Choice Mechanism for Construction of University Enterprise Joint Cryptography Laboratory and Its Application in Hainan University

Yongheng Zhou[1,2], Lebing Huang[1,2], and Jun Ye[1,2(✉)]

[1] School of Cyberspace Security, Hainan University, Haikou, China
yejun@hainanu.edu.cn
[2] Key Laboratory of Internet Information Retrieval of Hainan Province, Haikou, China

Abstract. As the core technology of information security, the teaching of cryptography is paid more attention. Many schools have proposed a ' school - enterprise cooperation to build laboratories ' program. The main function of school-enterprise joint laboratory is to provide students with complete equipment and training environment. But for colleges and universities, how to match the most suitable company cooperation between schools and enterprises become the biggest problem, then establish a school-enterprise cooperation selection mechanism is very necessary. In this paper, the decision tree is used to simply screen all enterprises, and then the analytic hierarchy process is used to solve the weight from the arithmetic average method, the set average method and the eigenvalue method respectively. The final index weight is obtained by averaging the weight obtained by the three methods. Finally, the fuzzy comprehensive evaluation method is used to establish the selection mechanism of school enterprise cooperation. Through the case analysis of six enterprises in Hainan University, it is proved that the evaluation mechanism is effective, so as to provide objective standards for universities to select partners and jointly establish password laboratories. Keywords: First Keyword, Second Keyword, Third Keyword.

Keyword: Decision tree · Analytic hierarchy · Fuzzy comprehensive evaluation · Crypto School enterprise joint laboratory

1 Introduction

Cryptography is an important technology to ensure the three elements of information security, namely confidentiality, integrity and availability. As the core technology of information security, the teaching of cryptography is paid more attention. In the course of teaching, we should pay attention to the cultivation of students' ability, so that students have a solid theoretical foundation and strong application ability. Usually, universities should establish a cryptography laboratory for the practice of related courses. Many schools have proposed a 'school - enterprise cooperation to build laboratories' program.

J. C. Hung et al. (Eds.): IC 2023, LNEE 1045, pp. 618–628, 2023.
https://doi.org/10.1007/978-981-99-2287-1_89

The main function of the school-enterprise joint laboratory is to provide students with complete computer supporting equipment and training environment. After completion, the multi-source heterogeneous data collection, processing, analysis, storage, application and other operations can be carried out to meet the daily practice teaching, curriculum design, graduation design and so on. Second, improve teacher training, college students ' innovation training and competition training mechanism. But for colleges and universities, how to match the most suitable company cooperation between schools and enterprises become the biggest problem, then establish a school-enterprise cooperation selection mechanism is very necessary.

Liu Pengqi and others analyzed the three laboratory construction methods of school enterprise construction, joint construction with key disciplines and internal excavation, and proposed new ideas for the development of central laboratory [1]. Zhang Tao et al. Proposed a demand-oriented model of co-management laboratory construction of school enterprises [2]. Peng Zheng and others analyzed the significance of the construction of a laboratory by school enterprises to both parties with specific examples from this school [3]. Kang Wenbiao and Chen Ye introduced the contents and results of the construction of the laboratory of the school enterprise [4]. According to the analysis of previous research, there is a strong subjectivity in the choice of building crypto labs in cooperation with schools. There is no set of scientific selection mechanisms for schools to use, thus affecting the long-term development of the construction of crypto labs by schools. At present, there are also many applications of hierarchical analysis and vague comprehensive evaluation at home and abroad. A decision-making method based on qualitative and quantitative analysis of elements that are always relevant to selection mechanisms broken down into levels such as objectives, guidelines, schemes, etc. The relative weight of the indicators in the emergency management capability is determined by the hierarchical analysis method of Hou Fenglei, and the emergency capability of subway construction units is evaluated by the vague comprehensive evaluation method [5]. Xu Jianan and others used the AHP- vague comprehensive evaluation method to construct a children's street pedestrian space safety evaluation system, through the evaluation of the existing three street pedestrian spaces in Dalian [6]. In this article, the decision tree is used to perform simple screening of all enterprises, and then use the hierarchy analysis method and vague comprehensive evaluation method to establish the selection mechanism of school-enterprise cooperation. Thus, provide universities with objective criteria for selecting partners and jointly establishing password labs. Establishment of Evaluation Index for Construction of University -Enterprise Joint Cryptographic Laboratory.

2 Establishment of Evaluation Index for Construction of University -Enterprise Joint Cryptographic Laboratory

2.1 Selection of Evaluation Index

In the selection of evaluation indicators, the evaluation index system should have both indicators that reflect the level of development and indicators that reflect dynamic changes. The index should have a clear concept and a high correlation with the evaluation target to be achieved. It is important and meaningful to ensure the content of the

index measurement for the evaluation target and the evaluation object. Combined with the basic principles of multi-dimensional, convenient access, and measurability of the evaluation system indicators, the selection model of this paper is obtained.

2.2 Establishing Two - Stage Multi - level Index System

The first stage needs to consider three main factors: enterprise research direction, enterprise operation situation and enterprise location. For example, in terms of operating conditions, for listed companies, for companies marked with ' ST or ST * ', the net profit of the audited two consecutive fiscal years is negative, or the net assets per share audited in the most recent year are lower than the current par value of the stock, then the risk of cooperation is huge, and these companies should be eliminated. In the second stage, objective multidimensional quantification is needed to comprehensively evaluate the companies left by the initial screening in the first stage. On the one hand, this stage needs to consider the basic re-sources of the enterprise, such as the ownership of high-level cryptographic technology and the situation of talents. On the other hand, the degree of matching between schools and businesses and the expectations of long-term cooperation need to be considered. After establishing the basic evaluation direction, through

Table 1. Selection mechanism index of university-enterprise joint crypto laboratory construction

Target layer	Criterion layer	Scheme layer
Enterprise selection mode (A)	Enterprise resource capability (B1)	Number of high-tech talents (C1)
		High-level cryptographic technology ownership(C2)
		Maintenance of national information security times (C3)
		Number of password talent reserve bases (C4)
	Basic business status (B2)	Financial situation (C5)
		Profitability (C6)
		Enterprise risk (C7)
		Corporate governance capacity(C8)
	Enterprise matching (B3)	Corporate research status (C9)
		School distance (C10)
		Enterprise cooperation willingness (C11)
		Internship students output (C12)

literature search and analysis, questionnaires, expert consultation and other methods, the selection mechanism indicators for the construction of university-enterprise joint cryptography laboratory were finally formed. The first-level indicators include enterprise resource capacity, enterprise basic situation, enterprise matching degree. There are three, and also 12 secondary indicators, as shown in Table 1.

3 Selection Mechanism of University- Enterprise Joint Cryptographic Laboratory Construction

3.1 Enterprise Selection Based on Decision Tree

Decision tree was first proposed to deal with decision problems. Decision tree has the advantages of simple structure, clear logic and good interpretability. The best decision tree is constructed by known 'prior data' to predict unknown data categories.[7] Using the idea of decision tree algorithm to extract the initial feature of some important indicators of enterprises, feature selection is to select the features with classification ability. If the classification result using a feature is not very different from the random classification result, this feature is said to have no classification ability. The indicators selected in this paper are whether the research direction of the enterprise is cryptography, whether the business situation is good, and whether the location of the enterprise is Hainan. The basic steps of constructing decision tree based on Gini value are as follows (Table 2):

Decision Tree Decision List and Calculation of Gini Value:
Two samples are randomly selected from the data set D, and the probability of inconsistent category labels is obtained. Therefore, the smaller the Gini (D) value, the higher the purity of the data set D:

$$\text{Gini}(D) = \sum_{k=1}^{|y|} \sum_{k' \neq k} p_k p_{k'} = 1 - \sum_{k=1}^{|y|} p_k^2 \tag{1}$$

Table 2. Decision Tree Decision List

Whether the research direction is cryptography ? (X)	Bussiness Status(Y)	Whether the location is Hainan? (Z)	Preliminary selection or not(E)
Yes	Good	Yes	Yes
No	Bad	No	No
Yes	Good	No	Yes
Yes	Bad	No	No
No	Good	No	No
No	Bad	Yes	No

Based on the decision list of the decision tree and the Gini value formula, the Gini values of the four indicators are as follows:

$$\text{Gini}(E) = 1 - \left(\frac{2}{6}\right)^2 - \left(\frac{4}{6}\right)^2 = 0.444444 \tag{2}$$

$$\text{Gini}\{X\} = 0.444444 - \frac{4}{6} \times 0.444444 - 0 = 0.148148 \tag{3}$$

$$\text{Gini}\{Y\} = 0.444444 - \frac{4}{6} \times 0 - \frac{2}{6} \times 0.48 = 0.284444 \tag{4}$$

$$\text{Gini}\{Z\} = 0.444444 - \frac{4}{6} \times 0.375 - \frac{2}{6} \times 0.5 = 0.0277773 \tag{5}$$

Construction of Decision Tree Model:
We then sorted the Gini values of the different indicators and build our decision tree to get the results shown in Fig. 1 below to facilitate the initial screening of enterprises.

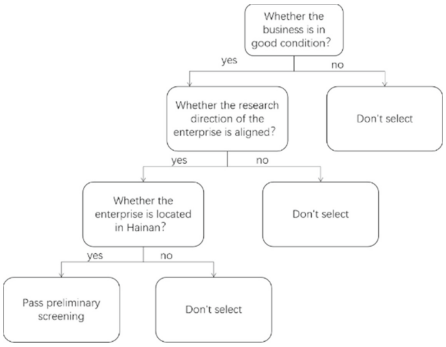

Fig. 1. Decision Tree Model

3.2 Determination of Evaluation Index Weight Based on Analytic Hierarchy Process

The comparison between many factors in the decision-making system often cannot be described in a quantitative way. At this time, semi-qualitative and semi-quantitative problems need to be transformed into quantitative calculation problems. Analytic Hierarchy Process is an effective method to solve such problems. The analytic hierarchy process layers the complex decision-making system, and provides a quantitative basis for analysis and final decision-making by comparing the importance of various related factors layer by layer. Because there are still few successful cases related to the school-enterprise joint cryptography laboratory, there is a lack of objective and accurate data. Therefore,

the analytic hierarchy model is established in the form of consulting experts, teachers and questionnaires to empower the indicators. The specific steps are as follows:

Constructing the Judgment Matrix of Each Level Index:
The indicators are shown in Table 1 above. The original matrix A can be expressed as shown in (6), and then the judgment matrix is confirmed according to the classical nine-digit:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{6}$$

Consistency Test of Judgment Matrix:
After constructing the judgment matrix, the consistency test is carried out to check whether the constructed matrix is too different from the consistency matrix:

The 1 step: calculate the consistency index

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{7}$$

Step 2: Find the corresponding average random consistency index RI.

n	1	2	3	4	5	6
RI	0	0	0.52	0.89	1.12	1.26
n	7	8	9	10	11	12
RI	1.36	1.41	1.46	1.49	1.52	1.54

Step 3: Calculate the consistency ratio CR.If $CR < 0.1$, it can be considered that the consistency of the judgment matrix is acceptable, otherwise the judgment matrix needs to be corrected until it passes the consistency test.

$$CR = \frac{CI}{RI} \tag{8}$$

Calculation of Index Weights:
In this paper, the arithmetic average method, the set average method and the eigenvalue method are used to solve the weights. Finally, the weights obtained by the three methods are averaged, so that the weights of the evaluation system are more accurate and reliable. The steps are as follows:

The first step is to use the arithmetic average method. The judgment matrix is normalized according to the column (each element is divided by the sum of its columns),

and the normalized columns are added (summed by rows). Finally, each element in the obtained vector is divided by n to obtain the weight vector.

$$w_i = \frac{1}{n}\sum_{j=1}^{n}\frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}}(i = 1, 2, \cdots, n) \tag{9}$$

The second step is to use the geometric average method for weight. The elements of A are multiplied by rows to get a new column direction. Each component of the new vector is multiplied by n times. Finally, the column vector is normalized to get the weight vector:

$$w_i = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}}}{\sum_{k=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{\frac{1}{n}}}(i = 1, 2, \cdots n) \tag{10}$$

The third step, eigenvalue method for weight. Find the Maximum Eigenvalue of Matrix A and Its Corresponding Eigenvector.Normalize the obtained feature vector to get our weight. Finally, the weights of the three methods are averaged, that is, our weights are obtained.

3.3 Comprehensive Evaluation Model for Evaluation

Fuzzy comprehensive evaluation is a very effective multi-factor decision-making method to make a comprehensive evaluation of things affected by many factors. Its characteristic is that the evaluation results are not absolutely positive or negative, but represented by a fuzzy set [8].

The first step is to divide the factor set, because our criterion layer has three factors, so $U = \{U_1, U_2, U_3\}$ The second step is to determine the alternative set, $V = \{1, 2, \cdots, n\}$, representing n enterprises together for selection.

The third step is to establish the following single factor evaluation matrix, and then calculate the membership degree of each factor.

$$R_i = \begin{bmatrix} r_{11}^{(i)} & r_{12}^{(i)} & r_{13}^{(i)} & \cdots & r_{1n}^{(i)} \\ r_{22}^{(i)} & r_{22}^{(i)} & r_{23}^{(i)} & \cdots & r_{25}^{(i)} \\ r_{31}^{(i)} & r_{32}^{(i)} & r_{33}^{(i)} & \cdots & r_{35}^{(i)} \\ r_{41}^{(i)} & r_{42}^{(i)} & r_{43}^{(i)} & \cdots & r_{45}^{(i)} \end{bmatrix} \tag{11}$$

Note: For quantitative indicators, there are specific data of enterprises. We normalize these data to obtain single factor evaluation value; for qualitative indicators, we through market research, consumer satisfaction as a single factor evaluation.

The fourth step, we combine R_i and corresponding weight comprehensive evaluation, it is concluded that U_i for V membership:

$$B_i = W_{ij} \times R_i(i = 1, 2, 3) \tag{12}$$

The fifth step, combined with the entropy weight method to determine the weight of the first level factors $U = \{U_1, U_2, U_3\}$ to make a comprehensive judgment:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} \tag{13}$$

$$B = W \times R \tag{14}$$

Finally, the best enterprise is determined according to the principle of maximum membership.

4 Calculation and Application of Cases

Taking Hainan University as an example, this paper collects the indicators of six enterprises. The professional teachers and relevant experts of the school evaluate the index evaluation value of each company.

Determine according to the classic nines, and combine with expert scoring to finally obtain the judgment matrix Table 3.

Table 3. Judgment matrix of indicators at all levels

A	B1	B2	B3		B1	C1	C2	C3	C4
B1	1	2	2		**C1**	1	1	2	1
B2	1/2	1	1		**C2**	1	1	2	1
B3	1/2	1	1		**C3**	1/2	1/2	1	1/2
					C4	1	1	2	1
B2	C5	C6	C7	C8	B3	C9	C10	C11	C12
C5	1	1	3	3	**C5**	1	3	1/2	1
C6	1	1	3	3	**C6**	1/3	1	1/6	1/3
C7	1/3	1/3	1	1	**C7**	2	6	1	2
C8	1/3	1/3	1	1	**C8**	1	3	1/2	1

After transforming and normalizing the original data, it can be obtained according to the calculation steps of the above analytic hierarchy process. [9].

The weights corresponding to each index, and through the consistency test, the weights are shown in Table 4.[10].

Then obtain the single factor evaluation value of the six enterprises as shown in Table 5.

Then, the membership degree of each index is obtained respectively, as shown below.

$$B_1 = W_1 \times R_1 = [0.1314, 0.1429, 0.1929, 0.2043, 0.1357, 0.1514] \tag{15}$$

Table 4. Index Weight Table

Evaluation indicators	Weight
B1	0.2384
B2	0.3808
B3	0.3808
C1	0.2857
C2	0.2857
C3	0.1429
C4	0.2857
C5	0.3750
C6	0.3750
C7	0.1250
C8	0.1250
C9	0.2308
C10	0.0769
C11	0.4615
C12	0.2308

Table 5. Single factor evaluation table

Factors	1	2	3	4	5	6
C1	0.12	0.18	0.17	0.23	0.13	0.17
C2	0.15	0.13	0.18	0.25	0.12	0.17
C3	0.14	0.14	0.15	0.15	0.15	0.14
C4	0.12	0.12	0.25	0.16	0.15	0.12
C5	0.16	0.15	0.16	0.16	0.25	0.25
C6	0.13	0.16	0.23	0.14	0.16	0.16
C7	0.12	0.14	0.13	0.20	0.14	0.23
C8	0.18	0.20	0.14	0.12	0.12	0.15
C9	0.15	0.12	0.20	0.16	0.14	0.13
C10	0.25	0.18	0.12	0.13	0.20	0.14
C11	0.16	0.17	0.12	0.12	0.12	0.14
C12	0.23	0.16	0.18	0.18	0.18	0.20

$$B_2 = W_2 \times R_2 = [0.1463, 0.1588, 0.1800, 0.1525, 0.1863, 0.2012] \quad (16)$$

$$B_3 = W_3 \times R_3 = [0.1808, 0.1569, 0.1523, 0.1438, 0.1446, 0.1515] \tag{17}$$

$$R = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \end{pmatrix} \tag{18}$$

$$B = A \times R = [0.1559, 0.1543, 0.1725, 0.1616, 0.1583, 0.1704] \tag{19}$$

From the above value of B, it can be concluded that the third enterprise has the highest degree of membership, so we should give priority to the third enterprise to achieve resource sharing and mutual benefit.

5 Conclusion

This paper studies the selection mechanism of school-enterprise joint construction laboratory, and puts forward a complete system for the current problem of how schools match the most suitable companies for cooperation, lacking a systematic and objective selection model. Combined with decision tree, analytic hierarchy process and fuzzy comprehensive evaluation method, the enterprises of cryptography laboratory co-constructed by school and enterprise are comprehensively analyzed and evaluated. Six enterprises taking Hainan University as an example are used to apply and analyze the cases, and the optimal cooperative enterprises are obtained, which overcomes the subjective and random selection methods and standardizes the selection mechanism. It provides a reference for the choice of joint venture between cryptology laboratory school and enterprise, and provides a basis for the development and construction of joint cryptology laboratory built by universities and enterprises to promote its promotion.

Acknowledgments. This work is partially supported by the Hainan Province Education and Teaching Research Found (Hnjg2022–23), the Science Project of Hainan University (KYQD(ZR)20021).

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