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第 24 卷, 第 2 號, 1998. 12. 31

An Analytic Delphi Network Process for Evaluating Telecommunication Management Network Operation Systems (TMNOS)

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Abstract

The problems of evaluating Telecommunication Management Network Operation Systems (TMNOS) are Multi-Criteria Decision Making (MCDM) problems. A method for evaluating the TMNOS has not yet been clearly defined. A study of an effective and efficient management methodology for TMNOS, which are heterogeneous and complex, is needed. The components of TMNOS have attributes of dependence between considered criteria or alternatives. This type of dependence impact between criteria or alternatives is a network structure. We suggest a methodology of Analytic Delphi Network Process (ADNP) for evaluating TMONS. The TMNOS problem of Korea Telecom (KT) is suggested as a case study of the ADNP.

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1. Introduction

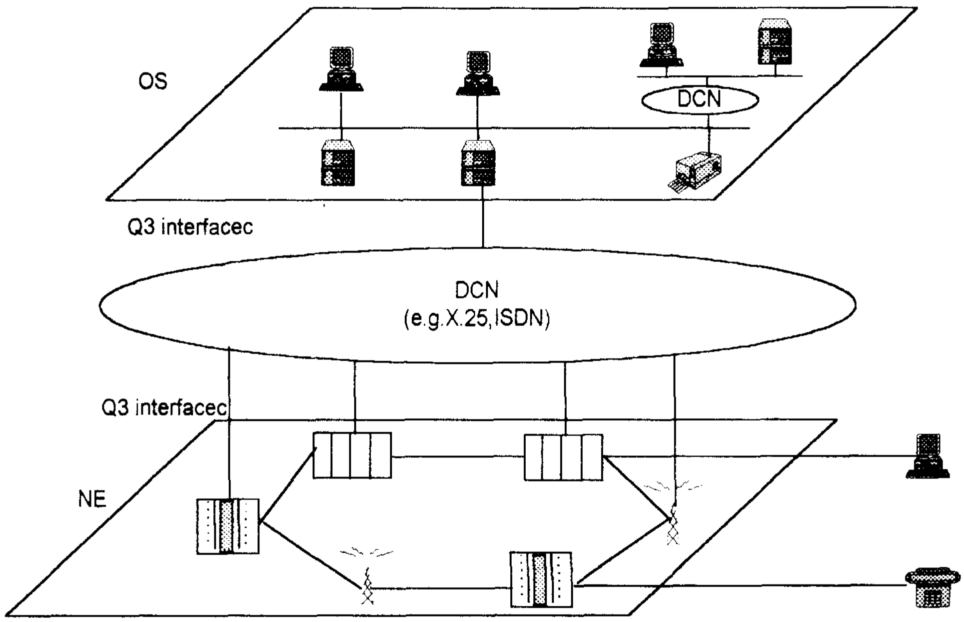
Although there have been many studies on the technology of telecommunication networks, there are few on the methodology of evaluating Telecommunication Management Network Operation Systems (TMNOS). To manage the effectiveness and efficiency of the telecommunication business as well as voluntarily meet highly complicated and intelligent environment unification and openness in the TMNOS methodology is necessary. In order to carry out this goal, the ITU-T(Telecommunicaton Standardization Sector of International telecommunication Union) has recommended the concept of TMNOS as an international standardization[Elston Carter and Januario, 1991; ITU-T, M. 3010, 1996].

To minimize the risk of investment inherent in the development of TMNOS utilizing the TMN concept, and to maximize its effectiveness, the investment should be made economically and systematically. Therefore, a study of the establishment of a framework for a rational analysis and evaluation appropriate area of network operation and management is needed, and a reasonable investment policy should be investigated. A study on the effectiveness and efficiency of telecommunications operating system based on the concept of TMN does not exist [Korea Telecom, 1996].

According to ITU-T M.3010, TMN is a network set up to oversee the efficient operation, administration and maintenance (OA&M) of communications networks and their associated components [Elston Carter and Januario, 1991; ITU-T, M. 3010, 1996]. The architecture of a TMN consists mainly of the operating system (OS) and the network elements (NE), which, as a rule, are connected via a public data communication network (DCN). While the OA&M functions are executed in OS, the real communications tasks--such as those executed by a multiplexer or exchanges in a subscriber line or core networks--are implemented in the NE. OA&M measures are not only carried out by TMN operators, but also can be performed by end users or initiated by software applications. While TMN operators work either via direct or remote operator terminals or via external systems such as other operating systems, end users execute OA&M measures in the context of customer network management

(CMN).

The TMN architecture is show in figure 1.



DCN : Data Communication Network
NE : Network Element , OS : Operating System

Fig 1. TMN architecture

In Korea, Korea Telecom (KT) and S.K Telecom actively strive to develop the infrastructure of the TMN concept because they recognize its importance [Korea Telecom, 1996]. The decision makers find it difficult to evaluate TMNOS because a methodology for evaluating TMNOS has not been suggested.

One of the reasons it is difficult to capture an evaluation item about the TMNOS is that we cannot be clearly assured of the degree of impact between the factors or criteria. One evaluation factor impacts another factor or factors, i.e., there is a interdependence (or influence relationship) between factors. Although a study of problems which have independent relationship among factors or attributes has been deployed, there are few studies of interdependent problems.

Structuring a problem involving functional dependence allows for feedback among considered criteria or alternatives. This is one type of network structure [T.L.Saaty, 1980, 1996]. T.L. Saaty accomplished a comprehensive study of this network structure. He suggested the Analytic Hierarchy Process (AHP) used to solve the problem of independence on alternatives or criteria and the Analytic Network Process (ANP) used to solve the problem of dependence among alternatives or criteria.

To determine the degree of the interdependent relation considered between alternatives or items, we need the discussion of expert group members and to converge the group opinion. Besides, the network relationship for evaluating TMNOS depends on the judgments of a Decision Maker (DM).

In this paper, we suggest an Analytic Delphi Network Process (ADNP) model for evaluation of TMNOS. The TMNOS case of Korea Telecom (KT) is suggested as a case study of the ADNP model. The case example in this paper is based partly on the contents of the KT project.

2. Analytic Network Process (ANP) and Delphi method

2.1 Analytic Network Process

To solve a complex problem, T.L. Saaty suggested the Analytic Hierarchy Process (AHP) method [T.L.Saaty, 1980; Fatemeh Zahedi, 1986]. The basic assumptions of AHP are that it can be used in functional independence of an upper part or cluster of the hierarchy from all its lower parts and the criteria or items in each level. Stephen F. Weber [1993] suggested a modified AHP and Hossein Azani and Reza Khorramshgol [1990] applied to strategic decision model using Delphi.

Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher level elements on lower level elements. Structuring a problem involving functional dependence allows for feedback among clusters. This is a network system. T. L. Saaty accomplished a comprehensive study of this problem. He suggested the Analytic Network Process (ANP) used to solve the problem of dependence among alternatives or criteria.

Generally we solve complex problems by discussing them with group members.

However, when we do not know the exact relationship in the network structure, it is dangerous to determine it by a decision maker. To determine the relationship of a network structure is most important function of ANP. An application methodology reflecting the group discussion is necessary. To propose a multi-criteria decision making model, this study combines The Delphi Method, a widely used managerial tool, with the ANP, a powerful mathematical model. This methodology is named the Analytic Delphi Network Process (ADNP) method.

2.2 Delphi Method

The Delphi method, which was designed to overcome the interpersonal behavior problems of groups and to converge the use of expert opinion through polling was introduced by O.Helmer and N.Dalkey in the early 1960s [Helmer, 1966; Linstone and Turoff, 1975]. The Delphi method is widely used to converge expert group opinions. The Delphi method is a systematic procedure for evoking expert group opinion. Dalkey [1971] summarized as three features of Delphi : (1) anonymity, (2) controlled feedback, and (3) statistical group response. Linstone and Turoff [1975] explain the process of conventional Delphi as follows: A small monitor team designs a questionnaire which is sent to a larger respondent group. After the questionnaire is returned, the monitor team summarizes the results and, based on the results, develops a new questionnaire for the respondent group. The respondent group is given at least one opportunity to re-evaluate its original answer based on examination of the group response. To a degree, this form of Delphi is a combination of polling procedure and a conference procedure which attempts to shift a significant portion of the effort needed for individuals to communicate from the larger respondent group to the smaller monitor team.

To structure a network model for evaluating TMNOS, the Delphi method is a very useful tool for picturing an uncertain framework of a network structure which has interdependent relations among the criteria or alternatives.

3. The proposed model: Analytic Delphi Network Process (ADNP) method

ADNP consists of the following steps:

Step 1. Form a Delphi panel which is composed of an expert group to conduct the Delphi inquires. The panel should consists of experts familiar with evaluating TMNOS problems.

Step 2. Use the Delphi method to determine objectives and identify criteria or evaluation items about the problems being considered. The panel should design a questionnaire in which the participants are asked to specify the objectives and identify criteria, alternatives, or evaluation items.

Step 3. Perform another Delphi to set up a network structure for problems which have been considered. Here, we determine the network framework: being influenced by other clusters and elements, or influencing other clusters and elements with respect to a criteria or evaluation items.

Step 4. Perform the process as a normal process of ANP. Here, the objectives specified in Step 2 and 3 should be presented to the participants in order to obtain their subjective value judgments for a pairwise comparison matrix. If consensus is not reached regarding any of the individual elements in this process, the arithmetic mean of the value judgments of all participants will be considered for that element.

Step 5. Obtain eigenvalues of the pairwise comparison matrix. The eigenvalues of this matrix represent the priority among criterion or evaluating alternatives.

4. Application of the proposed methodology

The following case was carried out by the Korea Advanced Institute of Science and Technology (KAIST) DSS Lab as a 1996 project of KT from June to November. We illustrate the application of ADNP to the evaluating of the TMNOS of Korea Telecom. As the result of Step 2, we have three criteria for evaluating the TMNOS. The criteria are necessity, functionality, and usability. Definitions of the criteria are as follows.

1) Necessity (NE): The degree of coincidence to the objective of a system, the degree of importance of a system, the degree of urgency of a system.

2) Functionality (FU): The part of a system having a basic characteristic, the possibility of system extension, interface to other systems, the degree of system scalability.

3) Usability (US): the direct or indirect effectiveness of the TMNOS.

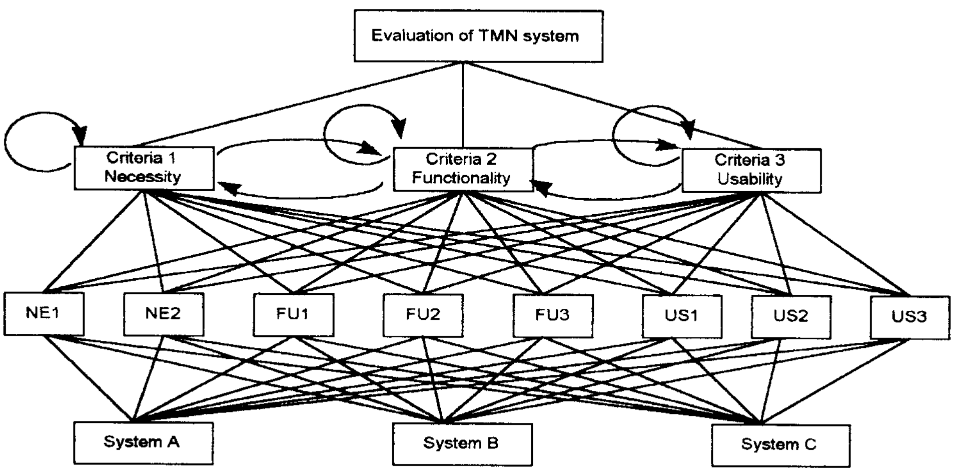
A specification evaluation of the items of these criteria is composed of eight factors: purpose, reality, system performance, system operability, the degree of support for management capabilities, the repercussion effects of information technology, the effectiveness of job improvement, and the repercussion effects of service.

The goal dominates the criteria; the criteria partly dominate the evaluation factors. The goal, criteria, and evaluation factors are defined as follows:

(1) Goal: Evaluation of the functional dominance of a TMNOS.

(2) Criteria: The three basic functions: necessity, functionality, usability.

(3) Evaluation factors: The eight factors shown above.

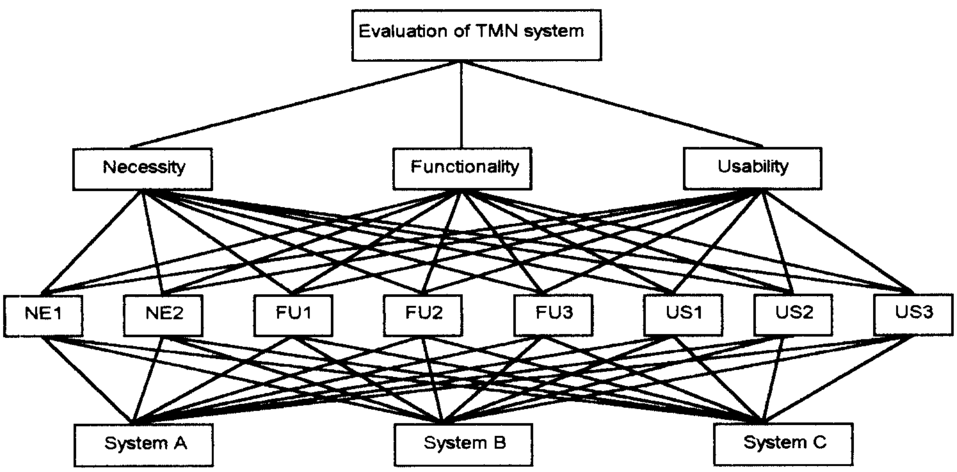


NE1 : purpose, NE2 : reality, FU1 : system performance, FU2 : system operability, FU3 : a degree of support for management capabilities, US1 : the repercussion effect of information technology, US 2 : the effectiveness of job improvement, US3 : the repercussion effect of service.

Fig 2. Hierarchies of TMN Evaluation(old)

At the beginning of this project, we assumed that the criteria could be regarded as independent. Therefore, we structured the framework model based on the AHP. This hierarchy is shown in figure 2.

At the result of the collection of a questionnaire from the expert group, we know there is some relationship between criteria and evaluation items in the model for TMNOS evaluation. From the Delphi method, we know that: At first, before deciding whether to develop or purchase the TMNOS, we investigated the necessity of the system. After the condition of necessity was satisfied, this necessity impacted on the functionality of the system. According to the system necessity, many parts of the functionality of the system can be changed. In other words, the necessity of system impacts to the functionality of the system. Likewise, according to the functionality of the system, the usability of the system can also be changed. In addition to this relationship, we considered the evaluation factors of the system concerning criteria impact on other factors or the impact received by other factors. Thus, in this situation, it is not appropriate to evaluate the system through simple structured hierarchies. In this relationship, it will be more correct to apply to the network model



NE1 : purpose, NE2 : reality, FU1 : system performance, FU2 : system operability, FU3 : a degree of support for management capabilities, US1 : the repercussion effect of information technology, US 2 : the effectiveness of job improvement, US3 : the repercussion effect of service.

Fig 3. A model for Evaluation of TMN System (new) which is based on the analytic network process. Based on the concept of the network model, as the result of the Delphi method, we suggested a new model for the evaluation of the TMNOS system, as shown in figure 3.

This figure shows that functionality is under the influence of necessity, functionality has an impact on usability, and each criteria has an impact on other criteria.

In applying Step 4, we do not follow the process of Saatys supermatrix [T.L. Saaty, 1980, 1996] method but the process of Saaty and Takizwas process [1986]. Based on Saaty and Takizwas concept, the procedure is shown as follows:

Procedure 1) assuming that there is independence of among the three criteria, we obtain the following relative weight for the criteria. W1= (Criteria 1, Criteria 2, Criteria 3)=(NE, FU, US)=(0.4, 0.4, 0.2)

Procedure 2) Compare the evaluation items, we obtain the following weight. In this case, we also assume that there is no dependence among the factors.

WNEE1=(NE1, NE2)=(0.4, 0.6), WFUU1= (FU1, FU2, FU3)=(0.3, 0.35, 0.35), WUSS1=(US1, US2, US3)=(0.3, 0.4, 0.3)

Procedure 3) The weight of the evaluation items of the criteria and the weight of considered among the criteria are shown in Table 1.

[Table 1] The weight of evaluation factors of criteria

W_6	NE	FU	US
NE1	0.4	0	0
NE2	0.6	0	0
FU1	0	0.3	0
FU2	0	0.35	0
FU3	0	0.35	0
US1	0	0	0.3
US2	0	0	0.4
US3	0	0	0.3
	W21	W22	W23

Next, we analyze the interdependence among the functions, when we consider the TMN evaluation, we cannot concentrate only on one function, i.e., we need to examine the impact of all the functions on each of them by using pairwise comparisons. An example questions for the comparison may be: in considering a TMN evaluation, given the function, FU, which function contributes to FU, more; and how much more? Similarly we repeat the same type of question for the other three functions. In this way, we obtain the data in table 2. A zero indicates no effect or no dependence.

[Table 2] The weight of considered among the factors

W_3	NE	FU	US
NE	1.0	0.6	0.0
FU	0.0	0.4	0.6
US	0.0	0.0	0.4

Procedure 4) we analyze the interdependence among the evaluation factors. When we design the Evaluation of the TMN system, we cannot concentrate on only one criterion and evaluation item as in procedure 3. Therefore, we need to examine the impact of all the factors on each of them by using pairwise comparisons. We obtain Table 3. The way of finding results is the same concept of procedure 3. In table 3, given the function NE1 of second column, 0.3 means that NE2 impact 0.3 to NE1. The other data have meaning of like these priorities in table 3.

[Table 3] The weight considering the impact of all factors

W_4	NE1	NE2	FU1	FU2	FU3	US1	US2	US3
NE1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NE2	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0
FU1	0.0	0.0	1.0	0.8	0.4	0.0	0.0	0.0
FU2	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0
FU3	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.0
US1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
US2	0.0	0.0	0.0	0.0	0.0	0.6	1.0	0.4
US3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6

Procedure 5) We now obtain the interdependence priorities of the criteria by synthesizing the results from Procedures 1 and 3 as follows:

$$W_C = W_3 \times W_1 = \begin{bmatrix} 1.0 & 0.6 & 0.0 \\ 0.0 & 0.4 & 0.6 \\ 0.0 & 0.0 & 0.4 \end{bmatrix} \times \begin{bmatrix} 0.4 \\ 0.4 \\ 0.2 \end{bmatrix} = \begin{bmatrix} 0.64 \\ 0.28 \\ 0.08 \end{bmatrix}$$

Thus we have (Necessity, Functionality, Usability)=(0.64, 0.28, 0.08)

Procedure 6) In addition, we obtain the priorities of the factors of the criteria by synthesizing the results from Procedures 2 to 4 as follows:

$$W_A = W_4 \times W_6 = \begin{bmatrix} 0.7 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.3 & 1.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 1.0 & 0.8 & 0.4 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.1 & 0.2 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.1 & 0.4 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.6 & 1.0 & 0.4 \\ 0.0 & 0.0 & 0.0 & 0.0 & 0.0 & 0.4 & 0.0 & 0.6 \end{bmatrix} \times \begin{bmatrix} 0.4 & 0.0 & 0.0 \\ 0.6 & 0.0 & 0.0 \\ 0.0 & 0.3 & 0.0 \\ 0.0 & 0.35 & 0.0 \\ 0.0 & 0.35 & 0.0 \\ 0.0 & 0.0 & 0.3 \\ 0.0 & 0.0 & 0.4 \\ 0.0 & 0.0 & 0.3 \end{bmatrix} = \begin{bmatrix} 0.28 & 0.00 & 0.00 \\ 0.72 & 0.00 & 0.00 \\ 0.00 & 0.70 & 0.00 \\ 0.00 & 0.105 & 0.00 \\ 0.00 & 0.195 & 0.00 \\ 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.70 \\ 0.00 & 0.00 & 0.30 \end{bmatrix}$$

Procedure 7) Finally, the overall priorities for the evaluation items are calculated by multiplying W_A by W_C .

$$W_O = W_A \times W_C = \begin{bmatrix} 0.28 & 0.00 & 0.00 \\ 0.72 & 0.00 & 0.00 \\ 0.00 & 0.70 & 0.00 \\ 0.00 & 0.105 & 0.00 \\ 0.00 & 0.195 & 0.00 \\ 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.70 \\ 0.00 & 0.00 & 0.30 \end{bmatrix} \times \begin{bmatrix} 0.64 \\ 0.28 \\ 0.08 \end{bmatrix} = \begin{bmatrix} 0.1792 \\ 0.4608 \\ 0.1960 \\ 0.2940 \\ 0.0546 \\ 0.0000 \\ 0.056 \\ 0.024 \end{bmatrix}$$

Our final result is (NE1,NE2,FU1,FU2,FU3,US1,US2,US3)=(0.1792, 0.4608, 0.1960, 0.2940, 0.0546, 0.0, 0.056, 0.024) .

These results are interpreted as follows. The most important factor in the TMN evaluation is the NE2 (Reality); the next is FU2 (system operability). Among the criteria, necessity is the most important part, and the weight is 0.64. The meaning of this result is that first of all the system evaluator has to focus to investigate the necessity part and concentrate his attention on the reality and the system operability part.

In Table 4, we show the results of priorities obtained from the old and new models, considering the interdependence among the criteria and evaluation factors.

[Table 4] Compare the priorities

Criteria, Items	old priorities	new priorities(1)	new priorities(2)	a reference
NE	0.4	0.64		
FU	0.4	0.28		
SU	0.2	0.08		
NE1	0.4	0.28	0.1792	Priorities Normalizing as [0,1]
NE2	0.6	0.72	0.4608	
FU1	0.3	0.56	0.1960	
FU2	0.35	0.224	0.0546	
FU3	0.35	0.216	0.2940	
SU1	0.3	0.0	0.0000	
SU2	0.4	0.692	0.056	
SU3	0.3	0.3068	0.024	

In this table, we found that there are many changes in priorities. When problems have interdependence and dependence among the criteria or items (alternatives), it is not correct to use the AHP model. This problem is correctly applicable to the ANP model.

5. Conclusion

When problems have interdependence and dependence among the criteria or items (alternatives), it is not correct to use the AHP model. Although thee are many research in independent problems, real world problems have interdependence or dependence property. These problems are correctly applicable to like the ANP model. This paper suggests a case study for dependence problem research. This paper moves a one step closer to the developing of a new methodology for interdependent IS selection.

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