Construction of Pediatric Medication Data Security Cloud Storage Model Based on Internet of Things Technology

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Abstract. According to the principle of database modeling and design standardization, combined with the design requirements of pediatric medication information database, the construction method of pediatric medication data security cloud storage model based on Internet of things technology is proposed, the overall structure of pediatric medication information model database is designed, and the overall planning of data storage model, the overall design and implementation of model database are given, the Internet of things technology is selected to optimize and describe the security structure of the database model, and the performance optimization strategy of the pediatric medication information model database is proposed, in order to lay the foundation for the construction of a multi-layer architecture and high efficiency medication data security cloud storage model.

Keywords: Internet of things technology · Pediatric medication · Secure storage

1 Introduction

At present, there are many problems in the circulation of paediatric drugs, such as the change of environment will lead to the change of drug quality or even complete failure. In the circulation process, a large number of fake drugs may be mixed, goods are in collusion and return. The virtual increase of circulation links. How to manage pediatric drugs effectively is a model project, involving many aspects, which has attracted widespread public attention [1]. In order to improve the efficiency of pediatric medication data management and the security of data storage, it is necessary to conduct research on the safe cloud storage method of pediatric medication data. This method utilizes modern means such as computer hardware and software technology and network communication technology to comprehensively manage pediatric medication information. It collects, stores, processes, extracts, transmits, summarizes and processes the data generated in each stage of medical activities to generate various information,

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so as to provide a comprehensive and automatic management and information management system of various services for the overall operation of the hospital [2].

At present, the study of the method for data security cloud storage has a lot of, for example, reference [3] proposed an identity based encryption the data security of cloud storage method, this method is mainly aimed at the demand of the users to share the data security in cloud storage, the identity of the proposed hierarchical encryption, identity management, improve the efficiency of the private key generation and the security of key management. The method of private key version number is introduced to improve the CP-ABE algorithm and improve the efficiency of attribute retraction, so as to further enhance the security of data cloud storage. Reference [4] proposed a data secure cloud storage method based on explicit exact minimum storage regenerated code. This method uses EEMSR code to encode the data, and then uploads the encoded data to the cloud to ensure the availability of the data. The encrypted hash function can verify the integrity of the cloud data through the Challenge-Re-sponse protocol. The EEMSR code is a regenerative code that can accurately recover lost chunks of data with less repair traffic, both of which enable secure cloud storage of data.

However, the above methods have poor adaptability in the safe cloud storage of pediatric medication data. Therefore, this paper builds a safe cloud storage model of pediatric medication data based on the Internet of Things technology. In order to solve the specific problems in the operation of pediatric medication information model and improve the security of pediatric medication data storage, it has a very important contribution and significance for the further development of medical information security field.

2 Pediatric Medication Data Security Cloud Storage Model

2.1 Design of Pediatric Medication Database

Pediatric drug use information model is a large online transaction processing model. There are many kinds of information in the model, large amount of data saved and historical data accumulated. This will lead to the increasing space occupation of the model and the corresponding decrease of the efficiency of the model. Therefore, in the overall design stage, we must plan the storage model of business data from a long-term perspective. The principle of master plan is to control the size of daily operation data table under the premise of ensuring data security. Therefore, the following two measures are taken: to establish logical database, which can be classified, stored and kept, and physical distributed database can be realized according to the needs; The overdue data can be classified, screened and sorted, stored regularly and separated from daily operation data tables. On the one hand, the model efficiency can be improved and the old data query will be facilitated [5]. The overall structure of the pediatric drug use information model database is shown in Fig. 1 below.

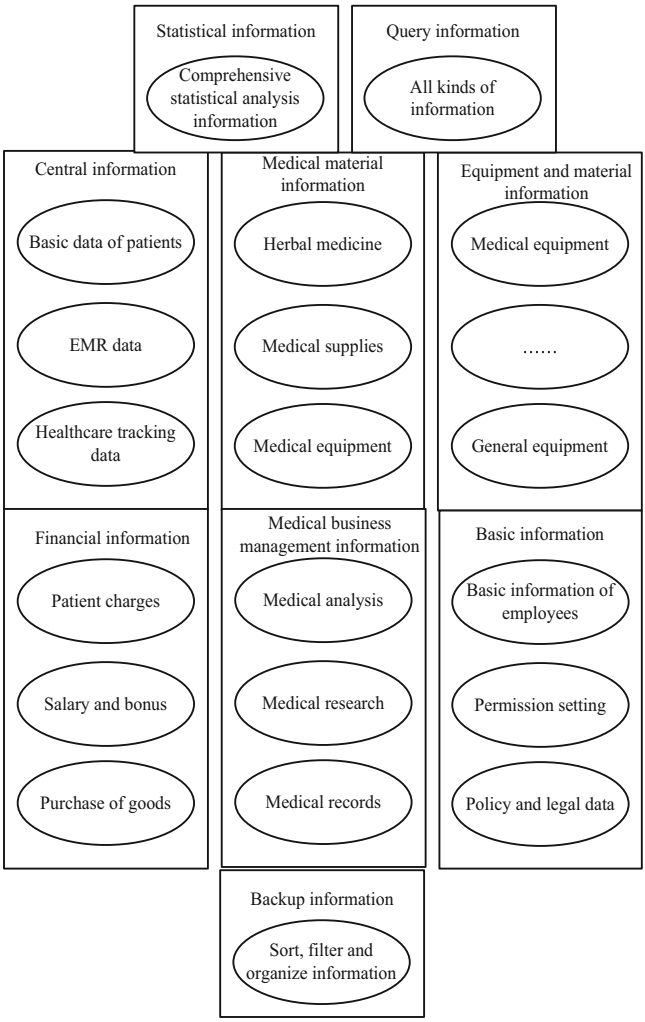

Fig. 1. Structure of pediatric medication database

By attaching labels on drug packaging and installing sensor devices in all places where drugs pass through, the identification and real-time acquisition of basic attribute information, status information and process information of drugs can be realized, and the collected and perceived data can be stored and transmitted in the form of Internet of things standard language PML, so as to make drug manufacturers drug wholesale companies, logistics companies, retail pharmacies, hospitals, drug buyers, superior authorities and other entities can obtain the information they care about in real time and transparently through cable [6]. In order to facilitate understanding, based on the knowledge of set theory, the physical meaning of each element in the drug circulation IOT model is shown in Table 1 below.

Table 1. Physical meaning of elements in IOT model of drug circulation

Describe	Physical significance and description
Input of drug circulation model	RFID tag number of drug entity object
Configuration document of drug circulation model	It is used to store parameters related to the description of drug circulation information
Output of drug circulation model	The output information includes: authenticity of drugs, basic attribute information of drugs, status information of drug circulation at a certain time, generated business documents and process information of drugs in the whole circulation
Storage template of drug circulation information	Define the standard structure of drug circulation information storage through PML header

The pediatric drug entity object is defined as the object set $S = \{S_1, S_2, \ldots, S_n\}$ and S, which can be a single drug or a package box or box composed of a batch of single products $S = \{S_1, S_2, \ldots, S_n\}$. Correspondingly, the object set S passes through a first-class point at time t, and its state information $Pt(s)$ can be described by nine elements.

$$P_t(S) = |Attr(S), t, Id(S), \text{Loc}(S), \text{Envi}(S), User(S), \text{Task}(S), \text{Rela}(S), Ord, S) \tag{1}$$

The specific meaning of each element is shown in Table 2.

Table 2. Characteristic description of drug status information

Element	Describe	Meaning and explanation
Id(S)	RFID tag number of drug entity object S	Because the drug entity object s can be a single drug, a packing box or a packing box, its corresponding label number is also different
Envi(S)	Environmental information of the location of the current drug entity object S	Through the sensor of drug storage location
Attr(S)	Basic attribute values of drug entity object S	Provided by drug manufacturers, such as drug composition, properties, pharmacology, etc.
t	Time when the state of drug entity object S changes	Automatic generation of S-tag of drug entity object read by RFID reader
Loc(S)	The place where the status of drug entity object s changes	The location LOC information can be obtained by reading the RFID reader number
Rela(S)	The RFID tag number of the entity object related to the drug entity object S	It is mainly used to express the relationship between a single drug and the packing box when the drug retail is unpacked
User(S)	The ID number of the operation user that causes the change of the s state of the drug entity object	They can be drug manufacturers, drug wholesalers, logistics companies, drug retailers and buyers
Ord(S)	The business document number corresponding to the drug entity object S	This variable is used to realize the association with the business data of the enterprise entities in circulation
Task(S)	Business type of drug entity object s in circulation process	The business types here mainly include packing case warehousing, packing case outbound, transportation, unpacking and retail

Based on the characteristic information in the above table, the circulation process of pediatric medication is described.

$$\mathrm{Proc}(\mathrm{Id}(S)) = \{\mathrm{Attr}(S), \mathrm{Loc}(S), U\mathrm{ser}(S), \mathrm{Task}(S), Ord(S)\} \tag{2}$$

Through the RFID number of electronic label of paediatric drug entity S, we can query the authenticity of paediatric drug use, basic attribute information of drug and the whole process information in pediatric drug circulation S [7]. When storing and expressing pediatric drug use information, users with different authority care about different circulation information, such as ordinary consumers are more concerned about authenticity, basic attribute information and environmental problems of circulation place of purchased drugs, while quality supervision department pays more attention to the inquiry of pediatric drug flow process, so that when problems occur in pediatric medication, drugs can be recalled in time, minimize the hazard. Therefore, in order to facilitate the real-time query of circulation information of various users, a storage model of pediatric drug use information based on PML is constructed [8]. Data warehouse is an integrated, subject-oriented, time-varying and stable data collection. The main function of data warehouse is to improve the efficiency of decision-making and analysis, and reorganize the corresponding data according to the application needs of specific fields, so as to produce a data environment that can adapt to decision-making [9]. Compared with the traditional database, data warehouse has a great difference. Data warehouse is mainly a means of obtaining information from massive data. The research results can be used to provide effective decision support for the decision-making of management. The traditional pediatric drug use database model is applied, detailed, small amount of primary operation data, can be updated, and is mainly used in the daily data operation process of database model. It is a transaction oriented design, and the corresponding data is stored in an operational database. However, data warehouse is an analytical, refined, one-time operation data with large amount and can not be updated, which is mainly used to manage data requirements and requirements in decision analysis. The data is stored in an analytical database. With the data abstraction tool, the data of pediatric medication which is useful for this model can be extracted from the mass information. After the integration and reorganizing, the data environment can be generated to adapt to the decision-making, which provides effective data support for decision makers to formulate corresponding specific policies. The data of pediatric medication is the theme of this data warehouse. Usually, the establishment of a data warehouse can be completed only according to the following steps (Fig. 2).

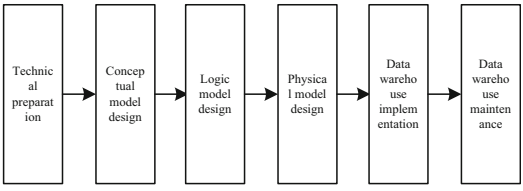

Fig. 2. Steps of pediatric medication information management

Through the standardized modeling of the basic attribute information, operation user information, business type information, business document information, circulation status information and circulation process information of drugs, the relevant information of drug circulation can be effectively stored and transmitted.

2.2 Data Security Algorithm for Pediatric Drug Network

In order to fully understand the information requirements of the Internet of things for drug circulation in tracking and tracing, it is necessary to model and analyze the tracking process of pediatric drug circulation, so as to plan the development of application platform through the model [10]. As the Internet of things has a graphical development interface and rigorous mathematical basis, it can play a normative role in guiding the development of the application platform in the later stage, so the Internet of things is selected to model and analyze the pediatric medication management information [11]. Using the incidence matrix method, the Internet of things model of drug information tracking process and the relevant definitions of the incidence matrix are as follows:

$$\left[C_{ij}^{-}\right]_{1+x16}=\begin{cases}1, & i=j\in[0,1\}\\ 1, & j=i+1, i\in\{2,3,\cdots,13\}\\ 0, & \text{other}\end{cases} \tag{3}$$

$$\left[C_{ij}^{+}\right]_{14\times16}=\begin{cases}1, & j=i+1, i\in[0,1\}\\ 1, & i=1, j=3\\ 1, & j=i+2, i\in[2,3,\cdots,13\}\\ 0, & \text{other}\end{cases} \tag{4}$$

In the process of management of pediatric drug storage model, two considerations are mainly based on: one is the level of user service, that is, there are enough suitable goods in the right place and time. The other is the order cost and the storage model holding cost to minimize the sum of the two. It can be seen that the management of pediatric drug storage model takes a single enterprise as the object, and its main purpose is to control the storage model level of the enterprise on the premise of meeting the customer service requirements, strive to reduce the storage model level as much as possible, improve the efficiency of logistics model, and strengthen the competitiveness. The storage model is classified and managed, and the ordering time and quantity are determined to minimize the total cost of the storage model. The storage model management decision model is designed and analyzed from the perspective of determining the quantity of each purchase. Its purpose is to determine the purchase quantity of storage model, so as to reduce the cost of storage model [12]. The establishment process of storage model is as follows:

(1) Query the historical data of sales volume and storage model volume of various pediatric drugs, and the specific data of current storage model pediatric drugs, and determine the data source of the model. The storage model commodities are classified and managed according to ABC classification.
(2) Referring to the previous pediatric drug purchase data, considering the constraints of funds and storage model capacity, the external factors such as demand,

customer service level and safety inventory that affect the purchase expectation were reasonably predicted, and different parameter values were set to determine the external constraints.

(3) According to the established pediatric medicine comprehensive storage model, the optimal pediatric medicine ordering quantity of main storage model materials under the optimal total cost was obtained [3].

(4) The results provide decision-making reference for senior managers. If the results meet the requirements, they can be executed. Otherwise, users can increase their own judgment on the basis of the output results of the reference model, so as to make a more reasonable storage model decision-making scheme, which greatly increases the flexibility of decision-making.

There should be pharmacy storage model information in pediatric medication database, and pharmacy storage model should indicate the pharmacy information. Pediatric drug use data storage model needs to know the associated drug SKU, while drug SKU does not need to know the storage model information. In addition, there are several groups of combination relationships in the pediatric medication database model, such as order class and order sub item class. One or more order sub items constitute an order. It is meaningless to talk about order sub items alone. When an order is created, the order sub items are created at the same time. When an order is deleted, all the same order sub items are deleted. After combing and analyzing these association relations, we also sort out the rank mapping relations with association relations, based on which we can get the association information of pediatric medication data category characteristics, and finally record the sorted information in the Table 3.

Table 3. Association of pediatric medication data category characteristics

Association class	Relationship	Order element relation
Drug delivery task-robot arm	Two way association	0 or 1 to 1
Drug SKU-order sub item	One way association	One to many
Pharmacy-pharmacy inventory	Two way association	One on one
Drug SKU -warehousing record	One way association	One to many
Drug SKU-drug delivery subtask	One way association	One to many
Drug SKU-drug inventory	One way association	One to many
Drug SKU-outbound record	One way association	One to many
Drug SKU-frozen inventory records	One way association	One to many
Pharmacy-orders	One way association	One to many
User- order	One way association	One to many
Medicine-medicine SKU	One way association	One to many
Dispensing task-dispensing window	One way association	0 or 1 to 1
Pharmacy-robotic arm	Synthetic relation	One to many
Pharmacy inventory-warehousing records	Synthetic relation	One to many

Based on the above table management information, the decision-making process of pediatric medication database management was further optimized, as shown in Fig. 3.

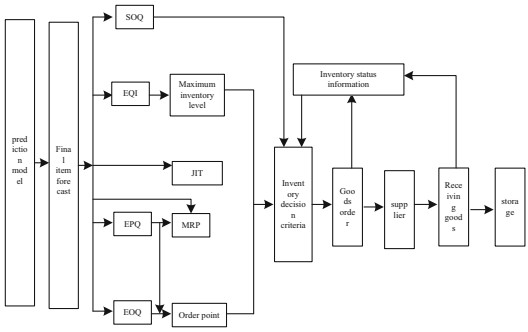

Fig. 3. Framework of drug storage management decision process

According to the characteristics of drugs, the statistical index with practical significance is selected as P, Q reflects the value of stored drugs and the level of use value, then the basic statistical index algorithm is.

$$W_j = Q_j \cdot P_j \tag{5}$$

Assuming that q_j is the intact rate of the storage model, the degree of difficulty or possible damage or deterioration of children's medication is further calculated

$$u = \left\lfloor \left(Q_j - q_j\right)/W_j + Q_j \right\rfloor \times 100\% \tag{6}$$

After the classification of storage models, different levels of storage models are managed according to the drug category, so as to selectively control the storage models and reduce the pressure of storage model management. Pediatric drug market forecasting process can be regarded as a guidance model, based on which the pediatric drug demand forecasting process is optimized, and the specific structure is shown in Fig. 4.

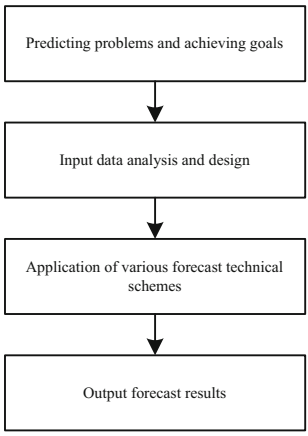

Fig. 4. Diagram of pediatric drug demand prediction process

As shown in the figure, the reliability of pediatric drug information processing can be improved by collecting and analyzing historical data.

2.3 Construction of Pediatric Medication Data Security Storage Model

According to the nature of pediatric medication data storage methods, they can be divided into qualitative prediction and quantitative prediction. Qualitative market prediction is a subjective prediction based on the nature and regulation of things. Quantitative prediction is based on the historical data and related factors of things, using statistical methods and mathematical models to study and speculate the use of pediatric drugs and its structural relationship, and predict various trends of production, sales and market demand. The model is divided into two modules: drug storage early warning module and intelligent decision support module (Tables 4 and 5).

Table 4. Function list of drug storage model management module

Functional module	Corresponding function name
Basic information management	Model information settings
	Drug dictionary editor
	Model login
	Drug base setting
Statistical inventory management	Inventory report
	Inventory forecast report
	Inventory alert report
Operator management	Management operator
Drug inventory management	Forecast model management
	Inventory model management
	Lower limit setting of drug inventory
	Upper limit setting of drug inventory

Table 5. Function list of intelligent decision support module

Functional module	Corresponding function name	
Decision support	Selection of inventory forecasting model	Weighted average forecasting model
		Seasonal forecasting model
	Inventory management model selection	Discrete storage model
		Continuous storage model
		Model of instant purchase and allowed shortage
		Continuous purchase and allowed shortage model
		Instant purchase, price discount
		Model of instant purchase and no shortage
		Continuous purchase and no shortage model

In the process of model design, the quantitative market forecasting method is selected in order to make the forecasting results as accurate and objective as possible. There are many kinds of forecasting contents for both qualitative and quantitative methods. Therefore, considering the design emphasis, only the storage model demand forecasting is described quantitatively. Using mongodb database to design the storage scheme of structured, semi-structured and unstructured data in the model. The structured data in the model will be stored by the database design method. Because the storage form of mongodb database is different from the traditional relational data storage model, the characteristics of mongodb database need to be considered in the database design. The electronic prescription and other document information are stored in Mongo DB documents through certain transformation. The images, videos and other data in the model will be stored by the Grid FS mechanism provided by MongoDB. Based on this, the storage mode of children's drug information is optimized, as shown in Fig. 5.

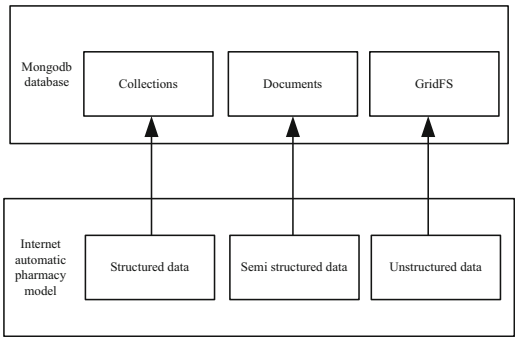

Fig. 5. Storage mode of children's drug information

The domain modeling idea is used to complete the requirement analysis of the model data, and the UML class diagram is used to complete the model design. The first step of model database design and development is to understand the function of the model and analyze its requirements. The first is the understanding of the domain model, that is, the understanding of the problem domain of the real model. Requirements analysis needs to find out the general requirements of the domain model, that is, the general requirements, and then organize the general requirements and description into a standardized problem statement. And the problem statement is analyzed, modified and improved. Finally, the class diagram model and data dictionary are constructed by object analysis technology. The whole requirement sorting process is shown in the figure, which is divided into five stages, namely, preparing problem statement, identifying class and attribute, developing digital dictionary, identifying association between classes, sorting UML class diagram of model, and constructing static domain data modeling steps of pediatric medication, as shown in Fig. 6.

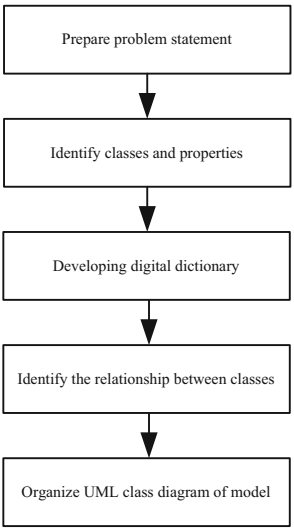

Fig. 6. Static domain data modeling steps

Demand forecasting is mainly to forecast the future sales volume of goods, in order to provide the necessary demand parameters for the storage model decision. At present, there are many forecasting models. Which forecasting model an enterprise chooses depends on many factors, such as the acquisition of historical data, forecasting preparation time, forecasting cycle, forecasting accuracy, forecasting cost, and product characteristics. Other issues that need to be further considered are the degree of flexibility of the enterprise (the stronger the enterprise's ability to respond quickly to changes, the higher the enterprise's flexibility), the lower the accuracy of the prediction model, and the consequences of bad prediction. The model of using inventory to meet the demand in time is a meaningful service index. The service level coefficient of demand can be defined as:

Service level coefficient of demand = Supply/Total demand.

Shortage level coefficient of demand = Shortage/Total demand.

The above relationship must be measured for a certain period, which can be the duration of lead time. The expected shortage quantity in an order cycle is:

$$E(M > B) = \int_{B}^{0} (M - B) f(M) dM \tag{7}$$

To get the out of stock level factor of the demand quantity in the order period, it is necessary to divide the demand quantity within the order period.

$$W = \frac{E(M > B)}{Q} \tag{8}$$

At present, there is still no corresponding decision support function for children's medication model, especially in the process of children's medication storage model management, decision support is one of the important issues concerned by the medical insurance department. At present, children's medication needs another function that storage model management model can provide, that is, it can provide data decision support for children's medication storage model management. All nouns and noun phrases are extracted from the problem statement, and the meanings of the extracted nouns and noun phrases are carefully considered, and whether they may become classes or attributes is screened. Based on this, the key words structure of children's medication attributes is standardized as follows (Table 6).

Table 6. Key words of medication attributes for children

User (role playing)	Drugs (definite things)
Prescription name (simple value, attribute)	Login (event)
Prescription address (simple value, attribute)	Drug freezing mechanism (concept)
Pharmacy for taking medicine	Mechanical arm (definite thing)
Take medicine window (clear things)	Window number (simple value, property)
Operation indication (simple value, attribute)	Pharmacy status (simple values, attributes)
Order (concept thing)	Drug quantity (simple value, attribute)
Drug delivery task (concept)	Manipulator status (simple values, attributes)

Generally, the management department of drug storage model mainly needs to obtain the following decision support information:

(1) The storage model management department needs to determine which storage model to choose, or adjust the storage model management model as needed.
(2) The storage model management department needs to count and analyze the warehousing data information in detail to understand the warehousing demand of drugs in different situations, so as to set a reasonable storage model lower limit.
(3) The storage model management department needs to count and analyze the data in detail, so as to understand the quantity of drugs in different cases, and then set a reasonable upper limit of the storage model.
(4) Reasonable choice of storage model and prediction model.

Based on the above steps, the general framework of children's medication storage model management is optimized, as shown in Fig. 7.

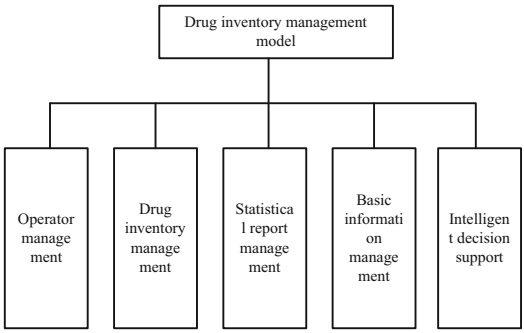

Fig. 7. Framework of drug data storage model management system

It can be seen from the figure that the data storage model management model for children's medication mainly includes five parts:

(1) Basic information management: including drug base setting, drug dictionary editing, etc.
(2) Drug storage model management: mainly includes drug storage management and drug delivery management.
(3) Statistical report management: mainly used for the management of drugs, financial and other statements.
(4) Operator management: mainly used for the management of operators.
(5) Intelligent decision support: mainly used for storage model alarm, model selection and prediction.

This model needs to count the demand and supply of drugs in hospitals or pharmacies, such as the total category of drugs, the number of suitable people, the level of drug safety, etc., so as to reasonably store or issue drugs according to the total amount of current drug storage model. Data mining methods such as analysis of variance, multiple linear regression and multi-element analysis are used to provide alarm information. In order to avoid the shortage of drug supply or a large number of drug waste and other problems, so as to manage the reasonable and effective drug storage model. The storage model management model should be effectively determined or timely adjusted according to the current operation situation, or fixed and reasonable storage model management model should be selected according to the needs. These models include deterministic model and stochastic model. To provide effective decision support for the storage model management, to meet the demand of drug supply, does not cause a waste of resources.

3 Analysis of Experimental Results

The specific functions of the model are verified, and the detailed contents of the model function design are given, including each module and the specific related functions under each module. The experimental results of some specific functions of the model are shown.

In the experiment, four computers in the lab LAN are used to build a distributed MongoDB cluster. Structured data and unstructured documents are stored in the Collection of MongoDB database in JSON format. The communication bandwidth of each machine is 10 Mbps, the processor is Lnter (R) Core (TM) i5 CPU, 2.40 Hz, memory is 4 GB, hard disk is 320 GB, and Java 1.7.0 is used to implement the index scheme proposed in this chapter. We build test data for the medical field. The structured data set is a database about drugs collected from a medical open website, which contains about 8000 drug records. Then, a web search was performed on the PubMed search engine of the children's medication database with each medication name as a keyword, and the first five items of the results were used as unstructured test data set. Three test data sets with different sizes were constructed, namely 350 MB(PM1), 700 MB(PM2) and 1G (PM3). For each dataset, a process with a concurrency of 4 is used to create a data security index for the mixed data. Based on this, the information query effect of pediatric medication data security storage model is tested, and the experimental results are shown in Fig. 8.

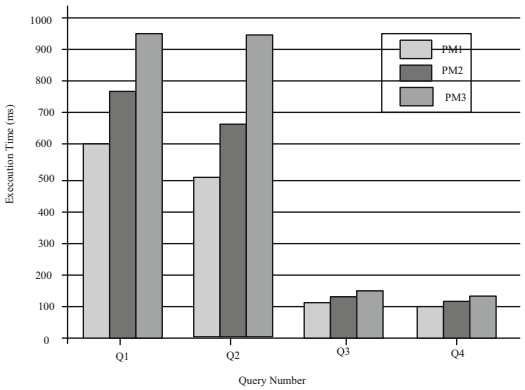

Fig. 8. Execution result of drug storage information query

It can be seen from the figure that when the amount of data gradually increases, the execution time of each query increases slightly, but it can be completed at the second level. With the same amount of data, the execution time of entity queries Q1 and Q2 is significantly less than that of relational queries Q3 and Q4. This is because relational queries also involve the semantic relationship between entities, so the execution process is relatively complex and needs more time. In addition, it can be seen from the figure that for the same type of queries, such as entity queries Q1 and Q2, the query

execution time increases only slightly with the increase of query complexity, indicating that the index mechanism has good scalability in processing the same type of queries. In the experiment, we compare the association index mechanism with the independent index mechanism, so as to verify the advantages of this scheme. The independent index mechanism uses two different indexes for structured and unstructured data, that is, the traditional document oriented inverted index and the database oriented Bree index. The two indexes do not interfere with each other, and the query is processed based on keywords. For the test data, we construct 10 queries manually, including both entity query and relation query. Then, the associated index and independent index mechanism are used to execute the 10 queries, and the accuracy of the query results is calculated. The accuracy is obtained by dividing the number of documents and records related to the query object in the query result set by the total entries in the query result set. The comparison results are shown in Fig. 9.

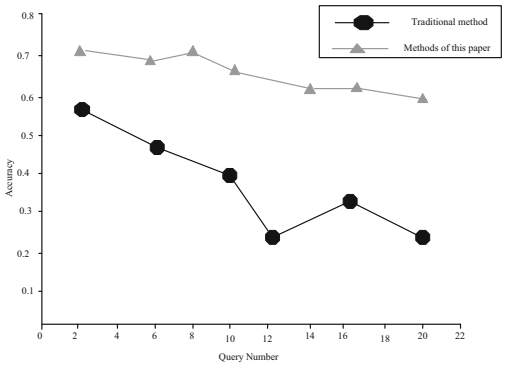

Fig. 9. Accuracy of pediatric medication data storage query

Analysis above, the pediatric drug use data stored query precision of this method is always higher than the traditional method, the reason is that the method of pediatric medicine information model database design, the overall structure of data storage model is also given the overall planning, overall design and implementation of model database, choose the Internet of things technology of database security model structure is optimized and description, Therefore, it has high precision of pediatric medication data storage and query.

4 Concluding Remarks

This paper mainly designs the pediatric medication data security cloud storage model based on Internet of things technology. The construction of hospital information model should follow the principles of meeting business needs, being practical and solving problems. As the background support of HIS, the model database was applied in the primary pediatric medicine. The results show that the pediatric medicine database

model is easy to operate, and all kinds of documents meet the actual requirements of the hospital, reaching the pre design standard. The security optimization of pediatric medicine database performance is realized, and the specific problems in the process of data security cloud storage model operation are well solved.

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