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A Review: DSS systems history and applications

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Abstract—Several information systems have been introduced from ages in providing a solution to a specific problem by obtaining an alternative among set of alternatives. DSS is replaced over MIS because they provide effective decisions as compared to MIS [1]. Various DSS have been proposed in variety of areas like education, diagnosis of diseases and corporate planning. From MIS to expert systems till now, various systems have been bringing in such as GDSS [29,24], Web DSS, intelligent systems etc. DSS evaluates crisp values as an input and produces an output corresponds to it which means that a value either belongs to a set or not i.e. true or false. Whereas in some cases there can be a value except given set due to which it is not applicable in every scenario[8]. Therefore different decision support systems have been described along with their demerits in this paper. So that one can evaluate and proposed an effective DSS which would perform effectively and efficiently.

Keywords— Decision making, DSS, GDSS, Fuzzy logics, FDSS

1. Introduction

Decisions are basic block building whereas an effective decision fixes on the growth and breakdown in a particular area. Decision support system integrates computer system for making interactive and adaptable decisions. This property of DSS helps to resolve problems by providing efficient solutions. Decision making can be done by an individual or within a group depends on the structure of the problem [1]. DSS roots come from information systems that have been used for formulation of different things in a business from years. Basically DSS works through knowledge that has come across understanding the raw data and formulates it into a meaningful data for further reference. There are numerous applications which are strategic in nature owing to implement DSS and use external data for processing [1].

Initially it has started with formulation or understanding of a problem, uncovers alternatives, models it, makes a good choice from alternative analysis and then implements it. This process involves in the basic Decision Support Systems and it is simplest version of making decision from a problem [5].

Whereas decision making includes intelligence, design, choice and review respectively. Decisions are basically categorized in three parts namely structured, semi structured and unstructured. Among these decisions, DSS supported semi-structured and unstructured decisions [5]. Mainly, Decision support system helps to make decisions by using logical values where a set defined either belongs to one or another.

Motivation behind using DSS is effectiveness of making decisions and the efficiency of the decision process increased [3]. Since 80's it has been contributed in different research areas like organization, for tracking of a particular disease or to get the knowledge about the product sales.

2. Role of DSS

DSS lean on four types of tools available such as Data warehouse; OLAP, Data Mining and web based DSS [5] and make them strong enough to be used in different areas. Originally it was started with database and then gradually comes on analytical processing through OLAP tool forwarded by data mining and last of all World Wide Web. As a result, this process causes an effective decision support system. DSS is not just a machine or a system; it is an intelligent system which calculates data or huge amount of data to find the alternatives from them and then among these alternatives effective decisions can be make out [11].

Due to its advantages provided in real world situations, Decision support system becoming part of every organizations or institutions. Some of the roles defined under DSS are pointed out here:-

- **Enlarge efficiency of the decision process**

DSS incorporates computer vision that proceeds through enormous data stored in the database. Thus due to the large volume for a human it is not able to process and understand the problem so DSS is helpful in understanding the data, process it and then obtain decision effectively [7,27]. As decision attained by this system is effective thus efficiency of the decision process will also be enhanced.

- **Improved quality of decisions**

Preceding efficiency of decisions are improved so as a result quality of the decisions are also improved which leads benefit to the organization. DSS supports high analytics which is the reason of acquiring quality oriented decisions.

- **Variations in decisions**

Decision tasks such as production decisions, cash management, investment decisions and plant expansion decisions have been taken through DSS proficiently. Thus it can be said that DSS provides variety of decisions according to the environment involved.

- **Enhanced ability of Manager**

DSS not only provides quality oriented decisions but also enhancing skills of the manager who implements decision making process by applying lower cost, timely and accurate decisions.

- **Architectural Design of DSS**

DECISION SUPPORT SYSTEM

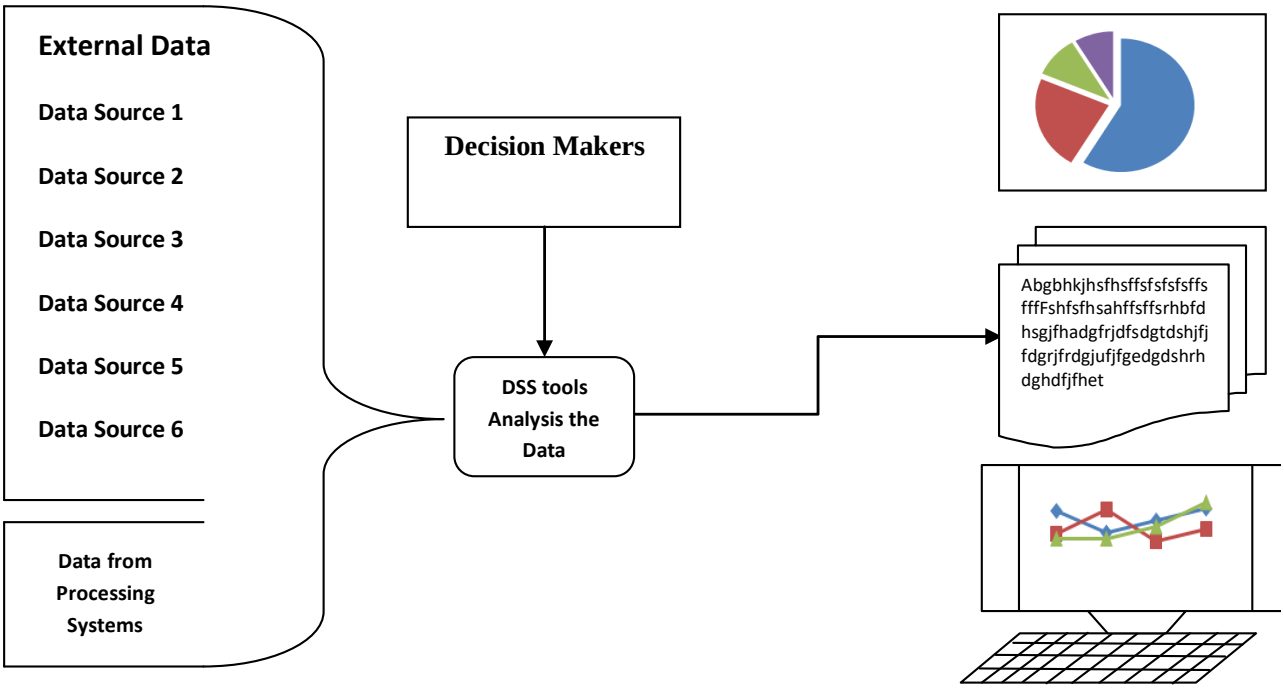

Figure1 : A DSS system representing the working scenario of the system with Datasources

- **Comprehended decisions**

Comprehensive decisions are afforded by the DSS based on huge volume of data in real time mode. Based on the crisp data values it is able to get complete information or inclusive results [20]. With the argument crisp data values means a fixed set of numbers either 0 or 1 for an instance.

Eventually, DSS supports graphics in a large amount. Above section described some of the effects performed on the data and obtained decisions.

Architectural behavior of DSS shows three layers i.e. data layer, business logic layer and view layer [30].

Data Layer: where data is captured and stored. Data is kept from different resources and follows to the Decision maker. Data can be of internal type that can be accessed from processing systems and external type that accessed from external resources.

Business logic layer: After capturing of data, collectively sends to the DSS tools analysis module shown above from where decision makers will be able to formulate rules and provides efficient decisions to the user. Decision makers use DSS tools so that obtained DSS must be effective and efficient.

View Layer (display processing results**):** And lastly processed data or decisions sends to the user in the form of pie charts, reports and graphs.

Applications Of DSS

3. Structural design of DSS

DSS provides broadness in terms of decision making and capable of generating flexible reports. Below this section structural design of DSS represents procedure of manipulation from initial to output generation in three layers. Essential part of DSS is the DSS tools which is helpful to the decision makers and due to which they are capable of analysis of data appropriately.

Beginning of 1980, Decision support system has been used in several areas especially in real world situations. As decision making is performed on the constraints, goals and consequences of possible actions which might be not precise initially [8].

By reason of that one's need a system that would be able to process incomplete information which can be done by Decision support system mentioned under. From the set of alternative crisp set, a decision has been taken and evaluated.

- **Incorporated with Banks**

Decision support systems are being incorporated with the banks which are laid on the decision models. In this process or models, human is allowed to retrieve the information from the database and precede it for a specific model. DSS for banks integrated into a subsystem which means combination of several models where input of one model proceeds to another model [1].

DSS for Banks works on decision models which allow managers to direct the system's activities without putting between intermediate staff. Resultant model will help reduction in cost and staff management. Formulation of a model in charged by the human not decision support system in this DSS.

- **Corporate Planning**

In the corporate most of the decisions are taken by the manager. With the advancement of DSS in corporate planning, it helps to identify, replicate existing decision process along with the alternative process specified by the manager. DSS is being used in corporate planning critically as decision taken by the manager plays a crucial role in the success and failure of that organization [1].

Corporate is based on the competition with the competitors and for the organization it is vital to take individual decision strategically so to put down their competitors. These reasons help to establish DSS for corporate planning with some pros defined here:

- DSS for corporate planning is helpful in decreasing total time which is used for generation of plans.
- It also provides deduction in time taken for manipulation of data along with high accuracy in the data.
- Another feature of DSS for corporate planning is that it defined better forecasting logic as well as internally consistent forecasts.
- As DSS analysis high amount of data due to which time can be increased for more diligent and elaborate analysis.

- **Verdict of diseases**

In the field of Medical, huge amount of data is generated which is equally important for the physician to diagnosis patient's health and finds out the disease struggled by them. But for an individual or physician it is difficult to attain a successful result from a large amount of data due to which DSS has been proposed for verdict or diagnosis for diseases observes in the patient [13, 14, 22].

Several DSS has been used for analyses of a disease in the patient so that a required decision can be taken as soon as possible. Benefits of using given DSS are:

- Patient's health can be recovered at earlier stage if right decision has been taken at the time of findings.
- In this decision model, input variables are taken which are the symptoms shows in the patient and then further decision has been taken by the physician.
- This system also helps in keep track of patient's health and maintains record of an individual patient.

Except Preceding applications of DSS, there are numerous other applications that have been used for various purposes such as: supply chain management, traffic control management, forecasting, and financial planning for small business etc. on the whole DSS is an advantage to the problems of real world situations for finding a solution.

4. TAXONOMIES OF DSS

DSS applications are emerging in most of the areas discussed earlier on which it can be categorized into different parts. In most of the applications it manipulates qualitative models, access large amount of data and then provides resultant data to the group or individual for making decisions. Based on the group or a signal person DSS can also be discriminates.

- **Model Driven DSS**

Model driven DSS works on limited data and parameters for making decisions. Comparatively, it did not use large databases to make decisions. Model driven decisions access data, manipulates financial data and obtained models as an output. Thus it provides optimization to small amount of data which is useful to small business. Some of examples which are using Model Driven system are sprinter, MEDIAC and Brandaid [11]. Initially the name given to Model driven system was model oriented DSS by alter in 1980, computationally oriented DSS, Spreadsheet oriented DSS and solver oriented DSS by Bonczek et al in 1981, holsapple in 1996 and whinston in 1996 respectively. This type of system has been used in several areas and also encouraging but on the other hand it not uniformly positive.

- **Data Driven DSS**

Data driven DSS works on time series of internal company data frequently but sometimes external and real time data can also be used for accessing and manipulation. Data Driven DSS provides highest level of functionality when it is used with OLAP. Executive Information systems are type of Data Driven DSS that have been used.

Originally data oriented name was given to Data Driven DSS then further analysis information system by alter in 1980 and lastly retrieval only DSS by Bonczek et al in 1981 respectively [11]. Data Driven DSS can work with large volume of data stored in the database to acquire decisions in the favor of the company. As described earlier, real time data can access through this type of Decision support system thus it can be concluded that system can work for large businesses.

- **Communications-Driven DSSs**

Communication Driven decision support system have been developed to make decision collectively or in a group. Network and communication technology comes under these types of systems. To make decision in a group it must required tools i.e. groupware, video conferencing and computer based bulletin boards. Correspondingly Group Decision Support System in 1980's has been introduced to solve problems through planning and modeling tools. Further it has been replaced with collaborative DSS in 1988 [11] which is interactive computer based system provides decisions when a group works as a team and acquires efficient results. Principally, Collaborative decision support system is used to solve ill-structured problems in a team.

Communication decision support system proven its ability only if it is provided with primary tools mentioned before.

- **Document Driven DSSs**

Document driven DSS has been used for storage and to process technologies so that document can be retrieved as well as analysis on that document can be performed. Databases especially large one consists of various documents like scanned

documents, hypertext documents, images, sounds and videos. Thus it can be used for project specifications. Search engine can be taken as an example in case of decision support system which is described as decision aiding tool. Document driven DSS also be known as text oriented DSS come into view in 1970s and 1980s [11].

Basic function of using this decision support system is for management planning and control. Due to the complexity included in these systems later on in 1995 World Wide Web technology gets recognized by the number of softwares for implementation of all types of DSS.

- **Knowledge Driven DSS**

Knowledge driven DSS referred as expert systems or intelligent systems as they suggest and recommend actions to managers. These systems emerging nowadays because of their specialty and experience in problem solving. Another term used for this system is Suggestion DSS by Alter in 1980 which acquire knowledge of a particular domain, understands that domain and skills at solving given problems by giving solutions to them [11].

Knowledge is driven through using tools based on PC to develop expert systems. It has several applications due to their proficiency such as to detect fraud, for scheduling in manufacturing and expedite financial transactions. Relational databases are combined with web based front ends through expert systems to enlarge the deployment and use of knowledge driven DSS.

5. background

Decision making is a central for any organizations growth and effective decision making plays decisive part. Thus decision making has been performed since years for the improvement in any particular area. Consequently this section explains history of DSS from early 80's to the present years. In the middle and last 80's MIS systems has been used for storage, updating and retrieval of information and then performs decisions on the basis of retrieved information [1]. Seeing that MIS performs operations on the fixed or predetermined report but in the real world this is not the scenario always. Due to the exploratory nature of the data, DSS has been introduced. MIS performs on low level of data and used for small businesses whereas DSS is a powerful tool for vast organizations.

Robert H. Bonczek et al [1] presented the idea of using DSS over MIS in 1980 to symbolize the capacity of computer based systems. Thus in this paper Robert enhances on the flexibility of the reports as decisions sometimes may be unstructured in nature. Accordingly, DSS can support all these features and performed in a better way.

Moreover, Ali Safari and Asefeh Asemi (2011) [20] has discussed MIS and DSS systems that show the characteristics, relations between them. Where it shows that due to the dynamic nature of the data MIS is not able to implement for some organizations.

Table 1: represents comparative analysis between MIS and DSS and results why MIS has been replaced by DSS.

Dimensions	MIS	DSS
Focused Area	MIS focuses on the gathering of information from different sources and performs in online mode.	DSS focus on the leadership as it has been used for making decisions on the gathered information and works in real time mode.
Efficiency	MIS relay on operational efficiency.	Whereas DSS lies on making effective decisions for the improvement in status of the organization.
Flow of information	Information comes from up and down i.e. from both sides.	Alternatively, upward is the only source of information for DSS.
Flexibility	Report generated from MIS is not flexible in nature.	Acquired reports are flexible in nature.
System Approach	MIS is all about the theory, no practical implementation is available.	DSS is all about practical implementation i.e. decision analysis; decision making is done through these systems.

From the above table it clearly shows that why MIS has been replaced by the DSS. MIS can satisfy different level of management and implies on fully structured decisions.

Furthermore, advancements have been done by various researchers in the field of DSS such as Group decision support systems has also been introduced in the middle of 80's. **Kraemer and King (1988) [11]** initiated **collaborative decision support system** which is a computer based system provides solution to the ill structured problems in a team or in a group.

Group decision support system provides DSS a wide area to communicate with a group or make decision in a team.

Paul Gray (1987) [29] proposes group decision support system over the conventional decision support system that helps to senior management and professional to make decisions in a better and effective way. Regardless of its merits it has been replaced due to several drawbacks such as it is not fit for every type of decisions, conflicts can occur between the same levels of employees and size of a group may not fit for GDSS in certain situations.

Below this section block diagram shows the flow of data and GDSS generator will help to make decision by taking data from the database, model base and groupware and provides output to the user.

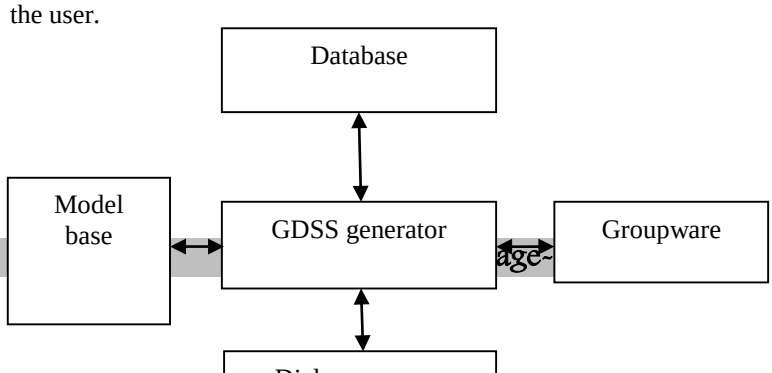

Figure2:-Group Decision Support System

Therefore, as the technology grows, DSS systems also starting adapting internet and web based systems for making decisions. Consequently, in the 21st century web based DSS are introduced in which www component has been proposed.

O.W. Samuel et al [16] follow this DSS and proposed web based decision support system for the diagnosis of typhoid fever along with fuzzy logic in **2013**. This system can be run on the internet due to which it able the physician to diagnose TF despite the consequences (location). And also provides treatment as soon as the disease acquired. Similarly fuzzy logic has been introduced in the late 80's.

All types of DSS that have discussed before can become web based DSS only after applying web services or web technologies. Web services like AJAX helps to promote client side interaction and communicate with the server.

Below representation shows how web based DSS works and provides output to the user. Initially it takes input from the communicator or mobile devices through World Wide Web and then proceeds to the simulator and analyzer where problem will be judged and through analytical processing data is fetched from the warehouse and lastly supply generated output to the sender all the way back.

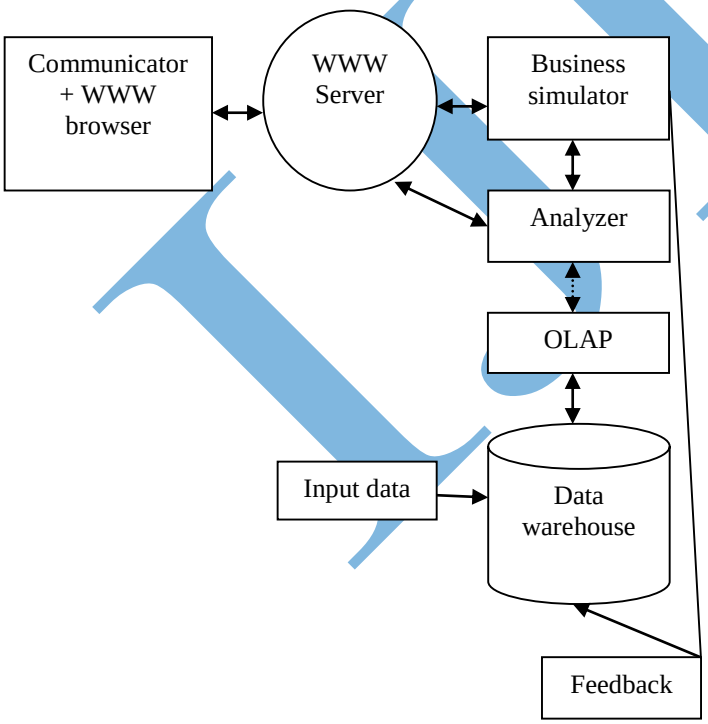

Figure 3: Web based DSS

6. Fuzzy Decision support system

Originally fuzzy control was explored by Mamdani and follows by Zadeh [2]. In the fuzzy logic, initially fuzzy variables have been defined from which fuzzy control rule has been obtained. Acquired fuzzy control rule implies in several areas to obtain relevant output. Fuzzy logic has been used to solve the problem of taking decision for many years because of its simplicity in language and understanding behind logic. It is a technique known as problem solving methodology helps in making decision efficiently. Fuzzy logic operates within two parts i.e. fuzzy sets and membership between the elements of the fuzzy sets. Fuzzy set is a set contains elements within a boundary without crisp values. Elements which are surrounded by the set may either have partial degree of membership means either element belongs to a set or not. Membership function defines mapping of a membership value between 0 and 1 in the given input space. Universe of discourse is another term used for input space. By using fuzzy control rule one can define a system called fuzzy system which can be used further for fuzzy decision support system. Basic fuzzy systems contain four processes or modules such as fuzzification, interference engine, knowledge base and defuzzification [12].

Below represents a simple fuzzy logic based system where initially system has started by taking crisp values as an input where fuzzification module converts crisp values into fuzzy sets. These crisp values evaluated into fuzzy variables with varying grade of membership. Obtained output from module then followed to interference engine where necessary control actions are evaluated and combined number of fuzzy sets in a single fuzzy set. Then resultant set send to the defuzzification module where fuzzy outputs are again converted into crisp sets for suitable actions. Knowledge base module contains information regarding data base and fuzzy control rule base. It also has information which is required to produce control rules.

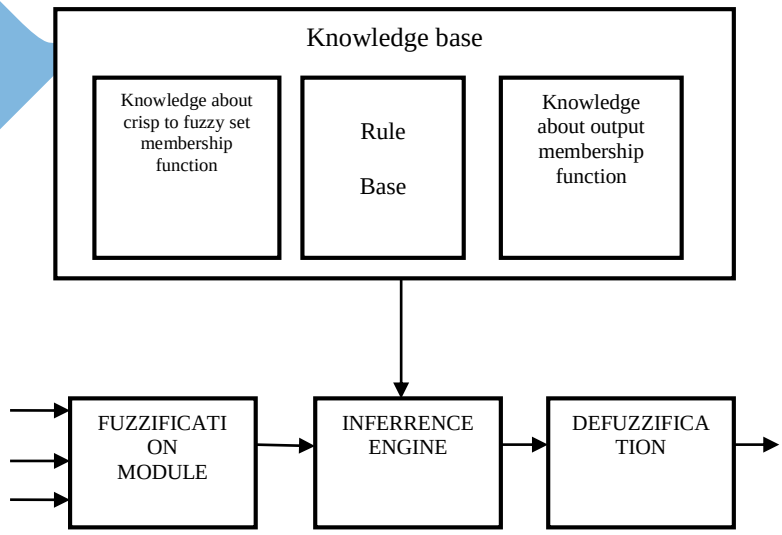

Figure 4: Fuzzy logic based system [12]

Fuzzy logic has been successfully applied in several areas such as education by Lalla and Facchinetti in 1999, accounting by comunale and sexton in 2005, engineering by Pundaleek, rathi and kumar in 2010 and medicine by Labrunda in 2008. The whole explanation is about the fuzzy logic which is the base of fuzzy decision support system. Bellman, R. E. and L. A. Zadeh (1970) [28] projected first decision model in which goals and constraints behaved as if fuzzy sets. From that year fuzzy

decision support system has started using in various applications to provide solution.

Fuzzy decision support systems (FDSS) works as human mind thinks. Due to its proximity, it's helpful in taking decisions in uncertain situations. It takes input variables and produces output variable corresponding with the help of membership functions, and fuzzy rule base. FDSS defines no sharp boundary due to which there can be possibility of a condition called gray between black and white. Classical DSS do not able to find alternative for black and white i.e. color of an object is either be black or white other than this color is not considered as the member of the class color which is wrong at some extent [28].

Table 2. Shown below describes related work which have done till now using fuzzy decision support system.

Source	Proposed work
Ahmed Abou Elfetouh Saleh et al. (2011)	**Origin:-** Breast cancer is the most common cause of death in women i.e. 18.9% approximately. This issue precedes author to give solution for the serious issue. **Method involved:-** Mamdani Inference for the application of fuzzy logics on the acquired database. **Motivation:-** This paper proposes a method to identify the risk of breast cancer and provided to the doctors for the treatment of the cancer. **Virtues:-** Uncertainty for diagnosis risk status of breast cancer can be handled.
Chang-Shing Lee et al. (2011)	**Origin:-** Healthcare sector produces huge amount of data and makes it difficult for making effective decision. Thus to extract useful information and to diagnose medical conditions such as heart and diabetes disease FDSS has been proposed. **Method involved:-** Web Ontology Language (OWL) has been used for representation of fuzzy diabetes ontology with fuzzy variables and numbers. **Motivation:-** Diagnosis of disease in medical area provides strength to the ability of the physician where an effective decision can be made. Author proposes a five layer fuzzy ontology that includes fuzzy knowledge layer, fuzzy group relation layer, fuzzy domain layer, fuzzy personal relation layer and fuzzy domain layer for making an efficient decision in diabetes disease. **Virtues:-** Provides ability for diagnose of several diseases with fuzzy ontology.
Sabina Nobari et al. (2012)	**Origin:-** Lack of right choice in selecting people for an organization will drop its graph from up to down. Thus for selecting right and deserved people for the particular designation it's important to make right decision. **Method involved:-** TOPSYS method collaborated with fuzzy involved in the paper to make effective decision on the base of weighting criterions. **Motivation:-** With the ability of making right choices of people for an organization can high the performance and the position in a market. Thus author proposes a method using fuzzy decision support system for evaluation of parameters in order to hire a person. **Virtues:-** For the measurement of qualitative traits of a person proposed techniques can be evaluate in human resource management.
Christian J. Schuh et al. (2013)	**Origin:-** Modern health care is a vast area to be concerned as it goes on changing as well as expanding. Thus there is a requirement of discovery of hidden patterns which can be performed by managing uncertainty of medical decision making. **Method involved:-** Clinical decision support system with fuzzy and fuzzy control has been used in this paper for evaluation of diseases and their treatment method. **Motivation:-** CDSS have no potential which can assist the physician to perform their daily routine work. It means that physician needs to be concerned about the CDSS for an effective use. Thus to avoid analyses and recommendation acquires from CDSS, CFDSS is proposed so that physician can focus on the factual parameters rather than all generated data. **Virtues:-**

	Proposed system helpful in making clinical advice for patient care using knowledge base. Additionally, imprecision, uncertainty can be achieved through available number of items of patient data.
Ather Ashraf et al. (2014)	**Origin:-** Natural phenomena are mostly fuzzy in nature due to which traditional method do not provide a degree of vagueness and uncertainty. Crisp values are not able to measure environmental criterion. Thus author proposes a new method for fertilizer. **Method involved:-** Type-II fuzzy sets for decision making in process of fertilizer. **Motivation:-** This method has been proposed to identify the behavior of the spatial entities. Moreover, linguistic classes of nutrients in soil provide high degree of uncertainty which can be handled by the method proposed. **Virtues:-** Requirement of fertilizers for any crop in terms of spatial patterns can be identified through proposed work.
T. Sheehan et al. (2016)	**Origin:-** Environmental conservation cannot perform with the limited boundaries value due to which a proposed work has been introduced. **Method involved:-** Environmental Evaluation Modeling System (EEMS) has been used for resource planning and for environmental and ecological studies. **Motivation:-** For the evaluation of large and complex models EEMS has been initiated. As it is platform independent fuzzy logic modeling framework it can be used for environmental decision making in different file types and with other software systems also. **Virtues:-** Proposed system can be easily adopted by different software and hardware environments. Furthermore different file types can use this system for spatial analyses.

7. Conclusion

This study of DSS highlights number of decision support systems applicable in different areas with number of demerits that allows for proposing a system that can generate decision depending upon real world situations. As in real life scenario there are no boundaries that contains only specific set of values by reason of that a system is required that should be simple enough in terms of language as well as mathematical calculations.

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