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Framework for Enhancing Supplier Selection Process by Using SOEKS and Decisional DNA

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Abstract.
Supplier selection process is one of the significant stages in supply chain management for industrial manufactured products. It plays an integral role to the success of any manufacturing organization, and is an important part starting right from selecting raw material to dispatch of finished products. This paper contributes to enhance the supplier selection process by proposing a multi-criteria decision making framework for industrial manufactured products. Proposed framework is based on smart knowledge management technique called Set of experience knowledge structure (SOEKS) and decisional DNA, which makes the proposed approach dynamic in nature as it updates itself every time a decision is taken.

Keywords: Supplier Selection Process, Multi-criteria decision making, Set of experience knowledge structure (SOEKS), Decisional DNA (DDNA)

1 Introduction

Supplier selection process plays a vibrant role for manufactures as every decision made during this process affects the success of production management [1].Therefore, companies are focusing more and more on supplier selection process to overcome the challenges of producing high quality products at lower cost [2]. Single criteria supplier selection approach, in which only low cost suppliers are selected, is almost redundant. In this era, supplier selection process is a complicated and multi-criteria decision making (MCDM) problem, which requires the consideration of various criteria and sub-criteria [3, 4]. Consequently, manufacturing organizations feel comfortable to work with suppliers who can provide products and services at required quality level, reasonable cost, and flexible to adopt any changes in design and manufacturing as anticipated [5]. In conjunction with this, companies also pay special attention towards the selection of alternative suppliers [4] to accomplish with uncertain global conditions e.g. recent COVID-19 global supply chain issues. Likewise, the use of multiple suppliers provides more flexibility due to the diversification of the organization's total requirements and brings up competitiveness among alternative suppliers [6].

Supply chain management (SCM) has improvised a lot during the third industrial revolution and organizations have been forced to implement continuous improvement attitude in their purchasing related matters. As a result of this, supplier selection process has also evolved significantly in the past forty years. These changes have been beneficial to both the purchasing clients and the suppliers. Decision making process involved in supplier selection depends on multiple qualitative and quantitative criteria [7]. In the past, supplier selection problem has been solved by the researchers by two different approaches i.e. individual and integrated approaches [8]. The most commonly used individual approaches are: the data envelopment analysis (DEA), mathematical programming, the analytic hierarchy process (AHP), the analytic network process (ANP), neural networks, structural equation modeling, multi-attribute utility theory, dimensional analysis (DA), fuzzy decision-making, genetic algorithms, and, the simple multi-attribute rating technique (SMART), etc. The integrated approaches use more than one approach jointly, e.g. integrated AHP and DEA, integrated AHP and goal programming, etc. [4].Meanwhile, the world is moving towards Industry 4.0, which is the fourth revolution of the industry. Conventional processes are to be replaced by new concepts, i.e., internet of things (IoT), internet of services (IoS), cyber-physical systems (CPS), mass collaboration, high-speed internet, and affordable 3D printing [9]. These advancements offer enormous opportunities for supply chain intelligence and autonomy establishing stepping stones for Industry 4.0 supply chains (SCs). Supplier selection process is the back bone of supply chain process, but unfortunately this has not been realized within Industry 4.0 supply chains [10]. Traditional supplier selection approaches based on MCDM fail to address the supplier selection problem in Industry 4.0, because of the large amount of data produced during product manufacturing in real time [11].

In this paper, we attempt to enhance the supplier selection process by proposing a frame work based on smart knowledge management technique called Set of Experience Knowledge Structure (SOEKS or SOE in short) and Decisional DNA [12]. The structure of the paper includes the literature review in section 2, which presents the basic concepts of supplier selection process, supplier selection decision-making criteria, and set of experience knowledge structure and decisional DNA. Proposed framework for supplier selection process and working algorithm of proposed technique are discussed in section 3. Finally, the conclusions and future work are presented in Section 4.

2 Literature Review

2.1 Supplier Selection Process

Supply chain management is the process of managing events related to flow and transformation of goods and services from the source point to usage point [13]. Supplier selection process is one of the important activities in supply chain management. Basically, it is the initial stage of supply chain management and can effect all the consecutive stages [14]. It is the process by which firms identify, evaluate, and contract with suppliers. The main objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and develop closeness and long-term relationships between buyers and suppliers [15]. In order to achieve these objectives, supplier selection processes need to consider various quantitative and qualitative criteria [14].

The literature on supplier selection criteria and methods is full of various analytical and heuristic approaches. Some researchers have developed hybrid models by combining more than one type of selection methods. In most of the manufacturing industries, the cost of raw materials and component parts represents the largest percentage of the total product cost. Therefore, selecting the right suppliers can lead towards the successful procurement process and can represent a major opportunity for companies to reduce costs across their entire supply chain [6]. Supplier selection methods and criteria are still critical issues for manufacturing industries, therefore this paper proposes a supplier selection method which uses previous experiential knowledge to solve the issue.

2.2 Supplier Selection Decision-making Criteria

Identification of decision making criteria is the back bone of supplier selection process. From the literature review, it has been found that few of the important decision making criteria for supplier selection process are: cost, quality, delivery, performance history, warranties & claims policies, production facilities and capacity, technical capability, financial position, procedural compliance, repair service, packaging ability, risk factor, reliability, process improvement, and product development [6].
Recent industrial advancements related to environmental, social, political, and customer satisfaction concerns make these criteria further complex [6]. This all makes the supplier selection process a multi-criteria decision making (MCDM) problem [4]. Whereas, MCDM approaches are formal methods to structure the decision problems with multiple, conflicting criteria or goals [8]. These approaches have been widely used in the fields of transportation, immigration, education, investment, environment, energy, defense, and health care [16].

2.3 Set of Experience Knowledge Structure and Decisional DNA

Set of experience knowledge structure (SOEKS) is a smart knowledge management technique. It collects and analyses formal decision events and uses them to represent experiential knowledge. A formal decision is defined as a choice (decision) made or a commitment to act that was the result (consequence) of a series of repeatable actions performed in a structured manner. A set of experience (SOE, a shortened form of SOEKS) has four components: Variables (V), functions (F), Constraints (C) and Rules (R). Each formal decision is represented and stored in a unique way based on these components. Variables are the basis of the other SOEKS components, whereas functions are based upon the relationships and links among the variables. The third SOEKS component is constraints, which, like functions, are connected to variables. They specify limits and boundaries and provide feasible solutions. Rules are the fourth component and are conditional relationships that operate on variables. Rules are relationships between a condition and a consequence connected by the statements ‘if/then/else’[17]. The four components of a SOE and its structural body can be defined by comparing it with some important features of human DNA. Just as the combination of its four nucleotides (Adenine, Thymine, Guanine, and Cytosine) makes DNA unique, the combination of its four components (Variables, Function, Constraints, and Rules) makes an SOE unique.

Each formal decision event is deposited in a structure that combines these four SOE components. Several interconnected elements are visible in the structure, resembling part of a long strand of DNA, or a gene. Thus, a SOE can be associated to a gene and, just as a gene produces a phenotype, SOE creates a value for a decision in terms of its objective function. Hence, a group of SOEs in the same category form a kind of chromosome, as DNA does with the genes. Decisional DNA contains experienced decisional knowledge and it can be categorized according to the areas of decisions. Furthermore, just as assembled genes create chromosomes and human DNA, groups of categorized SOEs create decisional chromosomes and DDNA. In short, a SOEKS represents explicit experiential knowledge which is gathered from the previous decisional events [18]. SOE and DDNA have been successfully applied in various fields such as industrial maintenance, semantic enhancement of virtual engineering applications, state-of-the-art digital control system of geothermal and renewable energy, storing information and making periodic decisions in banking activities and supervision, e-decisional community, virtual organizations, interactive TV, and decision-support medical systems, etc.[19].

3 Proposed Framework of Supplier Selection Process

Framework for supplier selection process by using "Set of experience knowledge structure (SOEKS) and Decisional- DDNA" is shown in Fig. 1. It comprises of acquisition phase, integrator, prognoser, solution, and supplier selection decisional DNA (SS-DDNA). The working of each section is explained as follows:

Acquisition phase*:*
Users can interact with the system by inputting data into the user interface. The data can be a simple query for supplier selection problem based on various criteria as disussed above, or it could be addition of new data, information, or knowledge to enhance the knowledge base of the platform.

Integrator:
The integrator receives data from the user interface and acquires information through various applications. It produces sub-solutions according to the objectives of the users. Furthermore, it transforms the information into a unified language and measurement system. It gathers and organizes the data and transforms it into sets of experience described by the unique set of variables, functions, constraints, and rules. The integrator interacts with the supplier selection decisional DNA (SS-DDNA) for similar sets of experiences and sends the results to the prognoser for further processing.

Prognoser:
The prognoser first produces sub-solutions provided by multiple applications according to its established objectives. Then depending on the various scenarios new sets of models can be built by taking into account measurements of uncertainty, incompleteness

and imprecision. The prognoser finally produces set of proposed solutions that are sent to the solution layer.

Solution:
The solution layer allows the user to select the best solution out of the proposed solutions. Based on the priorities defined by the user it chooses the best solution among the possible solutions provided. The decisional event is then sent to the SS-DDNA.

Supplier Selection Decisional DNA:
It is where the sets of experience and formal decisional events are stored and managed. One set of experience represents a decisional DNA gene [18]. Same category of genes are grouped together which is collectively called as decisional chromosome. Group of such chromosomes; product chromosome, process chromosome, and technology chromosome, constitutes a decisional DNA of the desired process. It also interacts with other components of the framework during the solution process and presents similar experiences that helps in finding a reliable solution in less time.

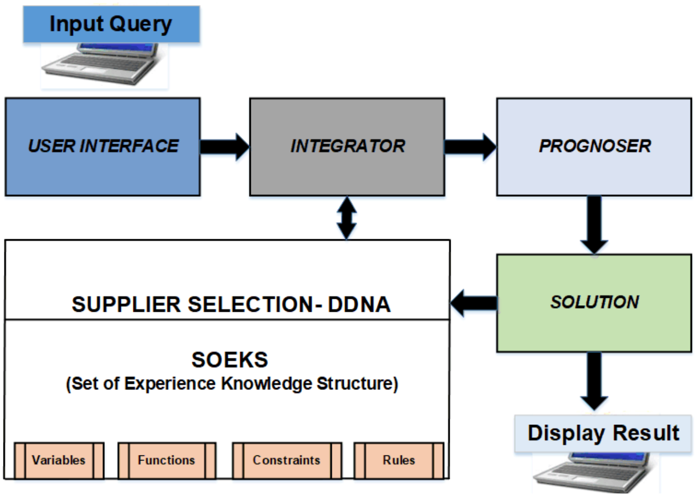

Fig. 1. Framework for supplier selection process by using SOEKS and Decisional DNA

3.1 Working Algorithm of Proposed Framework

Our proposed supplier selection framework is based on SOEKS and DDNA, which is a smart knowledge management technique and is capable of performing multi-criteria decision making. Various criteria and sub-criteria related to supplier selection process are captured, stored, recalled, and shared from the experiential knowledge in the form of set of experiences (SOEs). Whenever a similar query is presented during the supplier selection process, this stored knowledge is recalled to overcome the problem. It provides a list of proposed optimal solutions according to the priorities set by the user. By the passage of time, system achieves more expertise in its specific domains as it stores relevant knowledge and experience related to formal decision events. Working algorithm for proposed supplier selection method is shown in Fig.2.

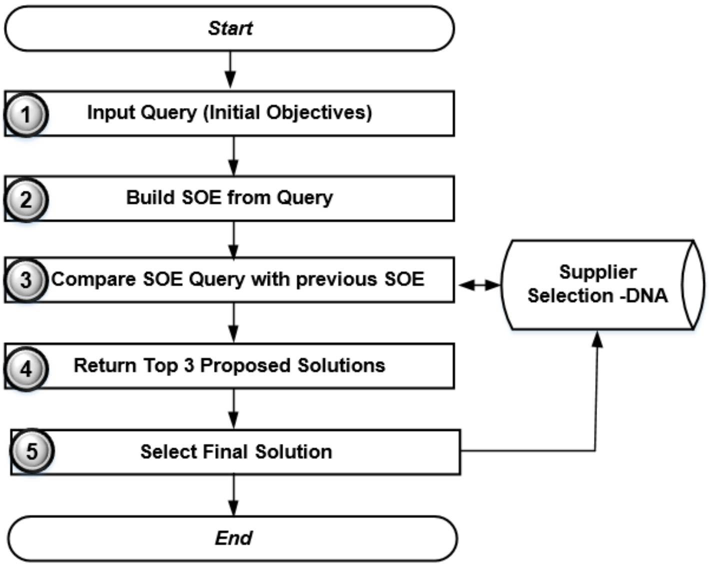

Fig. 2. Working algorithm of SSP-DDNA

Supplier selection process starts by inputting the query into the system based on the initial objectives/criteria. These objectives are entered in the form of variables (qualitative and quantitative criteria), functions, constraints and rules. In Step 2, the entered query is converted to a *SOE.* Built query is compared with available similar SOEs that are ranked according to the common initial objectives and their performance factor (PF). These SOEs are stored in SS-DDNA in a comma-separated values (CSV) file.
The pseudocode for parser reading CSV file for supplier selection process is shown below:

- *Reads variables, functions, constraints, and rules.*
- *Develops set of variables, set of functions, set of constraints, and set of rules.*
- *Creates a Set of Experience (SOE) = Set of variables + Set of functions +Set of rules.*
- *Form a chromosome of supplier selection process by collecting SOEs of the same category.*
- *Provide top 3 proposed solutions.*

Finally, a list of proposed top three solutions is returned and user selects the final solution. This final solution is then stored in the SS-DDNA and can be used for the future reference.

4 Conclusion and Future Work

This paper presented the framework to enhance the supplier selection process by using SOEKS and DDNA. Proposed framework supports multi-criteria decision making (MCDMA) approach and uses experiential knowledge of formal decisional events generated during supplier selection process. The proposed system is dynamic in nature as it updates itself every time a new decision is taken. It will benefit in performing supplier selection process for small and medium enterprises involved in product manufacturing. The next step will be the refinement of the algorithm in more detail and its translation into JAVA platform.

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