A Contemplation of Group Decision Support Systems

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***Abstract*— A Decision Support System (DSS) is an interactive computer-based information system that supports decision making and sometimes knowledge management. Essentially, it is fortitude of organizations, associations, corporation of information about the enterprise concerned, for support of assessment-making process. In assimilation with that enterprises relay on DSS tools, techniques and models in order to seek recommendations in business activities and strategies. One of the most important but vast areas specified for DSS is a Group Decision Support System (GDSS), that is a kind of electronic meeting system, a collective technology design for meetings and group works via a human computer interaction for effective group decision making. Though this is a relatively new and emerging field of DSS, there remain some problems and issues to be solved in GDSS such as its requirement of real time operation, process losses, time consuming and high cost required for its group coordination etc. This paper presents a review of numerous researchers' efforts regarding GDSS and their impacts. The rationale of our study in this paper is in twofold: first is to review the literature, highlight the shortcomings and their core ideas or strengths. Another perspective is to show a critical evaluation by comparison and contrast. The contribution of this paper is on surveying many researchers efforts pertaining to GDSS.**

Keywords- DSS, GDSS and collaboration

I. INTRODUCTION

Decision Support System (DSS) is considered as a combination of computing power and intelligent algorithms for supporting and improving the quality of decision making [1]. Furthermore, DSS provides assistance to decision makers to manage their decisions in an efficient and time appropriate manner to achieve the following functions: value added and cost reduction capabilities, supporting managers in their managerial and semi-structured decisions and improving decision effectiveness [2].

In addition, DSS assists decision makers to complete decision procedure activities in the following manners:

- It basically provides a means to acquire data, documents, information, knowledge and different types of modules.
- This system also enlarges the number of different aspects, accomplishes more understandability of the business processes and day-to-day activities, and also supports to get into the depth of uncertainty and get better solutions for these situations.
- They also support in acquiring new imminent and learning, assist improved communication, achieve cost and time savings, achieve better decisions, facilitate more effective teamwork and achieve better use of data resources [1, 2, 10 and 13].

Most advanced and new emerging fields in this challenging environment of DSS is GDSS which is a kind of human-computer system that facilitates the decision making process of a group of people [6]. Subsequently this represents an important role in actual organizations. The new economy demands that the decisions must be made quickly however without compromising the quality of the decision-making process or its results.

With the objective of making better decisions, more and more times decisions are taken for groups of individuals representing different organization perspectives [11]. Moreover, GDSS built for such purposes:

- It reveals the effectiveness of decisions made via group consensus as against an individual decision.
- It is used to train humans in learning to detect deception more accurately.
- It helps to benchmark automated agents against human performance [10, 13].

In accumulation to above, GDSS in its real application and implementation face some problems and issues amongst them; they are group management problem, time management problem. Because of its vast working environment, GDSS faces challenges due to improper coronations and cooperation of group members, and irregular work load on a single person due to miscommunication etc.

The main contribution of our study is in two-folds: 1) to review the literature and provide an overview of contributions of numerous researchers in the vast field of DSS. Moreover, this demonstrates the limitations, and more importantly the review shows dissimilar ideas of some researchers and 2) to articulate a critical evaluation through comparison and contrast, presented in a table.

The remaining paper is arranged in the followings way.: Section 2 elaborates a literature survey of research in the area of Group Decision Support System; section 3 compares and contrasts different works of researchers; section 4 reveals a tabular presentation of the survey. Concluding paragraph and future possibilities are given in section 5.

II. LITERATURE REVIEW

Chen et al. [1] suggested a model of complex large group decision support system which is basically composed of work breakdown structure, in both Internet and Intranet environments. In assimilation to this work breakdown structure it decomposed into independent projects, mutual influence and interrelated project units. Furthermore, for making good decision making in groups this structure utilized the technique of tree structure. In sum of that all system provided decision making groups breakdown to reduce complexity and breadth of groups. Main strengths of their work are as follow.

- It can avoid lost information and knowledge split in the process of decision-making problem structure breakdown.
- Through decision-making groups' breakdown to reduce the complexity and breadth of groups, so that it can better carry out group parallel decision-making, grading control, reduce coordination within the group, improving efficiency and groups' satisfaction.

Precincts of their work is that they have to further improve group behavior and knowledge constituents influence on group breakdown in order to make improvements towards practical approach.

Subsorn et al. [2] applied fuzzy logical concepts on web-based applications for making group decisions. Likewise a web-based group decision system framework has been constructed. Furthermore, a Group Decision Making (GDM) system has been developed which allows multiple users to work collaboratively in a group to solve decision problems. Additionally, they introduced a new method of fuzzy multiple-objectives linear programming method in order to generate satisfactory solution of multiple objectives decision making problem. At the end a fuzzy AHP is used to solve uncertain problems in making decisions within a group. Main potency of their exertion is that they utilized fuzzy logics in order to provide solutions to uncertain problems in a web-based environment for making better decisions. Limitation of their effort is that they have to take more and more set for its practical implementation for increasing the performance of the system.

Wu et al. [3] examined the frame of Product Design Evaluation Group Decision Support System (PDEGDSS). Consequently they also built Evaluation Problem Generating Databases (EPGD) and Evaluation Problem Solving Database (EPSD). They also suggested product design and design evaluation methods for making good decisions. To demonstrate the merits they implemented components of PDEGDSS namely as Human Computer Interaction System, model based management system and data base management system. The main strength of their work is that the evaluation and group decision method both serve as database foundations to structural GDSS for product design evaluation and good decision making. Limitation of their work is that PDEGDSS needs further improvement in order to support good decision making.

Rigopoulos et al. [4] reported on multi-criteria methodology focusing on classification decision by a collaborative team for modeling preferences and facilitate decision making. They utilized aggregation group producing a collaborative set of parameters. In addition with this order to support decision making an important architecture of GDSS was proposed. Which is composed of data layer, application layer and that of web layer? At last they have utilized a case study within a bank in order to determine that good decision making in multi-criteria groups is possible. Furthermore, members after evaluation in GDSS can select a problem and find a best decision or solution for it. The main strength of their effort is that multi-criteria methodology approach contributes to a better understanding of the individual multi-criteria decision making within a group environment. Limitation of their work is more improvement is required in its components for better decision making in multi-criteria environment.

Almedia et al. [5] dealt with a basic approach of scheduling in combining with that of GDSS through adoptive hypermedia. In amassing to this approach they have used integration of multiple problems to produce a single set of solutions and integration between group decision makers using different evaluation criteria to come to a single solution. Furthermore, they have developed distributed dynamic scheduling for geographically distributed multi-attribute, multi-criteria decision support in a complex manufacturing environment. Moreover, a main architecture of the system is composed of Scheduling Module (SM), Group Decision Support Module (GDSM) and that of Adoption Model (AM). Multiple agents worked in order to get multi-criteria solution. The application of different adaptive technologies in an integrated way for the development of Collaborative Framework for Scheduling will not be only an important alternative, but also a new solution innovation to support the scheduling process in manufacturing environments.

Yu et al. [6] have proposed a Multi-Objective Genetic Algorithm (MOGA) in order to model dynamics in GDSS. In association with this MOGA they have elaborated dynamics in two-ways information exchange pattern and emergence of social hierarchy. Furthermore, they utilized mathematical formulas in order to achieve some optimal solution and to compare different groups with diversity and activity level. Additionally they have utilized a genetic algorithm that is known to have a good searching capability for resolving group problem-solving processes. At last they exploited the clusters representation in order to show MOGA application in dynamic group decision support system. Strength of their work is that the basic model of MOGA is proficient for determining dynamics in group decision support system. The limitation of their work is that it doesn't support qualitative relationship between GA parameters and the variable that reflects dynamics in GDSS.

Esseghir et al. [7] have presented a model of Intelligent Decision Support System (IDSS) in order to create CNEARS decision makers and their evaluations. They have utilized multi-criteria aggregation method for making decision for ELECTRE TRI. Furthermore, they have defined IDSS

components namely data management sub-system, model management sub-system and user-interface. Additionally they introduced Knowledge Based Management System (KBMS). This helps in sharp decision making. At last they aggregated CNEARS that chooses weights for which the Weight Minority Vote (WMV) method was introduced. Moreover, KBMS was acquired from CNEARS experts for its qualitative criteria. The strength of their work is that they have introduced IDSS for good decision making which enhance proficiency of system. The limitation of their work is that further improvement is required in IDSS by introducing intelligent agent which uses in browsing on NET to update and verify the information contents.

Song et al. [8] utilized a group decision strategy in order to analyze threats and handle crises at enterprise level. Consequently they have taken Cheese organization in order to illustrate crises of multi-disciplinary problem which they have been tried to handle by Group Decision Making. Subsequently, a mathematical method was formulated for better decision-making named as AHP with clustering. At last they have discussed four majors to avoid crises and selection of alternative person, increases salary, recognized human resources and satisfaction of demand. Alike this they have applied judgment matrixes to apply these rules and handle crises. The plus point of their effort is that they have introduced a mathematical model in order to handle crises and threats analysis at enterprise level. The weakness of their work is they have to work on this method in depth as a blueprint for implementation.

Chambless et al. [9] recommended a model for analyzing Aerospace Corporation. They have utilized through group decision support system in order to get cost benefit for selection of final system. Furthermore, two main models have been developed. They are Multi-Criteria Decision Model (MCDM) and a model of Uncertainty in order to scrutinize group decision which improved decision making. Likewise, they identified group outcome using robust decision analysis. Finally they plotted efficient cost by graph representation to acquire logical decisions for group in Aerospace Corporation system. These logical decisions systems make it easy to allow group to come with unbiased decisions by consuming "rate and weight" model that also help in analyzing sensitivity in weights. The main strengths of their work lie in the utilization of Group Decision Support System (GDSS) in Aerospace Corporation. It is a main contribution to the field of decision support because this can be utilized by any organization as a template to improve their own collaborative decision-making processes. The pitfall of their work is that whole duty is on the group facilitator. In case of unavailability of the group facilitator, at any time, the decision makers will suffer from not reaching their goals.

Devoker et al. [10] worked on deception diction by providing a basic pattern of think-let with the full support of GDSS. In addition to the pattern that basically does operation of divergent, convergent, organizational, elaboration, abstraction, evaluation and consensus making. It used XML format for representation of think-let and do group activity by its pattern. Furthermore, it utilizes agent based activity and utilizes two basic agent groups' namely as automated agents and human agents. They have developed a system by using both human as well as automated agents named as "mixed initiative" decision support system. In amassing with all the above this system is useful in validating automated deception detection agents, benchmarking them against human performance and training human in learning to detect deception accurately. The strong point of their endeavor is that the process and the structure are used for validating automated agents to detect deception. The weakness of their work is that required enhancement in prototyping efforts and perform an evaluation to validate the design approach.

Almeida et al. [11] applied an Agent Based Scheduling Model (ABSM) for the development of appropriate problem solving strategies, by generating multiple solutions, in order to communicate and to share resources. Furthermore, they have expressed diversified agents having multi-field data, and having different algorithms for the sake of making schedule by utilizing GDSS for making good decision and finding optimal solutions. They also have presented a collaborative architecture of Group Decision Supporting Model (GDSM), which supports a number of scheduling meeting and facilitators. The main potency of their work is that proposed system allows evaluation of scheduling solutions by experts with different points of view incorporating their knowledge into the system.

Sun et al. [12] developed a model for data-warehouse in order to make group decision named as Supporting Enterprise Group Decision Data Warehouse Model (SEGDDWM). In accumulation with this it basically deals with enterprise fields integrating all kinds of primitive data and provides decision fast and efficient query. Moreover, in SEGDDWM, decision-makers get decision information for multi-data warehouse by decision integrating platform. Furthermore, in order to enhance the decision making capability in multi-data warehouse, another model of Object and Snowflake Mixed Model (OSMM) has been introduced that has a capability of high speed of querying. In summarization to these models of SEGDDWM and OSMM it expands the ability of a single data-warehouse, combines the inner and outer data-warehouses of the enterprise, and provides more objective information for decision making. The weak point of their work is that these models need to improve specially for Meta model which enhances the capabilities of data warehouses.

Wei et al. [13] suggested a new agent oriented architecture named as Business Intelligence Group Decision Support System (BI-GDSS). Its architecture is based on BI with that of traditional architecture of GDSS. Moreover, BI basically augments the qualities of GDSS by providing heterogeneous data sources for decision making process, provides gigantic area of knowledge brand by utilizing Extensible Markup Language (XML). Additionally BI also support GDSS by suggesting data analyzing tools with capabilities of OLAP methods such as drill-down, roll-up, slice, dice and pivot. They also have combined a centralized system with a distributed system. At the end to this, a model named as Multi-Agent cooperation mechanics based on blocked model has been developed in order to support

decision agent to take group decisions. The strengths of their effort are as follow:

- Architecture of BI-GDSS, they provided a feasible and effective method to improve decision making capabilities of GDSS.
- In this methodology they utilized advanced data management and analysis technology, such as data warehouse, data mart; data mining to be introduced into decision support field.

III. CRITICAL EVALUATION

Over the papers that are reviewed above, we evaluate and identify the similarities and differences among the writers pertaining to the working environment of GDSS.

Almedia et al. [11] developed an agent based scheduling model which is based on the concepts of scheduling by Almedia et al. [5]. Both models reflect the similar core concept of GDSS for its decision making. Subsequently in contradiction to [11], the authors [5] chose a different set for its scheduling through hypermedia in which multi-agents work for multi-criteria solutions. Furthermore, quite a different approach of [5] is its Adoption model.

Analogous to the approaches in [5, 11], Chen [1] have utilized a GDSS for good decision making. They have nevertheless, [1] utilized some alternative approaches like group break-down structure and its corresponding tree structure. Subsequently, in gainsay fields to [5 and 11] are internet and intranet environment. By applying these efficient and effective structures it can avoid lost information and knowledge during its decision making

As a different approach from [5, 11, 1] Subsorn et al [2] suggested and applied a disparate approach namely fuzzy logic concept on web-based application. The other aspect of contribution by [2] which is distinctive from [5, 11, and 1] is the application of multiple objective linear programming methods in order to generate multi-objective decisions making. Furthermore, they [2] have also applied analytical hierarchy processes as a solution for solving uncertain problems. Agent based GDSS was also used by Subsom et al [2] for decision making.

On the contrary to all the above approaches Wu et al. [3] has applied a frame of product design group decision support system. Conversely to [2], the authors in [3] have built an evaluation problem solving database and evaluation generating database. Alike to all above approaches they also utilized GDSS for group decision making.

Supporting the above arguments, Rigopoulos et al. [4] have utilized GDSS for supporting multi-criteria decision making in a collaborative team system. They contradict to [5, 11, 1, 2 and 3] in the modeling under multi criteria setting which is formulated with respect to the aggregation procedure. Moreover, their methodology contradicts in the variation of the overall criteria methodology focusing on classification decision by the collaborative team. In accumulation to that their approach also opposes in GDSS approach which is basically composed of three layers namely as application layer, data layer and web layer. Subsequently they have utilized a case study upon the topic of identifying classification problems in the bank.

By evaluating Yu et al [6] with that of enormous efforts of different researchers we have analyed that they have unique amplification regarding its sole implementation of multiple-objective genetic algorithm for modeling dynamics in GDSS. Furthermore the divergent approach mainly to above all is its cluster representation for showing MOGA application in dynamics GDSS.

In correspondence to the core application of the idea of [4], Esseghir et al. [7] have been working on the basic scenario of implementation of multi-criteria aggregation for making decision in the field of ELECTRE TRI. Two unique models namely intelligent decision support system and that of knowledge based management system is likely to be the different dimension of [7] which shows their work proficiency.

Song et al. [8] has applied discrepant method of group decision strategy in order to analyze threats and handle crises. Similar to [7] they have illustrated multi-disciplinary problem. Consequently, a mathematical method named as AHP with clustering has utilized alike to that of [7] concept. In variance to all above researchers/ efforts [8] have applied a special mathematical approach named as judgment matrix for crises handling and that of threats management at enterprises.

In corporation to that of [4, 7 and 8] Chambless et al. [9] has recommended a model as multi-criteria decision model for a better support of decision making. It is quite a dissimilar approach from [4, 7 and 8] that they have suggested a new model called model of uncertainty for producing a better decision. Furthermore a new feature is proposed that by the authors about a model of unbiased decision consuming “rate” and “weight”, that differs from other writers’ point of views.

Reasonably Devoker et al. [10] exploited a differing approach in comparison to [7, 8 and 9] especially and all other writers partially by applying a special approach of “mixed initiative” model incorporating both human based and automated agents. Moreover, another feature is the concept of pattern generation for thin-lets in GDSS environment. The core idea that is consistent with all other writers is GDSS for decision making process.

Sun et al. [12] have worked on “data warehousing” with relation to GDSS which is different from the mainstream. Two important models by the authors are SEGDDWM and OSMM. The authors however used agent based system for its decision making too.

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IV. CONCLUSION

In this paper, we have surveyed and presented a reflection over a number of papers regarding different perspectives and dimensions in the realm of GDSS in this fast growing research environment. Various approaches that are undertaken by different researchers are looked into. Consequently, we identified some limitations from the efforts made by a number of authors. Additionally we highlighted their strengths as a whole that supports the design of GDSS for good decision making. The contribution of our paper is the literature review of numerous papers and provided a substantial amount of information which would be a useful reference for researchers who are interested in this field. Furthermore this depicts a critical evaluation in which comparison and contrast have been made to show the similarities and differences among different concepts by the authors. At the end we show a tabular chat of these papers in which various methods, tools and techniques are shown. Also, the specialties of their efforts and distinctive fields in which they have worked have been mentioned. This paper is supposed to provide researchers with a good understanding about GDSS. From the review of the existing researches on GDSS, it is looked forward that some innovative GDSS models would be proposed in the future.

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Authors	Main Area of Research	Architecture or Model Developed	Specialty of Papers	Method and Techniques Applied
Chen et al. [1]	In internet or intranet for making decision on complex large GDSS.	A model of large group complex decision support system.	Decomposing the decision problems by using the work breakdown structure for finding solutions.	It utilized the linear tree -like hierarchical structure of decision making.
Subsorn et al. [2]	Work on a Web-based application in a fuzzy logical environment.	A model of web-based group decision system framework.	Development of GDM and delivery platform facilitates group members to develop satisfactory solution.	Fuzzy AHP and fuzzy multiple objective linear programming are utilized
Wu et al. [3]	Work on product design evaluations by GDSS.	Frame of Product Design Evaluation Group Decision Support System (PDEGDSS).	Build Evaluation Problems Generating Database (EPGD) and Evaluation Problems Solving Database (EPSD) which are fit for product design.	Linear Assignment method (LAM),Elimination of Choice Translating Reality(ELECTRE), Analytic Hierarchy Process(AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Data Envelopment Analysis (DEA) etc.
Rigopoulos et al. [4]	GDSS for collaborative teams in enterprises.	Aggregation model, Model of multi-criteria analysis and a case study on analysis of bank problem.	Multi criteria decision making within a group setting.	For the aggregation of values they utilized the Social Judgment Scheme (SJS), Various cutting levels of the multi criteria methodology (ELECTRE TRI) were also defined.
Almeida et al. [5]	Collaborative Scheduling through Adaptive Hypermedia and Group Decision Support.	Scheduling Model (SM) architecture, GDSM architecture and Adaptation Model.	Scheduling agents will integrate different kinds of knowledge in a global view and potential synergy with the collaborative activity will work for multiple criteria.	Multiple problem-solving methods called agents. Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS).
Yu et al. [6]	Multi objective genetic algorithm in GDSS.	Architecture of Modeling GDSS process with MOGA.	MOGA are proficient for determining dynamics in group decision support system and designing the proper human-machine interface in GDSS.	Evolutionary Algorithm has been developed in order to get better decision solutions.
Esseghir et al. [7]	Evaluation of scientific research structures through GDSS.	A model based on an Intelligent Decision Support System (IDSS).	They have introduced IDSS for good decision making which enhance proficiency of system also multi criteria outranking procedure ELECTRE-TRI.	Introduced Aggregation procedure and Multi criteria Decision Aid etc for better decision process.
Song et al. [8]	Threat analysis for enterprises with the help of GDSS.	Clustering hierarchical diagram and a mathematical method by utilizing judgment matrix.	Taken Cheese organization in order to illustrate crises of multi-disciplinary problem by applying GDSS.	Some techniques for calculating judgment matrix, mathematical formulas for getting solutions to avoid crises happening.
Chambless et al. [9]	Aerospace Corporation along with the group collaboration and good decision making	Multi-criteria decision models (MCDM) and models of uncertainty (or risk) and a “rate” and “weight" decision Model.	GDSS recommendation for The Aerospace Corporation that allows users to generate ideas electronically, make quantitative judgment.	Group collaboration techniques
Devoker et al. [10]	Deception detection based on collaborative process by GDSS	Architecture of GDSS Based Framework for Deception Detection.	The system validates automated deception detection agents, benchmarking them against human performance, and training humans for DSM.	It use XML format for representation of think let.
Almedia et al. [11]	Collaborative scheduling with the help of GDSS.	Agent based Scheduling Module, GDSM architecture and Model of decision support collaborative Framework for scheduling.	Multiple agents worked in order to get multi criteria solution.	multiple problem-solving methods (agents), Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)
Sun et al.[12]	Multi-data warehouse utilizing GDSS for its better decision making.	Supporting Enterprise Group Decision Data Warehouse Model (SEGDDWM) and Object and Snowflake Mixed Model (OSMM).	The proposed model united cooperative decision supporting platform for decision services.	A process of assembling dimension for data warehouse has been carried out.
Wei et al.[13]	Business Intelligence along with GDSS.	An Agent Oriented Architecture Called as Business Intelligence Based Group Decision System BI-GDSS.	It always Gathered Information from Warehouse, Data mining and OLAP.	Block Based Agent Cooperation’s.