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Abstract

In order to cope with the coming of future digital television broadcasting, terrestrial broadcast companies have started to upgrade their program transmission relay devices from analog to digital. Although well-defined specifications can be referenced from all manufactures, with all the intricate factors such as functionalities, features, pricing, operation cost, and after service, it becomes a heavy burden as far as how to choose the most appropriate equipment in the procurement of digital microwave relay system. The goal of this report is to set up all kinds of evaluation items utilizing hierarchical structure model, and to choose the most appropriate digital microwave equipment using fuzzy assessment method.

1. Introduction

The digital microwave relay system plays an important role in the future digital television broadcasting system and can be used for more than ten years. Therefore, the chosen microwave machine needs not only to meet the standards of product specifications and features but also to consider the future expansion capability such as most up to date functionalities, adequate spare parts, inexpensive long-term operation cost, and business opportunities.

This study presents a real case for evaluation. The north-south bound microwave relay system in the west of Taiwan has 8 stations and 7 sections; total up to 14 sections back and forth (Refer to Fig. 1). Average

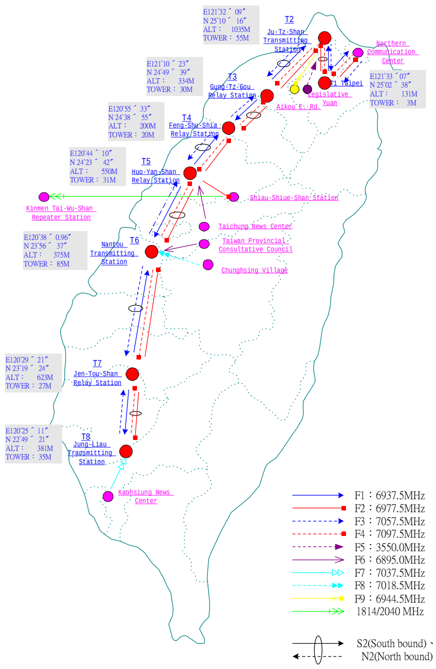

Fig.1 Western digital microwave relay system map

distance between each section is about 30 kilometers and above. In order to meet the system reliabilities and basic function requirements, project specifications are published in advance for vendor's reference. Three machines from two manufactures are selected for consideration, to comply with the basic requirements. Therefore, other criteria need to be used on top of the basic requirements and specifications in the assessment process.

2. Theory Exploration

2.1 Fundamental Requirements of Digital

Microwave Relay System

Digital microwave transmission channel in this project requires one route for DS3 (44.736Mbps — program transmission) and one route DS1 (1.544Mbps — enterprise intranet), system reliability is set for 99.975% and above (with disconnection rate 21.6 second per day).

2.2 Factors contribute to System Reliability

System reliability involves microwave machine transmission power, receiving threshold, FEC (forward error correction) function, hot stand-by architecture and adoption of space diversity, etc. (Please refer to Table 1). Although the three machines from the two manufactures do achieve more than 99.975 % system reliability, they retain the leading position in some areas of the system architecture. Especially when all figures are derived from theoretical computation rather than reality, this increases difficulty during the assessment.

System gain, which is one of the system reliability elements, includes transmission power (dBm) and receiving threshold (dB). Therefore, the higher the transmission power and the lower receiving threshold are, the larger the system gain will be. (Please refer to Table 1) System reliability is also relatively increased. Among other items; factors such as FEC function can increase system gain 2 ~ 2.5dB and hot stand-by function increases overall system reliability 50 % should not be neglected. In additional, machine with lower transmission power tends to have less long-term operation cost. Cost saving can be used to acquire additional receiving antenna to increase t he system reliability through space diversity technology. The resulting effect is far better than increasing output power.

Table 1 General function comparison

Brand	A	B	C
Model	MDR-XXXX	DVR-XXXX	C-XXXX
Frequency Band(GHz)	6.425~7.125	6.875~7.125	U6
Modulation(QAM)	16	64	32
FEC	N/A	Single-Lee	Reed-Solomon
Capacity	DS3+DS1	DS3+DS1	DS3+4XDS1
System Reliability	99.9841	99.977	99.99
Frequency Stability	0.001%	0.001%	0.0003%
TX BW.(MHz)	15	10	14
TX Power (dBm)	30, 33	29, 31	29
T/I Ratio Cochannel 32dB(dB@10^{-6}BER)	27(dB@10^{-3} BER)	30(dB@10^{-3} BER)	30(dB@10^{-6} BER)
T/I Ratio Adjacent channel -3dB(dB@10^{-6}BER)	-4(dB@10^{-3} BER)	-8(dB@10^{-3} BER)	-22(dB@10^{-6} BER)
Dispersive Fade Margin (dB@10^{-6}BER)	57(dB@10^{-3} BER)	59(dB@10^{-3} BER)	60(dB@10^{-6} BER) 61(dB@10^{-3} BER)
RX Threshold (dBm)	-78.5	-76	-76
Network Management	Non-SNMP Architecture	Non-SNMP Architecture	Starview/SNMP
Hot Stand-By	SouthBound-Yes, NorthBound-No	SouthBound-Yes, NorthBound-No	SouthBound-Yes, NorthBound-Yes
Prices	NT$: 29192256	NT$: 34565321	NT$: 30001290

2.3 Wave Usage Charge

Wave usage charge calculation formula published by Ministry of Transportation and Communication in 1990 is as follow:

Formula: (BW÷1MHz)×(W÷1Watt)×14000 ×0.4

Identical bandwidth, Power 2W, 1W are used for comparison.

2W: (15MHz÷1MHz)×(2W÷1W)×14000 ×0.4
= 168000 dollars/year.

1W: (15MHz÷1MHz)×(1W÷1W)×14000 ×0.4
= 84000 dollars/year.

Price difference for the 14 sections of the entire system is 1176000 dollars per year. Annual saving of 1.17 million would be adequate for the purchase of two receiving antennas (RFS UXA12-65A one unit costs 665176 dollars). Using space diversity technology can increase system reliability.

2.4 Transmission Channel Capacity

Capacity of DS3 and DS1, even though all three machines fulfill the basic requirements, one of the machines has one route for DS3 plus 4 routes for DS1. As the commercial value of DS1 channel declines with the opening of the three major fixed-network communication companies, the utilization of the enterprise intranet and the enhancement of efficiency cannot be quantified by dollar figures. This item is, therefore, included as one of the important elements.

3. Fuzzy Assessment Model

3.1 Hierarchical Structure Model

Due to the wide range of areas covered by selection criteria, there are a lot of items need to be considered. A hierarchical structure model as shown in Fig. 2 is used in order to take into equal consideration of all areas to build an assessment architecture model.

3.2 Grade of Evaluation and Grade of Importance of the Evaluated Items

Different items are evaluated in the selection process. Each item has its own grade of evaluation and grade of importance as shown in Table 2 [1]. Each grade of evaluation and grade of importance is further divided into 11 linguistic variables.

Great deal of uncertainty and fuzzy occur when using linguistic variables in many circumstances.

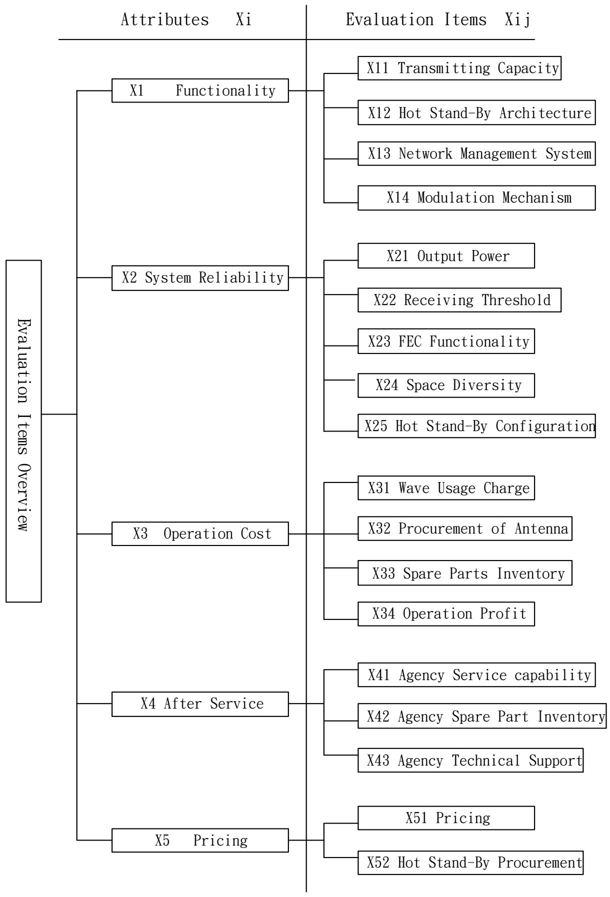

Fig. 2 A hierarchical structure model

Therefore, ambiguous linguistic variables are represented by triangular fuzzy numbers as shown in Table 3 [1].

3.3 Evaluating the Aggregative Rate Method

Let w_i represent the weight of the attribute X_i, and w_{ik} denote the weight of the item X_{ik} as shown in Fig. 1, $g(a_{ij}, b_{ij})$ represent the value [1] which is derived by the defuzzfied method after multiplying the grade of evaluation (a_{ij}) and grade of importance (b_{ij}).

In referencing the Lee et al. [2] algorithm, calculation steps are as follows:

Step 1. Let

$$R2(k)=\frac{\sum_{j=1}^{n(k)} W_{kj} * g(r_{kj}, i_{kj})}{\sum_{j=1}^{n(k)} W_{kj}}$$

$$=\sum_{j=1}^{n(k)} W_{kj} * g(r_{kj}, i_{kj}) \qquad (1)$$

for k=1, 2, …, 5, where $n(k)$ is the number of evaluation items for attribute X_k, then we have $n(1)=4$, $n(2)=5$, $n(3)=4$, $n(4)=3$, $n(5)=2$; $g(r_{kj}, i_{kj})$ is the rate of pair (k, j) for each evalution item X_{kj}; $W_{k,j}$ is the weight of the item X_{kj}.

Step 2. The final rate of aggregative evaluation is by the centroid method as follows:

Let $$R1=\frac{\sum_{k=1}^{5} W_k * R2(k)}{\sum_{k=1}^{5} W_k}$$

$$=\sum_{k=1}^{5} W_k * R2(k) \qquad (2)$$

Then, the value of R1 is the rate of aggregative evaluation.

3.4 Data Example

Assume there are 3 sets of actual data representing selected machines A, B and C. Other company may assign different weight values to each attribute and evaluation item according to actual demand. Fixed Weight Value and Grade of Importance are used in the selection process. The values do not affect by different machine model. Evaluation Rate and Grade of Importance of each item are shown in Table 4.

Final evaluation result can be obtained after calculation through above mentioned fuzzy assessment algorithm. As shown in Table 5, the result after sorting is B＞A.

Table 2 Linguistic variables of grade of Evaluation and grade of importance [1]

11 Evaluation Rate Sequence	11 Grade of Importance Sequence
1: 11th Grade	1: Extremely Unimportant
2: 10th Grade	2: Especially Unimportant
3: 9th Grade	3: Very Unimportant
4: 8th Grade	4: Unimportant
5: 7th Grade	5: Somewhat Unimportant
6: 6th Grade	6: Ordinary
7: 5th Grade	7: Somewhat Important
8: 4th Grade	8: Important
9: 3rd Grade	9: Very Important
10: 2nd Grade	10: Especially Important
11: 1st Grade	11: Extremely Important

Table 3 Fuzzy numbers of grade of valuation and grade of importance [1]

Grade of evaluation	Fuzzy Numbers	Grade of Importance	Fuzzy Numbers
1	(0.0,0.0,0.1)	1	(0.0,0.0,0.1)
2	(0.0,0.1,0.2)	2	(0.0,0.1,0.2)
3	(0.1,0.2,0.3)	3	(0.1,0.2,0.3)
4	(0.2,0.3,0.4)	4	(0.2,0.3,0.4)
5	(0.3,0.4,0.5)	5	(0.3,0.4,0.5)
6	(0.4,0.5,0.6)	6	(0.4,0.5,0.6)
7	(0.5,0.6,0.7)	7	(0.5,0.6,0.7)
8	(0.6,0.7,0.8)	8	(0.6,0.7,0.8)
9	(0.7,0.8,0.9)	9	(0.7,0.8,0.9)
10	(0.8,0.9,1.0)	10	(0.8,0.9,1.0)
11	(0.9,1.0,1.0)	11	(0.9,1.0,1.0)

4. Conclusion

This study attempts to assess the most appropriate digital microwave system from the perspective of fuzzy theory. Weight values, evaluation items and grade of importance, which can be adjusted according to real situations in order to fulfill company’s requirements.

Reference

[1] Huey-Ming Lee, “Applying fuzzy set theory to evaluate the rate of aggregative risk in software development”, Fuzzy Sets and Systems, 79 (1996) 323-336

[2] Huey-Ming Lee, Shu-Yen Lee, Tsung-Yen Lee and Jan-Jo Chen, “A new algorithm for applying fuzzy set theory to evaluate the rate of aggregative risk in software development”, Information Sciences, 153 (2003) 177-197

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Table 4 Sample data

Attributes	X1				X2					X3				X4			X5	
Weight(Wi)	0.25				0.3					0.25				0.1			0.1	
Items	X11	X12	X13	X14	X21	X22	X23	X24	X25	X31	X32	X33	X34	X41	X42	X43	X51	X52
Weight(Wij)	0.30	0.30	0.25	0.15	0.20	0.20	0.20	0.20	0.20	0.30	0.30	0.20	0.20	0.30	0.40	0.30	0.60	0.40
Grade of Importance	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Machine A (MDR-XXXX)																		
Grade of evaluation	5	4	3	3	7	6	4	1	2	5	6	5	5	4	2	3	4	2
g (s,i)	0.2450	0.1850	0.1250	0.1250	0.3650	0.3050	0.1850	0.0228	0.0650	0.2450	0.3050	0.2450	0.2450	0.1850	0.0650	0.1250	0.1850	0.0650
Machine B (DVR-XXXX)																		
Grade of evaluation	5	4	3	4	6	4	5	1	2	7	5	6	5	3	2	2	2	2
g (s,i)	0.2450	0.1850	0.1250	0.1850	0.3050	0.1850	0.2450	0.0228	0.0650	0.3650	0.2450	0.3050	0.2450	0.1250	0.0650	0.0650	0.0650	0.0650

Table 5 Final evaluation values of selected machines

Machine A	Machine B
0.192668	0.222668