Design of a National Student Financial Aid System Based On Information Integration Technology and Fuzzy Comprehensive Evaluation

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Abstract

This paper puts forward problems and demands in China's student financial aid system, including information accuracy, information sharing, and fairness and justice in financial aid process. In order to solve these problems, a design framework of national student financial aid system is provided based on information integration technology and fuzzy comprehensive evaluation. According to the organizational structure, data process and business model, the design framework contains three levels of data centers and five levels of application systems. The internal and external data flows are exchanged and integrated by service bus platform. Then, in the school level systems, a fund qualification method based on fuzzy comprehensive evaluation is provided.

Keywords: *Student Financial Aid System, Information Integration, Fuzzy Comprehensive Evaluation, Enterprise Service Bus (ESB)*

1. Introduction

At present, in our country, there are not prefect and nationwide student management systems and high school student financials. Some provinces build absolute student management systems and student financial aid systems. The student information can not be shared among provinces and systems. On the one hand, from a macro point of view, the establishment of a unified national student financial aid system is an effective way to improve the education management level and to manage and regulate the financial aid process. On the other hand, from the micro point of view, it is a very important work to improve the financial aid systems in the school level. The accuracy and integrity of initial information which is collected, settled and managed by school level systems influence the effectiveness of the whole system. At the same time, the system also undertakes the core function which is aid qualification. At present, the common qualification methods are poverty proof method, horizontal comparison method, consumption level qualification method and lowest living security line method. There are some defects in these above methods. For example, information source is not complete, and qualification methods are subjectivity and blindness.

All in all, based on the analysis of current problems about student aid system, some key design requirements of this system are summarized as follows:

    (1)   Accuracy of information

Student financial aid system should share data with school systems and related systems of Ministry of Public Security and Ministry of Human Resources and Social Security, in order to ensure the accuracy and timeliness of student information.

  (2) Sharing of information

Systems in different provinces should share information. At the same time, systems in different education sections also should share information with each other.

  (3) Fairness and justice of student financial aid

Standardization and scientific of fund qualification methods are the key cores to ensure fairness and justice of student financial aid. Excessive interference of anthropogenic should be avoided.

In order to meet these demands, a design framework of national student financial aid system is provided based on information integration technology and fuzzy comprehensive evaluation. According to the organizational structure, data process and business model, the design framework contains three levels of data centers and five levels of application systems. The internal and external data flows are exchanged and integrated by service bus platform. Then, in the school level systems, a fund qualification method based on fuzzy comprehensive evaluation is provided.

2. Related Theory and Technology

2.1. System Theory in Management Science

System theory is a kind of fundamental view in philosophy, namely, overall view, universal relation and movement view. In the view of management science, organization is seemed as an organic with linked management businesses. Scholars of management science pay attention to the analysis on the structure and the application of system theory, research management activities and management processes, and establish system models as an important research method. These methods are provided by F. E. Kast, J. E. Rosenzing, R. A. Johnson and other American management experts[1][2], based on general system theory.

Student financial aid system can be regarded as an open socio-technical system with many subsystems, such as goal-value subsystem, technology subsystem, social psychology subsystem, organization structure subsystem and management subsystem. It is not a nonlife information system, but a integration system containing people, materials, and other resources under a certain target. At the same time, financial aid management is not an isolated case and financial aid system is not an isolated system. Present studies and solutions are limited to technology, while ignoring the structure error of the system.

2.2. Data Exchange Platform and ESB

Data exchange platform is a basic platform for information resources sharing. Data exchange platform can link information isolated islands, transfer data between interconnected heterogeneous systems, and share information between different systems, databases, LAN. It can integrate information and optimize services[3]. The architecture of
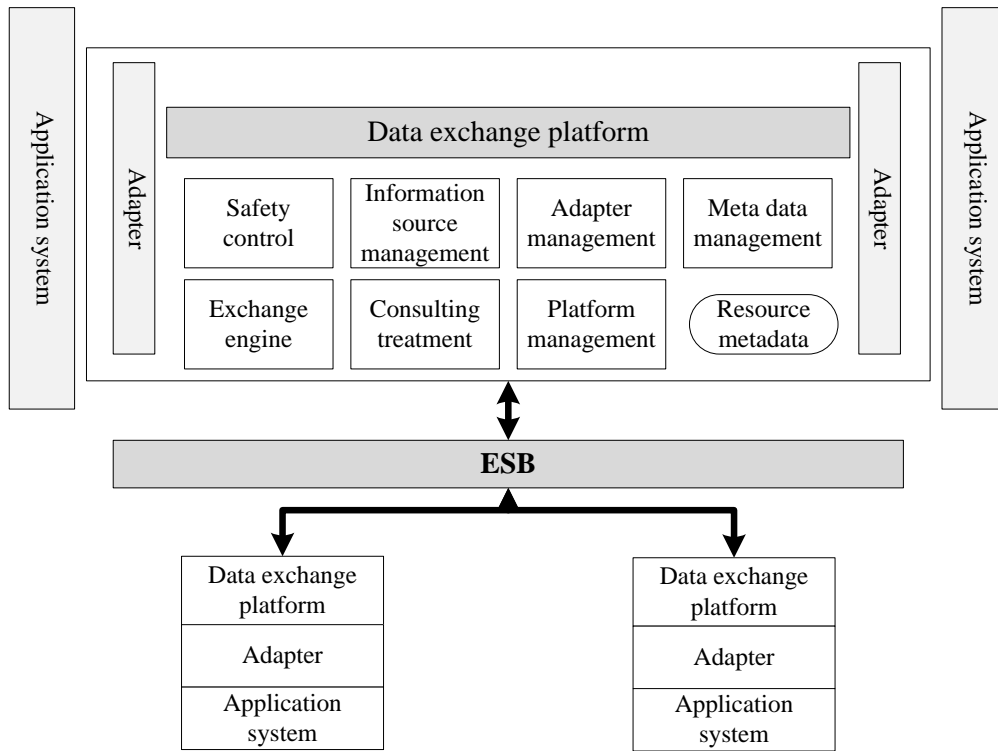

data exchange platform is shown in Figure 1.

Figure 1: The Architecture of Data Exchange Platform

Data exchange platform attempts to resolve the problem of data integration and sharing from the structure and realization mechanism, and Enterprise Service Bus (ESB) is the core of the technology. ESB is a set of basic architecture functions of Service Oriented Architecture (SOA), based on middleware technology. ESB provides a connection among new and existing software applications within enterprise and across enterprises [4]. The architecture of ESB is shown in Figure 2.
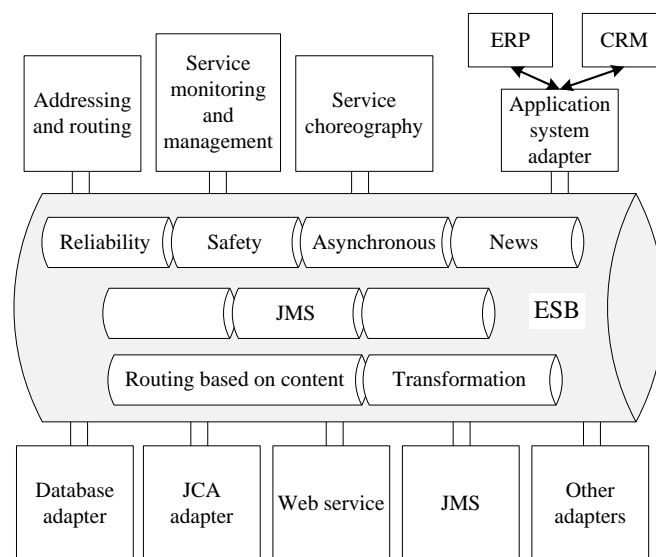

Figure 2: The Architecture of ESB

2.3 Fuzzy Comprehensive Evaluation

There is no clear boundary between poor students and other students. Poor student is a fuzzy concept, which can not be determined by simple "yes" or "no". Therefore, fuzzy comprehensive evaluation method is introduced to measure the poverty degree of students scientifically. Fuzzy comprehensive evaluation considers various factors based on the application of principles of fuzzy transform and maximum membership degree. It is a kind of system analysis method combined with qualitative and quantitative methods. The process of fuzzy comprehensive evaluation is shown in Figure 3.
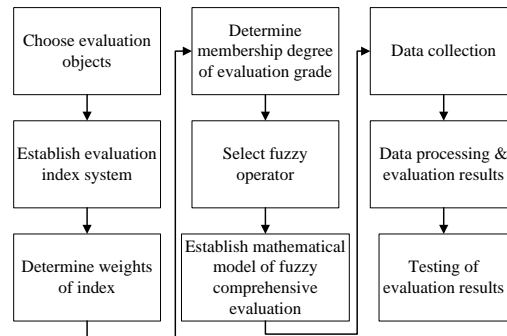

Figure 3: The Process of Fuzzy Comprehensive Evaluation

Specific process is as follows:

(1) Regard the evaluation target as a set of fuzzy composed of factors (factor set U);

(2) Set evaluation grades of these factors to constitute fuzzy set of comments (comment set V);

(3) Calculate the belonging degree of each single factor on the evaluation grade (fuzzy matrix);

(4) Get the evaluation quantitative solution by computing fuzzy matrix synthesis, according to the weight distribution of various factors on evaluation targets.

3. Analysis and Design of National Student Financial Aid System

3.1 Business Analysis and Business Models

(1) Organization model

The organizational structure of the national student financial aid system contains 5 levels from top to bottom—national student financial aid management center, provincial management center (including finance department), municipal management center (including finance department), county management center (including financial department), as well as school level. The organization model of national student aid system is as shown in Table 1.

Table 1: The Organization Model of National Student Aid System

Business personnel	Duty
National student financial aid management center	Implement national financial aid policies, manage financial aid business of feeder schools, and supervise and improve related works in all levels.
Provincial management center	Implement national and provincial financial aid policies, manage financial aid business of feeder schools, and supervise and improve related works in this province.
Municipal management center	Implement national and municipal financial aid policies, manage financial aid business of feeder schools, and supervise and improve related works in this city.
County management center	Manage financial aid business in this county, be responsible for collection, management and maintenance of student information.
School level	Manage financial aid business in this school, be responsible for collection, management and maintenance of student information.

(2) Basic data flow

The student financial aid database includes basic information of poor students, family economic status and poor grades. This information derives from student management databases in various education stages. After new students provide his family economic status and other related aid information, school submits financial aid qualification to student aid foundation database. Change of data must obtain a permission of superiors. Student financial aid data will be examined one by one, and then they are reported to the higher level. Basic data flow of student financial aid system is shown as Figure 4.
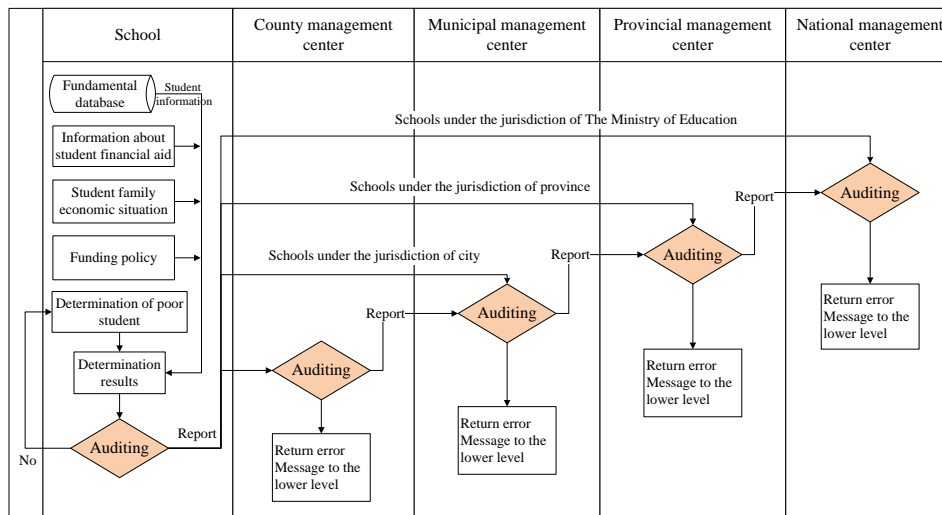

Figure 4: Basic Data Flow Of Student Financial Aid System

(3) Business models

Business models of student financial aid system can be described by a two-layer structure "process-activity". Each business process is composed of multiple business activities. Business process of student financial aid management can be divided into three parts — information management, business management and statistical analysis

management. Specific business activities of each business process are shown in Table 2.

Table 2: Business Models

Business process	Business activity
Information management of student financial aid	Define data standard of student financial aid information
	Collect students' family economic status
	Manage financial aid qualification
	Manage request of change of controlled field
	Manage financial aid history
Business management of student financial aid	Manage financial aid policy
	Manage Quota and budget
	Manage application for student financial aid
	Manage examination information
	Manage sources of funds
	Manage availabilities of capitals
	Manage funders list
	Manage release information of funds
	Manage student loan information
Statistical analysis management of student financial aid	Count sharing ratio of capital
	Count implementation of capital
	Count usage of capital
	Count financial aid information
	Count personnel changes of students
	Count financial aid information by household register
	Count financial aid information by sources
	Count financial aid information by grade
	Count financial aid information by ethnic
	Count financial aid information by age
	Count financial aid information by gender
	…

3.2 System Architecture

In general, student financial aid system architecture contains four levels of data centers and five levels of application systems. The four levels of data centers contains national data center, provincial data center, municipal data center, and county data center. The five levels of application systems contains national application system, provincial application system, municipal application system, county application system and school application system. Among them, high school student financial aid system is constituted by three levels of data centers and five levels of application systems. National and provincial high school student financial aid systems should be centered on, and municipal and county systems should be built according to the actual situation. System architecture is shown as Figure 5.
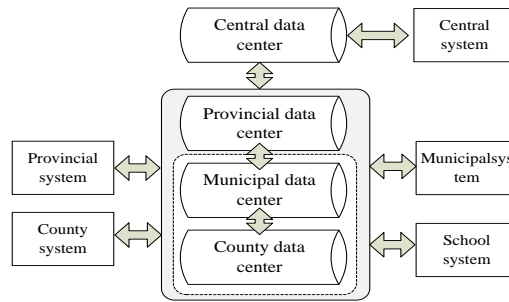
Figure 5: System Architecture of High School Student Financial Aid System

High school student financial aid system must share information with student, school, teacher management system, and exchange data with basic education, vocational education, higher education and other basic information databases which are distributed in different geographic locations and different departments. Therefore, data exchange platform technology is necessary. This technology can control the complex interactive data by unified news service, and solve the data transmission problem of various data exchange processes by unified management mechanisms and technical standards. The data architecture of high school student financial aid system based on data exchange platform is shown as Figure 6.
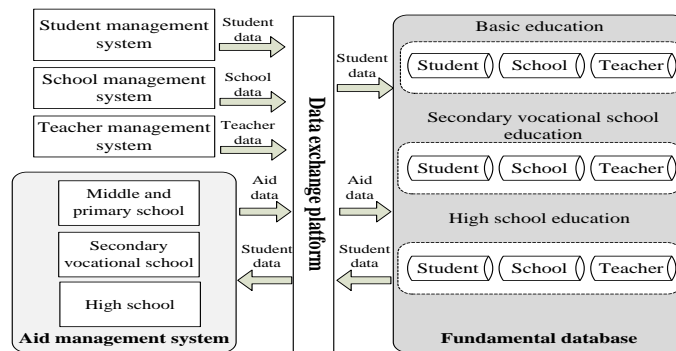

Figure 6: The Data Architecture of High School Student Financial Aid System Based On Data Exchange Platform

In reality, educational systems may have been established in different exchange platforms. Therefore, ESB can integrate them into a whole logical system. Figure 7 shows the data sharing based on ESB.
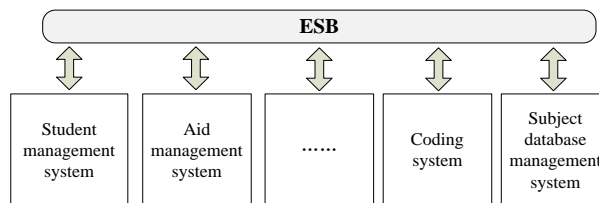

Figure 7: Data Sharing Based On ESB

3.3 Analysis on Internal Data Flow

In the education internal systems, "three data sharing" should be achieved. Firstly, student data should be shared from preschool education to higher education. Student information should be tracked to avoid multiple registrations. Secondly, financial aid data should be shared from preschool education to higher education. Family economic status of students should be tracked to maintain the continuity of financial aid and to avoid multiple financial aid. Thirdly, student data and financial aid data should be shared to ensure that only students who have official schools can get financial aid.

The national student financial aid management information system includes four parts—preschool education financial aid system, compulsory education and ordinary high school financial aid system, secondary vocational school financial aid system, and college student financial aid management system. All the systems are based on data of school systems, and log data of financial aid into foundation database. Internal data flows in education systems are shown in Figure 8.
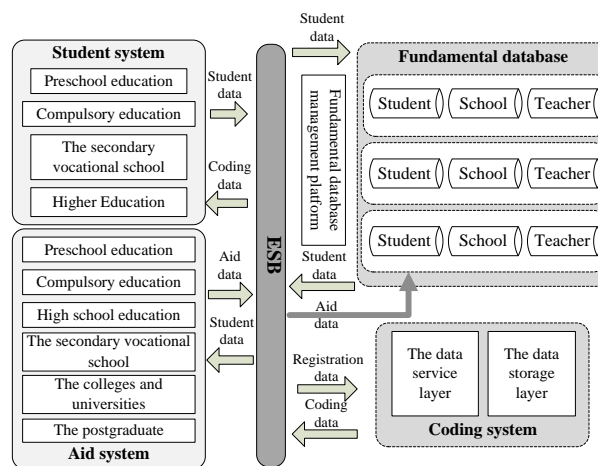

Figure 8: Internal Data Flows in Education Systems

Data flows among school, county, city, province, nation levels can be divided into two types—capital flow and data flow.

(1) Capital flow

The Ministry of Education and the Ministry of Finance issue quota allocation and budget of finance aid to central competent departments. Central competent departments issue quota allocation and budget of finance aid to provincial education and finance departments and schools at the same level. Provincial competent departments issue quota allocation and budget of finance aid to municipal education and finance departments and schools at the same level. Municipal competent departments issue quota allocation and budget of finance aid to county finance departments. County finance departments issue quota allocation to schools.

(2) Data flow

After new students provide his family economic status and other related aid information, schools submit financial aid qualification to student aid foundation database.

Then, schools post application results. The aid application lists are reported to the superior departments. Finally they are reported to the central level department. Data flows are shown as Figure 9.
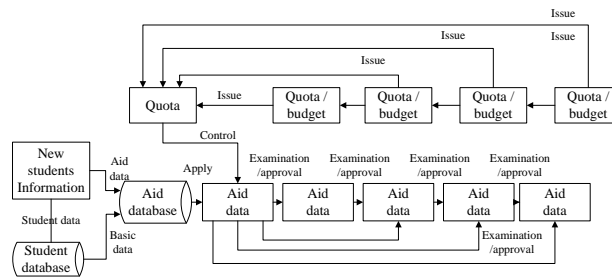

Figure 9: Data Flows of Student Financial Aid System

3.4 Analysis on External Data Flow

National student financial aid system does not only share data with The Ministry of Education and management departments in all levels, but also link to Ministry of Public Security, banks, tax and customs etc., namely six "docking". Firstly, national student financial aid system must dock to the authentication information management system of Ministry of Public Security to avoid false registration. Secondly, national student financial aid system must dock to student management information system of mechanic colleges of Ministry of Human Resources and Social Security to avoid false registration. Thirdly, national student financial aid system must dock to bank system to track the aid progress. Fourthly, national student financial aid system must dock to the tax, social security and other departments to acquire information about family income and employment of funded students. Fifthly, the system has to dock to customs and local government and education department. The external data flows are shown in Figure 10.
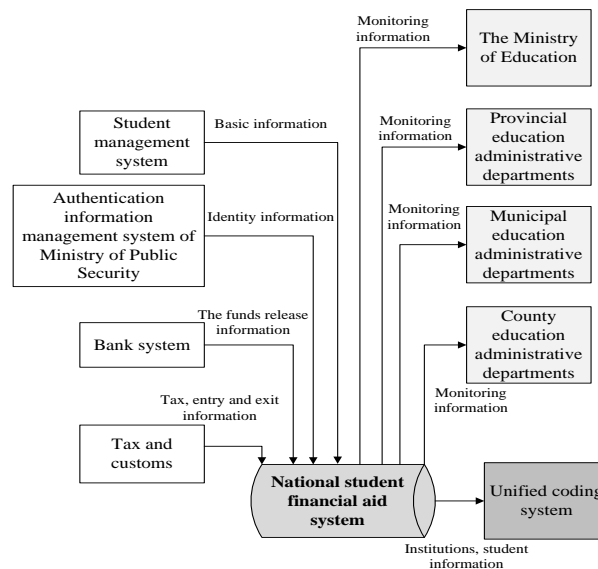

Figure 10: The External Data Flows among Other Systems

4. Aid Qualification Based on Fuzzy Comprehensive Evaluation

4.1 Evaluation Factors, Evaluation Content and Index Weights

The index system of the fuzzy comprehensive evaluation in national student financial aid system contains three levels, $U=\{u_1, u_2, u_3, \ldots\}$, $u_1=\{u_{11}, u_{12}, u_{13}, \ldots\}$, $u_2=\{u_{21}, u_{22}, u_{23}, \ldots\}$, $\ldots$ A set of comments $V=\{V_1, V_2, V_3, V_4\}=\{$special poverty, poverty, poverty, non poverty$\}$. How to determine the weight of fuzzy comprehensive evaluation directly affects the evaluation results. Methods to determine weights of index are Delphi method and AHP (The Analytic Hierarchy Process) etc.[5]. Because of the particularity of student financial aid system, Delphi is adopted to determined the weight of each index. Index set is $U=\{u_1, u_2, u_3, \ldots\}$, and corresponding weight set is $W=\{w_1, w2, w3, \ldots\}$ ($\sum_{i=1}^{m} w_i = 1$).

4.2 Membership Matrix

Membership matrix is a kind of intermediate to describe differences, and is an approximation from accuracy to fuzzy[6]. Its mathematical description: A is a fuzzy subset of domain U, and for any $x \in u$, assign a corresponding real number $f(x) \in (0, l)$, which is called degree of membership of U to A. Assume the single factor evaluation comment of u_i is V_j, fuzzy vector is $R_j=(r_{i1}, r_{i2}, \ldots, r_{im})$, $i=1,2,\ldots,m; j=1,2,\ldots,n$. Assume r_{ij} is the degree of membership of u_i to v_j ($0 \leq r_{ij} \leq 1$). If the comprehensive evaluation is carried out on N elements, the result is a matrix with n rows and m columns, which is the membership matrix R_k.

$$R_k = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nn} \end{bmatrix}$$

Each row of the matrix is a evaluation result to a single factor, and the whole matrix contains all information about evaluation results from set V to set U. Assign a weight w_i ($i=1,2,\ldots,m$) to each index u_i ($i=1,2,\ldots,m$), which is called degree of membership of u_i to w.

$$w = \frac{w_1}{u_1} + \frac{w_2}{u_2} + \cdots + \frac{w_m}{u_m}$$

4.3 Fuzzy Evaluation Matrix

Using the fuzzy vector w to synthesize evaluations of different things, we can get the membership degree of evaluated things to all grades of fuzzy subsets, which is called fuzzy comprehensive evaluation vector B.

The principle of hierarchical fuzzy comprehensive evaluation is as follows.

(1) Fuzzy comprehensive evaluation is carried out according to fuzzy matrix constructed by bottom factor set and evaluation set.

(2) Weight according to corresponding weight of factor set.

(3) Comprehensive evaluation is carried out until the highest level.

(4) Get the final evaluation results.

Firstly, single factor evaluation of first grade indexes to i second grade indexes is carried out, and fuzzy mapping $f_i \rightarrow T(V)$ is built and a single factor evaluation matrix $\boldsymbol{R}_i$ is got. Each u_i is regarded as a factor, and $U=\{ u_1, u_2, u_3, \ldots \}$. Then is a factor set, and the single factor evaluation matrix is as follow[7].

$$B_j = \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_s \end{bmatrix} = \begin{bmatrix} b_{11} b_{12} & \ldots & b_{1m} \\ b_{21} b_{22} & \ldots & b_{2m} \\ \vdots \quad \vdots & \ddots & \vdots \\ b_{s1} b_{s2} & \ldots & b_{sm} \end{bmatrix}$$

Secondly, fuzzy evaluation matrix $\boldsymbol{R}$ is built which reflects the fuzzy relations between main factor set U and evaluation set V. Each u_i has a weight, $\boldsymbol{W}=\{ w_1, w_2, w_3, \ldots, w_n \}$. Assume comprehensive evaluation matrix of first grade indexes is $\boldsymbol{B}_i$, and the evaluation results is $\boldsymbol{B}_i=\boldsymbol{W}_i \cdot \boldsymbol{R}_i$, ($i=1, 2, 3, 4$). Then, the comprehensive evaluation vector of second grade indexes is as follow.

$$\boldsymbol{B}=\boldsymbol{W} \cdot \boldsymbol{R}= (b_1, b_2,\ldots,b_m)$$

Normalization of $\boldsymbol{B}$ is carried out, then get $\sum_{j=1} b_j = 1$.

4.4 Calculation of the Comprehensive Evaluation Value

The maximum membership degree method, fuzzy distribution method and weighted average method all can be used to deal with the evaluation results. Generally, the component of the above comprehensive evaluation results is a set of decimal numbers. Each element of this vector is multiplied by 100%, and a group of percentage numbers is got, which reflects the percentage of the numbers of students in "special poverty, poverty, poverty, non poverty". In practical application, each grade in evaluation set is reflected by a corresponding number. Hence, assign values to the evaluation set by median method, and a evaluation grade vector $\boldsymbol{C}= (90, 80, 70, 60)$ is got. According to the standard scores of the evaluation set, weighted average is carried out with elements in $\boldsymbol{Z}$ as the weights, and gets the quantitative scores of poor students which reflect the poverty of students. If comment scores at all levels respectively are $V(E_1)=90$, $V(E_2)=80$, $V(E_3)=70$, $V(E_4)=60$, the total scores are $V=z_1 \times V(E_1) + z_2 \times V(E_2)+z_3 \times V(E_3)+z_4 \times V(E_4)$.

5. Conclusion

In this paper, some key design requirements about student aid system are summarized, such as the accuracy of information, the sharing of information, and the fairness and justice of student financial aid. In order to meet these demands, a design framework of national student financial aid system is provided based on information integration technology and fuzzy comprehensive evaluation. According to the organizational structure, data process and business model, the design framework contains three levels of data centers and five levels of application systems. The internal and external data flows are exchanged and integrated by service bus platform. Then, in the school level systems, a fund qualification method based on fuzzy comprehensive evaluation is provided.

Student financial aid system is not only a information system, but also an open,

integrated system constituted by people, materials, and other resources with common goals. In essence, it is an optimization process of management structure. According to the theory of system, the study should not be limited in technology, but should focus on the overall structure of the problem. This paper builds a huge structure covering various regions of the country from a macro perspective, and it has both good theoretical and practical value.

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