A Control Mapping Data Model for Internal Controls Construction in Database Design

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Abstract

The internal controls construction of a transaction system is important to management, operation and auditing. In the environment of manual operation, the internal controls of the transaction process are all done by manual mechanism. However, after the transaction processing environment has been changed from manual operation to computerized operation, the internal control techniques have been gradually transformed from manual mechanisms to computerized methods. The essence of internal controls in operational activities is the data expressions or constraints. The adoption of information systems often results in internal control deficiencies and operating risks due to the data unavailable in database for the data expressions of internal controls. Hence, how to design database schema to support internal controls mechanism is becoming a crucial issue for a computerized enterprise. Therefore, this paper referred Entity-Relationship model (ER model) in order to propose a Control Mapping Data (CMD) model to design database to support internal controls construction. Finally, a simple simulated case is prepared for illustration of the CMD model. It will enhance the reliability of information systems through internal controls construction by applying the model to design databases.

Keywords: Information Systems, Control Mapping Data (CMD) Model, Internal Controls Construction, Internal Control Deficiency, Database Design

1. Introduction

With the advancement of information technology, organizations rely significantly on information systems to support their transactions and data processing. Information systems have played a crucial role in business operation. The manual mechanisms of traditional internal controls need to be re-designed and transformed into automated controls to achieve control objectives [3]. As information systems should undertake more internal control functions, the reliability of information systems becomes an important issue.

Managerial problems and operational risks may arise if the automated control mechanisms are not properly implemented into information systems.

As the business rules are introduced for the integrity of transactions, the database constraints are in place for the accuracy of data processing. While transaction activities are mapped against data processing, internal control rules are mapped to database constraints. In other words, the essence of internal controls in operational activities is the data expressions or constraints in database [5]. The transaction data corresponding to the requirements of internal controls should be built into the database for enabling the presentation of the data expressions and constraints. However, IT professionals didn't pay much attention to the above issue during database design process. As indicated by Bohem (1976) that it takes much more efforts to install the requirements at post-implementation stage than at analysis and design stage. Therefore, to propose database design schema incorporating the information needs of internal control becomes a crucial issue for organizations.

In 1976 Peter Chen published the original entity-relationship (ER) model which provided a friendly approach to logical database design [12]. The model is comprehensive, yet it avoids the complications of storage and efficiency considerations, which are reserved for physical database design. In the more than three decades since then, a lot of uses have adopted the original model and used it enthusiastically after minor changes. In addition, a number of researchers have extended the model to enhance its capabilities so that it is more appropriate for their particular endeavor. The most comprehensive extension includes REA accounting model which shares the enterprise financial and non-financial data proposed by McCarthy (1982).

Therefore, this study use the mapping mechanisms between controls and data of internal controls in transaction activities, referred Entity-relationship model to propose a control mapping data (CMD) model. By using this model, the operational rules are mapped to data expressions, and data expressions are analyzed to design the desired database schema, during the developing stage of information systems. Finally, a simple simulated case is prepared for illustration of the CMD model. It will enhance the reliability of information systems through internal controls construction by applying the model to design databases.

2. Literature Review

2.1 Internal controls

Internal controls, implemented by the board of directors, management and others, aim to provide a reasonable assurance of the reliability of financial reporting, the compliance with laws and regulations and the effectiveness and efficiency of operating [1, 4, 11, 15, 2]. The quality of the design of internal controls, more often than not, is critical to the success of an organization. Therefore, to ensure the efficacy of internal

controls, managers have to pay attention to the design of internal controls.

Doty et al. (1989) argued the similarity between an organization's internal control techniques and expressions/constraints in database. The application controls of information system are a set of programmed procedures to assure the data quality all the way from input, processing to final output [8]. As a result, the essence of internal controls in operational activities is the data expressions or constraints in database.

Companies have to implement various control measures to achieve targets. On the basis of the timing of control events, internal controls can be divided into preventive controls, detective controls and corrective controls [15]. Preventive controls are ex-ante in nature, such as the control over accounts and passwords for the prevention of illegal uses from logging into the system. Detective controls are the control over the happening of events, e.g. the inspection of product codes to confirm the existence of products. Corrective controls are ex-post nature. For example, an automated procurement system can calculate the procured quantity once the inventory falls below a control point, and then generate a purchase order to make up for the inventory shortfall.

The execution of internal controls can be divided into manual controls and computerized controls [14]. Manual controls refer to the control mechanisms implemented by users, e.g. manual reviews of the results processed by the computer. Computerized controls refer to the automated control run by computer programs, such as a check on whether debts and credits are balanced in the accounting entries made by users.

According to No. 3 of the Statements of Auditing Standards (SAS) set forth by the American Institute of Certified Public Accountants (AICPA), the structure of internal controls in the EDP environment can be divided into general controls and application controls [9]. General controls can be further divided into organization and operation controls, systems development and documentation controls, built-in equipment controls, access controls and other data and procedural controls. Application controls can also be further divided into input controls, processing controls and output controls. In other words, general controls are about the control of the whole IT environment, with the goal of ensuing the security and reliability of the IT system. Application controls are about the control over application software, aiming to maintain the accuracy and integrity of data from inputs when processed to outputs. Regardless of how perfect the design of an internal controls system, it is difficult to completely work out the functions of internal controls, due to practical limitations and the cost/benefit tradeoff, as well as the continued likelihood of illegal activities [10].

2.2 Data model

This section is mainly to explore and analyze the relationship between the constructs (components), their manipulation values of data model and characteristics of database. Usually, data model is a tool to integrate views of external users into conceptual database schema, which can be divided into

Entity-Attribute-Relationship models (EAR models) and Object-Relationship models (OR models) [18]. For example, Entity-Relationship model (ER model) is the most popular EAR models and Nijssen Information Analysis Methodology Model (NIAM model) is one of OR models.

The entity-attribute-relationship (EAR) approach provides a simple way to understand yet comprehensive methodology for logical database design independent of storage or efficiency considerations [12]. The problem that Chen solved with the ER model is the complexity of logical database design. The conventional process of database design is based on mapping real-world information directly to a user schema, specific to a certain type of database management system (DBMS). The ER approach simplifies the process by introducing an intermediate design called an enterprise view or enterprise schema. The enterprise schema, expressed as an ER diagram, is a conceptual database design which is a pure representation of the real world and yet is independent of hardware considerations.

The ER model is widely used during requirements analyses and for conceptual database modeling. Because of its simplicity, it is an easy way to understood by non-technical individuals. Implementations in the real world environment have shown it to be an effective communications tool between database designers and end users.

The main constructs (components) of the entity-relationship model are entity types, relationship types, and attributes. An entity is defined as a “thing” which can be uniquely identified. It can be an ORDER, an ITEM, or a concept about which an organization wants to store data. Entities sharing similar properties can be classified into entity types, such as CLIENT and ORDER. Entities may have certain relationships with one another which can also be classified into relationship types. For example, DELIVERS is a relationship type between entity types CLIENT and ORDER. The relationship may be one-to-one, as MARRIES between exactly MAN and WOMAN two entities, one-to-many as DELIVERS between one CLIENT and many ORDER entities, or many-to-many as CONTAINS between many ORDER and many ITEM entities.

In Chen’s model, entities and relationships have properties, called attributes. For example, ADDRESS is an attribute of CLIENT entity and QUANTITY is an attribute of a CONTAINS relationship between an ORDER and an ITEM entity. An attribute can attain values of a certain value type. Each entity must have a unique identifier to distinguish it from other entities of the same type. This might be an attribute already in use, such as a client’s code, or might be an attribute introduced for its uniqueness, such as an order number. Chen compares the entity identifier to the concept Compared the entity identifier to the concept of primary key in conventional databases. Relationships are identified by using the identifiers of all entities involved in the relationship.

The constructs (components) of each model possess their own manipulation values required for designing the characteristics of database. In order to build a database with the characteristic of internal controls

supportable, it is necessary to explore constructs and their manipulation values of data model which mainly possesses three control constructs: entity or object, relationship and attribute. In order to design database schemas with different characteristics, it could be accomplish by applying different manipulation values of constructs. For example, manipulation values of resources, events and agents of “entity” construct in REA accounting model could be used to integrate financial and non-financial data and result in integration of transaction data of an enterprise [16, 17].

Operational database mainly comprises database schema and transaction data. From the perspective of database schema, this paper attempts to design database schema with characteristic of internal controls supportable by applying construct of “attribute” and its manipulation value of control-data-mapping in system analysis and design stages.

3. Ontology of Internal Controls

3.1 Transformation of internal control techniques

In a computerized corporate environment, transactions are automatically generated or executed in information systems. In order to ensure the reliability of information system, internal control methods are also supported with information technology. This results in variances between the internal control techniques in the information technology environment and the manual environment. The adoption of new information technology gradually shifts the transaction processing procedures from manual to automation. The internal control methods in the manual environment cannot be implemented to a computerized corporate environment [10, 14]. Therefore, the internal control techniques should change along with information technology development and application, in order to avoid internal control deficiencies resultant from incompatibility between internal control mechanisms and the information technology environment. Hence, it is a crucial issue for a corporate to adapt its internal control techniques in line with information technology evolution and adoption in order to ensure the continuing effectiveness of internal controls and the achievement of operational objectives.

As Figure 1 indicates, along with the development process of information systems, corporate manual controls have been gradually replaced by computerized controls of information systems. If the control mechanisms could not be established in information systems appropriately, a lot of managerial control problems will occur, and result in the risk of corporate operation.

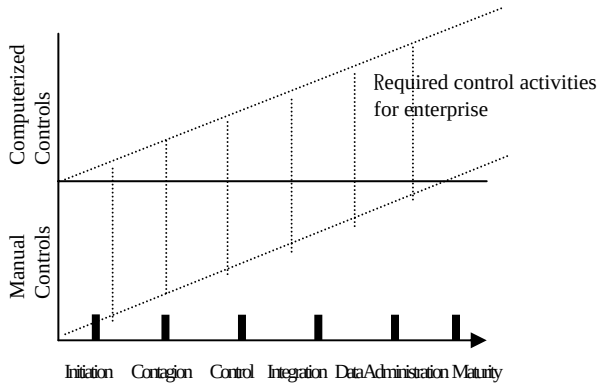

Figure 1 manual and computerized controls needed in different stages of information systems application

Therefore, when an enterprise adopts new information technology, the internal control techniques should be adapted along with the computerization degree [7,13] However, it is difficult for enterprises to construct and maintain the needed internal controls in information systems, due to the database design problems, which leads to internal control deficiencies when enterprises develop and implement information systems. Internal control deficiencies will negatively affect the efficacy of internal controls and operating performance, and result in enterprise risk [9] 。

3.2 Essence of internal controls

An enterprise has many transaction activities, which could be any transaction cycle or business process, for example, sales transaction system. As illustrated in Figure 2, a transaction cycle is composed of a few processes, and a process is a transaction step or an event, for example, “Order approving” is a process of sales transaction cycle. In order to accomplish the content of the process, a set of rules must be followed to ensure the achievement of operational objectives. A control rule will be mapped to the attributes of related entities in the process, and a data expression will be used to represent the transaction rule. A transaction cycle is composed of many processes, and there will be a few explicit and tacit control rules in order to meet the operational objectives. Hence, the operational control rules could all be mapped to the attributes of related transaction entities, and be represented by data expressions or constraints.

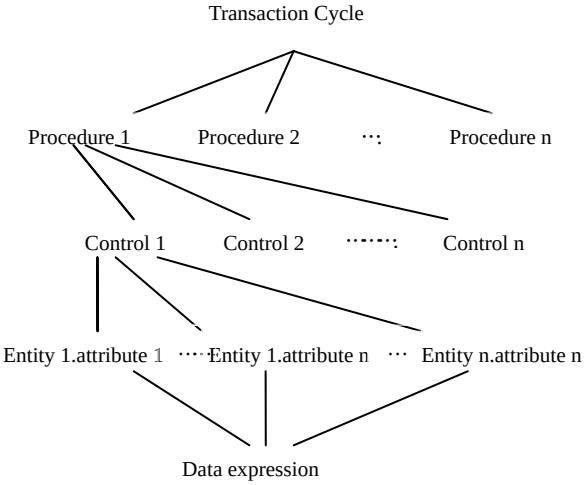

Figure 2 the relation of processes, control rules and data expressions

As Figure 3 indicates, There are two transaction rules which are “client’s credit balance must be greater than or equal to the amount of order” and “ item stock must be greater than or equal to the quantity of an item in an order” in the process of order approving. The former is mapped to the related entities of CLIENT and ORDER, while the latter maps to the entities of

ORDER and ITEM. In order to express the control rules, the expressions of attributes of related entities can be used. The expression of control rule for “client‘s credit balance must be greater than or equal to the amount of order” will be as following:

Client. Credit balance >= Order. amount

And the expression of control rule for “item stock must be greater than or equal to the quantity of an item in an order” will be as following:

Item.stock >= Order.item.quantity

Therefore, the data expressions would be employed to control the transaction processes. It means the transaction follows the control rule when the expression is true, whereas it means the transaction denies the control rule when the expression is false.

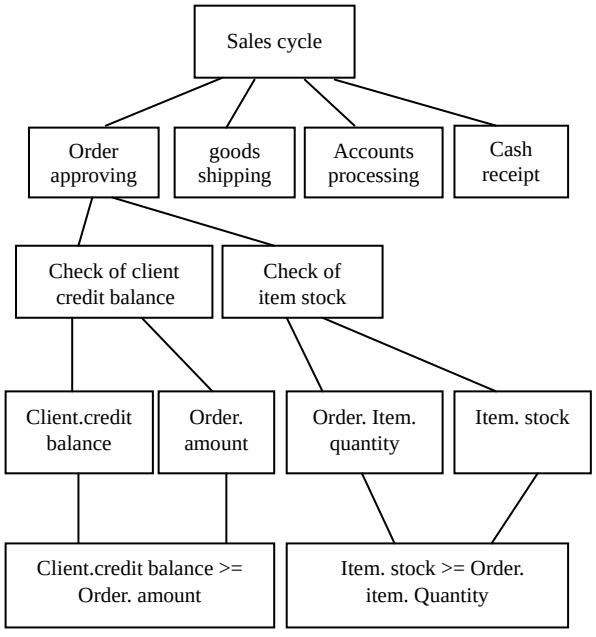

Figure 3 the relation of processes, controls and expressions for partial sales cycle

Hence, the essence of internal controls of operational activities is data expression. However, the database schema could not support the required data of internal controls due to the negligence of insightful consideration of internal controls during the analysis and design stages of information systems development.

4. Illustration of CMD Model

4.1 Theoretical foundation of CMD model

In order to meet the required data of expressions of internal controls, McCarthy(1982) suggested the design of database schema must follow the need of internal controls in REA accounting model. Hence, the design of database schema should comply with the data expressions of internal controls in order to ensure the internal controls construction of information systems during the development stage.

Therefore, as figure 4 illustrates, a process may have a few control rules, and a control rule (CR_i) could be mapped to a data expression or a constraint. A data expression (DE_i) may require a few data to demonstrate. Through the computation of a function (f_i (DB)), the required data of an internal control could be retrieved from database. A function defines the way to get the needed data of an expression from database.

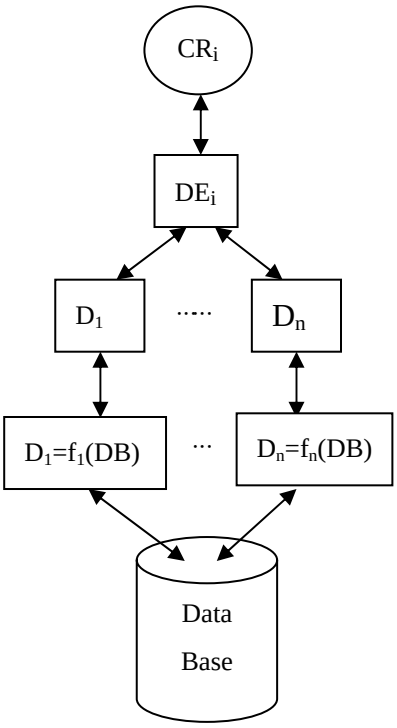

Figure 4 mapping mechanisms of control expressions and database

The program codes of internal controls may be embedded in applications, or the expressions or constraints may be defined in database to demonstrate the internal controls during the stage of information systems development. Whether embedding the program codes of internal controls in applications, or defining the data expressions of internal controls in database by using the trigger codes is still an issue to be explored in both academics and practices.

The auditability of internal controls means the way to get the required data of a data expression for an internal control is clear, and the data of internal controls are available during all the operating period. In order to ensure the auditability of internal controls, the design of an enterprise database should follow the control-data-mapping mechanism.

4.2. Exploration of CMD model

ER model is the popular tool for designing database schema. It is mainly established by four steps: (1) identifying entity types such as classes of resources, agents, and events that exist in the conceptual world and the relationship types that connect those entities, (2) constructing an ER diagram that will exhibit the semantic nature of identified relationships, (3) defining the characteristics of entity and relationship types that will be of interest to particular system users, and specifying mappings that will identify those characteristics, and (4) organizing the results of previous steps into entity/relationship tables and identifying a key of each entity/relationship table (Chen, 1976; McCarthy, 1979).

ER model does not yet consider the issue of internal controls construction. CMD model uses construct of attribute and its “control-data-mapping” manipulation value to design the database schema with the characteristic of internal controls supportable.

CMD model includes the following five steps: (1) identifying entity types and the relationship types that connect those entities, (2) Constructing an CMD Diagram, (3) defining the characteristics (attributes) of entity and relationship types, (4) designing related attributes for internal controls using control-data-mapping mechanism, and (5) Organizing the results of previous steps into entity/relationship tables and identifying a key of each entity/relationship table.

(1) Identifying entity types and the

relationship types that connect those entities

In transaction system, entity is the anything that we concern [12]. In sales transaction system, entity types could be CLIENT, ORDER, ITEM, etc. In other words, entity types refer to data targets we intend to process in transaction systems. The relationship types are another kind of data targets that connect those entities. According to rules of transaction processing, the relationship between entities could be one-to-one, one-to-many or many-to-many. It is assumed that a client could give many orders to the enterprise and each order could only belong to a client; thus, the relationship between the client and order is one-to-many; an order might include various kinds of items and one kind of items might be appeared in many orders; thus, the relationship between order and item is many-to-many.

The data expression of an internal control could be related to many entities and relationships types; therefore, all the corresponding entities and relationships required for internal controls construction should be identified during this step.

(2) Constructing an CMD Diagram

In the ER model, an entity type is represented by a rectangle with the name of the entity type inside it. A relationship type is presented by a diamond, with the relationship name inside. Related entity types are connected to this diamond by straight lines. Each line is marked with a “1”, “n” and “m” to indicate 1:1, 1: n or m: n relationship types.

The required data of internal controls should be defined and the related entities and relationships also should be identified during this stage. For example, if the client’s credit balance will be used in the data expression of an internal control, as Figure 5 indicates, then the related entities of CLIENT, ORDER and RECEIPT should be located using dotted lines with arrowhead.

This step can result in CMD diagram of simple sales transaction as Figure 5 indicated.

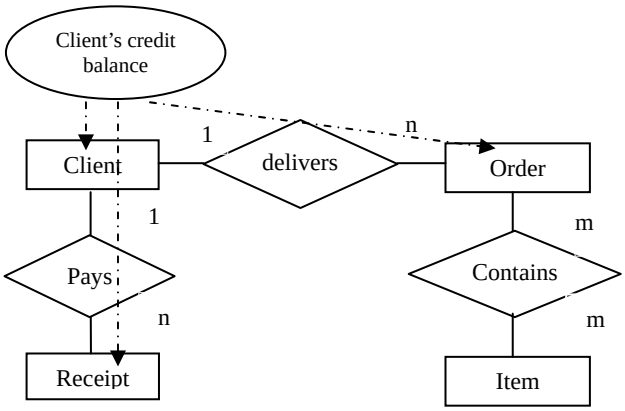

Figure 5 CMD diagram of partial sales transaction

(3) Defining the characteristics (attributes) of entity and relationship types

In Chen’s model, entities and relationships have properties, called attributes, for example CREDIT LINE is an attribute of a CLIENT entity and QUANTITY is an attribute of a CONTAINS relationship between an ORDER and an ITEM entities.

In order to describe the characteristics of an entity/relationship type, the attributes required must be defined. For example, CLIENT entity type should be described by the attributes such as CLIENT CODE, CLIENT NAME, PERSON IN CHARGE,

CREDIT LINE, TELPHONE NUMBER and ADDRESS.

(4) Designing related attributes for internal controls using control-data-mapping mechanism.

In order to ensure the data source of internal controls during the operating period, the required attributes of both entity and relationship types must be defined. In other words, the needed data of expressions for internal controls could be retrieved from database during the operating period. Therefore, the design of the attributes of entities and relationships should follow the control-data-mapping mechanism.

For instance, if there is a control rule of "the client's credit balance must be greater than or equal to the amount of order", then the credit balance of a client and the amount of an order should be get from the attributes of entities and relationships. Hence, in order to get the needed data of data expressions from database during all operating period, the design of database schema should use the control-data-mapping schema.

For example, in order to acquire the credit balance of clients, the attribute of CREDIT LINE in CLIENT entity, and the attribute of AMOUNT in both ORDER and RECEIPT entities must be designed. The equations of getting the credit balance of a client and the amount of an order can be defined as following:

$$\textit{Credit balance} = \textit{client.credit line} - \left[\sum_{i=1}^{m} \textit{order.amount} - \sum_{j=1}^{n} \textit{receipt.amount}\right] \quad (1)$$

$$\textit{Amount of order} = \textit{Order.Amount} \quad (2)$$

(5) Organizing the results of previous steps into entity/relationship tables and identifying a key of each entity/relationship table.

Key is constructed by one attribute or many attributes of entity/relationship and only it possesses the characteristic to recognize this entity/relationship. CLIENT CODE is considered to be a key and CREDIT LINE is not.

When transferring entities and relationships into tables, if the relationship between two entities is one-to-one, the key of any entity could be placed to the table of another entity as a foreign key in order to establish the relationship between two entities. If the relationship between two entities is one-to-many, the key of "one" entity must be placed to the table of "many" entity as a foreign key in order to establish the relationship between two entities. For example, when the relationship between CLIENT and ORDER entities is one-to-many, the key CLIENT CODE of CLIENT must be placed to the table of ORDER as a foreign key. If the relationship between two entities is many-to-many, the keys of two entities should be placed to the table of relationship as the key.

AS indicated in Figure 6, after accomplishing the previous steps, conceptual database schema will be created as the base for constructing physical database.

5. Scenario and Elaboration

Assuming that there is a sales transaction cycle and its transaction policy reveals that a client will deliver many orders and one order merely belongs to one client; an order might involve many kinds of items and one kind of items might be ordered by many orders.

In the "Order Approving" process, there are two control rules to test whether the credit balance of a client is equal to or greater than the amount of current order and whether the quantity of any item in an order is not exceeded the stock of the item.

The following is an example using CMD model to explore how to construct a database of supporting the required data of internal controls. The steps are as follows:

1) Using CMD model to design database schema.
2) Preparing test transaction data.
3) Validating if there is required data in database to support internal controls mechanism.

First, using CMD model to design database schema with internal controls supportable and prepare test transaction data in order to validate if database keeps data trails to support internal controls mechanism.

5.1. Using CMD model to design database schema

At the analysis and design stage of system development, according to CMD model, a conceptual database schema, as indicated in Figure 6 finally was generated. There are five tables of sales transaction. The solid underlined fields refer to key attributes and the attributes with dotted underline are foreign key attributes. The attributes framed with solid line are the attributes supporting internal controls.

Client (Client code, Client's name, person in charge, Credit line, telephone number, address)

Order (order code, date of order, amount, Client code)

Order detail (Order code, item code, quantity, unit cost, unit price, discount)

Receipt (Receipt code, date of receipt, amount, client code)

Items (item code, item name, item specification, beginning stock, current stock, total cost)

Figure 6 DB conceptual schema of the scenario

5.2. Preparing test transaction data

There are eight tables of test data which five tables for partial sales cycle and three tables for related purchase cycle, prepared for the illustration of CMD model.

Table 1 Test data of client table

client code	client's name	person in charge	*credit line*	telephone number	address
C01	May Co.	Johnson Brown	20,000	(214)345-6789	9335 Main St,Dallas,TX
C02	Dalecom	Michell Duke	36,000	(714)666-7777	7712 Digital Blvd,Irvine,CA
C03	Vacomvia	Sam Smith	28,000	(213)235-6789	649 Millenia St,Fullerton, CA

Table 2 Test data of order table

Order code	Date of order	*amount*	Client code
O01	01/09/2010	6,500	C02
O02	01/17/2010	560	C01
O03	02/01/2010	4,600	C03
O04	02/27/2010	2,600	C02
O05	03/08/2010	5,900	C01
O06	03/22/2010	3,650	C01
O07	04/19/2010	7,800	C03
O08	05/29/2010	13,700	C03

Table 3 Test data of order details table

Order code	item code	*quantity*	Unit cost	Unit price	discount
O01	I01	30	100	130	0
O01	I02	10	200	260	0
O02	I03	8	50	70	0
O03	I02	15	200	260	0
O03	I03	10	50	70	0
O04	I02	10	200	260	0
O05	I02	20	200	260	0
O05	I03	10	50	70	0
O06	I01	10	100	130	0
O06	I02	5	200	260	0
O06	I03	15	50	70	0
O07	I02	30	200	260	0
O08	I01	40	100	130	0
O08	I02	30	200	260	0
O08	I03	10	50	70	0

Table 4 Test data of item table

Item code	Item name	Item specification	*Beginning stock*	*Current stock*	Total cost
I01	PDA	piece	100	80	8,000
I02	Cellular Phone	piece	180	150	30,000
I03	Digital Camera	set	66	73	3,650

Table 5 Test data of receipt table

Receipt code	date of Receipt	*amount*	Client code
R01	03/09/2010	6,500	C02
R02	04/07/2010	6,460	C01
R03	05/23/2010	12,400	C03

Table 6 Test data of supplier table

Supplier code	Supplier's name	person in charge	telephone number	address
S01	Wenyu Co.	Jeffery Compoton	(217)369-7797	911 Stone St, Suville,TX
S02	Sunny Co.	Linda Web	(713)333-1636	127 Wood Blvd,Irvine,CA
S03	Fundata	Steve Strong	(215)379-2277	3327 Cook St, Los Angels, CA

Table 7 Test data of purchase table

Purchase code	Date of purchase	cost	Supplier code
P01	01/03/2010	8,000	S02
P02	01/15/2010	1,000	S01
P03	01/27/2010	6,000	S03
P04	02/25/2010	5,000	S02
P05	04/05/2010	7,000	S01

Table 8 Test data of purchase detail table

Purchase code	item code	*quantity*	Unit cost
P01	I01	40	100
P01	I02	20	200
P02	I03	20	50
P03	I02	30	200
P04	I03	20	50
P04	I02	20	200
P05	I02	20	200
P05	I03	20	50
P05	I01	20	100

5.3. Validating if there is required data in database to support internal controls mechanism.

In order to compute the credit balance and amount of order of data expression (Credit balance >= Amount of order) for the control rule which credit balance should be greater than or equal to amount of order, two formulas must be defined as following.

Credit balance = client.credit line –

$$\sum_{i=1}^{m}(order.amount\ |before\ the\ date\ of\ order) + \sum_{j=1}^{n}(receipt.amount\ |\ before\ the\ date\ of\ order) \quad ……………………………….(3)$$

$$Amount\ of\ order = Order.Amount \quad (4)$$

Table 9 Credit balance check

Order code	Client code	Credit balance	Amount of order	Validating result
O01	C02	36,000	6,500	True
O02	C01	20,000	560	True
O03	C03	28,000	4,600	True
O04	C02	29,500	2,600	True
O05	C01	19,440	5,900	True
O06	C01	13,540	3,650	True
O07	C03	23,400	7,800	True
O08	C03	28,000	13,700	True

In order to compute the item stock and order quantity of data expression (item stock >= order quantity) for the control rule which item stock should be greater than or equal to order quantity, two formulas must be defined as following.

Item stock = item.beginning stock +

$$\sum_{i=1}^{m}(purchase\ details.quantity\ |before\ the\ date\ of\ order)$$

-

$$\sum_{j=1}^{n}(order\ details.quantity\ |\ before\ the\ date\ of\ order) \quad ……………………………….(5)$$

$$order\ quantity = order\ details.\ Quantity \quad (6)$$

Table 10 Item stock check

Order code	Item code	Order quantity	Item stock	Validating result
O01	I01	30	140	True
O01	I02	10	200	True
O02	I03	8	86	True
O03	I02	15	220	True
O03	I03	10	78	True
O04	I02	10	225	True
O05	I02	20	215	True
O05	I03	10	88	True
O06	I01	10	110	True
O06	I02	5	195	True
O06	I03	15	78	True
O07	I02	30	210	True
O08	I01	40	120	True
O08	I02	30	180	True
O08	I03	10	83	True

Table 9 indicates the control rule of credit balance should be equal to or greater than the amount of order, while table 10 shows the control rule of item stock should

be greater than or equal to the quantity of any item in an order. After compute the required data for the data expressions of internal controls, the data expressions of internal controls are all validated. Therefore, the CMD model was proven to be an effective method to design enterprise database schema which could support internal controls construction.

6. Conclusion

In the environment of manual operation, the internal controls of the transaction process are all done by manual mechanism. However, after the transaction processing environment has been changed from manual operation to computerized operation, the internal control techniques have been gradually transformed from manual mechanism to computerized methods. The essence of internal controls in operational activities is the data expression or constraint. The adoption of information systems often results in internal control deficiencies and operating risks due to data unavailable for the data expressions of internal controls. Hence, through the dedicated design of using CMD model, the needed data of control rules will be deployed in enterprise information systems.

This paper found that the characteristics of database would be affected by the "construct" and its "manipulated value" of the data model. In order to design the characteristics of internal controls supportable of a database, the ER model is referred. This paper explores the construct of "attribute" and its manipulated value of "control-data-mapping", and then presents a CMD model. Finally, a simple simulated case is prepared for illustration of the model. With controls mapping data, the internal controls system of a transaction system will be constructed. It will make auditing, control and management of the transaction easier.

References

[1] A. D. Bailey Jr., G. L. Duke, J. Gerlach, C-E. Ko, D. R. Meservy, and A. B. Whinston, "TICOM and the Analysis of Internal Controls," T*he Accounting Review*, Vol. 20, 1985, pp. 186-201.

[2] A.D. Korvin, M.F. Shipley, and K. Omer, "Assessing risks due to threats to internal control in a computer-based accounting information system: a pragmatic approach based on fuzzy set theory", *Intelligent Systems in Accountin*g, Finance and Management Vol. 12, 2004, pp. 139-152.

[3] C. Stringer, and P. Carey, "Internal Control Re-Design: An Exploratory Study of Australian Organisations", *Accounting, Accountability & Performance*, Vol 8, 2002, pp.61-86.

[4] D. G.. Baird, and R.K.Rasmussen,. "Four (or Five) Easy lessons from Enron", *Vanderbilt Law Review*, Vol. 55, 2002, pp.1787-1808.

[5] E. A. Doty, A. Sen, and S. C. Wang, "Effect of Internal Controls in Data Base Design", J*ournal of Information Systems*, Vol. 3, Spring 1989, pp.70-91.

[6] G. A. W. Boehm, "Shaping decisions with system analysis," *Harvard Business Review*, Vol. 54, 1976, pp. 91-99.

[7] G.. B. Davis, and R. Weber, "The Impact of Advanced Computer Systems on Controls and Audit Procedures: A Theory and an Empirical Test", *Auditing: A Journal of Practice & Theory*, Vol.5, 1986, pp.35-49.

[8] G.. H. Grant, C. M. Karen, and A. Fatima, "The effect of IT controls on financial reporting", *Managerial Auditing Journal*, Vol. 23, 2008, pp. 803-823.

[9] H. Ashbaugh-Skaife, D. W. Collins, and W. R. Kinney Jr., "The discovery and reporting of intenal control deficiencies prior to SOX-mandated audits", *Journal of Accounting and Economics*, Vol. 44, 2007, pp.166-192.

[10] J. W. Lainhart, "An IT assurance framework for the future", *Ohio CPA Journal*, Vol. 60, 2001, pp.

19-23.

[11] L. A. Cunningham, “The appeal and limits of internal controls to fight fraud, terrorism, other ills”, *Journal of Corporate Law,* Vol. 29, 2004, pp. 267-336.

[12] P. P. Chen,. “The Entity-Relationship Model: Toward a Unified View of data,” *ACM Transaction on Database Systems*, March 1976, Vol. 1, pp. 9-36.

[13] R. Weber, “Audit Trail System Support in Advanced Computer-Based Accounting Systems,” *The Accounting Review*, 17(2), 1982, pp. 311-325.

[14] S. Lee, and H. Ahn, “The organizational contexts, controls and implementation of e-business”, *Journal of Computer Information Systems*, Vol. 51, 2010, pp.114-124.

[15] U. J. Gelinas, S. Sutton, and A. E. Oram, *Accounting Information Systems*, South-Western, Cincinnati, 1999.

[16] W. E. McCarthy, “An Entity-Relationship View of Accounting Models,” *The Accounting Review*, Vol. 14, October 1979, pp. 667-686.

[17] W. E. McCarthy, “The REA Accounting Model : A Generalized framework for Accounting Systems in a Shared Data Environment,” *The Accounting Review*, July 1982, pp. 554-578.

[18] Y-G. kim, and S. T. March, “Comparing Data Modeling Formalisms,” *Communications of The ACM*, Vol. 38, June 1995, pp. 103-115.