An Approach to Recommend Resources for Business Processes

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Abstract. Workflow management is an important technology of business process management that links tasks and qualified resources as a bridge. Researches have been carried out to improve the resource allocation of workflow that is often performed manually and empirically either by mining resource allocation rules or by optimizing the resource allocation for tasks to achieve certain goals such as minimal cost or duration. None of these approaches can guarantee to give the suitable solution to resource allocators because of the dynamic natures of business process executions. In this paper we propose an approach, *BNRR* (Bayesian Network-based Resource Recommendation), to recommend the most proficient sets of resources for a business process based on event logs, which gives the allocators chances to find the most suitable solution. Our approach considers both the information about the resource dependency and the information about the resource capability. The approach can be applied to recommend resources either for a whole workflow or for an individual task. The approach is validated by experiments on real life data.

Keywords: Resource recommendation, staff assignment, Bayesian Network, business process management.

1 Introduction

Workflow management is such a business process technology that links tasks and resources as a bridge [2]. Human beings, as the kind of resource that we focus on in the paper, play an important role in workflow management systems because human beings cannot be replaced entirely by computers or machines in many business processes. Hence resource allocation of workflow, namely allocating right persons for right tasks at right time, becomes the basis of a successful business process. Researches have been carried out to loosen the dependence on personal experiences for resource allocation, e.g. mining resource allocation rules (e.g.[3]), finding suitable resources for tasks iteratively(e.g.[5]), and analyzing resource patterns [7]. New directions are emerging on these work. One is that more types of information available, more precise resources recommended. The other is that allocating resources for a whole workflow is better than that for individual tasks in most occasions [6]. Till now resource allocation is still a challenging topic in process mining [8].

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Following the second direction, we extend our work [9] to deal with general workflow models and propose an approach, $BNRR$ (Bayesian Network-based Resource Recommendation), to recommend the most suitable sets of employees for a business process based on its event logs. The $BNRR$ works like a search engine. The $BNRR$ will recommend suitable sets of employees according to a submitted workflow model or a workflow instance, and rank these employees sets by their proficiency values. All information required for the allocation has to be mined out of event logs which record execution history of business processes concerned. Event logs are chosen as the input of the approach because they are widely available in information systems. Furthermore, a ranked list of candidates rather than the optimal one are recommended for allocators because of the dynamic natures of business process execution. The results of experiment on real world workflow event logs show that $BNRR$ works as expected.

The $BNRR$ can work either as a filter of the resource allocation mechanism available in a legacy PAIS to propose the most efficient sets of candidates for tasks, or as a framework of resource allocation which can deal conveniently with additional staff assignment rules, with employees joining in or leaving dynamically, and with new tasks, by changing the abundant parameters of $BNRR$. Since event logs are easily obtained, the $BNRR$ would have widespread applications.

2 Preliminaries

We extend the Workflow Net by adding information about task performers. Figure 1(A) graphically describes an extended workflow as an example. The grey part of the figure depicts the control flow of the workflow, where places are denoted with cycles and tasks with squares. A dashed line links a task and its candidate employees.

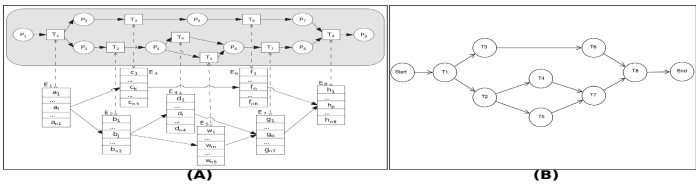

Fig. 1. (A)An extended workflow model (B)A Bayesian Network model

Bayesian Network (BN) is a tool for solving inference problems in which thousands of random variables are linked in complex ways. BN has been widely used in fields such as bioinformatics and speech processing [4]. Figure 1(B) is a graphical BN model. A node depicts a random variable, and an edge from a *parent node* to a *child node* indicates assignment of the child node depending on the value of the parent node. These dependence relationships are described mathematically by conditional probability distribution functions, which are referred to as *potential functions*. These functions are parameters of a BN model.

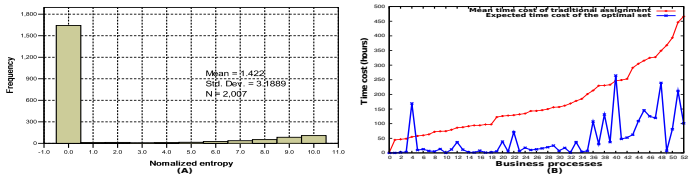

Fig. 2. (A)The normalized Shannon's entropy distribution of cooperative proficiency of employees (B)Time costs of 52 business processes

3 Bayesian Network-Based Resource Recommendation

The first step of the $BNRR$ is converting a given extended workflow model W into a bayesian network model B by means of the proposed algorithm $W2B$, which works similarly to a breadth first traversal of a graph. The principles of conversion include 1) a discrete random variable whose values are IDs of candidate employees for the task, and 2) each pair of tasks in W are connected by a directed edge in B if they were executed consecutively at least once. Figure 1(B) depicts a BN model converted from the workflow model shown in Fig. 1(A) by means of the W2B.

The second step of the $BNRR$ is calculating the parameters. $BNRR$ requires two kinds of parameters, i.e. the individual proficiency of an employee for a task and the cooperative proficiency among employees. Since proficiency is skillfulness deriving from practice, the two kinds of parameters can be approximated naturally by execution frequency of the task by the employee and by co-occurrence frequency of the employees for consecutive tasks respectively.

The last step is calculating the optimal sets. The Bucket Elimination (BE) algorithm [1] is extended for $BNRR$, by calculating the top N proficient sets rather than the optimal set of employees at each iterative step, and by considering both individual proficiency and cooperative proficiency.

4 Experiments and Evaluations

The data used in experiments are real life workflow event logs generated during last three years by PAIS systems running respectively in three vehicle manufacturing companies in China. These logs contain 7158 successful executions of 52 workflow models and 691 different tasks performed by 484 different employees. Each model has at least five executions.

Figure 2(A) depicts the impact of staff assignment of an antecedent task on that of the subsequent task. Given a task and its performer, 81.86% of performers for the subsequent tasks are determined(the leftmost bar), and only 5.38% of performers are allocated randomly(the rightmost bar). Namely 94.62% of assignments of tasks depend on those of the parent tasks in these companies.

Figure 2(B) depicts that the expected time cost of a process with the optimal set is less than the mean value apparently. This complies with the common sense

that proficient person costs less for a task, so does the optimal set for a business process. It is important to note that we cannot guarantee that $BNRR$ would find out a set of employees with the minimum expected time cost of a process.

5 Conclusion and Future Work

In this paper, we propose an approach, $BNRR$, which offers a novel way of aiding to allocate employees for a business process in whole rather than only for individual tasks based on workflow event logs. A BN model is adopted as a tool to describe dependency relationships among employees. We present an algorithm to derive structure of a BN model from a workflow model, describe how to extract information from logs, and extend the BE algorithm to calculate the most proficient sets of employees for a business process. Experiment results reveal the existence of dependency relationships among employees, and validate the feasibility of the approach.

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