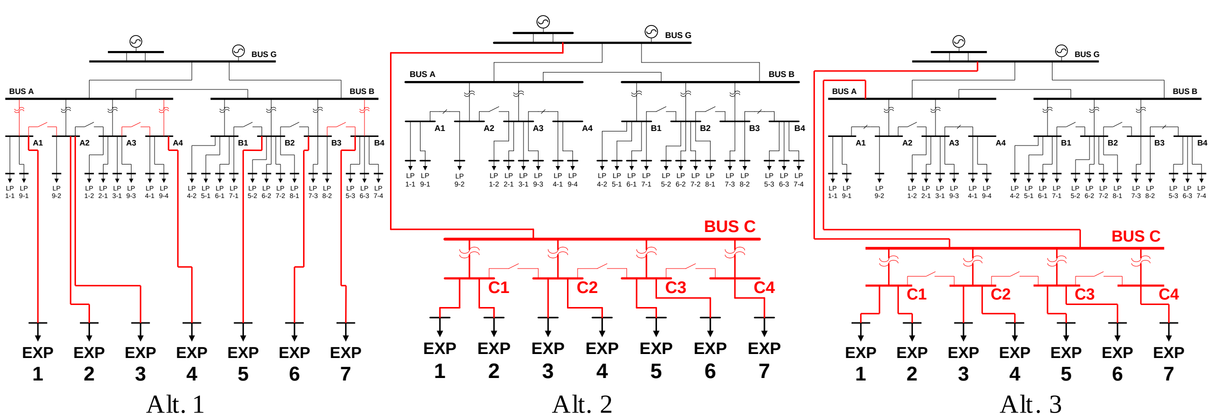

Figure 5. Alternatives for electric distribution system

This paper calculates system-wide indices of power quality and operating costs for 3 Alternatives. Calculation procedure is depending on IEEE Standards (IEEE 1995, 2001; Math 2003), data (IEEE 1992), and algorithm (Lee, 2008). The results are shown in Table 2.

Table 2. System-wide indices and operating costs for each Alternative

Inconvenience (Power supply)		Alt. 1	Alt. 2	Alt. 3
Reliability	SAIDI	20.8830620	21.1635240	20.8589927
	SAIFI	.1183291	.1282283	.1144025
	MAIFI	.2382605	.2716871	.2187430
Voltage Sags	$SARFI_{70}$	4.534779	4.88244	5.26872

Inconvenience (Clear sinusoidal)		Alt. 1	Alt. 2	Alt. 3
Harmonics	THD_{sys}	0.033489	0.040973	0.041712
Voltage Devation	V_{sys}	0.00449	0.00042	0.00044

Costs	Alt. 1	Alt. 2	Alt. 3
Harmonic Aging Cost	116,035	149,890	170,985
System Loss Cost	3,997,451	2,934,162	2,886,332
Harmonic Loss Cost	60,094	44,150	43,537
Annual Operating Cost	698,000	928,000	959,000
PQ Cost	4,871,580	4,056,202	4,059,854

To calculate competitiveness using Ideal AHP, this paper proposes Ideal and Possible states considering electrical engineering characteristics for each index, and shows values in Table 3. Here, Ideal values reflect perfect power quality, and Possible value reflect extreme low power quality. For rescaling, this paper set a=1.912489289 (by y=0.1, x=0.3) for indices, and a=1 for the cost.

Table 3. Setting of [Ideal] and [Possible] states for each index and cost

States		[Ideal]	[Possible]
Power Supply	SAIFI	0.	1.
	SAIDI	0.	200.
	MAIFI	0.	3.
	SARFI	0.	50.
Clear Sinusoidal	THD_{sys}	0.	0.2
	V_{sys}	0.	0.2
Cost		0.	200,000,000

Because Ideal AHP need 1:1 matrix, this paper proposes build it arbitrarily, and shown it in Table 4.

Table 4. One-to-one Matrix

	Power Supply				Clear Sinusoidal		Cost
	SAIFI	SAIDI	MAIFI	SARFI	THD_{sys}	V_{sys}	Cost
SAIFI	1.000	0.952	2.000	20.00	10.00	0.333	0.200
SAIDI	1.050	1.000	1.667	25.00	12.50	0.500	0.250
MAIFI	0.500	0.600	1.000	10.00	5.000	0.200	0.100
SARFI	0.050	0.040	0.100	1.000	0.500	0.125	0.050
THD_{sys}	0.100	0.080	0.200	2.000	1.000	0.025	0.017
V_{sys}	3.000	2.000	5.000	8.000	40.00	1.000	0.033
Cost	5.000	4.000	10.00	20.00	60.00	3.000	1.000

From Figure 4,5 and Table 2,3,4, eigenvalues are obtained, and show them in Table 5. These eigenvalues can be used as Unified Power Quality Index.

Table 5. Eigenvalues and Unified Power Quality Index.

	Alt. 1	Alt. 2	Alt. 3
Unified index	0.01533	0.01543	0.01421

5. Conclusion

Even though Price and Quality of a product can be compared to any other products, many people want an absolute competitiveness for each product. For example, a score of an examination at school is shown from 0 to 100. If evaluator has Ideal and Possible value, a product can be evaluated as an absolute competitiveness, and Ideal AHP can it possible.

First, this paper presents the concept of Ideal AHP which has three states: [Ideal] – [Actual] – [Possible] States. Here, calculation procedure is the same as traditional AHP. Second, this paper shows an example which applied to hamburger shop competitiveness model. Finally, this paper shows an application of decision support for investment of electric distribution system, and obtained unified power quality index.

As a further study, authors have a plan to expand criteria based on already evaluated competition. This study would have problem which eigenvalue is bigger than 1, sometimes.

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