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A business process activity model and performance measurement using a time series ARIMA intervention analysis

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ABSTRACT

The degree of performance excellence that an enterprise can achieve greatly depends on the business process flow that the enterprise adopts, where the more efficient and effective the business process flow, the greater the degree of performance excellence the enterprise can achieve. Most conventional business process analyses focus on qualitative methodologies, but these lack solid measurement for supporting the business process improvement. Therefore, a quantitative methodology using an activity model that is described in this paper is proposed. This model involves the use of an adjacent matrix to empirically identify inefficient and ineffective activity looping, after which the business process flow can then be improved. With the proposed quantitative methodology, a time series intervention ARIMA model is used to measure the intervention effects and the asymptotic change in the simulation results of the business process reengineering that is based on the activity model analysis. The approach is illustrated by a case study of a purchasing process of a household appliance manufacturing enterprise that involves 20 purchasing activities. The results indicate that the changes can be explicitly quantified and the effects of BPR can be measured.

1. Introduction

The business process is a framework for activities to participate and interact so as to produce a product or a service and achieve the well-defined objectives of an enterprise (Hammer & Champy, 1994; Keung & Kawalek, 1997), and the structure of it greatly affects the overall performance of the enterprise. Moreover, in this ever changing global marketplace, the better the performance of the enterprise, the greater the competitiveness the enterprise can achieve. An enterprise not only faces challenges in external global competition but also faces root challenges of internal business process improvement to drive the performance towards excellence (Schorr, 1998). It is then important to evaluate and analyze the internal business process of the enterprise for the necessary partial or complete redesign of the process to improve the business performance (Morrow & Hazell, 1992).

Very often, an enterprise may need to perform a dynamic analysis of their business process so as to simulate and evaluate different sets of processes that could ensure the efficiency and effectiveness of the business process flow as well as improve the overall performance of the enterprise (Alera, Borrajoa, Camachoa, & Sierra-Alonsob, 2002). Business process analysis is based on the business process flow or business process model that the enterprise has adopted. Business process modeling is one of the business tools that help an enterprise to achieve competitive advantages and improve business performance. The business process flow can be systemically represented and mapped by the model, and business process analysis can then be carried out. With the analyzed results, the business process can be revolutionized, redesigned or reengineered, so the enterprise can then achieve the great benefits of enhanced competitiveness (Evans, Towill, & Naim, 1995).

Business process modeling and business process analysis are two inter-related research areas. In the research area of business process modeling, research interests ranges from process enactment, such as ECA Rules (Bae, Bae, Kang, & Kim, 2004) and collaboration with business process choreography (Jung, Hur, Kang, & Kim, 2004) to process monitoring, such as enterprise information portal (Hur, Bae, & Kang, 2003) and run-time environment (Kim, Kang, Kim, Bae, & Ju, 2000). Some leading approaches to business process modeling representation have been discussed in the literature, such as the family of Integrated Computer Aided Manufacturing Definition (IDEF) (Defining IDEF, 1992; Kusiak, Larson, & Wang, 1994; US Air Force, 1981), petri-nets approach (Van der Aalst & Van Hee, 1996), hyper-graph approach (Huang, 1997), entity relationship modeling (Maker et al., 1992), the role activity diagrams approach (Ould, 1995), and state-driven approach (Lee, Kim, Kang, Kim, & Lee, 2007). On the other hand, research into

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business process analysis ranges from process analysis to process improvement, entailing aspects such as workflow mining (Van der Aalst & Aj, 2004), process measurement (Cardoso, 2005), and process optimization (Ha, Bae, Park, & Kang, 2006). Moreover, there are a number of analysis techniques that have been discussed in the literature, such as reachability graph (Yang & Liu, 1998), the structural analysis approach (Sadiq & Orlowska, 1999), Queueing theory (Kleinrock, 1975), self-organizing map (SOP) or dimensional output space (Díaz, Domínguez, Cuadrado, & Fuertes, 2008).

The research discussed in the literature and the approaches for business process modeling and analysis all have different advantages and disadvantages. However, research into business process modeling and analysis still has room to improve, since most of the work focuses on the qualitative approach that concerns the logical correctness of the defined process instead of the performance of the defined process. Therefore, in this paper, we propose a quantitative approach using an activity model for business modeling and analysis, in which, adjacent matrixes can be applied to provide explicit performance indicators for the enterprise to identify the inefficient and ineffective activity looping, and the business process flow can then be improved. Moreover, the proposed quantitative methodologies use a time series intervention ARIMA model to measure and compare the simulation results of the business process reengineering. This is based on the process activity analysis, so that the intervention effects and the asymptotic changes can be determined.

After this introduction, the rest of this paper is organized as follows: Section 2 contains the description of the basic six types of business activity interactions. The description of the activity model and analysis for business process are proposed in Section 3. Then a time series intervention ARIMA model for measuring process activity changes is discussed in Section 4. The simulation analysis and the results of time series intervention ARIMA analysis of the business process reengineering based on the proposed activity model analysis are presented in Section 5. Finally, conclusions are given in Section 6.

2. Types of business activity interaction

There are many different types of activities in a business process, the activities may be discrete events but their interactions are continuous and co-related. Despite various routing of the activities in the business process, the ultimate aim is to achieve the objectives of the enterprise. In the routing of activities in the business process, different combinations of routing may directly affect the overall performances of the enterprise, however, there is no "standard best" routing of activities that an enterprise can follow, and enterprises rarely have a distinctive business process flow. In order to effectively model and analyze the business process, a structural approach can be used to represent the routing.

Since the interaction activities in the business process are continuous and co-related within the enterprise, the relationship between activities in the business process can be represented in a Boolean adjacent matrix of $A = [a_{ij}]_{n \times n}$, where n is the number of activities in a business process, and a_{ij} defined as

$$a_{ij} = \begin{cases} 1, & \text{activity } i \text{ is previous to activity } j \\ 0, & \text{otherwise.} \end{cases}$$

For any business process, despite the difference in the characteristics or routing of the process flow, there are basically six types of business activities interacting between entities, i.e. Start (START), Serial Interaction (SEI), Merge Interaction (MEI), Split Interaction (SPI), Merge and Split Interaction (MSI) and End (END), these six types of activities interaction can be empirically represented according to the Boolean adjacent matrix of $A = [a_{ij}]_{n \times n}$. A case study of purchasing business process flow in a household appliance manufacturing enterprise, with its mapping of the business activity interactions, is illustrated in Fig. 1.

2.1. Start

START is an initiation and the first interaction activity in a business process, which leads to the development of the subsequent activities. The interaction of START in the adjacent matrix with column sum equal to zero is represented as

$$\text{START} = \left\{ i : \sum_{j=1}^{n} a_{ij} = 0, \quad \text{where } i = 1, 2, \ldots, n \right\}.$$

2.2. Serial interaction

SEI is a straightforward serial activity interaction in a business process. It directly interacts with its single previous and single succeeding activity, and the interaction of SEI in the adjacent matrix with column sum and row sum both equal to one is represented as

$$\text{SEI} = \left\{ i : \sum_{j=1}^{n} a_{ij} = 1 \text{ and } j : \sum_{i=1}^{n} a_{ij} = 1, \quad \text{where } i,j = 1, 2, \ldots, n \right\}.$$

2.3. Merge interaction

MEI is a collection activity interaction in the business process, in which several previous activities are merged and combined, and then processed in a single succeeding activity. The interaction of MEI in the adjacent matrix with column sum greater than one, and row sum equal to one is represented as

$$\text{MEI} = \left\{ i : \sum_{j=1}^{n} a_{ij} > 1 \text{ and } j : \sum_{i=1}^{n} a_{ij} = 1, \quad \text{where } i,j = 1, 2, \ldots n \right\}.$$

2.4. Split Interaction

SPI is a splitting activity interaction in a business process, in which a single previous activity is split into its several succeeding activities. The interaction of SPI in the adjacent matrix with column sum equal to one, and row sum greater than one is represented as

$$\text{SPI} = \left\{ i : \sum_{j=1}^{n} a_{ij} = 1 \text{ and } j : \sum_{i=1}^{n} a_{ij} > 1, \quad \text{where } i,j = 1, 2, \ldots, n \right\}.$$

2.5. Merge and split interaction

MSI is a combination activity interaction of merge and split in a business process, in which it merges several previous activities of a business process, then processes and splits them into several succeeding activities. The interaction of MSI in the adjacent matrix, with both column and row sum greater than one, is represented as

$$\text{MSI} = \left\{ i : \sum_{j=1}^{n} a_{ij} > 1 \text{ and } j : \sum_{i=1}^{n} a_{ij} > 1, \quad \text{where } i,j = 1, 2, \ldots, n \right\}.$$

2.6. End

END is an ending and the final interaction activity in a business process. When the business process reaches END, then the whole business process is complete and the objectives of the enterprise