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Reorganization of Historical Data to Support the Analysis of Organization's Behavior

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Abstract—**If the historical data about the operations of an organization can be systematically and continually used, the analysis of organizational behavior for management control will be much easier and effective. Based upon Ashby's concept of black box and protocol, the paper proposes an approach to reorganizing the historical data of an organization. A data model containing two time variables to represent the cycle time of operations in the organization and the time length for behavior analysis has been developed. Using this model, a new data base containing a) the data files of all protocols describing the input state and output state of the activities concerned and b) the numerical data files of the statistics of interactions between and/or among entities concerned can be created from historical data removed from daily operational data base (DODB). The evidence from a case study in a general teaching hospital in Taiwan shows that the proposed approach can be implemented and the use of historical data to support the analysis of organization's behavior analysis for management control can be realized.**

I. Introduction

A daily operational data base (DODB) is designed to support the day-to-day transaction processing operations in organization. Basically, all detailed data items related to functional departments in an organization must be embodied in the DODB [1], thus the DODB usually consists of records about processes and results of operational activities in the organization [2]. As a result, too much information can be derived from the repertoire [3], [4]. Therefore, a DODB means an information-rich world [5] has been set up in the organization.

Once a transaction has been completely processed, then the data about that transaction must be removed from the DODB. Those data removed from the DODB will become historical data. As the cost and effort for data storage decreasing, the tendency to keep everything and throw away nothing will contribute to the storage of large amount of data [6]. Hence, the volume of historical data will grow to a large amount gradually. Since the historical data is the inactive DODB, the contents and structure of the historical data must be same as that of the DODB. Hence, the historical data are also rich in information about the organization. Therefore, the historical data have been recognized as the valuable data resources for the planning and analysis of organization [7]. The value and usefulness of historical data are specially apparent when the statistical analysis is desired [7], [8].

Although the value of historical data have been well recognized, the approaches or methods for systematic and continuous use of historical data generated from DODB have not been well developed. It has been mentioned in the literatures that the difficulties occurred in the use of historical data to support the analysis of organizational behavior can be contributed to the lack of understanding of the institutional context of organization

Manuscript received May 4, 1988; revised September 11, 1988.

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IEEE Log Number 8825075.

operations [9], [10]. Therefore, if we can reorganize the historical data in such a way that both the data entities and data attributes can consist with the institutional context of organization's operations, then the historical data can be systematically and continuously used for the purpose to support the analysis of organizational behavior.

Applying Ashby's concept of black box investigation [11], this paper presents an approach and the procedures to reorganize the historical data generated from DODB. A case study demonstrating the implementability of the method proposed is also reported. The paper finally discusses the implications of the approach.

II. Approach to Reorganize Historical Data

A. The Guiding Concept for Historical Data Reorganization

1) The Characteristics of Historical Data: The historical data generated from DODB are composed of past processing records and results of functional operations in an organization due to its orientation to support daily operations. Hence, the historical data generated from a DODB usually have following characteristics. First, the historical data grow constantly or even exponentially, therefore, if those data have not been regularly collected and filtered, pertinent data will be divergently stored and more costly to access. Second, the historical data generated from DODB are basically record-oriented and thus are nonnumerical forms in nature. Third, the different historical data items are removed from the DODB in different time sequences depending upon the time length when a data item becoming inactive, therefore, some relationships among data items will not be able to identify if the time period to collect those historical data has not been properly chosen.

2) Needs of Data Model: In order to use the historical data generated from DODB systematically and continuously, the characteristics of historical data mentioned above should be well considered in methods to reorganize them. It is necessary to develop a new data base because the characteristics of historical data limit the possibility of direct use of historical data to support the analysis of organizational behavior. The new data base should contain data entities and data attributes consisting with the institutional context of organizational operations. Hence, the historical data should be regularly collected from DODB with proper time length. Therefore, an operational data model must be constructed to conduct the development of the new data base.

3) The Guiding Concept for Data Model Development: The data model to be developed must be able to guide the construction of the new data base. Ashby [11] proposed the concept that when a system is regarded as a black box, then the system can be investigated by the collection of a long protocol, drawn out in time, showing the sequence of input and output states. It is obvious that we can apply Ashby's concept to develop a data model performing the collection and reorganization of the long protocol drawn out in time from DODB. Since the historical data removed from DODB are record-oriented, the data model must be able to filter, condense, and aggregate these record-oriented historical data and then to transform them into numerical cross-data form with canonical order to represent the relationships among input states, black box, and output states. Hence, a data model based upon Ashby's concept can be developed to construct the new data base composed of historical data generated from DODB to support the analysis of organization's behavior.

B. A Data Model for Historical Data Reorganization

1) *Structure of the Data Model:* Based upon Ashby's concept of black box and protocol, the following four entities are defined in the data model for the reorganization of historical data removed from DODB:

a) A historical data set $H(t)$ is the set of historical data representing the observed activities occurred in a given time period t. The data elements of $H(t)$ are collected from DODB.
b) A state data set $V(t)$ is the set of all protocols describing the input state and output state of the system being studied during time period t. The protocols in $V(t)$ are collected from $H(t)$. The data elements of $V(t)$ are arranged in vectors representing input state and output state.
c) A union data set $V(T)$ is the union of $V(t_1), V(t_2), \cdots, V(t_n)$, where $t_1, t_2, \cdots, t_n$ are sequential time period and T is the sum of $t_1, t_2, \cdots,$ and t_n.
d) A numerical data set $U(T)$ is the set of statistical data generated from $V(T)$.

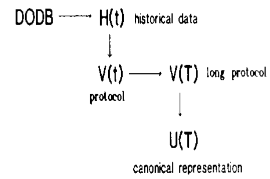

Fig. 1. Structure of data model.

In order to construct the data model in terms of entities defined, the following requirements have to be satisfied:

a) The data items $d_{p1}, d_{p2}, \cdots, d_{pm}$ related to an operational activity A_p are all kept in the DODB.
b) The processing cycle time ct_p for each operational activity A_p can be identified, thus the observing time period t of $H(t)$ can be defined as t equals to longest ct_p.
c) The length of time T required for the analysis of organizational behavior can be defined.

Then the structure of data model can be shown as Fig. 1.

2) Creation of New Data Base: According to the data model described above, the new data base can be created with the following steps.

a) *Create historical data set $H(t)$ from DODB:* Since the data items $d_{p1}, d_{p2}, \cdots, d_pk$ related to an operational activity A_p might be kept in $f_1, f_2, \cdots, f_g$ different files of the DODB, the data items describing the behavior of interested entities must be extracted from different files in DODB and restored in a new file. Let h_p be the number of events of operational activity A_p occurred in time period t, then the new file $H_p(t)$ created must have the record number h_p to store data items $d_{p1}, d_{p2}, \cdots, d_{pk}$ of every event. Then, the set of all new files $H_p(t)$ (for $p = 1,2,\cdots,m$) is the historical data set $H(t)$ derived from DODB.
b) *Create state data set $V(t)$ from historical data set $H(t)$:* Since the data items $d_{p1}, d_{p2}, \cdots, d_{pk}$ of file $H_p(t)$ represent the record of observed phenomena of activity A_p, the file $H_p(t)$ can be split into two files to represent the input state and output state of activity A_p respectively. The file $V_{pi}(t)$ stores the data items representing the inputs of activity A_p only, while the file $V_{po}(t)$ stores the data items representing the outputs of activity A_p. Because some data items of $H_p(t)$ might not be able to identify as input or output of activity A_p, the summation of the number of data item of $V_{pi}(t)$ and $V_{po}(t)$ will less or equal to the number of data item of $H_p(t)$, i.e. k. Then the set of all input state files $V_{pi}(t)$ and output state files V_{po} (for $p = 1,2,\cdots,m$) is the state data set $V(t)$.
c) *Create union data set $V(T)$ from data set $V(t)$:* Since the time length T required for the analysis of organizational behavior is defined as the sum of sequential observing time period $t_1, t_2, \cdots, t_n$, a file $V_{pi}(T)$ stores all input protocols of all activities $A_p(t_j)$ (for $j = 1,2,\cdots,n$) occurred in time

T can be created as the union of input state files $V_{pi}(t_j)$ (for $j=1,2,\cdots,n$) with record number of r_{pi} ($r_{pi}=\Sigma h_{pij}$, h_{pij} is the record number of $V_{pi}(t_j)$). Thus another file $V_{po}(t)$ can also be created as the union of all output state files of $V_{po}(t_j)$ (for $j=1,2,\cdots,n$) with record number of r_{po}. Then the set of all union input state files $V_{pi}(T)$ and union output state files $V_{po}(T)$ (for $p=1,2,\cdots,m$) is the union data set $V(T)$.

d) *Create numerical data set $U(T)$ from union data set $V(T)$:* The interaction among entities of an organization is the major concern of organizational behavior analysis. If the behavior of interaction among entities of an organization can be expressed in terms of statistical data, the analysis of organizational behavior will be very convenient. Hence, the interactive interesting entities must be identified first. Since the entities of input state or output state of an operational activity will not have any interaction among themselves, the statistical data of interactive entities identified must be derived from different state files. When the state files $V_{pi}(T)$ and $V_{qo}(T)$ (for $p,q=1,2,\cdots,m$) containing the interactive entities e_1 and e_2 have been identified, a file $Ue_1\times e_2(T)$ with record number S ($S=he_1\times he_2$, he_1 is the number of events of entity e_1 occurred in $V_{pi}(T)$, while he_2 is the number of events of entity e_2 occurred in $V_{qo}(T)$) can be created to store the statistics about the interaction between entity e_1 and entity e_2 from state file $V_{pi}(T)$ and $V_{qo}(T)$. A file stores the statistics about the interactions among entity e_1, e_2, and e_3, i.e., $Ue_1\times e_2\times e_3(T)$ can be created with the same method. Then the set of all $Ue_i\times e_j(T)$ $(i\neq j)$ files and all $Ue_i\times e_j\times e_k(T)$ $(i\neq j\neq k)$ files is the numerical data set $U(T)$ representing the statistics of interaction among entities of an organization.

III. Case Study

A. Background

For the purpose to demonstrate the implementability of the proposed approach, a case study has been conducted on a medium-sized teaching hospital in Taiwan. The hospital has launched a PC-based computerization project since July 1985. The daily operational activities in the hospital such as registration, ward bed management, medical charge calculation, payment claim of insured inpatients and outpatients, and drug and material management have been computerized [12]. Hence, a well-functioned DODB has been established in the hospital to support the daily operations. The historical data about the outpatient operations removed from DODB are selected to test the implementability of the approach proposed. The background information of the case hospital are shown as Table I. The historical data removed from DODB are data generated from three activities and kept in seven different files. Both the observing time period t and the time length for behavior analysis T required for the reorganization of historical data are defined as one day and one month respectively.

B. Implementation

1) *Create Historical Data Set $H(t)$ from DODB:* The data items stored in seven different files of hospital's outpatient DODB are to be removed for reorganization. Then, three historical data files of registration, medical, and charge activity $H_p(t)$ ($p=1,2,3$) in the outpatient department (OPD) can be created respectively.

a) *Create historical data file $H_1(t)$ for registration activity:* Since all events of daily outpatient registration have been stored in both daily outpatient registration file and patient personnel data file, the data items of historical data file $H_1(t)$ for registration activity must be extracted from these two files daily. The data items of both daily outpatient registration file and patient personnel data file are shown as Table II. There are five items to be extracted from daily outpatient registration file and eight data items to be extracted from patient personnel data file. These extracted data items will be stored in file $H_1(t)$ and shown as Table III. The record number of $H_1(t)$, i.e. h_1, can be determined by the counted number of outpatients occurred in daily patient registration file every day. Consequently, the historical data file $H_1(t)$ for registration activity is created as a file of 700 records containing 13 data items with record length of 78 bytes to store daily data generated from DODB.

b) *Create historical data file $H_2(t)$ for medical activity:* For medical activity, all events of daily outpatient medical record have been stored in daily outpatient medical file, outpatient test file, outpatient treatment file, and outpatient drug file. And there are eight data items to be extracted from daily patient medical file and eighteen items to be extracted from drug, test, and treatment files. These extracted data items will be stored in file $H_2(t)$ and also shown as Table III. The record number of $H_2(t)$, i.e. h_2, is the same as that of $H_1(t)$ because the number of daily outpatients will maintain the same for all activities in OPD. As a result, the historical data file $H_2(t)$ for medical activity is created as a file of 700 records containing 26 data items with record length of 198 bytes to store daily data generated from DODB.

TABLE I
Background Information about the Case Hospital

Information Item	Status
Outpatients visit	700 visits/day
Physicians available	60 physicians
Professional department	14 departments
Diseases identified	360 kinds of disease
Drugs used	800 kinds of drug
Tests provided	300 kinds of test
Treatments supported	500 kinds of treatment
Charge accounts concerned	14 accounts

TABLE II
Related Data Files of DODB for Registration Activity

Data File of DODB	Data Item	Data Item Length (Bytes)	Record Length	Record Number
Patient's personnel data file	Patient's registration Number	6	120 bytes	80,000 records
	Name	8		
	Sex	1		
	Blood type	2		
	Birthday	6		
	Address	60		
	Phone	9		
	Profession code	2		
	Category type	2		
	Insurance number	12		
	First-registrated day	6		
	(reserved)	6		
Daily patient registration file	Patient's number	6	50 bytes	About 700 records per day
	Patient's name	8		
	Physician code	4		
	Physician name	8		
	Department code	2		
	Department name	8		
	Diagnostic-room code	4		
	Series number	4		
	(reserved)	6		

TABLE III
HISTORICAL DATA REMOVED FROM DODB

Activity A_p	Data Files $H_p(t)$	Data Items	Record Length	Number of Records
Registration	Patient's registration process file	Patient's registration number and name sex, birthday, region, profession's code, category type, insurance number, Physician code & name, Department code & name, Diagonstic-room code	78 bytes	About 700 records per day
Medical	Patient's medical process file	Patient's registration number and name Disease code and name Physician code and name Department code and name Test code and quantity Treatment code and quantity Drug code, drug quantity and total quantity	198 bytes	About 700 records per day
Charge	Patient's charge process file	Patient's registration number and name category type, insurance number, charge code, charge amount, total charge	86 bytes	About 700 records per day

TABLE IV
STATE DATA FILES

Data File $H_p(t)$	Data Items Representing Input State, $V_{pi}(t)$	Data Items Representing Output State, $V_{po}(t)$
Patient's registration process file	Patient's registration number, age, sex profession's code, region's code	Physician code, Department code
Patient's medical process file	Patient's registration number, Physician code, Department code, Disease code	Test code and quantity, Treatment code and quantity, Drug code and total quantity
Patient's charge process file	Patient's registration number, Category type	Charge code, Charge amount, Total charge

c) *Create historical data file $H_3(t)$ for charge activity:* For charge activity, all events of daily outpatient charge record have been stored in daily outpatient charge file, and there are nineteen data items to be extracted from daily patient charge file. These extracted data items will be stored in file $H_3(t)$ and shown as Table III. The record number of $H_3(t)$, i.e. h_3, is also the same as that of $H_1(t)$. Consequently, the historical data file $H_3(t)$ for charge activity is created as a file of 700 records containing 19 data items with record length of 86 bytes to store daily data generated from DODB.

2) *Create State Data Set V(t) from Historical Data Set H(t):* All data items of each $H_p(t)$ $(p=1,2,3)$ are divided into two groups as input state and output state shown as Table IV, and then stored in file $V_{pi}(t)$ and file $V_{po}(t)$ $(p=1,2,3)$ respectively. The data items that are not related to the behavior analysis or unable to identify as variables of input state and/or output state should be removed from $V_{pi}(t)$ file and/or $V_{po}(t)$ file. Therefore, Table IV shows that the data items of $V_{pi}(t)$ and $V_{po}(t)$ are different and the sum of the number of data items of $V_{pi}(t)$ and $V_{po}(t)$ is less than that of $H_{pi}(t)$.

3) *Create Union Data Set V(T) from Data Set V(t):* Once the six daily input state file and output state data files have been created for one month, all records of these daily state files are scanned day-by-day in sequence to count the record numbers of everyday's file. Then, three new data files $V_{pi}(T)$ with same data items of $V_{pi}(t)$ having the record number r_{pi} of about 20000 are created to store all these daily data of $V_{pi}(t)$ $(p=1,2,3,\ t=1,2,\cdots,31)$ of that month. Three new data files $V_{po}(T)$ to union the $V_{po}(t)$ of the whole month can also be created with same process. Once these six data files of $V_{pi}(T)$ and $V_{po}(T)$ have been created, the daily data files of $Vpi(t)$ and $Vpo(t)$ of that month can be erased. As a result, about 3,000 K (bytes) is needed to store the data generated in one month.

4) *Create Numerical Data Set U(T) from Union Data Set V(T):*

a) *Identify interactions between entities concerned:* Since disease, physician, department, drug, test, treatment, and charge are major entities in hospital system, interactions of disease-related and physician-related entities are identified for behavior analysis and shown as Table V.

b) *Derive numerical data files $Uei \times ej(T)$:* For each interactive entities $e1$ and $e2$, number of events $he1$ and $he2$ have been counted from the union files containing the entities $e1$ and $e2$. It has been found that there are about 140 kinds of disease occurred, 420 kinds of drug used, 100 kinds of test applied, and 50 kinds of treatment provided for outpatient's visits per month in one year. To create numerical data files $E_{e1} \times_{e2}(T)$, the data items related to entities $e1$, entity $e2$, and the required statistics (frequency, summation, mean, variance, etc.) about the interaction between $e1$ and $e2$ are defined first. Next, arrays of the statistics with dimension $h_{e1} \times h_{e2}$ are also defined in the corresponding application program. Then, every record of $V_{pi}(T)$ file and $V_{qo}(T)$ file are sequentially scanned to identify the occurrence of events of entity $e1$ and entity $e2$. When the records of $V_{pi}(T)$ file and $V_{qo}(T)$ file are scanned, the statistics about the interaction between $e1$ and $e2$ can be counted and calculated. Finally, a new file is created to store those monthly statistical data and is the numerical data file $U_{e1} \times_{e2}(T)$. Thus, Table V shows all nine numerical data files containing statistical data about

TABLE V
DISEASE-RELATED AND PHYSICIAN-RELATED NUMERICAL DATA FILES

Numerical Data Files $U_{ei \times ej}(T)$	Number of Records	Interactions Concerned	Statistical Data Provided
Disease × revenue (140 × 1)	140	Contribution and deviation of revenue of each disease	Monthly summation, mean and variance of revenue for each disease
Disease × charge (140 × 14)	1960	Distribution among charge accounts of each disease	Monthly summation, mean and variance of all charge accounts for each disease
Disease × drug (140 × 420)	9000	Drugs used by each disease	Monthly frequency and quantity of drugs used by each disease
Disease × test (140 × 100)	2100	Tests assigned by each disease	Monthly frequency and quantity of tests occurred in each disease
Disease × treatment (140 × 50)	850	Treatments occurred in each disease	Monthly frequency and quantity of treatment used by each disease
Physician × revenue (60 × 1)	60	Each physician's monthly contribution to revenue	Monthly summation, mean and variance of revenue for each physician
Physician × drug (60 × 420)	8500	Each physician's preferred drugs	Monthly frequency and quantity of drugs used by each physician
Physician × test (60 × 100)	500	Each physician's preferred tests	Monthly frequency and quantity of tests assigned by each physician
Physician × treatment (60 × 50)	300	Each physician's preferred treatments	Monthly frequency and quantity of treatments used by each physician

the interactions between disease-related and physician-related entities in outpatient department (OPD).

Since the statistics generated from the new data base $U_{ei} \times_{ej}(T)$ is the representation of the behavior of interactions among entities concerned, it is obvious that the statistical data in $U_{ei} \times_{ej}(T)$ file can be used to support the analysis of organizational behavior. In the case hospital, based upon the statistics provided from the new data base $U_{ei} \times_{ej}(T)$, the analysis of disease-related and physician-related medical behavior can be conducted more efficiently.

C. Results

Using the statistical data generated from the new data base $U_{ei} \times_{ej}(T)$, the decision makers of the case hospital found that among 140 kinds of outpatient disease there are 19 kinds of disease contributing 80 percent of the monthly revenue in the past year. Furthermore, the type and the drugs used, the tests assigned, and the treatments applied by these 19 main diseases can also be identified from the statistics stored in the new data base $U_{ei} \times_{ej}(T)$. Hence the case hospital decide to adopt a disease-dependent policy to manage the medical resources to support the outpatient operations in the hospital. Therefore, the layout of dispensary is rearranged to facilitate the handling of the drugs used by these 19 main diseases. The inventory level and the acquisition policy of the drugs used by these 19 main diseases are also changed to reduce the storage cost of drugs. Besides, the physicians, nurses, and staffs of the hospital are all requested to pay special attention to patients of these 19 main diseases to increase the competition ability of the hospital in the region.

From the statistics about the monthly frequency and monthly quantity of drugs used by each physician, the decision makers of the case hospital found that the medication behavior of the first year residents is different with that of the visiting doctors. The statistics indicate that the first-year residents have the preference to use antibiotic and injection in their medication decisions. Hence, a series of seminars on prescription filling are held for the first-year residents to increase the adequateness of medication decisions.

Based upon the feedbacks provided by the new data base, the case hospital improves her management control on both medical resources and physician's medication behavior significantly.

IV. CONCLUSION

To support the analysis of organizational behavior, the systematic and continuous use of historical data representing the institutional context of organization operations is needed. The study analyzes the characteristics of historical data generated from DODB, then proposes an approach to reorganize historical data in an organization based upon Ashby's concept of black box and protocol. A data model containing two time variables to represent the operation cycle time t across all concerned activities in the organization and the time length T for behavior analysis has been proposed. Then, a new data base containing: (a) the data files of all protocols describing the input state and output state of the activities concerned in time T; and b) the numerical data files of the statistics of interactions among entities concerned in time T can be created from historical data removed from DODB. The evidence from a case study in a general teaching hospital in Taiwan shows that the proposed approach can be implemented, and the new data base created can provide adequate statistical data to support the analysis of behavior for management control in the hospital.

The historical data reorganized by the data model proposed in this study is the feedback information about the operations of an organization. The feedback information is the major information source for management control. Hence, the numerical data files created in this study can be viewed as an information source providing feedback information to support decisions on management control.

It can be found that the composite entities of the organization, the processing cycle time of operational activity t, and the time length for behavior analysis T are the key variables of the data model to manipulate the reorganization of historical data generated from computerized DODB. The determination of the length of processing cycle time t and the time length T for behavior analysis depends on the characteristics of operational activity and the nature of organization. Since every operational activity in an organization is composed of a series of repetitively executed procedures, the processing cycle time t of operational activity can be determined as the average time length to complete all required procedures before repetition. As to the determination of the time length for behavior analysis T, because the macro and long-term behavior pattern of the system is the focus of organizational behavior analysis, the value of T can be chosen under condition that the scale of time for T is larger than that for processing cycle time t. Naturally, the macro behavior pattern of the system under the scale of time chosen for T can be easily recognized. For example, one day (t) and one month (T) are adequate for the behavior analysis in outpatient department (OPD) of hospital.

Both the processing cycle time t of operational activity and the time length T for behavior analysis play significant role in the reorganization of historical data generated from computerized DODB. If the processing cycle time t of operational activity has been ingnored, the access of historical data generated from DODB will be too costly or too difficult. If the time length T for behavior analysis has been ignored, the latent information about the interactions among entities of interesting will not be able to derive from the existed DODB. Hence, it is suggested that the recognition of time variables underlying the operations of an organization should be emphasized in accessing historical data removed from DODB.

The study shows that the historical data removed from DODB can be reorganized to generate information about the behavior of interactions among entities of an organization. Therefore, the effective use of historical data removed from DODB can be realized.

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