CHEMICAL ENGINEERING TRANSACTIONS

VOL. 51, 2016

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Tichun Wang, Hongyang Zhang, Lei Tian

ISBN 978-88-95608-43-3; **ISSN** 2283-9216

DOI: 10.3303/CET1651159

Enterprise Internal Control System Model Based on Workflow Mining

Wei Li[a*], Yun Teng[b]

[a]Dalian Maritime University, Liaoning Dalian, China
[b]Dalian Commodity Exchange, Trading department, Dalian Maritime University , Dalian, China
huntercet@qq.com

To ensure correct and timely implementation of enterprise internal control, it needs the integration of idea of internal control and enterprise management, so we should ensure am appropriate business process model in technology. Workflow mining technology and its framework provide the authenticity and robustness of business process, and they can be well integrated to complex internal control environment. This paper explains the current research of enterprise internal control and its corresponding models. The working principles of workflow mining, especially for system logs data pre-processing, mining algorithms and intermediate model subsystem design are also discussed. Then based on the analysis of above theoretical knowledge we propose the business process reengineering framework of data mining model under enterprise internal control environment. The feasibility and correctness of internal control system model is verified by case study.

1. Introduction

Enterprise internal control system means that the evaluation subject generally evaluates the effectiveness of enterprise internal control system, forms evaluating idea and recognizes internal control defect. Although the given scheme regulates some theories of principle, content, program, flaw evaluation in internal control evaluation, these regulations are too general and cannot provide. At present, there are broad studies in internal control evaluation from academics (Nguyen, 2006; Su and Zeng, 2012). However, most of these studies are from the perspective of external evaluators who only depend on the revealed information of enterprise. Therefore, evaluating accuracy is suspicious and it cannot be directed in experience and it will be bad for improving enterprise internal control. Thus, at present, it is urgent to set up operational internal control evaluation system in order to direct practice of internal control evaluation. The application of workflow technology in enterprise is based on integrating computer resources including current network, server and client of company, systematically designs workflow according to predetermined principles and performs human-computer interaction in sequence (Dulce and Pedro, 2003). Workflow technology utilization cannot only improve operating efficiency of enterprise and enterprise resource utilization but it can also improve flexibility and adaptation of enterprise production as well as operation. Therefore, enterprise concentrates on key business, tracks testing business process, reduces man-made errors and improves market competition in enterprise. (Tammaro, 2016)

This paper first analyses the workflow concept and workflow principle, and studies related theory in workflow management system. On this basis, this paper studies workflow mining technology in detail including workflow mining model and studies common problems in current workflow mining technology. After related studies of workflow mining and enterprise internal control are completed, workflow mining technology is applied in enterprise internal control, combines with business process reconstruction, studies and analyses workflow mining of practical business operation in enterprise. During this process, we study the application of enterprise internal control and puts forward corresponding workflow mining application framework (Diamantis, 2002). Finally, based on previous work, this paper completes empirical analysis of workflow mining technology in enterprise internal control, utilizes workflow mining technology to diagnose and reconstruct practical business process and finishes empirical analysis of workflow mining technology in enterprise internal control.

Please cite this article as: Li W., Teng Y., 2016, Enterprise internal control system model based on workflow mining, Chemical Engineering Transactions, 51, 949-954 DOI:10.3303/CET1651159

2. Application model of workflow technology in enterprise internal control

The effective implementation center of internal control is to guarantee all business activities of enterprise to be based on requirement standard processing steps (Zhao et al., 2011). Workflow technology application in internal control is mainly based on internal control activity requirement to define the processing rule of business activity and this rule is transformed into workflow in system (Zhu, 2007). Through workflow analysis, the critical control point and common control point are judged (Yang et al., 2009). The critical control point refers to the critical factor during measuring quality job. It holds the critical point so it can control the global situation to effectively avoid decision deviation (Zhou and Ruan, 2014). Common control point refers to common factor during business activity and it will not seriously affect the global situation (D. John, et al, 2008). Application essence of workflow technology in enterprise internal control is mutual cooperation and interpenetration between workflow and internal control. Each process node adds internal control standards so that internal control (Anonymous, 2013) is penetrating in workflow of enterprise operating activity. Another purpose to adopt workflow technology is to set up enterprise application system integration platform (EAI), embed workflow engine into the application and increase reusability and maintainability of software.

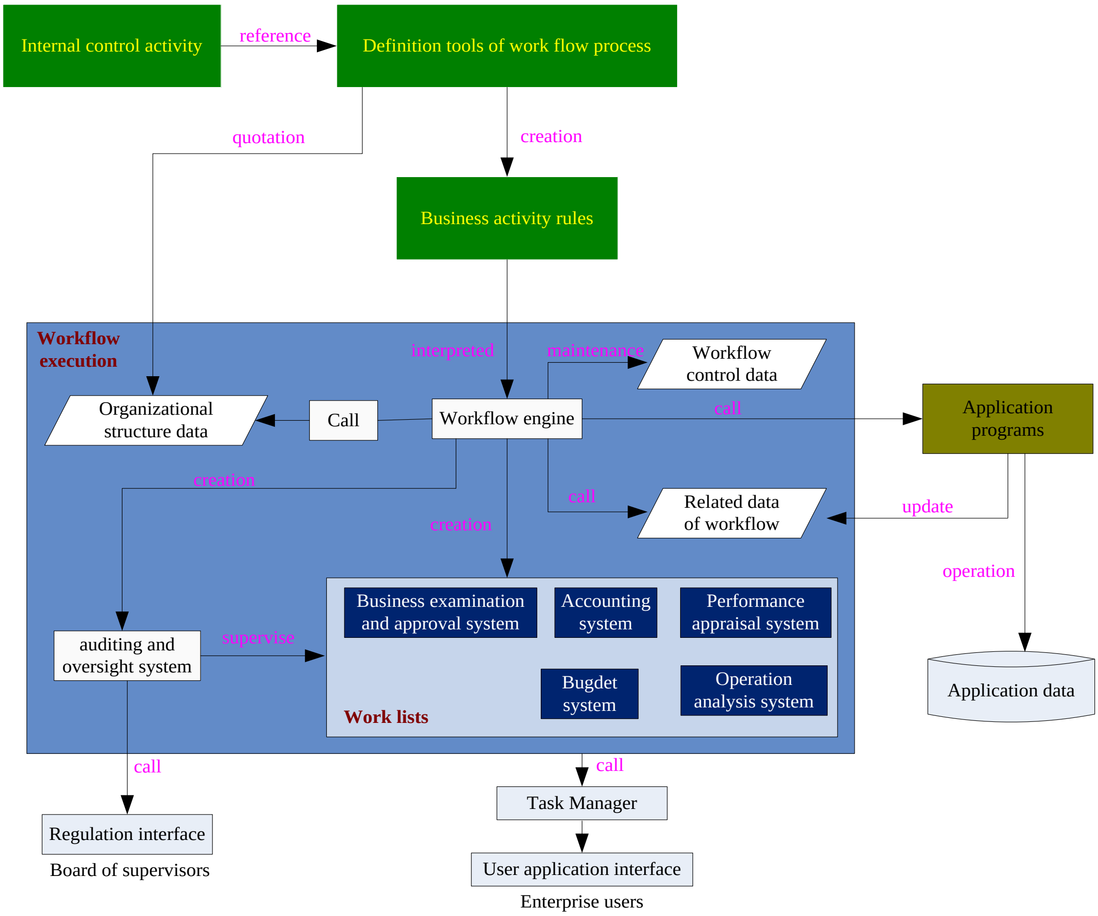

Figure 1: Integrated Application System of Internal Control

3. Workflow System Modeling and Mining Key Technology

3.1 Framework of Workflow Mining

At present, various information systems are broadly applied in enterprise. These business systems such as enterprise resource plan, supply chain management system and client relationship management system will record much log data in practical operation (Sun, 2007). Workflow mining will mine corresponding workflow model after these log data are processed. These are effective means for workflow reconstruction and enterprise internal control enhancement. However, logs in various systems do not have unified data structure and log data need to be in unified management and processing in unification. After these data quality of workflow mining is guaranteed, mining technology and mining tools are introduced to be modeling practical workflow in enterprise to obtain the expected workflow model. A good workflow framework can ensure authenticity and robustness of workflow model and effectively merge in precise and relatively complex internal control environment. Nowadays, most enterprises have experienced information for a long time and got considerable achievements. Therefore, these achievements should be applied to construct workflow mining framework in enterprise to manage enterprise more deeply.

Workflow reconstruction introduction is very effective to set up the perfect internal control (Decker Michael, 2009). This paper takes workflow reconstruction as clue and carrier to merge workflow mining into internal control environment and design a framework which uses workflow mining in internal environment. Workflow mining can expand the internal control framework to enterprise diagnosis for analysis. The reason is that process modeling implementation can discover business contradiction at any time during model operation and then correct during model reconstruction. Furthermore, the combination between workflow and internal control cannot only keep flexibility but also keep preciseness in terms of enterprise workflow reconstruction. The extension from model diagnosis stage to enterprise diagnosis can evaluate business model and can also retrospect enterprise business operation. Framework in figure 2 focuses on implementing workflow reconstruction in system, and introduces workflow mining and tools to support framework implementation, offer scientific description, operate and diagnose environment and finally merge the overall framework into enterprise internal control environment.

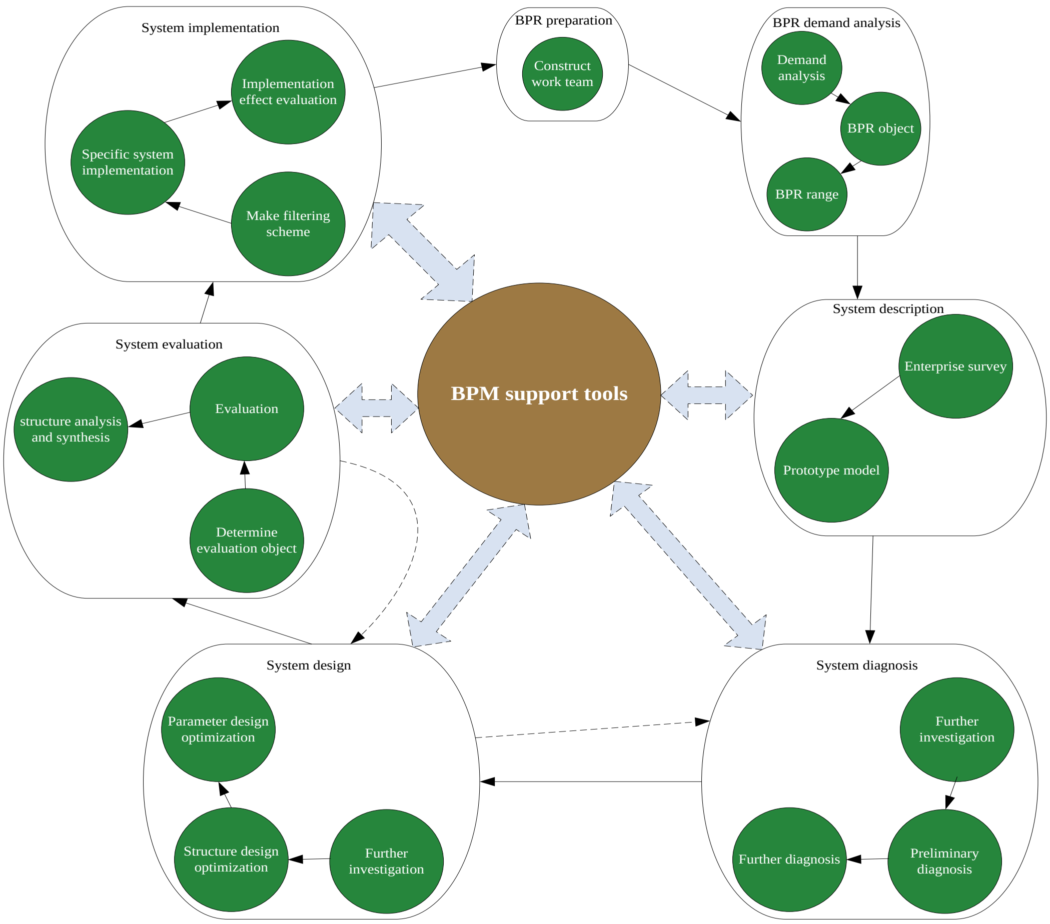

Figure 2: Framework of Internal Control

3.2 Workflow Performance Analysis Based on Workflow Mining

The resume workflow in enterprise business activity is usually complicated and uncertain. Corresponding workflow mining algorithm can perform the performance analysis on workflow model.

The main means is to process log data, determine control process in specific time interval, perform deep analysis deduction and finally obtain basic reference data of operating resource and time in system.

We Assum the workflow performance network as a quintuple (W, η, α, β, V). W is workflow net WF-net (P.T.F). Library P denotes the activity state of business; Transition set T denotes the behaviors of transaction

processing; relationship set F denotes the logic relationship between connection state and transition. η is positive set of η(t).η(ti) is the reciprocal of average processing time for transition time; α is the set of non-negative number α(t). α(ti) is the average time of process being triggered during instance execution. β is positive set of β(fi), which denotes the task distribution proportion of selection according to conditions; V is a positive number that denotes the happened business flow per hour of certain workflow in given working day.
Conditionally selecting route represents classification phenomenon in practical bushiness. Therefore, during constructing and designing workflow network, workflow structure needs to be classified and performance analysis will be divided. Meanwhile, the branch structure will also be combined so as to obtain business classification of workflow network.
Time performance
$\beta=\{\delta_{i1}, \delta_{i2,...}, \delta_{in}\}$ means the percent of all transactions. It is acquired by the analysis of workflow performance; $\lambda_i=V\times\beta=\{\lambda_{i1}, \lambda_{i2,...}\lambda_{in}\}$ denotes the arriving rate of each transaction in the model.
Assuming α is one workflow net and the number of transitions triggered in unit time is described as B=Vxα $\{V\alpha_{i1}, V\alpha_{i2,...}V\alpha_{in,}\}$. It is decided by the trigger on each transition of each finished instance of α.
Resource utilization
The control process of transaction model has uncertainty and fuzziness, but each task must be in accordance with the transition used in the process when using the resource. Then we introduce transition-resource matrix C_{mxn}. If C(Y)=μ(Y)/(mxp$_i$), it shows the starting success of transition t_j needs the participation of resource R_{e_j} ; if C_{ij}=0, it shows the opposite case.
According to above parameters we can acquire the arriving speed of transactions instances of corresponding resource as $w=C_{mxk}(B_{1xk})^T$.
The average service speed of resource is:

$$\eta_j = \sum(\mu_i \times \lambda_{ti} / \sum \lambda_{ti}) \quad (1)$$

The resource load is:

$$\rho_i = \omega_i / \mu_i \quad (2)$$

$\lambda_i = \min_Y(1/C(Y))$ and C(Y)=μ(Y)/(mxp$_i$) are the sum of transition executing time of recycling time μ(Y) in basic loop Y.

4. Case study

Illustrated by the workflow model of certain enterprise to handle client's complaint as an example, model mining will be explained in detail. Figure 3 refers to the process model of one enterprise to handle client's complaint in directed graph. Activity a1 refers to complaint registration, activity a2 refers to mail questionnaire, and activity a3 refers to complaint evaluation. After complaint evaluation, complaint processing or skipping the processing can be selected. Activity a4 refers to processing questionnaire, activity a5 refers to handling complaint, activity a6 refers to check results and activity a7 refers to archive. When enterprise receives complaint and register, to process questionnaire and evaluate complaint will have parallel relationship in logic. After evaluation, to process complaint or to skip the process can be chosen. Therefore, there has logic or relationship in activities after activity a3.

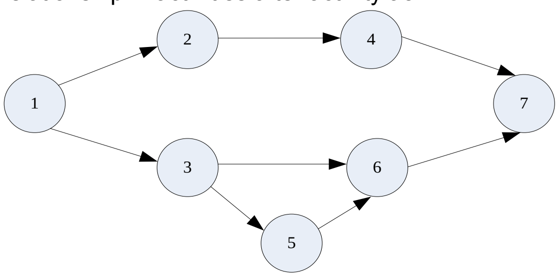

Figure 3: Complaint Processing Model

There are lots of repeated cases in workflow log. To filter repeated cases in data pretreatment can largely reduce the processed data quantity. For log S_0, we can get workflow set of instances S when the repeated instances are deleted. It is divided into multiple sub-set {S_1, S_2,…, S_n}, satisfying that if $I_i \in S_i$ in $\forall S_i$, $\forall I_i \in S_i$ and $AS(I_i) = AS(I_j)$, $S=S_1 \cup S_2 \cup ... S_n$.

For the workflow model depicted in figure 3, the log is processed to acquire the set of instance as follows (a_i^s and a_i^e denote the start event and ending event):

$$I_1 = (a_1^s, a_1^e, a_2^s, a_3^s, a_2^e, a_4^s, a_3^e, a_5^s, a_4^e, a_5^e, a_6^s, a_6^e, a_7^s, a_7^e)$$

$$I_2 = (a_1^s, a_1^e, a_2^s, a_3^s, a_3^e, a_5^s, a_2^e, a_4^s, a_5^e, a_6^s, a_4^e, a_6^e, a_7^s, a_7^e)$$

$$I_3 = (a_1^s, a_1^e, a_3^s, a_2^s, a_3^e, a_6^s, a_2^e, a_4^s, a_6^e, a_7^s, a_7^e)$$

S_1= {I_1, I_2}, S_2= {I_3}

After data processing we can get the set of instances $S_1, S_2, …, S_n$. Each instance is defined as dependency matrix to acquire corresponding results. For example, sets of instances S_1, S_2 in the complaint processing model can be computed to get dependency matrix M_1 and M_2:

$$M_1 = \begin{matrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7 \end{matrix} \begin{bmatrix} 0&1&1&1&1&1&1 \\ 0&0&0&1&0&0&1 \\ 0&0&0&0&1&1&1 \\ 0&0&0&0&0&0&1 \\ 0&0&0&0&0&1&1 \\ 0&0&0&0&0&0&1 \\ 0&0&0&0&0&0&0 \end{bmatrix}, \quad M_2 = \begin{matrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7 \end{matrix} \begin{bmatrix} 0&1&1&1&1&1&1 \\ 0&0&0&0&1&0&1 \\ 0&0&0&0&0&1&1 \\ 0&0&0&0&0&0&1 \\ 0&0&0&0&0&0&1 \\ 0&0&0&0&0&0&1 \\ 0&0&0&0&0&0&0 \end{bmatrix}$$

After the dependency matrices M_1, M_2, …, M_n are generated, we need to delete the non-global dependent relationship in each matrix and create global dependency matrix M_0 containing all the activities of logs. Then we apply *CompDirDepend* to get the direct dependency relationship among the activities of the set of instances, to ensure the minimum workflow model.

Finally, *CompEDG* is used to expand logic or relationship between activities in directed graph G and the final workflow model is acquired.

Java language is adopted in Windows XP system platform to realize algorithm in this paper and Dell PowerEdge 2850 server with 4G memory respectively uses synthetic data and practical data to test and then to simulate the algorithm. Mining result is shown as figure 4. Abscissa refers to node number in simulating experiment while ordinate refers to accuracy. Accuracy is defined as the dependent relationship quantity of the mined models satisfying accuracy, that is, the dependent relationship quantity in original model. From data, on the basis of the mining algorithm in this paper, average accuracy is 95% above. Along with node number of processing model increasing, its mining accuracy is also increasing. Abscissa refers to simulating experiment node number while ordinate refers to simulating time.

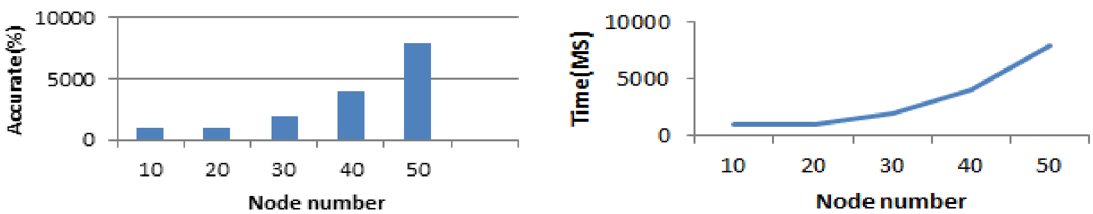

Figure 4: Accurate and complexity analysis of mining results

5. Conclusion

This paper takes enterprise workflow as carrier, introduces workflow mining into enterprise internal control and applies workflow mining technology in internal control environment. On this basis, workflow reconstruction is completed and workflow mining is mingled with enterprise internal control and enterprise management. After current workflow mining implementation framework and workflow reconstruction framework are analysed and integrated, compound framework in internal control environment is proposed and internal control application performance in workflow technology is analysed to set up the application model. Application feasibility and accuracy of workflow technology in enterprise internal control is verified through customers' complaint model in practical project.

Acknowledgement

This work is supported by the fundamental research funds of the central universities（3132016043） and key issues of social science of Dalian (2015dlskzd035)

References

Anonymous, 2013, Exhaust gas cleaning system operates inside U.S. emission control area, Sea Technology, 16, 2,465-478.

Diamantis Z.G.,2002,Optimization of an active noise control system inside an aircraft, based on the simultaneous optimal positioning of microphones and speakers, with the use of a genetic algorithm, Computational Optimization and Applications,16,2,256-278.

Dulce D., Pedro V., 2003, A dynamic role based access control model for adaptive workflow management systems, Proceedings of the International Conference on Enterprise Information Systems, 167-173.

John D., Stockton B., 2008, Control point policy: efficiency within make-to, Physical Sciences, 61, 6, 70-82.

Michael D., 2009, A location-aware access control model for mobile workflow systems, International Journal of Information Technology and Web Engineering, 4, 1, 50-66. doi:10.1016/j.future.2013.05.010.

Nguyen V., Lee R., Dutta K., 2006, An aspect architecture. for modeling organizational controls in workflow systems, Information Technology Journal, 5, 3, 460-470. doi:10.1016/j.jnca.2011.03.029

Su W., Zeng G.Z., 2012, Access control model in migrating workflow system with site service alliance, Advances in Intelligent and Soft Computing, 160, 2, 139-145.

Sun Y., 2007, Application evaluation research on enterprise resource plan based on AHP and mutiple level fuzzy synthetic evaluation, Technology Economics, 12, 2, 64-69.

Tammaro M., Mauro A.W., Montagud C., Corberán J.M., Mastrullo R., 2016, Hot sanitary water production with CO2 heat pumps: Effect of control strategy on system performance and stratification inside the storage tank, Applied Thermal Engineering, 15, 6,455-478.

Yang Y., Liu H., Fan Y.Q., XU L., Zhou J.L., 2009, Application research of workflow technology In management system, International Symposium on Distributed Computing & Applications to Business, 32, 5, 31-36.

Zhou Z.Y., Ruan S.J, 2014, Workflow based assembly process control and management method for complex product, Applied Mechanics and Materials, 491, 15, 514-518. doi:10.1016/j.is.2014.01.006.

Zhao Z.M., Ji P.P., Liu F., 2011, Plate mode standard system chart & logistics enterprise standard management, Standard Science, 21, 5, 21-28.

Zhu C., 2007, Research of workflow technology and application in OAS, Journal of Zhejiang Wanli University, 17, 9, 50-58.