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ANALYTIC-BASED DECISION ANALYSIS TOOL FOR EMPLOYEE-JOB ASSIGNMENTS BASED ON COMPETENCY AND JOB PREFERENCE

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This paper discusses an analytic-based decision analysis tool called Employee-Job Assignment System (EJAS) for solving the employee-job assignment problem (EJAP). The EJAS is intended to determine an employee-job assignment (EJA) solution that optimizes the employees' work efficiency and job satisfaction. Two person-job (P-J) fit criteria are considered: (1) competency-based P-J fit, and (2) preference-based P-J fit. Depending on the decision-maker's selection, the EJAS determines an EJA solution that maximizes the chosen P-J fit. Additionally, it is capable of generating several *near-optimal* solutions to assist the decision-maker in selecting a suitable EJA solution.

Significance: Effective management of the human resource is an important issue for every business organization. Assigning the right employees to the right jobs can help the organization to increase its productivity and/or enhance its service efficiency. The proposed decision analysis tool enables responsible decision-makers to develop the employee-job assignment solution that considers both competency and job preference; thus, achieving increased productivity and better job satisfaction.

Keywords: Employee-job assignment, workforce management, person-job fit, competency, job satisfaction, decision support system

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1. INTRODUCTION

In this day and age, it is necessary for every organization to optimally manage its human resource to ensure not only an increase in employees' work efficiency and job satisfaction, but also a decrease in management cost. To achieve this purpose, the organization has to obtain, develop, utilize, evaluate, maintain, and retain its efficient employees. Improving the employee's knowledge, skills, and abilities has long been essential because high work efficiency normally leads to high productivity. It is also important to make sure that employees are assigned to the right jobs since the congruence between employees and jobs helps to achieve the maximum productivity in the workplace. To retain efficient employees, an organization needs to recognize the impact of job satisfaction on job performance. If employees are not motivated or if they feel dissatisfied with their job, their work efficiency usually declines and could, to some extent, contribute to poor organizational performance or low productivity level. Nebeker et al. (2001) surveyed job satisfaction of employees working at 60 airport stations. The findings showed that when employees are dissatisfied with their jobs, the organizational performance and customer satisfaction could be negatively affected.

The employee-job assignment (EJA) is a management practice to *assign/reassign* employees to jobs so that the maximum work efficiency and/or the greatest job satisfaction level can be achieved. The need for EJA may arise as a result of the restructuring of an organization (or the business process re-engineering), from which some existing jobs may be revised or eliminated, and some new jobs may be created. Additionally, some organizations might reshuffle current employee-job assignments to prevent individuals from using their job perks for personal gain/profit. Unlike job rotation in which a fixed reshuffling pattern exists, the reshuffling is performed without a fixed pattern and each employee does not usually know to which new job he/she will be assigned after his/her current job. Moreover, the length of stay at the new job could be relatively long (one year or more).

In many organizations, the assignment of employees to jobs is based on the subjective opinion of a designated person or team. A lack of quantitative measures and an appropriate decision-making tool contributes to the common use of subjective judgment to decide *who* will be assigned to *which job*. Jaturanonda and Nanthavanij (2004) formulated the employee-job assignment problem (EJAP) as three linear programming models and used two person-job (P-J) fits, competency-based (C-based) and preference-based (P-based) that are quantitative measures of the levels of work efficiency and job satisfaction, respectively, as objective criteria. When solving the EJAP to optimality, only one solution (the optimal solution), which may or may not be usable, will be generated.

Decision Support System (DSS) concept has been applied to employee assignment in both service and manufacturing organizations. Decision-assisted tools were developed for scheduling nurses (Ozkarahan, 1989), airline pilots (Verbeek, 1991), aircraft maintenance crews (Dijkstra et al., 1991), and computer lab attendants (Lauer et al., 1994). For a manufacturing environment, researchers developed DSS applications for scheduling technical personnel (Parker et al., 1994; Ducote and Malstrom 1999; Grabot and Letouzey, 2000; Horng and Cochran, 2001). A number of DSS applications were also developed to deal with other areas of human resource management, for example, productivity improvement (Young, 1989), performance analysis (Ntuen et al., 1994), career management (Bellone et al., 1995), and personnel selection problem (Ntuen and Chestnut, 1995; Nussbaum et al., 1999). In many DSS applications, spreadsheet programs were used as a tool to generate solutions since they are popular and easy to use (Ntuen et al, 1994; Laitinen, 1999; Buehlmann et al., 2000; Novak and Ragsdale, 2003).

An analytic-based decision analysis tool called Employee-Job Assignment System (EJAS) for solving the EJAP is discussed in this paper. Both C-based and P-based P-J fits are considered when generating feasible assignment solutions. The paper is organized as follows. Firstly, we explain both C-based and P-based P-J fits and how they can be quantified. Next, we describe the structure of the EJAS and its four modules, namely, database, input, problem-solving, and solution. Then, we use a hypothetical case example to demonstrate how to use the EJAS to find both optimal and near-optimal EJA solutions. We also present a comparison of the assignment solutions obtained from human decision-makers and the EJAS.

2. EMPLOYEE-JOB ASSIGNMENT PROBLEM

The employee-job assignment problem (EJAP) is a management problem that is concerned with assigning employees to the right jobs based on the person-job (P-J) fit. The P-J fit can be conceptualized as the degree to which an individual's preferences, knowledge, skills, abilities, needs, and values match job requirements (Brkich et al, 2002). Jaturanonda and Nanthavanij (2004) introduced two quantitative P-J fits to represent the degree of compatibility between a person and a job. They are: (1) competency-based P-J fit (when the compatibility measure is based on the competency), and (2) preference-based P-J fit (when the assignment is considered according to the job preference of employees).

2.1 Competency-based Person-Job (C-based P-J) Fit

Competency is defined as the employee's attribute or the job characteristic determined by the organization that is relevant to the EJA. In this paper, competency is divided into two categories, namely, core competency and functional competency. The latter is further divided into technical and behavioral competencies.

For simplicity, we shall refer to the set of competencies and their competence levels that an employee possesses as the "employee profile," and those required by a job (job specifications) as the "job profile." When any pair of employees and jobs is being evaluated, it is important that only the core, technical, and behavioral competencies that are included in both the employee and job profiles are considered. The competence level can be assessed using a numerical scale from 1 to 10, where 1 represents the lowest competence level and 10 represents the highest competence level. A difference in competence level for a given competency between the employee and job profiles is called a "competency gap."

Letting ec_{ik} and jc_{jk} be competence level of core competency k of employee i and that required by job j, respectively, the gap of core competency k between employee i and job j, Gc_{ijk}, can be computed from

$$Gc_{ijk} = \begin{cases} 0 & \text{if } jc_{jk} \le ec_{ik} \\ jc_{jk} - ec_{ik} & \text{if } jc_{jk} > ec_{ik} \end{cases} \quad \ldots \quad (1)$$

The gaps of technical and behavioral competency k between employee i and job j, Gt_{ijk} and Gb_{ijk}, respectively, can be computed in the same manner.

Within the same competency category (core, technical, or behavioral), it is assumed that all competencies are equally important. Thus, an "average competency gap" will be determined for each competency category. Next, an "employee competency gap" is calculated from the three average competency gaps. Depending on how important the organization judges the three competency categories, weights will be assigned to them. As a result, the employee competency gap is simply a weighted average value. Readers should note that for a particular employee-job pair, the employee competency gap indicates the degree of compatibility between the employee and the job (i.e., the P-J fit). More specifically, the smaller the gap, the better the P-J fit is.

When several employees are to be assigned, their employee competency gaps are summed to yield a "total competency gap" of an assignment solution. Since the total competency gap tends to increase with the number of employees, the assignment solution involving several employees is likely to yield a larger total competency gap than the solution involving fewer employees. Therefore, it is necessary to normalize the total competency gap by the number of employees. The ratio of the total competency gap to the number of employees is called an "EJA competency gap" since it reflects the overall P-J fit of the EJA solution.

The EJA competency gap G can be computed from

$$G = \frac{1}{n}\left[\sum_{i=1}^{n}\sum_{j=1}^{n}\left\{wc\left(\frac{\sum_{k\in Sc_j} Gc_{ijk}}{nc_j}\right)+wf\left[wt\left(\frac{\sum_{k\in St_j} Gt_{ijk}}{nt_j}\right)+wb\left(\frac{\sum_{k\in Sb_j} Gb_{ijk}}{nb_j}\right)\right]\right\}\right] \quad \text{... (2)}$$

where n — number of employees or jobs being considered
nc_j, nt_j, nb_j — numbers of core, technical, and behavioral competencies, respectively, required by job j
Sc_j, St_j, Sb_j — sets of core, technical, and behavioral competencies, respectively, required by job j
wc, wf, wt, wb — weights of core, functional, technical, and behavioral competency categories, respectively

2.2 Preference-based Person-Job (P-based P-J) Fit

To alleviate possible problems arising from the EJA due to job dissatisfaction, an organization could ask each employee to choose the jobs that he/she prefers (as his/her new job) and assign ranks to those jobs. Customarily, a numeric scale is used to indicate the preference rank. The job with the smallest numeric rank, i.e., one, is the most preferred job. Vice Versa, the job with the largest (allowable) rank is the least preferred job (among those on the list). When an employee is assigned to the job which he/she prefers the most, it is reasonable to assume that his/her job satisfaction is at the greatest level. Hence, for a given employee, the assignment that results in a small preference rank indicates high job satisfaction.

When assessing the P-based P-J fit, it is possible to consider two quantitative indices: (1) the number of satisfied employees (those employees who are assigned to any job on their "preferred jobs" lists), and (2) the average preference rank (an average of the preference ranks on the assigned jobs computed from all employees). For the first index, the greater the number of satisfied employees, the better the EJA solution is. For the second index, the smaller the average preference rank, the better the EJA solution is. In this paper, both indices are considered, with the first index being optimized first.

The number of satisfied employees S and the average preference rank R can be computed from

$$S = \sum_{i=1}^{n}\sum_{j=1}^{n} z_{ij}\cdot x_{ij} \quad \text{... (3)}$$

$$R = \frac{1}{S}\left(\sum_{i=1}^{n}\sum_{j=1}^{n} r_{ij}\cdot x_{ij}\right) \quad \text{... (4)}$$

where r_{ij} — preference rank of job j as specified by employee i
x_{ij} — binary variable representing employee-job assignment, {0,1}
1 if employee i is assigned to job j; 0 otherwise.
z_{ij} — binary variable representing the preference selection of jobs, {0,1}
1 if employee i selects job j as one of the preferred jobs; 0 otherwise

2.3 Optimization Approaches to the EJAP

The model formulation of the EJAP is based on the following assumptions: (1) the number of employees to be assigned is equal to the number of jobs that are available, (2) all employees can be assigned to any job that is available, (3) each employee can be assigned to only one job, and (4) each job requires only one employee. For each competency, the competence level ranges from one to ten, inclusive, where one represents the lowest competence level and ten represents the highest level. The employee's preferred jobs are defined by job ranks. No ties are allowed.

Jaturanonda and Nanthavanij (2004) developed three optimization models for EJAP. The first model, called ECG model, is aimed to optimize the C-based P-J fit by minimizing the EJA competency gap (ECG). The second and third models are aimed to optimize the P-based P-J fit by maximizing the number of satisfied employees (NSE) and minimizing the average preference rank (APR), respectively. These two models are therefore called the NSE and APR models, respectively. They also developed two multiple objective optimization approaches for solving the EJAP: (1) the *Efficiency-then-Satisfaction* (ETS) approach, and (2) the *Satisfaction-then-Efficiency* (STE) approach.

The ETS approach will firstly optimize work efficiency (i.e., to minimize the EJA competency gap). From the resulting optimal solution, job satisfaction (based on the number of satisfied employees and their average preference rank) will be optimized next. In other words, the three models are solved according to the following sequence: ECG → NSE → APR.

The STE approach considers job satisfaction as its first priority and tries to optimize the number of satisfied employees and the average preference rank consecutively. Next, work efficiency will be optimized. The sequential solution procedure is as follows: NSE → APR → ECG. For more explanation of the model development and both optimization approaches, see Jaturanonda and Nanthavanij (2004).

A major drawback of the optimization approach is that only one optimal solution is usually generated. This will hinder its application especially when the optimal solution is not usable or not preferred. Although some problems may have multiple optimal solutions, it is still rather difficult to find all of those solutions.

3. EMPLOYEE-JOB ASSIGNMENT SYSTEM (EJAS)

An Employee-Job Assignment System (EJAS) is developed on Microsoft Excel using Visual Basic for Application (VBA). The computation is performed using the "Premium Solver," which is added on Microsoft Excel. The EJAS consists of four modules, namely, database, input, problem-solving, and solution. In addition to an optimal EJA solution, the EJAS can generate several alternative solutions according to the user's preference. The user can interact with the EJAS via graphical user interfaces; thus, making it a user-friendly decision analysis tool. The architecture of EJAS is depicted in Fig. 1. The four modules are described in the following sections.

3.1 Database Module

To use the EJAS, the user must firstly visit the "Database Module (DM)" to enter required information. The DM consists of four screens for the current employee-job assignment, competency titles, employee profiles, and job profiles. The steps listed below help to guide the user to enter all necessary information.

Step DM-1: The user will enter the current employee-job assignment for all employees. The DM requires the employees' names and their current job titles. Employee IDs and department titles are both optional. The database can contain up to 44 employee-job assignments.

Step DM-2: Before creating either the employee or job profile, the user needs to define all competencies (core, technical, and behavioral). Up to 15 competencies can be defined in each category.

Step DM-3: After choosing to enter the employee profiles, the DM will display all employee names (as defined in Step DM-1) and all competencies in each competency category (as defined in Step DM-2). The user can then enter the competence level (between 1 and 10) in each of the shown competency columns for all employees.

Step DM-4: Similar to the previous step, the job profiles will be entered. From the displayed job titles (as defined in Step DM-1) and the competencies in each category (as defined in Step DM-2), the user can enter the required competence scores in the corresponding competency columns.

3.2 Input Module

The next module of the EJAS is the "Input Module (IM)." The IM allows the user to select the database and import all necessary data, specify employees and jobs, choose the solution approach, and define the weights for individual competency categories. The steps are as follows.

Step IM-1: In the first step, the user must select the database that contains the data previously entered via the database module.

Step IM-2: After selecting the database to retrieve the data, a list of employees and jobs are shown. The user can then specify the employees and jobs to be considered in the assignment problem. The user may choose either all or only some employees and jobs for the consideration. Also, in this step, the user can enter the list of preferred jobs for each employee by entering the rank number in the corresponding job column.

Step IM-3: The solution approach to search for the optimal and alternative solutions must be specified. The user has two options: (1) to generate the assignment solution(s) using the EJAS, or (2) to generate the assignment solution by the user.

For the first option, the user would next specify the primary objective, either to maximize work efficiency (i.e., to minimize the EJA competency gap) or to maximize job satisfaction (i.e., to maximize the number of satisfied employees). The number of assignment solutions (up to 10) to be displayed can also be specified. For the second option, the user would personally match employees and jobs based on his/her preference. EJAS will calculate the quantitative indices that represent the P-J fit to quantify the appropriateness of the solution.

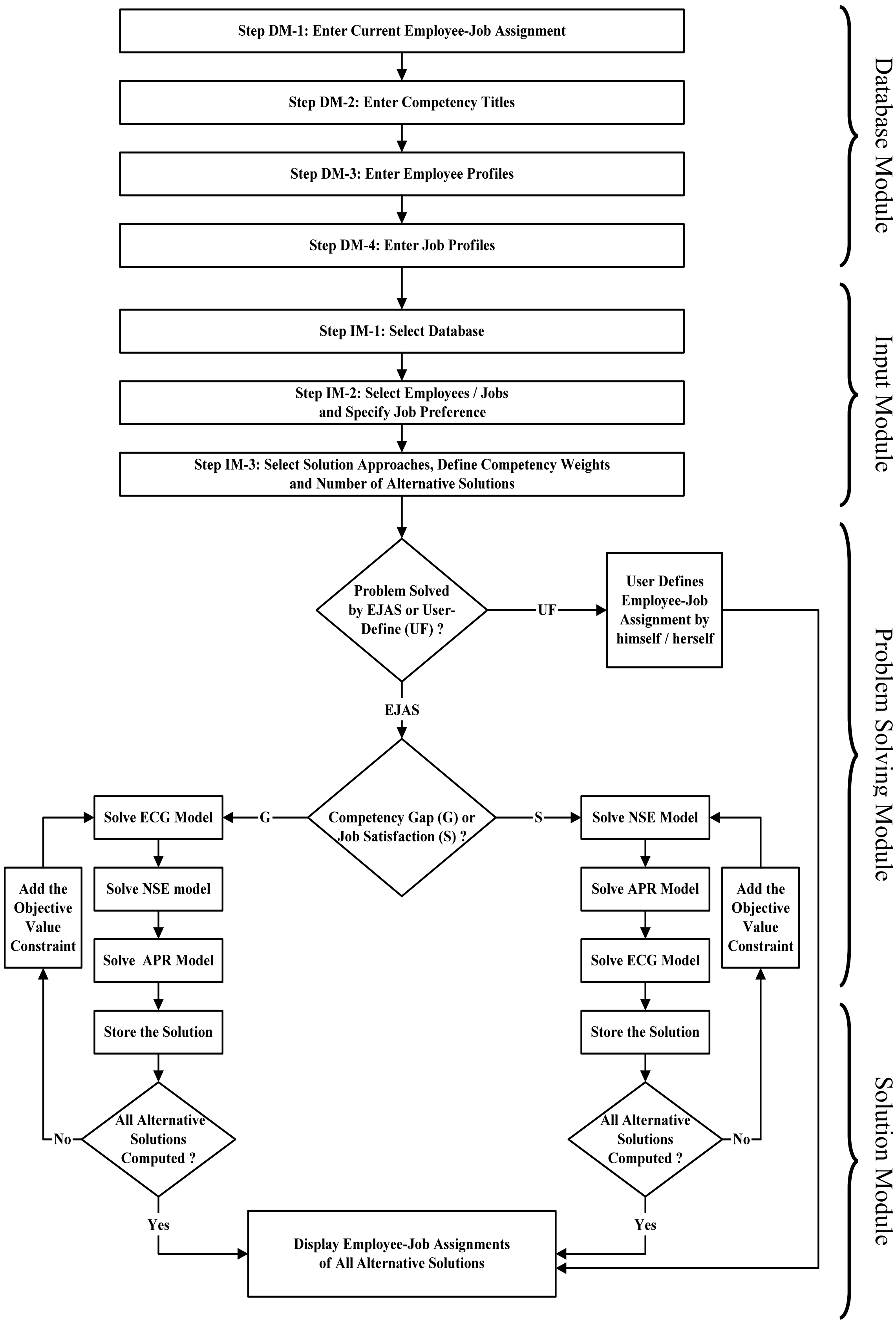

Figure 1. Four EJAS modules and flow of operations

Additionally, the importance weights for the core, technical, and behavioral competency categories can be specified.

3.3 Problem-solving Module

The next module of the EJAS is the "Problem-solving Module (PM)." The EJAS uses preemptive optimization technique to find the assignment solutions. This technique requires a hierarchy of priorities to be established. For example, suppose that the primary and secondary objectives are to maximize work efficiency and job satisfaction, respectively. The ECG model will be optimized first to find a solution with the minimum EJA competency gap. If there are multiple optimal solutions, the NSE and APR models would be optimized next. At the same time, the objective value from the first model would become another constraint in the subsequent models. Therefore, the final assignment solution would be an optimal assignment with respect to both objectives. In addition, the EJAS allows the user to specify the number of alternative assignment solutions that he/she wants to obtain.

To generate alternative (near-optimal) solutions, the EJAS employs a search algorithm that sets an objective value of the previous solution as a constraint in the first mathematical model of the chosen solution approach. Then, the problem-solving module is run again to generate the EJA solution. The search algorithm will be repeated until the specified number of alternative solutions is achieved.

If the user chooses to assign jobs to employees by himself/herself (as defined in Step IM-3), he/she has to enter all suggested job titles manually. However, the EJAS will still determine all three quantitative indices and display them for further evaluation.

3.4 Solution Module

The last module of the EJAS is the "Solution Module (SM)." The SM will display the assignment solutions (optimal and alternatives) and the summary of the EJA competency gap, average number of satisfied employees, and average preference rank. The display screen is divided into two blocks. The left block displays the quantitative indices from the solutions based on the ETS approach and the right block displays those quantitative indices based on the STE approach. In either block, the first assignment solution (Result No. 1) is always the optimal assignment solution. The remaining solutions are the alternative (near-optimal) assignment solutions. For each solution, the SM will arrange the quantitative indices according to the sequence of the optimizations.

4. HYPOTHETICAL CASE EXAMPLE

Suppose that a hypothetical organization wants to assign 20 employees (E1 – E20) to 20 jobs (J1 – J20). The Human Resource (HR) Department obtains job profiles of the 20 jobs from corresponding divisions/departments. The job profile consists of five core competencies (C1 – C5), five technical competencies (T1 – T5), and five behavioral competencies (B1 – B5). The importance weights of the core and functional competencies are 0.70 and 0.30, respectively. Within the functional competency category, the technical and behavioral competencies are judged to be equally important. Additionally, the 20 employees are evaluated by their supervisors to assess their competence levels based on all 15 competencies. Such assessment therefore results in the employee profiles. Tables 1 and 2 show the employee profiles and job profiles of the 20 employees and jobs, respectively.

To account for job satisfaction, the 20 employees are allowed to specify the jobs to which they would like to be assigned. Each person can choose up to seven jobs and he/she must indicate his/her preference by giving ranks to the chosen jobs (1 is the most preferred job). The job preferences are shown in Table 3.

After selecting the employees and jobs from the database, the preferred jobs and their ranks are listed for the 20 employees. Also, in the input screen, the desired solution approach, number of alternative solutions, and all importance weights are defined. Fig. 2 shows the input screen of this case example. Note that both the competency gap minimization (ETS approach) and job satisfaction maximization (STE approach) are chosen. Four alternative solutions for each solution approach are also required. Including the optimal solution, the number of solutions to be displayed is five solutions.

The summary of assignment solutions (optimal and alternatives) are displayed in Fig. 3. It is seen that when the given case example is solved using the ETS approach, the optimal assignment solution will yield the *minimum* EJA competency gap of 2.03, the number of satisfied employees of 5, and the average preference rank of 3.20. The last two quantitative indices are not at their global optimum since they are optimized based on a condition (or constraint) that the EJA competency gap must not be greater than 2.03. In the four alternative solutions, it is seen that the EJA competency gap grows bigger but the number of satisfied employees is also greater (i.e., better).

Table 1. Employee profiles (20-employees case example)

Employee	Core Competency					Technical Competency					Behavioral Competency				
	C1	C2	C3	C4	C5	T1	T2	T3	T4	T5	B1	B2	B3	B4	B5
E1	1	6	1	2	8	2	8	8	2	9	10	5	9	2	1
E2	10	8	5	1	3	6	1	8	10	4	2	8	8	3	2
E3	7	6	5	7	10	8	6	3	2	3	4	10	8	10	10
E4	7	6	8	5	7	2	7	10	7	7	7	4	1	7	10
E5	4	9	3	7	9	1	1	1	1	3	1	6	7	10	4
E6	2	3	2	3	7	2	10	9	4	5	3	1	6	10	4
E7	5	1	7	4	3	8	8	10	1	8	6	1	9	9	4
E8	4	6	1	1	6	10	9	7	5	8	3	5	5	10	1
E9	1	4	1	8	10	8	3	1	1	5	1	10	5	2	6
E10	1	7	6	6	8	2	5	3	1	1	3	9	1	8	9
E11	8	6	5	9	9	10	3	7	6	8	5	10	4	9	7
E12	3	8	9	3	3	5	4	1	1	4	4	5	10	4	6
E13	7	3	10	2	8	1	3	8	7	1	2	5	9	10	1
E14	2	4	3	1	9	1	1	2	8	2	9	3	7	9	1
E15	5	3	5	1	4	9	1	7	3	1	3	2	2	3	7
E16	4	6	2	1	4	5	3	2	9	9	2	10	4	5	7
E17	5	10	4	6	2	9	9	5	10	5	1	2	1	4	5
E18	3	1	2	6	6	4	2	3	3	1	4	4	1	6	7
E19	6	8	7	1	10	1	6	10	9	10	1	1	3	8	4
E20	7	1	10	8	7	6	5	2	7	6	9	5	4	5	6

Table 2. Job profiles (20-employees case example)

Job	Core Competency					Technical Competency					Behavioral Competency				
	C1	C2	C3	C4	C5	T1	T2	T3	T4	T5	B1	B2	B3	B4	B5
J1	6	8	-	-	10	5	-	-	8	7	-	8	9	-	9
J2	-	-	-	6	7	6	8	5	6	10	9	-	-	-	10
J3	-	10	5	5	-	10	9	-	7	10	-	-	-	9	8
J4	5	5	9	9	-	10	9	-	8	9	8	-	-	9	10
J5	9	5	-	5	10	5	10	-	-	-	-	10	9	8	-
J6	6	-	-	8	-	5	6	8	-	6	-	-	-	-	6
J7	-	-	9	9	-	9	7	7	6	-	-	-	-	8	6
J8	-	5	9	-	8	6	8	6	9	7	10	10	7	10	8
J9	-	8	-	6	-	8	6	-	7	5	10	6	9	5	7
J10	10	7	-	9	-	8	7	5	-	-	6	9	-	7	8
J11	5	-	6	10	-	8	5	6	8	9	-	9	8	8	7
J12	10	-	10	6	-	5	-	-	5	10	9	-	7	10	-
J13	-	10	6	-	7	6	10	8	7	-	8	-	-	9	6
J14	9	9	10	8	6	5	8	7	-	-	10	10	-	10	9
J15	5	6	9	-	7	6	10	-	9	-	6	-	-	5	-
J16	-	9	-	10	8	10	-	8	6	5	8	8	9	8	10
J17	7	8	9	5	9	9	7	8	9	6	5	-	9	6	-
J18	-	-	8	-	10	5	7	6	10	7	10	-	9	8	-
J19	-	-	8	-	9	6	-	9	-	6	8	9	10	8	6
J20	-	10	-	7	-	7	-	-	9	-	-	6	5	8	6

Note: "-" means that the competency is not required by the job.

Table 3. List of preferred jobs (20-employees case example)

Employee	Preferred Job						
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
E1	J5	J8	J11	J12	J13	J16	J7
E2	J18	J15	J12	J7	J10	-	-
E3	J2	J6	J7	J12	J16	J17	-
E4	J20	J18	J15	J16	J17	J4	J5
E5	J8	J10	J11	J1	-	-	-
E6	J1	J13	J19	-	-	-	-
E7	J17	J12	J3	J8	J10	J15	-
E8	J10	J20	-	-	-	-	-
E9	J20	J16	J1	J3	J4	J6	J7
E10	J10	J4	J14	J6	J18	-	-
E11	J16	J20	J12	J8	J1	J2	J3
E12	J4	J7	J10	J14	J19	J1	J15
E13	J2	J6	-	-	-	-	-
E14	J4	J9	J10	J12	J13	-	-
E15	J15	-	-	-	-	-	-
E16	J12	J13	J18	J5	J6	-	-
E17	J2	J3	J8	J11	J15	J20	-
E18	J17	J13	-	-	-	-	-
E19	J6	J7	J12	J18	J19	J2	J1
E20	J1	J3	J14	J9	J10	-	-

Using the STE approach, different solutions are obtained (as seen in Fig. 3). Since this approach emphasizes the maximization of job satisfaction, the optimal assignment solution (Result No. 1) shows the *maximum* number of satisfied employees of 20 (all employees), the average preference rank of 1.70, and the EJA competency gap of 3.18. When the alternative solutions are determined, the result is an improvement of the EJA competency gap, with a decrease in the number of satisfied employees.

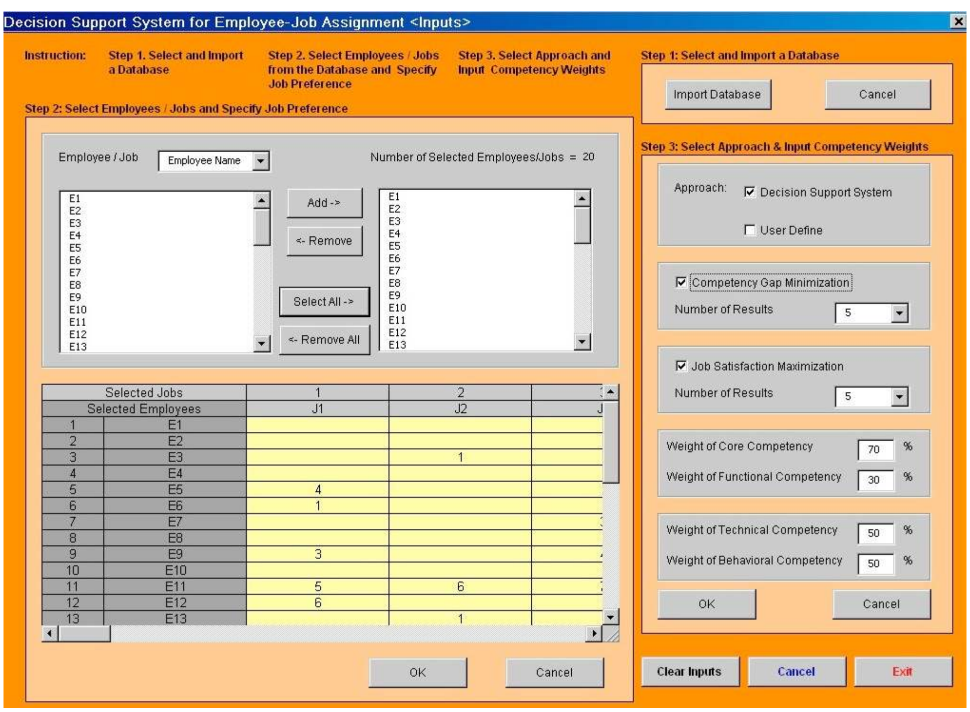

Figure 2. Input screen of EJAS

Figure 3. Summary of the assignment solutions from both ETS and STE approaches

From the results shown in Fig. 3, the user can choose to view the detailed employee-job assignments of any result by first clicking on the "View Assignments" button. The empty employee-job assignment table will be displayed. The assignment table shows the employee name, ID, current job title, suggested job title (by the EJAS), and job rank. At the left side of the table, a series of 20 buttons will be seen. The first 10 buttons are reserved for the ten solutions that can be generated using the ETS approach while the last 10 buttons are for those generated using the STE approach. By clicking on any desired button (result), the employee-job assignment for all employees based on that result will be seen and the summary of obtained quantitative indices will also be shown at the bottom of the table. Fig. 4 shows the 20 employee-job assignments based on Result No. 1 from the ETS approach.

For ease of comparison, all employee-job assignment solutions from both ETS and STE approaches are summarized in Table 4. The values of the quantitative indices are also presented. Note that only in R1 (of both solution approaches) the primary quantitative index is optimal (as indicated by "*").

4. COMPARISON BETWEEN HUMAN DECISION-MAKERS AND EJAS

Three EJA cases with 5, 10, and 15 employees (and 5, 10, and 15 jobs, respectively) were used in a comparative study to validate the EJAS and to investigate its assignment solutions as compared to those developed by human decision-makers. The emphasis of the comparison is placed on the quality of the solution, not the solving time.

Three HR managers of large business corporations in Thailand voluntarily agreed to participate in this study. The cases were assigned to the three HR managers on a random basis. Each case is assigned to only one HR manager. The details of the cases (including the current employee-job assignments, employee profiles, job profiles, and a list of up to five preferred jobs), explanations about the objective of the study, P-J fit, and purposes of employee-job assignments (both solution approaches) were provided. The HR managers were asked to find the *best* employee-job assignment solution and two alternative solutions using each solution approach alternatively. No time limit was set for the determination of the assignment solutions. The importance weights of the core and functional competency categories were assumed to be 0.70 and 0.30, respectively. Furthermore, the importance weights of the technical and behavioral competency categories were assumed to be equal (i.e., 0.50). The results (only the three quantitative indices) obtained from the human decision-makers and from EJAS based on both solution approaches are shown in Table 5.

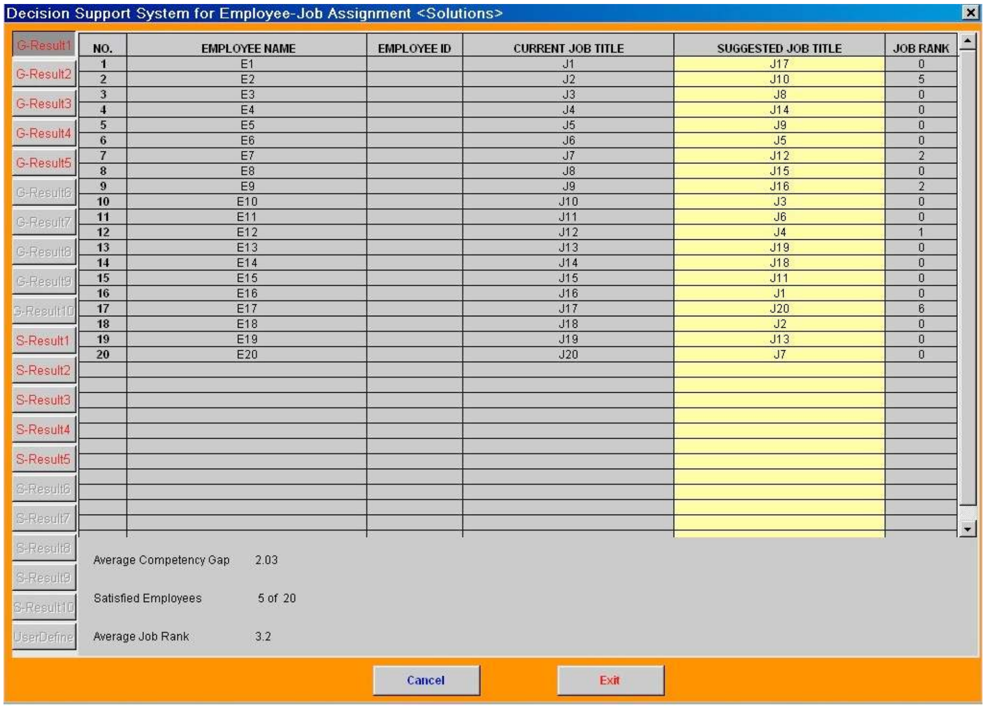

Figure 4. Employee-job assignments of Result No. 1 (ETS solution approach).

Table 4. Optimal and alternative assignment solutions from the ETS and STE approaches

	Assignment Solutions Based on the ETS Approach						Assignment Solutions Based on the STE Approach				
	R1	**R2**	**R3**	**R4**	**R5**		**R1**	**R2**	**R3**	**R4**	**R5**
E1	J17	J5	J5	J5	J16	**E1**	J5	J5	J5	J5	J5
E2	J10	J10	J10	J10	J10	**E2**	J18	J18	J18	J18	J18
E3	J8	J8	J8	J8	J8	**E3**	J6	J6	J2	J2	J2
E4	J14	J14	J4	J4	J17	**E4**	J20	J11	J11	J11	J14
E5	J9	J9	J9	J20	J9	**E5**	J8	J8	J8	J8	J8
E6	J5	J13	J13	J2	J13	**E6**	J19	J19	J1	J1	J1
E7	J12	J12	J12	J12	J12	**E7**	J17	J17	J17	J17	J17
E8	J15	J15	J15	J17	J5	**E8**	J10	J10	J10	J10	J10
E9	J16	J16	J16	J16	J6	**E9**	J1	J20	J20	J20	J20
E10	J3	J3	J3	J14	J14	**E10**	J14	J14	J4	J14	J9
E11	J6	J6	J6	J11	J11	**E11**	J16	J16	J16	J16	J16
E12	J4	J4	J14	J9	J4	**E12**	J4	J4	J7	J4	J7
E13	J19	J19	J17	J19	J19	**E13**	J2	J2	J19	J19	J19
E14	J18	J18	J18	J13	J18	**E14**	J9	J9	J9	J9	J4
E15	J11	J11	J11	J15	J15	**E15**	J5	J15	J15	J15	J15
E16	J1	J1	J1	J1	J3	**E16**	J12	J12	J12	J12	J12
E17	J20	J20	J20	J3	J20	**E17**	J11	J3	J3	J3	J3
E18	J2	J2	J2	J6	J2	**E18**	J13	J13	J13	J13	J13
E19	J13	J17	J19	J18	J1	**E19**	J7	J7	J6	J6	J6
E20	J7	J7	J7	J7	J7	**E20**	J3	J1	J14	J7	J11
G	2.03*	2.04	2.05	2.07	2.08	***S***	20*	19	18	17	16
S	5	7	9	10	11	***R***	1.70	1.47	1.39	1.29	1.19
R	3.20	2.71	3.67	3.10	4.00	***G***	3.18	3.07	2.93	2.85	2.82

G = EJA competency gap, S = Number of satisfied employees, R = Average preference rank
** = Optimal solution*

The assignment solutions obtained from the HR managers were only the two *best* solutions, one from the ETS approach and the other from the STE approach. All three HR manager admitted that it was very time consuming to try several methods to assign jobs to employees until they could obtain what they believed to be the two best assignment solutions. For the HR manager who was assigned to solve the 15-employee example, several work-hours were spent to search for the assignment solutions using a trial-and-error procedure. None of the three HR managers provided the alternative solutions that are nearly as good as their best solutions. When the EJAS was used to solve the same three cases, the optimal assignment and two alternative assignment solutions were found within just a few minutes for each solution approach.

Using the ETS approach, it is seen that the EJAS outperforms the HR managers in all three cases. Not only that EJAS can find a solution with the minimum EJA competency gap *G**, it also obtains the numbers of satisfied employees *S* (in the 10- and 15-employee examples) that are greater than those from the HR managers.

Table 5. Comparison of quantitative indices obtained from ETS and STE solution approaches

EJA Case		ETS Solution Approach			STE Solution Approach	
		HDM[1]	EJAS		HDM	EJAS
5 Employees	*G*	3.16	2.62*	*S*	5	5*
	S	3	3	*R*	1.60	1.40
	R	2.33	1.67	*G*	2.88	3.27
10 Employees	*G*	2.62	1.95*	*S*	10	10*
	S	3	4	*R*	1.60	1.50
	R	3.33	3.50	*G*	3.22	3.14
15 Employees	*G*	2.52	2.08*	*S*	15	15*
	S	3	6	*R*	2.06	1.80
	R	2.00	3.00	*G*	2.78	2.81

[1]HDM = Human decision-maker
G = EJA competency gap, S = Number of satisfied employees, R = Average preference rank
** = Optimal solution*

For the assignment solutions based on the STE approach, the three HR managers and the EJAS could yield the solutions with the maximum number of satisfied employees *S** in all three cases. However, the solutions from the EJAS have a smaller average preference rank *R* (the secondary index for job satisfaction). In other words, the employees are assigned to the jobs that are at the top of their list of preferred jobs.

It is thus clear that the EJAS is able to generate the employee-job assignment solution that is superior to the solution obtained from the human decision-maker. The EJA solution can also be obtained in much shorter time. The EJAS can find not only the optimal EJA solution but also several alternative solutions that are nearly as good. If the problem size is large, such superiority is expected to be even more pronounced.

5. CONCLUSION

Based on the concept of P-J fit and three quantitative indices, the EJAP can be mathematically formulated and solved to determine the optimal EJA solution. The quantitative indices, namely, EJA competency gap *G*, number of satisfied employees *S*, and average preference rank *R*, help to make it practical and convenient to compare different assignment solutions. The EJAS, a practical decision-assisted tool to determine an optimal and alternative employee-job assignment solutions based on the decision-maker's preference, is discussed in this paper. EJAS can be utilized to generate several alternative assignment solutions so that the decision-maker can select the most appropriate solution.

The EJAS consists of four modules: (1) database module (DM), (2) input module (IM), (3) problem-solving module (PM), and (4) solution module (SM). The DM allows the user to build a database of employee and job profiles, and also current EJA. Through the IM, the user can select employees and jobs to be considered, define preferred jobs for each employee, and choose how the assignment solution will be generated. The PM then determines the assignment solutions (optimal and alternatives) based on the preference given in IM. Finally, the SM displays the summary of the three quantitative indices for all solutions, and also detailed employee-job assignments.

The EJAS helps to make the employee-job assignment more objective and practical. Owing to its computational algorithms, the EJAS can generate an optimal and several alternative solutions. The assignment solution can be generated using either the ETS approach (with its primary emphasis on work efficiency) or the STE approach (with its primary emphasis on job satisfaction). Using the EJAS, the decision-maker can make the appropriate decision even though multiple objectives are concerned.

The concept of person-job fit is very applicable in a manufacturing environment as well. Through some modification, the EJAS can be used to assign the right workers to the right industrial tasks, machines, or workstations based on their congruence. Due to its capability to consider two objectives, tasks can be assigned to workers based on the skill level and physical capability not only to achieve high productivity but also to enhance the workers' safety.

6. INDUSTRY APPLICATION

At minimum, the employee-job assignment is performed once when new employees are employed at the first time. Most organizations have a policy to re-assign their employees or allow them to transfer to other positions (in the same organization) at some given intervals. Frequently, the re-assignments and/or transfers are decided by human decision-makers. When there are many employees (and jobs) involved, it is rare that the outcomes are optimal. The re-assignments are typically based on competency (productivity) whereas the transfers are based on job satisfaction. To consider both objectives concurrently is a difficult task to perform especially for human decision-makers. Nevertheless, it is undeniable that the productivity (or efficiency) and job satisfaction are essential for achieving profitable business operations.

A mathematical programming approach can be applied to determine an optimal employee-job assignment solution. If, for any reason, the optimal solution is not usable, alternative solutions need to be determined. The EJAS is able to generate several alternative solutions that are nearly as good as the optimal solution. It is thus a practical tool for any business organization (either manufacturing-oriented or service-oriented) to generate several employee-job assignment solutions with known quantitative indices from which the most appropriate one can be chosen.

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