A Conceptual Framework for a Problem Resolution Support System (PReSS)

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***Abstract*—Decision-making is the most critical task of management. Organizations use decision support systems (DSS) to improve decision-making by senior managers. Other than those provided by organizational decision support systems, little attention has been given to decision-making in resolving unstructured problems and issues within organizations. More often, such decisions are left to the individual department responsible for the problems for it to resolve often without access to relevant data, information or expertise. These issues are mainly related to daily operational and administrational issues arising out of poor cooperation between departments. This paper proposes a conceptual problem resolution support model utilizing the technique of multi-criteria decision-making (MCDM) to help organizations in identifying, prioritizing and resolving unstructured organizational issues. The paper shows how the MCDM evaluates and validates the proposed solutions to come up with an ideal solution.**

***Index Terms*—decision support system, decision-making, organizational issues, multi-criteria decision-making, problem resolution support model**

I. Introduction

A decision support system (DSS) is developed to help decision-makers in formulating the right decision. It collects data from many systems such as Transaction Processing System (TPS) and Management Information System (MIS) to enrich the input of the DSS [1]. Data that are gathered from internal and external sources is deployed in making structured and unstructured decision [2]. Organizations implement DSS to support top management in making strategic decisions. This is due to the fact that strategic decisions are important because they consume significant resources and capabilities and they are not easily reversible [3].

In this essence, organizations implement the DSS to achieve better decision-making and competitive advantages. However, some DSS fail due to organizational issues and weak pre-implementation plans. In addition, the decision might not be accurate due to data inaccuracies. In decision-making, there is a saying “right information at the right time leads to a right decision”. Accordingly, if an organization fails to collect the right information, it will lead to wrong decisions and additional operational and strategic costs [4].

Identifying issues of an organization includes gathering information related to the activities in operations, manufacturing, marketing, and supply chains among others. The data gathered are essential to provide clearer picture of the organizational issues. The interactivity and connectivity among departments are important to formulate an organization-wide decision-making. This is because strategic decision involves all the resources and capabilities of the organization and includes all the departments. There is a saying in the German business “If Siemens knew what it knows, it would be a rich company.” This indicates that sharing the issue and the interactivity between departments leads to reduction in operational cost [5].

In many organizations, problems resolutions are viewed as regular processes of finding solutions to identified problems. Many of these problems are resolved via ‘common’ problem resolution processes as dictated by the literature that include steps of defining the problem; generating alternative solutions; evaluating and selecting an alternative; and implementing the selected solution [3, 6, 7, 8]. While many methods have been researched and applied in these steps, the question that remains is whether the selected solution is the best solution for the problem or is there a better solution than the best.

The other perspective of this issue is that the common problem resolution steps would be applicable and useful only for objective problems such as those related to technical issues, e.g. replacing a faulty component of a machine to resume operation. However, subjective problems such as those often encountered in business are often more complex in nature, requiring a more focused and detailed approach involving many related parameters or criteria to consider. This subjective organizational issues could be resolved via a distributed problem-solving approach that utilizes software agents.

Software agents are programs developed to perform specific tasks autonomously [9]. Previous studies have deployed software agents to support the activities of DSS.

Manuscript received Nov. 13, 2016; revised Jan. 6, 2017.

doi: 10.12720/jait.8.2.148-153

DSS explains how agents can be deployed within information systems to help the decision-makers to choose the best decision and hence perform actions. Decision-making involve procedures to collect relevant information (internal, external, and local environment), then modeling the problem, to produce potential and alternative solutions. Those solutions are tested and justified while observing and considering the environment's changes to implement a credible decision.

Consequently, we proposed a multi-agent system (MAS) approach to such complex problem utilizing the multi-criteria decision analysis technique [10]. In this approach, interactivity and connectivity in an organization are critical issues that need to be identified as possible criteria to decision-making. Software agents are deployed to gather information from across the organization including the data, information and knowledge from existing systems as supplementary resources for this complicated endeavor. Thus, identifying issues in the organization are essential for better decision-making, which leads to integrated decision-making.

The use of multi-criteria decision-making is beneficial because it helps organizations to come up with organizational issues, evaluate and rank these issues accordingly [10]. Based on the identified issues, MCDM then identifies possible solutions and suggest an ideal one. Consequently, a multi-agent framework utilizing the multi-criteria decision-making technique is proposed as a reference for organizations and as an optional decision-making system. We call this system as the Problem Resolution Support System, or PReSS.

This paper presents the work-in-progress of our research in problem resolution support system with the aim to achieve the following objectives:

To identify the common issues of departments in organizations.

To determine the parameters that are related to the issues.

To construct a model that is built upon these parameters for which a multi-agent system could be deployed to assist in problem-solving.

We organize the paper as follows: Section II reviews the literature in organizational issues, intelligent software agents, and MCDM. Section III discusses the development of a conceptual framework and Section IV concludes the paper.

II. Literature Review

In the last decade, many organizations have invested in software packages of support systems such as enterprise resource planning (ERP), customer relationship management (CRM), and supply chain management (SCM). These are used as information and operational management through business processes [5].

Failure of applying the enterprise software packages or enterprise systems (ES) have been reviewed in information systems literature [11]. Some studies have shown that implementing ES might lead to reduced organization's profits or bankruptcy and collapse [5]. Enterprise systems have indicated to the researchers and managers to realize that organizational issues are more critical than the technical considerations of the ES. It has been indicated through changes to business practices and decision-making [12].

Lorenzi and Riley [13] pointed out four reasons for the failure of any information systems. It goes back to the technical considerations, project management considerations, explosion of information considerations, and organizational issues [13].

Change management of the organization refers to handling changes of the behavior of the organization from the current old fashion to a new one. Organizations usually deploy technology to implement changes to the organization's behavior. Organizational issues that lead to failed implementation of information systems include communication, complexity, technology, and leadership issues. The change in an organization's leadership may cause the change of strategy [13].

Managers usually face different decision situations that need various types of data for decision-making. For example, one critical decision that a Human Resource Manager faces is the performance assessment of the organization's employees. The employee may be an individual or a member of a project team. The evaluation helps to create competiveness among the employees according to their knowledge, skills, and contributions. The method of performance assessment differs from an organization to another according to the objectives and the assessment system [14]. A new method has been suggested using Fuzzy approach by considering the criteria used to evaluate the factors and issues of the employee's performance [8, 15].

Decision-making is a multi-process activity that recognizes the use of intelligent machines to complete specific processes in accomplishing the decision-making process in a fast and accurate way. In one decision support system, a multi-agent system (MAS) involves components that work autonomously, in which intelligent software agents observe the environment analyze it, then produce results. It refers to the so-called "agents" that define a new concept of distributed, open and complex systems. Software agent technology has been applied in many different applications such as e-commerce, manufacturing, or distributed environments [17, 18].

Cooperation and coordination between agents provide functionalities of human-computer interaction, user management and presentation of tasks' information. Cooperation and coordination through communication between agents consist of multi-agent systems that meet the design objectives in an environment [10]. It helps to reduce humans' or users' workloads, improve flexibility and maintains the intelligent systems [9].

Software agents are probably the fastest growing area of information and communication technology. They have already been used for applications as diverse as personalized information management, electronic commerce, interface design, computer games, and management of complex commercial and industrial processes [19].

The research in software agents have progressed over more than a decade emerging from research in distributed artificial intelligence and distributed computing. The knowledge in software agents is becoming more important due to the dynamic and open environments in which they reside and the complexity of tasks they can perform [19].

Wooldridge (1995) has defined software agents as entities that function continuously and autonomously in a particular environment that is often inhabited by other agents and processes [19]. Probably the most general way in which the term agent is used is to refer to the hardware- or software-based computer systems that include the following properties [19]:

1) Autonomy

Agents should be able to perform the majority of their problem solving tasks without the direct intervention of humans or other agents, and they should have self-control of their own actions and their own internal state.

2) Social ability

Agents interact with other agents or humans via some kind of Agent Communication Language (ACL) to complete their own problem solving.

3) Responsiveness/Reactivity

Agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the Internet, or perhaps all of these combined), and respond in a timely fashion to changes that occur.

4) Pro-activeness

Agents do not simply act in response to their environment; they are able to exhibit goal-directed behavior by taking the initiative where it is appropriate.

Within existing applications, three various types of agents can be identified [19]:

- **Gopher agents:** it is the simplest level of agent that will perform straightforward tasks based on pre-specified rules and assumptions.
- **Service performing agent:** it is the next level of sophistication that will perform well-defined tasks at the request of the user.
- **Predictive agents:** it is the final level of the agent that volunteer information or services to a user, without being explicitly asked, whenever it is considered appropriate.

Merging these agents and their attributes within the system makes the agents a fundamentally new paradigm that is able to solve complex tasks.

Business decisions usually depends on the relevant internal and external data of the organization. Internal data can be obtained from the business activities within the organization, and external data is extracted from competitors. The data must be included and integrated into a data warehouse, which enables the organization to store and restore vast amount of organizational data from operational systems for efficient responses [20]. According to Lavbič and Rupnik [20], there is a lack of frameworks for information systems in business and MAS paradigm integration.

Decision problems have attracted considerable attention from the industry and academia. Consequently, multi-criteria decision-making (MCDM) technique is modeled according to the ways humans are thought to make decisions. Although different MCDM methods, techniques, and approaches have been studied, the basic components of MCDM are the same: a finite or infinite set of actions, at least two criteria, and one decision maker [6].

With these elements, MCDM assists in decision making mainly by choosing, ranking, or sorting the actions. MCDM is not only a collection of theories, methodologies, and techniques but also a specific perspective in dealing with decision-making problems [6]. Over the past few decades, decision-making theory has been successfully applied to a growing number of diverse domains and has assisted in decision making. MCDM can handle multiple conflicting criteria [21].

Improper selection of a decision may result in incorrect strategic decisions and affect the financial aspects of the organization. Multiple-criteria decision-making techniques such as TOPSIS, WPM, WSM, SAW and HAW can be used to select the best decision according to metrics, which are weighted and evaluated to form a matrix. MCDM helps in decision-making by scoring, ranking and selecting the actions. It can maintain multiple conflict criteria [6, 8].

Analytic hierarchy process (AHP) is a multi-criteria decision-making approach for dealing with complex decision problems. Weighted sum model (WSM), in operation research, is a well-known and the simplest MCDM method for evaluating a number of alternatives in terms of a number of criteria.

Weighted product method (WPM) is one of the simplest and earliest MCDM techniques. It is almost similar to WSM; the only difference between both methods is that addition is the main mathematical operation in WSM, whereas multiplication is the main mathematical operation in WPM.

Simple additive weighting (SAW) is also known as the weighted sum method, is probably the best known and most widely used MCDM method. The basic logic of SAW is to obtain the weighted sum of the performance ratings of each alternative over all attributes.

In SAW each criterion value is divided by the largest criterion value among all alternatives. Unlike SAW, the Hierarchical adaptive weighting (HAW) method is composed of the following steps: rescoring, ranking the alternatives based on the mission effectiveness, and then ranking the alternatives according to the descending values of the alternatives.

Finally, the technique for order performance by similarity to ideal solution (TOPSIS) allocates scores to each alternative on the basis of their geometric distance from the positive and the negative ideal solutions. According to this technique, the best alternative would be the one with the shortest geometric distance to the positive ideal solution and the longest geometric distance to the negative ideal solution determined by going through the following steps: construction of the normalized decision matrix, construction of the weighted normalized decision matrix, determining the ideal and negative ideal solutions, separation measurement calculation based on the Euclidean distance, closeness to the ideal solution calculation, and then ranking the alternative according to the closeness to the ideal solution [6].

III. The Development of a Conceptual Model

The proposed conceptual model that is illustrated in Fig. 1 addresses three major components at any organizations:

- Identify Organizational Issues
- Modelling the Issues.
- Multiple-Criteria Decision-Making as Software Agent

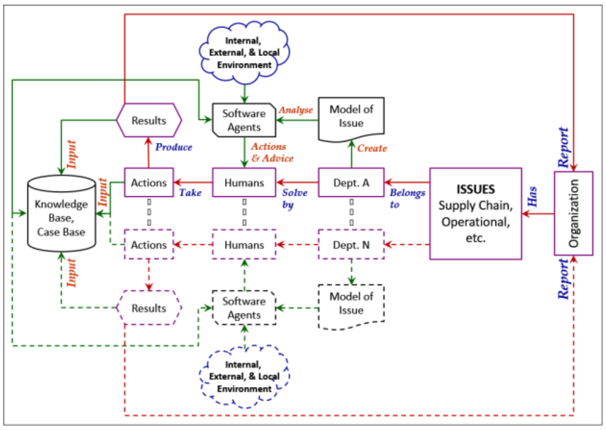

Figure 1. Conceptual model of the problem resolution support system (PReSS).

An organization has a Senior Manager who is the leader of the whole organization. The organization has various departments, which has a Head of Department (Middle Manager) reporting to the Senior Manager of the organization. The managers of each department must regularly report the department's problems and their resolutions to the organization's Senior Manager to control and monitor the situation of the organization. Senior Managers with the Board of Directors or Operational Managers and Administrators regularly make strategic decisions on the organization because they consume strategic resources. Hence any risky issues within the organization or failure of the decision support systems may lead to catastrophic strategic decisions.

When each head of department solves a problem, the solution is stored in a Knowledge/Case Base for sharing and future use. Other departments may not know the kind of problems occurred in the other departments that may affect the organization's strategy. Therefore, the problem is the non-coordination between departments to observe the solution of the current problem that may be similar to problems that have occurred in the past. Consequently, there is a need to create such a Knowledge/Case Base to store the problems/cases of the organization with the solutions to be used in the future.

Humans usually identify issues and propose a solution, or they postpone the issue without considering decisions that are delayed or that have influence on the organization's processes.

Failure of selection and adoption of decision support systems such as ERP and ERS may economically and strategically affect the organization. Researchers pointed out that strategic decisions are important because organizational resources are consumed that are used as a basis for strategic decisions [3].

A. *Identify Organizational Issues*

Each department should identify issues affecting the department to discover the most critical issues that need to be solved. Issues can be identified by conducting structured interviews as a qualitative study approach to determine the most critical issues that need resolutions. Studies show that structured interviews are efficient and effective than unstructured interviews due to the mechanisms that help to make the interviews systematic [22].

To make more validated data of identifiable issues, the interview is conducted with three major employees within the department. They are the head of department, the deputy head of department (middle manager), and a few senior employees (operational managers and administrators). It may result, for example, seven issues which are pertinent to the department. The issues are without priorities of importance and it can be reduced to the most critical issues that require immediate resolutions [22].

A typical example of issues in a department could be reduced sales, increased customer complaints, and increased competition.

B. *Modelling the Issues*

Modeling the issues entails the identification of the pertinent factors that directly or indirectly cause the issues or problems. For example, if the issue is reduced sales, the pertinent direct factors could be lower quality product, poor marketing, poor customer service and indirectly, increased competition. To identify these factors, a data collection task on the issue needs to be conducted. A quantitative approach via a survey questionnaire could be used to solicit information from both employees and customers. Subsequently, the data needs to be statistically analyzed using SPSS via factor analysis.

Alternatively, fuzzy logic could be used in a fuzzy inference system that maps the factors as inputs of the system to an output using *MATLAB* toolbox [23]. Factors are evaluated via pertinent rules from the rule-base, then a defuzzification process produces the output result as an index. This process is illustrated in Fig. 2.

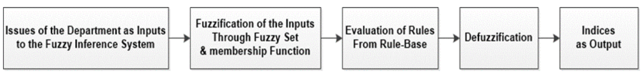

Figure 2. Fuzzy logic technique to set issues indices.

The analysis results are tabulated as shown in Table I. Index value ranges between *0* and *1*, and the issue is arranged in descending order. The fuzzy approach ranks the factors that are important. It may reduce the number of factors, for example, from seven to four. Consequently, the factors manifest a set of variables, the relationships between which, manifest a model of the issue [24].

TABLE I. EXAMPLE OF RESULTS OBTAINED FROM FUZZY SYSTEM

Factors	Fuzzy Results	Ranking
F_1	$Index_1$	Based on the indices, the issues are ranked as the most critical issues
F_2	$Index_2$	
F_3	$Index_3$	
F_4	$Index_4$	
Example of Clerk Achievement Assessment in Human Resources Dept.		
Quantity of the Work	0.520	4
Late Attendance	0.665	2
Initiative	0.6	3
Confidence	0.717	1

The issues may be resolved by humans who perform actions after deciding on a solution, which is then stored in the Knowledge/Case Base for sharing or future use. For our conceptual model, multiple software agents could be deployed to analyze these factors, which manifest a multi-criteria analysis approach of the issue.

C. Multiple-Criteria Decision-Making as a Software Agent

Multiple-criteria decision analysis involves analyzing a set of factors or criteria from which a decision is made. In real world problems, there are typically multiple (but usually conflicting) criteria that need to be evaluated in making decisions [10].

In multiple-criteria decision-making (MCDM), the concept is summarized by analyzing a set of criteria to evaluate an issue in determining the most credible solution to the issue. Consequently, a multi-agent approach would be suitable to handle the multiple-criteria nature of the issue and suggest a solution. Each department has its own multi-agent system to analyze its issues and offer solutions to those issues. If the organization needs to resolve the most critical issue within the whole organization, the MAS implements MCDM with a common set of criteria, the results of which are reported to the senior managers and its board members for strategic decision-making [7, 11].

Software agents observe the internal and external environments for changes. These changes are exploited to retrieve previous cases stored in the Knowledge/Case Base to discover solutions to the issues and advice a resolution to humans for decision-making. The results are reported to the relevant senior managers of the organization.

The major parts of MCDM include the *decision matrix (DM)*, the *alternatives* (the issues), the *criteria*, and the *weights* of importance [16]. The result is a matrix called evaluation matrix or decision matrix containing the criteria (C_N), the issues (A_M), and the weights (W_N) as depicted in Fig. 3.

The criteria used to evaluate the issues based on measures chosen as criteria to result the rating of the issue (a_{MN}). The rating of issue is assigned by value to facilitate insertion of the data matrix into the agent. Each technique of MCDM has equations that can be programmed by *Java* to implement the technique as software agent. The equations are pointed out in [7, 11].

$$\begin{array}{rcc}
 & & \underline{\textbf{Criteria}} \\
 & \underline{\textbf{Alt.}} & \begin{array}{ccccc} C_1 & C_2 & C_3 & \cdots & C_N \\ W_1 & W_2 & W_3 & \cdots & W_N \end{array} \\
DM = & \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_M \end{array} & \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1N} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2N} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3N} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{M1} & a_{M2} & a_{M3} & \cdots & a_{MN} \end{bmatrix}
\end{array}$$

Figure 3. Decision matrix that consists of alternatives as issues and criteria to evaluate the issues [6].

Finally, a solution to the issue that is recommended by the agent is executed by the humans who are the main actor of the decision-making process. Furthermore, the results can be stored by the agent into the Knowledge/Case Base, or by the humans for future use.

IV. CONCLUSION AND FURTHER WORKS

In decision support systems, it is essential to get a candidate solution fast. Organizations usually have diverse departments that have different issues needed to be modeled, analyzed and solved. Assuming that we have N-departments in which each department may have some issues such as supply chain, human resources, return on investment, revenue, operational, and so on. Those issues often are solved by humans who belong to that department. The solutions are usually passed to the department's manager to take actions and hence produce results. The results are reported in documents and stored in a knowledge base as cases that have been resolved for future use.

A multi-agent approach to the resolution of issues can be applied by creating a model of the issues by identifying the pertinent factors causing the issues. Software agents then scan the environments based on the model's factors and consult the Knowledge/Case Base for similar solutions. The agents use the multiple-criteria decision-making (MCDM) approach to arrive at a solution for each issue. The results are returned to the highest level in the organization as reports, and inserted into the Knowledge/Case Base as new cases.

At the current stage of the research, this paper only presents a conceptual framework for a problem resolution support system utilizing the multi-agent approach. In our future work, we shall refine the concept further with a real world organizational issue depicting a complete treatment of the resolution process.

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