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Constructing a decision support system for management of employee turnover risk

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Abstract In the time of knowledge economy, competency among enterprises is focused on the competency of human resources. Employee turnover risk is becoming an important facet influencing the stability and development of enterprises. After analyzing employee turnover risk factors that could threaten enterprise production and operations, we proposed a multi-level model of the evaluation system for employee turnover risk based on the analysis of factors influencing employee turnover risk. A decision support system is proposed for employee turnover risk management using message processing mechanisms and software combination technology and system integration. Data, information and knowledge needed in the system come from enterprises' internal application systems and external systems. The structure and components of the system which is based on Web Services are presented. We also proposed an analytic system based on knowledge management. At last, strategies to effectively manage employee turnover risk are proposed.

Keywords Decision support system · Employee turnover risk · Enterprise management · Knowledge management · Self-learning mechanism

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1 Introduction

As E-Business continues to grow, information technology (IT) becomes a very important tool in a dynamically changing business environment [24]. Enterprises are increasingly exploring theoretical and practical options to support strategic decisions [25, 26].

Information systems are one of the most useful tools on which enterprises depend to aid in decision-making [9, 22, 28, 51]. They have developed from the early electronic data processing to management information systems to the current decision support systems. In the 1960s, the majority of information systems were transaction processing systems for operation level management. After that, management information systems concept was conceived and focused on providing mid-level management with predefined reports that would give them the managerial support they needed for tactical decision making [40]. In the 1970s, the concept of decision support systems was proposed. Scholars in DSS including Keen, Morton, Sprague, and Whinston developed the concept as well as the academic discipline [17]. The birth of model-oriented DSS marks the beginning of information systems specifically designed for upper level management [40].

Given the growing complexity and uncertainty in many decision situations, managers are in urgent need of help to

support their decision-making processes. Many researchers and management scientists have investigated this topic from various perspectives and begun to understand the behavioral and technical challenges of designing, developing and implementing effective decision support systems [10–12, 14, 30].

Great progress has been made in both DSS theory and practice since the 1980s. Through integration with networking technology, artificial intelligence, and enterprise information systems, various types of DSS, such as distributed decision support systems (DDSS), intelligent decision support systems (IDSS), and integrated decision support systems (IDSS), have been developed [29, 39, 45, 50, 52, 54]. The concept of executive information systems (EIS) was developed because most corporate executives did not directly use the analytical capabilities of DSS. On-line analytical processing (OLAP) can be considered an extension of DSS. The goal of OLAP is to provide subject-oriented, multidimensional, ad-hoc decision support to upper level management. In the mid-1990s, web-based DSS also became an active research field [36, 40, 55].

Models in DSS should provide a simplified representation of a situation that is understandable to a decision maker. The general types of quantitative models used in DSS include algebraic and differential equation models, various decision analysis tools including analytical hierarchy processes, decision matrices and decision trees, multi-attribute and multi-criteria models, forecasting models, network and optimization models, Monte Carlo and discrete event simulation models, and quantitative behavioral models for multi-agent simulations [13, 48, 56, 57]. Today, complex techniques like decision analysis, mathematical programming, and simulation are increasingly being used to build DSS [30, 47].

Decision support systems have been designed to solve many problems in human resource management (HRM). Employee turnover risk is one of the major problems in HRM [23, 49, 58]. Employee turnover risk is the probability of loss from an employee's turnover in an enterprise. In the time of knowledge economy, people play an increasingly important role in enterprises. Business employees' capabilities, skills and intelligence are critical factors for business success [38]. To a great extent the competency of an enterprise is based on the competency of human resources.

The employee turnover in enterprises causes serious losses of intangible assets while, at the same time, weakening cohesiveness and personnel morality, which has a great influence on enterprise competency. In fact, the problem of employee turnover is becoming an important cause influencing the stability and development of enterprises [35] and should not be ignored or underestimated. If the employee turnover risk cannot be managed effectively, the organization will be left in a very weak position. Enterprises must find out the potential employee turnover risk factors that could threaten their production and operation activities in order to develop corresponding management strategies and make smart decisions to manage that risk effectively [41]. With the development of information technology especially the development of data warehouses (DW), on-line analytical processing and data-mining (DM), we now have the capability to construct decision support systems to deal with employee turnover risk effectively [8, 20, 21].

This paper is organized as follows: Sect. 1 briefly summarizes the prior research and development of DSS. The basic concepts associated with decision support systems and employee turnover risks are also introduced. Section 2 begins with a description of employee turnover risk factors, followed by the analyses of these factors. Specifically it suggests a hierarchical structure and creates a four-level index system model of employee turnover risk. Section 3 focuses on the construction of DSS for employee turnover risk management. After analyzing the problems in building the DSS, we proposed some methods to solve the problems and presented components included for the DSS model. Then we explained the integration of heterogeneous data and the requirements of data integration and analyzed the analytic system (AS) learning mechanism [59]. Section 4 discusses strategies to deal with employee turnover risk, such as strengthening human resources information management, making use of advanced incentives, and establishing constructive corporate culture. The final section summarizes the analysis and reviews the paper with some thoughts on DSS construction for employee turnover risk management.

2 Analysis of employee turnover risk factors

With keen market competition, enterprises have progressively realized that human resources are one of the most important aspects of their key competency. Employee turnover risk is one of the most serious problems that could threaten the stability and development of enterprises.

Thus, potential employee turnover risk factors must be researched and analyzed. We need to evaluate the risk and make scientific decisions to effectively manage the risk.

2.1 The influencing factors of employee turnover

Employee turnover risk factors mainly come from outside enterprise conditions, inside enterprise conditions and employee conditions [31]. These factors have impacts on employees' ideas of choosing jobs, and thus influence their decisions to turnover. The influencing factors of employee turnover are as follows (see Fig. 1):

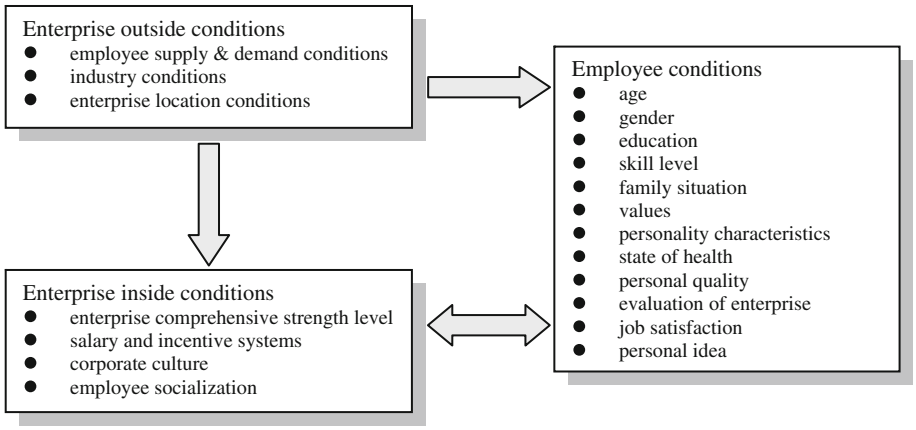

Fig. 1 Environmental factors of employee turnover risk

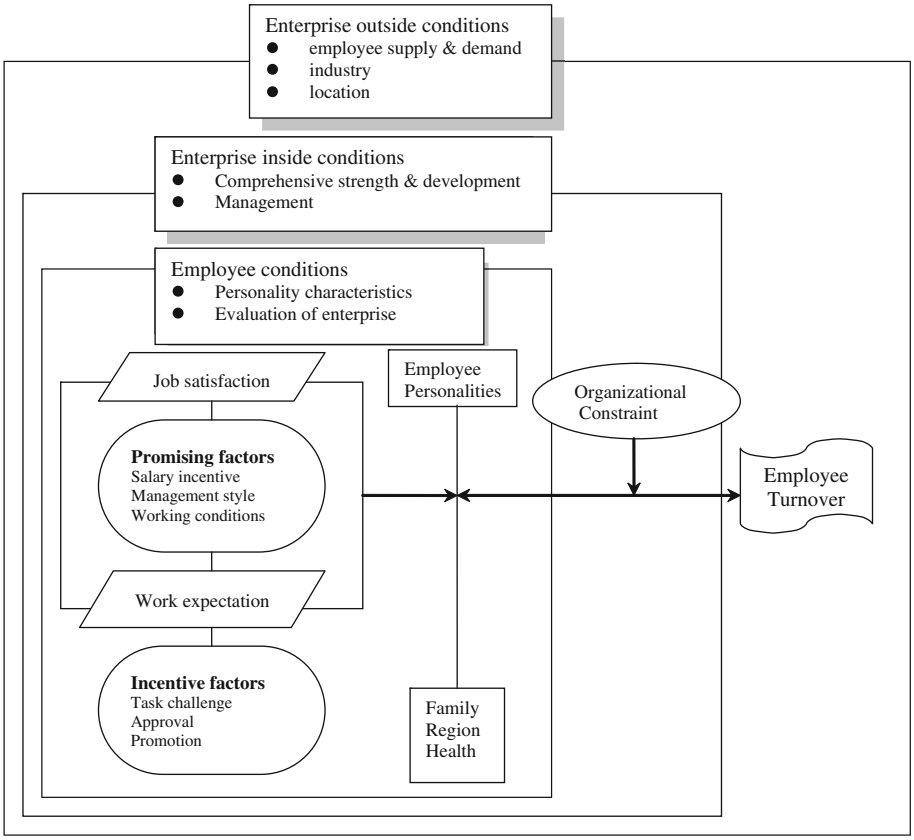

Fig. 2 Illustration of employee turnover factors

By combining work motivation theory and interactions between all the influencing factors, and then analyzing the outside enterprise conditions, inside enterprise conditions and employee conditions comprehensively, a model of factors influencing employee turnover is constructed (see Fig. 2).

Outside enterprise conditions are factors related to general economic development, policies, laws and regulations. These conditions act on enterprise development and management directly and affect employees' ideas of choosing jobs. At the same time, inside enterprise conditions and employee conditions affect and act on each other.

2.2 Hierarchical analysis on employee turnover risk factors

According to the above analysis of employee turnover factors, a hierarchical index model of employee turnover risk was built. Some of the indices can be obtained from statistics, and some can only be obtained through professional evaluation methods [31].

The employee turnover risk index model should meet the need to evaluate the risk of employee turnover in order to carry out the overall evaluation on employee turnover risk from a multi-layer viewpoint. By comprehensively

analyzing outside enterprise conditions, inside enterprise conditions and employee conditions, a hierarchical model of analyzing factors influencing employee turnover was constructed.

Employee turnover risk evaluation is the basis for enterprise management of employee turnover risk. Employee turnover risk evaluation means to evaluate the risk factors and to help construct the system of employee turnover risk factors through identifying the influence levels and importance of each factor. Employee turnover risk evaluation aims to provide a basis for effective employee turnover risk management in enterprises. It is not only useful for determining enterprise strategies and their applications but also beneficial to human resource management and enterprise culture building.

The construction of evaluation model is a key part of employee turnover risk evaluation. It is important to the validity and veracity of evaluation result. Thus, research on the risk evaluation model's construction process, construction techniques and methods is of great significance.

Our employee turnover risk evaluation model divides the risk factors into different groups. There are four levels altogether (see Fig. 3) when considering each group as one level.

The highest level of the employee turnover risk evaluation model was named the integrated index level, which expresses the situation of employee turnover risk in enterprises. It presents a comprehensive effect of all the indices.

The second level is the macro-index level. It divides the target information into evaluation index collections. The macro-index includes three types: outside enterprise index, inside enterprise index and employee index.

The third level is the micro-index level, which is more detailed than the macro-index. The three types are the following:

- Outside enterprise index mainly includes employee supply and demand conditions, industry conditions, and enterprise location conditions.
- Inside enterprise index mainly includes enterprise comprehensive strength level, enterprise management conditions and enterprise development prospects. Furthermore, enterprise management condition index includes salary and incentive systems, corporate culture, employee socialization, leader quality, etc.
- Employee index mainly includes evaluations of the enterprise and employee personality indices. The former includes job satisfaction and confidence in enterprise prospects. The latter includes personal ideals and values, personality characteristics, the family situation, the state of health, etc.

The fourth level is the enterprise case level, which means different estimations of each level index of employee turnover risk factors in accordance with each enterprise's specific situation. Thus, enterprises may make different uses of the employee turnover risk index depending on their situations.

According to the above analysis, the employee turnover risk evaluation model can turn the qualitative descriptions of employee turnover risk into a hierarchical structure,

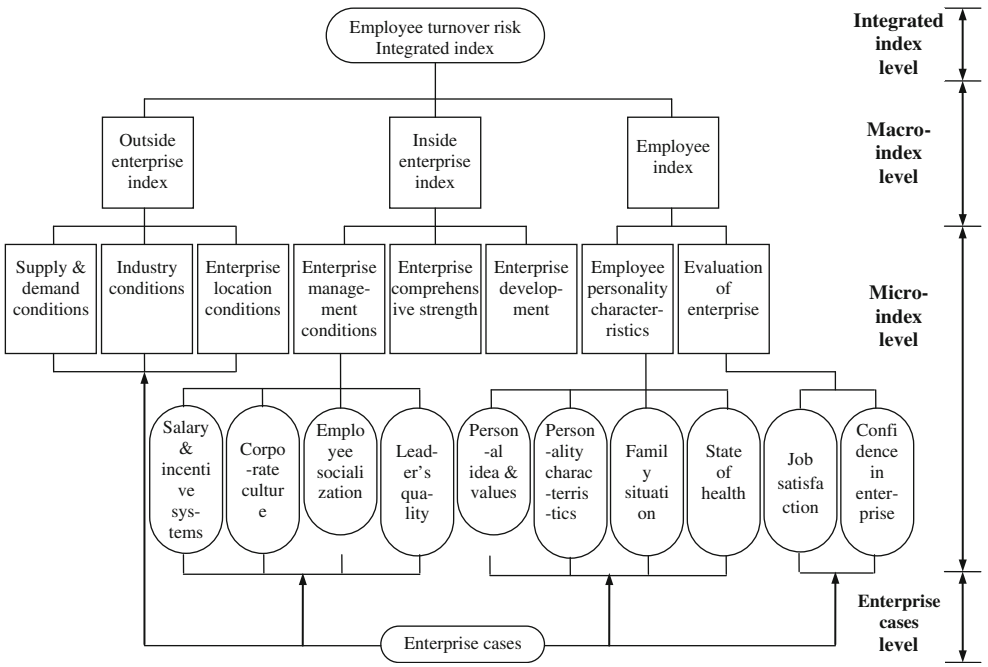

Fig. 3 Hierarchical index model of employee turnover risk

which has clear cut levels and is easier to manage. Thus, we can act on the evaluation of employee turnover risk with a well-defined objective in mind.

3 Structure of decision support system for employee turnover risk management

Decision support systems (DSSs) are supporting tools used by decision makers primarily for semi-structured and unstructured problems [15]. Traditional DSS is static (passive) in the sense that it operates on standardized or well-defined input data using a pre-programmed set of routines and responds only to a pre-specified set of inputs from the user [1]. However, most real world decision-making environments are not static. Active DSSs are proactive and are able to deal with complex, unstructured decision-making situations that involve ambiguities. DSS tools span the entire spectrum from simple tools aiding in ''what-if?'' analyses to complex knowledge-based tools that can be used to automate systems [43, 44].

Decision support systems can help managers make better decisions. Decision support systems of employee turnover risk are related to many technologies and application systems (i.e. data warehouses, data analysis, data-mining, data display, and system interfaces) [27]. Through exchange with systems that include human resource information, decision support systems of employee turnover risk management use databases and Knowledge Warehouses (KW) to provide the traditional inquiry and report functions [53]. They can do multi-dimensional data analysis and data-mining based on subject-oriented integration data built by DW. Through all kinds of algorithms and models, decision support systems can provide decision-makers with analytical reports on employee turnover risk and help settle on a plan.

There are five parts in this section. In the first sub-section, we analyze problems of building the DSS for employee turnover risk management and give some methods to solve them. In the second sub-section, a decision support system model of employee turnover risk is constructed, and the components of the model are presented. The third and the fourth sub-sections explain the integration of heterogeneous data and the requirements of data integration, respectively. In the fifth sub-section, we analyze the AS learning mechanism and how it works effectively.

3.1 Methods to solve the problems of DSS for employee turnover risk management

Employee turnover risk factors mainly come from outside enterprise conditions, inside enterprise conditions and employee conditions. Relevant data, information and knowledge reside in many information systems, both inside and outside the enterprise, i.e. human resource management information systems (HRMS), career planning systems, office automation (OA), national or departmental information systems, and even ERP, SCM and CRM systems [3]. Thus, information exchange between decision support systems of employee turnover risk and the systems mentioned above is required.

Because of the development process of information technology itself, many enterprises' internal information systems were supplied by other companies, operating independently and using different information technology. These systems acted like many "solitary islands" inside the enterprises, and there was little information communication and sharing between them. Thus, construction of decision support systems of employee turnover risk needs to solve the two major problems: communication and sharing with both external and internal information systems.

On one hand, a decision support system of employee turnover risk management is integrated with other enterprise functions through information systems. Data and information may communicate dynamically and automatically through the integrated system and will make resource sharing a reality on the data and functions level.

On the other hand, we can improve the functions of transforming data into information and then transferring information into knowledge. We can also use advanced information technology to solve problems of data and information collection for human resource management decisions.

DSS of employee turnover risk management need to make use of all kinds of models and algorithms, computing and simulating test cases for the forecasting purpose. Many of the models and algorithms are independent and based on different tools and different circumstances. Due to the lack a suitable mechanism to integrate and compare the models and algorithms, DSSs often have the following shortcomings:

- Decision makers found it hard to compare the results between each model and algorithm.
- If the restraint conditions of each model and algorithm were the same as the ones transferred from the database or data warehouse, there was no way to judge them directly.
- Some universal methods for models or algorithms could not be transferred for practical purpose.
- Intermediate results, comprehensive information or algorithm results of other models and algorithms in the database or data warehouse were slow to be shared.

The development of information technology has provided a feasible method for the construction of decision support systems of employee turnover risk. Internet technology based on Web Services has been integrating

information resources into a shared, mutual-operated, framework-unified, flexible and dynamic expanding system [18, 19]. For example, EXtensible Markup Language (XML) can facilitate interoperability of DSS developed on different platforms with different models, data and software environments.

Web Services are reusable application components that dynamically interact with each other using standard protocols over the Internet. If appropriate XML implementations are created for DSS, then it is also possible to employ simple object access protocol (SOAP) and Universal Discovery Description and Integration (UDDI) to publicize and reuse model components (data, models, solutions, or presentation mechanisms) to implement the best model or models. SOAP is a protocol for the exchange of information in a decentralized, distributed environment. It is an industry-standard message format that enables message-based communications for Web Services. UDDI is a directory of Web Services. The Web Services Description Language (WSDL) is an XML format for describing a Web Service [18, 42]. Essentially, it describes the operations (methods) a service provides, details of the data formats and necessary protocols, and the details of protocol-specific network addresses (URL).

Web Services mainly aim to build a universal technology level that has nothing to do with platforms and languages, based on the present heterogeneous platforms. Information techniques based on Web Services provide good mechanisms for cross-platform data exchange and sharing by message passing, service search and collaboration [2, 6]. The applications on all the different platforms depend on the technique layer to connect and integrate with each other.

A system based on Web Services integrates various information resources so that all the information can be shared [5]. The development of Web Services provides new theoretical methods for constructing and improving the DSS of employee turnover risk management. It also reduces the cost of the whole system.

In the protocol stacks of Web Services, the definitions of data, messages, services and registries are included. Some specific standard technologies, such as XML, SOAP, WSDL, and UDDI are also discussed. XML is used to describe data from different layers so that data and messages from different platforms and environments can be transferred [3]. SOAP is used for exchanging messages in XML. WSDL is used to describe services universally. UDDI, working with WSDL and SOAP to manage Web Services, provides a unified architecture and interface for programming, publishing and providing discovering services [33].

In order to improve the performance of decision support systems of employee turnover risk management, an Analytic System (AS) is constructed according to the practices of management based Web Services. AS provides decision-maker optimized solutions that are rational, effective and scientific [37].

3.2 Components of the DSS model of employee turnover risk management

The DSS of employee turnover risk management, which is platform-free and improves the interoperability of heterogeneous systems, is a comprehensive system composed of message processing mechanisms, software combination technology and system integration. Data, information and knowledge the system needs come from enterprise internal application systems and external systems. A DSS model for employee turnover risk management is constructed (see Fig. 4).

DSS of employee turnover risk management integrate all the internal and external enterprise information systems into a comprehensive whole using information techniques. They may obtain considerably stable data, information, knowledge and many functions of information systems, thus providing a basis for employee turnover risk identification, evaluation and management.

The model is mainly composed of three sub-systems: Data Base Management System (DBMS), Model Base Management System (MBMS) and Dialogue Management System (DMS). The model has seven components: Platforms, Database systems, Data warehouses, Data-mining systems, Algorithms & models systems, Knowledge warehouse systems, Analytic systems and Client interfaces (see Table 1).

3.3 Integration of heterogeneous data

As different enterprises are in the different phases of information construction, they may store their data about production and operation in different formats with different data management systems (from simple files to complicated net databases) and different storage. This causes heterogeneous data [59].

The existing data satisfy the current users of separate systems but do not necessarily meet the need of corporation users who often want to be aware of all the existing data in different formats. Thus, a distributed application system, built upon the heterogeneous data, is necessary [5]. Additionally, with cloud technology, enterprises can take advantage of more facilities and information, while at the same time greatly reducing operating costs. Hence, enterprises are exposed to a trend where a distributed application system becomes even more important [53].

Based on the practices of data warehousing, heterogeneous data is added to an integrated database by

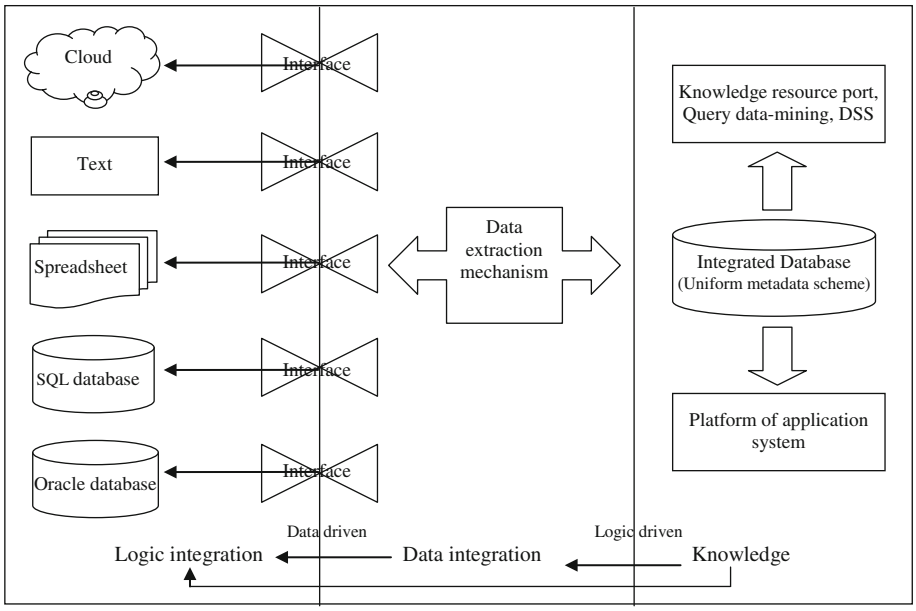

Fig. 4 Integration of heterogeneous data

Table 1 Components of DSS for employee turnover risk management

Type	Contents and functions
Platforms	Include hardware platforms, i.e. internet systems, computers, memory systems, fire walls, etc., and software platforms, i.e. operating systems
Database systems	To deposit enterprise internal and external information, i.e. on-job employee information, off-job employee information, employee dynamic performance information and employee supply & demand information in the same industry
Data warehouses	To deposit risk-oriented comprehensive information
Data-mining systems	To obtain effective and scientific data, information or knowledge through various algorithms for decision making
Algorithms and models systems	Includes algorithms & models warehouses, systems and algorithms & models exploitation tools
Knowledge warehouse systems	Includes knowledge warehouses and knowledge management systems
Analytic systems	Directly related with DM, DW, KW and Model Exploitation Tools
Client interfaces	To execute human–computer interaction functions in order to communicate with the above systems

exchanging access technology. The architecture consists of three segments, which are the logic operation layer, the data extraction layer and the knowledge layer.

In order to meet the requirements of heterogeneous data integration, data warehouse technology and data extraction tools are used often to integrate heterogeneous databases and heterogeneous types of files, such as text, spreadsheets, as well as unstructured information on the web. This is done among the logic operation layer and data extraction layer to satisfy the constraint of logic operation layer and data extraction layer [33, 45, 55].

At the data extraction layer, based on the pertinent data formats, the data extraction mechanism adapts to these formats easily by switching to different situations extracted from the formats. An independent data transforming code secondary development is executed to collect raw data, clean wrong data, integrate heterogeneous data, transform data structures and refresh data periodically.

At the knowledge layer, the platforms of application systems and knowledge resources are based on the integrated database with a uniform metadata scheme.

3.4 The requirements of data integration

The aim of integrating heterogeneous data is to provide unified, safe, and timely information for system applications to meet the requirements of queries, data mining and decision making. Therefore, integrated data has to have integrity and security in data access.

1. *Integrated*: After the integration of separate information from different isolated systems, queries can be uniformly executed in a data warehouse that integrates various data, without accessing each isolated system. Data is no longer stored separately in each database.
2. *Integrity*: Integrity refers to the data integrity and restriction integrity. Data integrity refers to extracting data without loss, while restriction integrity means

preserving the relationship between different data, which is the only way to present the logic of data. Restriction integrity is the basis for data publication and exchange and can improve both processing and efficiency.

3. *Consistency*: Different information differs semantically and causes all kinds of incomplete and wrong information. From name to structure, semantic conflicts cause redundancy and interference in the processing, publication and exchange of data. Integrated data should be transformed following the data structure rules and codes [33].
4. *Data Access Security*: Different data resources belong to different companies, and each database can be controlled by a different company. Therefore, access and security management are not centralized. In order to secure access of a data source against intrusion and shield the original data access controls, designing a unified user security management system is necessary.

Thus, heterogeneous data is integrated into the database (see Fig. 5).

3.5 AS self-learning mechanism

Decision support systems of employee turnover risk are loose-coupled systems. The coordination between systems, including coordination of shared resources and problem solutions, is accomplished by Analytic Systems. Coordination of shared resources, including both the coordination of diversity of time, space and the combination of resources, is based on the connections between those resources. The coordination of problem solutions refers to the discussion between sub-systems in the attempt to achieve one optimized solution.

In the AS integrated model (see Fig. 5), all the interfaces of knowledge systems and models are encapsulated universally by Web Services and registered in the AS UDDI register center following the mechanisms of UDDI (①). A decision-maker either finds out the required knowledge and solutions in the AS UDDI register center (②), or the AS recommends a solution to the decision-maker and invokes the relevant knowledge or model by the message mechanisms of SOAP [4].

Knowledge management systems (KMS) are technologies employed by organizations to better retain and utilize organizational knowledge, as well as support knowledge sharing within and between organizations [34]. KMS are strongly tied to the organizational practice of knowledge management (KM), which is expected to lead organizations to positive outcomes such as better decision making, improved productivity, and enhanced competitiveness [7].

As a part of knowledge management systems, it is necessary to improve the efficiency and accuracy of solutions provided by the system. Therefore, feedback and refinement algorithms are important during the process of application [32]. The integrated AS model can aggregate feedback from users or other systems and the latest algorithms through a self-learning mechanism. New knowledge, models and algorithms are added to the system as upgrades. The process of self-learning is the key component of system construction.

Through statistics, which encompasses the comparison and analysis of historical results, especially the decisions, knowledge is cumulated, while algorithms and models are adjusted and optimized [39, 46]. Meanwhile, the process of self-learning is evaluated and recommended as follows:

- The knowledge, models or algorithms related to the solution are analyzed and compared in terms of their effectiveness and efficiency.
- The award-based mechanisms are applied. The decisions from the AS are compared with those of experts.

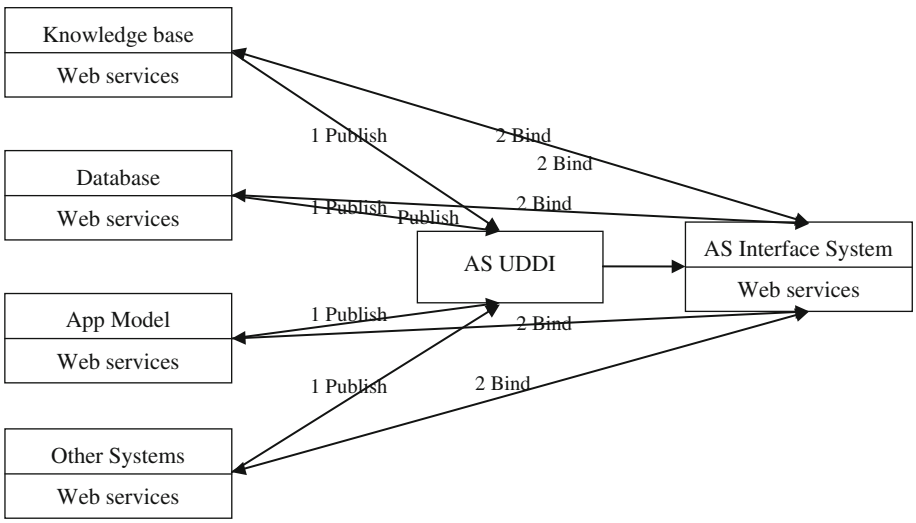

Fig. 5 Integrated AS model based on Web Services

Suggestions and knowledge that is never used in the solution are provided.
- Adjust the conditions, scopes and grades of each algorithm and model, according to the results of the specific cases.

4 Strategies to deal with employee turnover risk

In accordance with employee turnover risk management, corresponding management strategies should be taken in enterprises.

1. *Strengthen human resources information management*: Using inside and outside information, enterprises can find out about employees' situations. Thus, they can deal with cases which are likely to happen. At the same time, the information can also provide managers more ways to create a personnel employment and retention strategy.
2. *Make use of advanced incentives*: By providing more career-development chances, creating harmony in the working environment, developing systematic training, etc., enterprises can encourage employees to maximize their efforts to contribute more to the enterprise.
3. *Establish constructive corporate cultures*: Based on people-oriented beliefs, employees will be willing to strive to fulfill their goals and the goals of the company, thus lowering their turnover probability [16].
4. *Other Ways*: Paying attention to personnel retention, making regulations to enhance management, creating incentive systems, establishing a learning organization, etc., are also functional strategies to deal with employee turnover risk.

5 Conclusion

The problem of employee turnover is important to enterprises' existence and development. The influencing factors may come from conditions outside and inside the enterprises as well as employee conditions.

Evaluation model construction is a key part of employee turnover risk evaluation. It is also important to the validity and veracity of evaluation results. Thus, it is meaningful to study the construction of risk evaluation models, the construction process and methods. In our study, we built a hierarchical index model of employee turnover risk to research ….

Based on the analysis of the influencing factors and on the hierarchical index model of employee turnover risk, this article proposed a decision support system of employee turnover risk. The proposed DSS is a complex and comprehensive system that can be created by message processing mechanisms, software combination technology and system integration. Data, information and knowledge that the system needed come from enterprise internal application systems and external systems. The application of Web Services and AS based on knowledge management changes the pattern of development and reduces the cost.

According to the results of our decision support system, enterprises can strengthen human resources information management, and establish a constructive upward corporate culture to avoid employee turnover.

Although the system has been designed, suitable mechanisms for encouraging contributions to the system should be further studied.

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