An Information Sharing Method for Skilled Management Operations based on Bayesian Network Inference

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Abstract: Given the poor state of the economies all over the world, almost every manufacturing site has been supported by a lot of part-time, temporary, or mid-career personnel. And expert managers of front-line workers must design more complex human resource strategies that take into consideration the workers' skills. However, tacit knowledge existing only in the minds of expert managers is very difficult to capture with most organizations depending entirely on the explicit knowledge. Therefore, the purpose of our study is to develop a model with a bayesian network using the operation histories of expert managers, and to verify some factors that would make it easier for nonexperts to assign human resources. First, the operation histories are collected. Next, some differences of human resource planning procedures for expert managers and nonexperts are discussed by dividing into the purposes of either minimizing makespan or workload. Finally, the effectiveness of the expert managers' operations is verified by constructing a bayesian network model based on the operation histories, and is discussed by way of probabilistic inference.

1 INTRODUCTION

Recently, the number of regular, full-time employees has been decreasing at general production factories. On the other hand, the number of part-timers or temporary employees has been increasing. For a long time, most companies had recruited, trained and held onto many talented people as their regular employees. However, it is difficult to support all of the regular employees without outsourcing due to poor economic conditions. Therefore, the leaders of the front-line workers must assign each worker appropriate tasks according to the quantity and quality of work.

Mohanty et al. discussed the evolution of a decision support system (DSS) for human resource (HR) planning in a petroleum company. The DSS helped the HR division of the company analyze HR decisions to overcome many problems, to cut down on delays in implementing new projects and to expand the business into new areas (Mohanty, 1997). Further, Parush et al. showed the impact of visualization and contextual factors on performance with enterprise resource planning (ERP) systems. They showed that some graphic information visualization displays for ERP systems can increase the probability of a successful implementation and enhance the capabilities of the human operators (Parush, 2007).

Furthermore, Abdinnour-Helm et al. studied the pre-implementation attitudes and organizational readiness for implementing an ERP system. Despite an extensive amount of time, money and effort, the length of time with a firm and position had a greater impact on attitudes toward ERP capabilities, value, acceptance and timing than high levels of pre-implementation involvement (Abdinnour-Helm, 2003). Youngberg et al. discussed the determinants of professionally autonomous end user acceptance in an ERP system environment. The study surveyed 66 professionally autonomous end users and gathered information on their perceptions related to several technology acceptance factors for a newly installed ERP system component (Youngberg, 2009).

On the other hand, Corominas et al. studied the planning of annualized hours with a finite set of weekly working hours and cross-trained workers (Corominas, 2007). Lusa et al. also attempted to determine the most appropriate set of weekly working hours for planning annualized working time. Their paper proposes a method for selecting the most appropriate set of weekly working hours

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and establishing an annual plan or working time for each worker as a way of optimizing service levels (Lusa, 2008).

However, most HR planning systems do not consider workers' skills. According to hearing surveys with some small and medium-sized enterprises (SMEs), it is enough to have even the simple support tool that a sub-leader, rather than the leader, can redesign the current strategy using an interactive interface.

Thus, it is used that a tool which has already developed with "An Inference Method of Management Operations using Bayesian Networks (Kataoka et al, 2010)" using the Program Evaluation and Review Technique (PERT) to collect a lot of operation histories. That is the reason why our cooperative researcher is a middle iron work's company in Japan.

Furthermore, our paper has also already suggested an inference method of management operations using bayesian networks (Kataoka et al., 2011). However, it is not enough that the effectiveness of an inference method is shown in only a sample data of human resource planning.

Therefore, this paper researches to develop a model with a bayesian network using the operation histories of expert managers, and to verify some factors that would make it easier for nonexperts to assign human resources.

2 BAYESIAN NETWORK

A Bayesian network is one of the probabilistic models which express the dependence between random variables by a conditional probability.

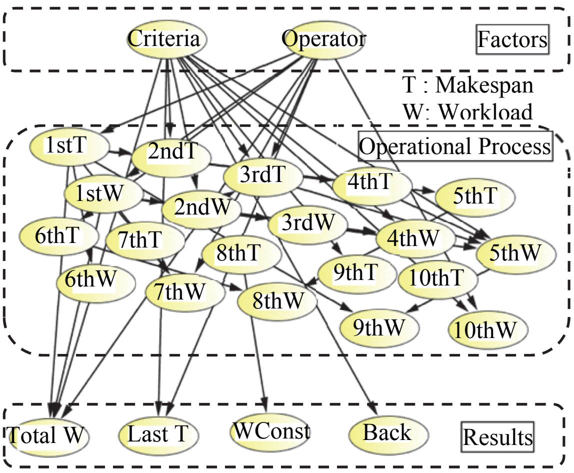

Figure 1: Bayesian network model.

Based on a sample data, each variable has already classified into three categories and each causal relationship has also already specified in our paper as shown in Figure.1 (Kataoka et al., 2011).

Firstly, some factors like worker's skill or operational targets are arranged as parent nodes. Next, operational processes from 1st operation to 10th are arranged with causal relationships to the increase or decrease value of makespan and workload. Every operational process is recorded to show the difference between the expert manager and nonexperts clearly. Lastly, some results are arranged with causal relationships to operational processes.

3 SKILLED OPERATIONS

3.1 Makespan and Workload

In the operation purpose to minimize makespan, it is verified that the result of the expert manager who will greatly decreases makespan time at the first stage is better. Figure 2 shows a graph where the mean value of the increase or decrease in workload when makespan times of each operation decrease by one unit is shown. There are not so many differences in the increase or decrease of both experts and nonexperts at the first stage. However, the expert manager greatly decreases the workload in the latter half. As a result, it can be judged that the expert manager is finally obtaining a great result for both makespan and workload.

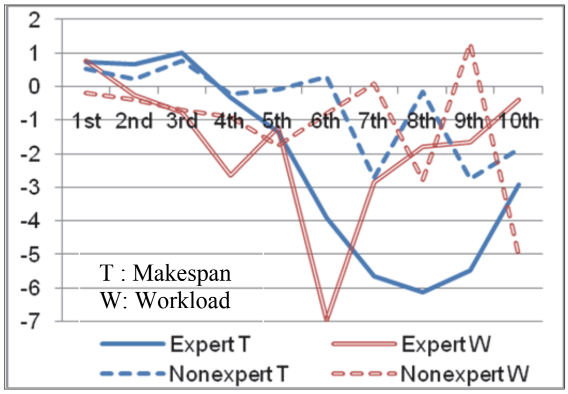

Figure 2: The increase or decrease ratio of reworks to a decrease per unit time.

3.2 Reworks

Figure 3 shows the mean value of makespan and workload in the case that some reworks will occur or not to minimize workload. The decision to minimize workload is done without decreasing makespan. Therefore, workload is approached to zero at the last stage, and makespan is shortened. As a result, many reworks will occur because operators fall greatly into disorder.

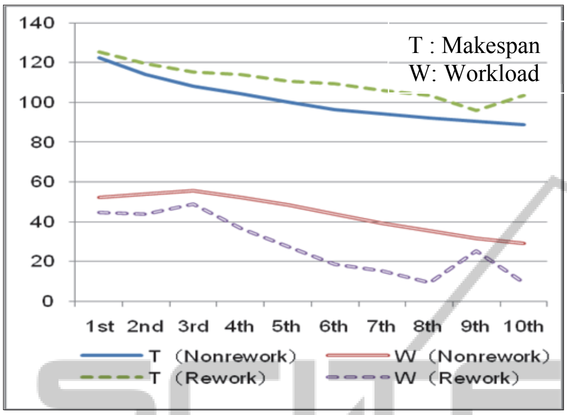

Figure 3: Difference of procedure in reworks.

4 EXPERIMENT

4.1 Sample Data

As a comprehensive experiment, 4 sample data is prepared as shown in Table 1. Some small scale projects might be defined to have 100-200 hours as total operation time (TepStep, 2011).

Therefore our study assumes that the number of maximum process is 35 and the number of minimum process is 14 in case of 7 hours per process.

Table 1: Sample data for comprehensive experiment.

	Process	Worker
Sample0	35	10
Sample1	35	4
Sample2	14	10
Sample3	14	4

4.2 Experimental Results

Modes of experimental results for each sample are shown in Table 2. CPT means Conditional Probability Table. In case of many processes (Sample 0 and 1), experts could operate the tool better than nonexperts. Especially, it seems that nonexperts could not understand the way to decrease total workload as shown in the results of 'Minimum Total Workload'.

In case of less workers (Sample 1 and 3), it seems that nonexperts tend to rework a lot.

Table 2: The first result of comprehensive experiment.

		Minimum Makespan				Minimum Total Workload			
		Expert		Nonexpert		Expert		Nonexpert	
		Mode	CPT	Mode	CPT	Mode	CPT	Mode	CPT
Sample0	Makespan	136~140	0.72	136~140	0.30	216~220	0.67	206~210	0.30
	Workload	131~135	0.25	136~140	0.08	21~25	0.24	46~50	0.07
Sample1	Makespan	131~135	0.68	141~145	0.25	206~210	0.29	216~220	0.14
	Workload	176~180	0.08	196~200	0.04	91~95	0.21	151~155	0.05
Sample2	Makespan	66~70	0.69	66~70	0.53	66~70	0.50	66~70	0.38
	Workload	0	0.69	0	0.35	0	0.08	0	0.73
Sample3	Makespan	96~100	0.90	96~100	0.90	111~115	0.53	111~115	0.53
	Workload	11~15	0.92	11~15	0.92	1~5	0.71	1~5	0.71

4.3 Instructions to Nonexperts

Instructions expected to be effective for the improvement are shown in the following.

<Common instructions>

Operate to decrease the schedule from the left or the right point to avoid overlaps on critical path.

Operate up to 1st-4th operation (Sample0:1, Sample1:2, Sample2: 4, Sample3: 3) to minimize makespan as a first object.

<Only to sample 0 and 1>

Assign a worker who takes a long operation time for a task in case of 'Minimum Total Workload'.

<Only to sample 3>

Operate to decrease the most overlapped workload for a task in case of 'Minimum Total Workload'.

4.4 Verified Results

The result that nonexperts try it again based on the instructions of **4.3** is shown in Table 3.

As a result, almost samples are improved. Additionally, nonexperts got to tend not to rework as shown in Table 4.

4.5 Inductive Modelling

An information sharing model (:inductive modelling) based on our experimental results is shown in Figure 4.

Firstly, a set of experts' skilled operation histories is prepared. Next, nonexpert's operations are compared with a set of skilled operations in real time, and some instructions are given to a nonexpert based on differences and causal relationships of bayesian networks. Lastly, a bayesian database is updated, and next operation is considered with an object.

Table 3: The result of comprehensive experiment.

			Nonexpert		Expert	Improvement
			Before	After		Rate
Sample 0	Minimum Makespan	Makespan	146.4	141.8	137.6	3.1%▲
		Total Workload	153.4	152.4	140.3	0.6%▲
	Minimum Total Workload	Makespan	205.4	214.8	216.9	4.5%▽
		Total Workload	79.9	36.2	32.3	54.6%▲
Sample 1	Minimum Makespan	Makespan	148.2	131.9	132.8	10.9%▲
		Total Workload	203.3	161.9	176.1	20.3%▲
	Minimum Total Workload	Makespan	210.6	170.6	196.1	18.9%▲
		Total Workload	163.8	120.4	100.7	26.4%▲
Sample 2	Minimum Makespan	Makespan	67.4	66.0	66.0	2.0%▲
		Total Workload	3.6	0.0	0.0	100.0%▲
	Minimum Total Workload	Makespan	88.1	68.1	66.7	22.7%▲
		Total Workload	0.3	0.0	0.2	100.0%▲
Sample 3	Minimum Makespan	Makespan	92.3	97.2	96.0	5.3%▽
		Total Workload	46.2	15.1	14.5	67.3%▲
	Minimum Total Workload	Makespan	129.4	113.2	112.3	12.5%▲
		Total Workload	19.9	6.7	5.5	66.4%▲

Table 4: The total number of reworks.

	Expert	Nonexpert	
		Before	After
Sample0	0	5	0
Sample1	0	31	0
Sample2	0	4	0
Sample3	3	33	0

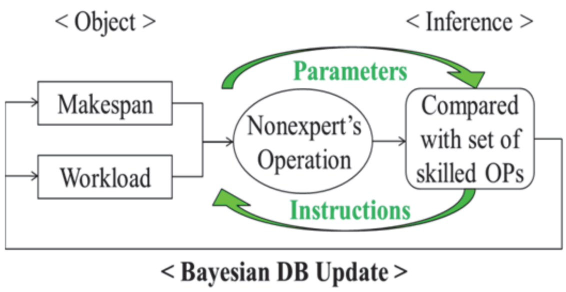

Figure 4: Information sharing model.

5 CONCLUSIONS

This paper showed an information sharing model with a bayesian network using the operation histories of expert managers, and verified some factors that would make it easier for nonexperts to assign human resources.

In the future, the decision of HRP to assume all situations needs to be verified, and the improvement of further inference accuracy is requested.

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