Multi-agent based decision Support System using Data Mining and Case Based Reasoning

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Abstract

A knowledge-based society determines organizations to focus their activities on improving management quality by using knowledge. Huge data stores become important once the real significance of data is discovered. Data mining techniques are involved in different knowledge processes, as one can notice in various public applications of the researchers. Managers can use these techniques in order to extract patterns, relations, associations from data initially considered of little value. Over the past decade, case-based reasoning (CBR) has emerged as a major research area within the artificial intelligence research field due to both its widespread usage by humans and its appeal as a methodology for building intelligent systems. More recently, there has been a search for new paradigms and directions for increasing the utility of CBR systems for decision support. This paper focuses on the synergism between the research areas of Data Mining, CBR System, Multi-agent System and decision support systems (DSSs). A conceptual framework for DSSs based on MAS using DM and CBRS is presented. Nowadays, intelligent agents represent an important opportunity to optimize knowledge management. The research implications of the evolution in the design of DSS based on MAS using DM and CBR systems from automation toward decision-aiding is also explored.

KEYWORDS**:** *Multi-agent system, Data Mining, Case Based Reasoning, Decision Support System, Supply Chain Management*

1. Introduction

In this paper it is proposed build a model integrating Decision support system , Data mining , Case Based Reasoning system and Multi-agent System . An approach has been made to develop a decision support system which will take decision under complex environment. The probability of uncertainty guides the respective system to define the direction automatically to take the decision.

Designing an effective decision-support system has become crucial in recent years. Systems have to be able to deal with the uncertainty and volatility of modern markets. In such systems, the ability to learn and adapt to new conditions in the environment is of paramount importance. Data mining is the process of extraction of hidden predictive information from large databases; it is a powerful technology with great potential to help organizations focus on the most important information in their data warehouses. The automated, prospective analyses offered by data mining move beyond the analyses of past events provided by retrospective tools typical of decision support systems. Data mining is one of the tasks in the process of knowledge discovery from the data. The data stored in the database is used to discover the patterns of data, which then interpreted by applying the domain knowledge. The data mining applications can be generic or domain specific. The generic application is required to be an intelligent system that by its own can takes certain decisions like: selection of data, selection of data mining method, presentation and interpretation of the result.

Over the past decade, case-based reasoning (CBR) has emerged as a major research area within the artificial intelligence research field due to both its widespread usage by humans and its appeal as a methodology for building intelligent systems. Conventional CBR systems have been largely designed as automated problem-solvers for producing a solution to a given problem by adapting the solution to a similar previously solved problem. Such systems have had limited success in real-world applications. More recently, there has been a search for new paradigms and directions for increasing the utility of CBR systems for decision support. This paper focuses on the synergism between the researches areas of CBR and

decision support systems (DSSs). A conceptual framework for DSS is presented and used to develop taxonomy of three different types of CBR systems: 1) conventional, 2) decision-aiding, and 3) simulative. The major characteristics of each type of CBR system are explained with a particular focus on decision-aiding and simulative CBR systems. The research implications of the evolution in the design of CBR systems from automation toward decision-aiding and stimulation are also explored.

In recent years, intelligent agent concepts have been applied in decision support systems (DSS) for business users .Agent technology is increasingly being used to support executive decision-making in DSS environment. DSS are computer programs that aid users in a problem solving or decision-making environment. These systems employ data models, algorithms, knowledge bases, user interfaces, and control mechanisms to support a specific decision problem. Various researches have shown the uses of DSS in order to handle complex decision modeling and management process. We propose a multi-agent architecture in DSS especially for distributed environment. In this paper, multi-agent technology is proposed in developing DSS to enhance the system to be able to work in any complex environments and support the adaptability of the system. Agent is defined as a software abstraction and logical model. The idea is that agents are not strictly invoked for a task, but activate themselves. Related and derived concepts include intelligent agents where they have the ability to adapt on the new situation with some aspect of learning and reasoning. Another derived concept is multi-agent systems that involve distributed agents that do not have the capabilities to achieve an objective alone and thus must communicate. In the environment of distributed system, agents play a major role in assisting a real user in making decisions where these agents are given the authority to communicate to each other in order to achieve the objective. Supply Chain Management (SCM) involves a number of activities from negotiating with suppliers to competing for customer orders and scheduling the manufacturing process and delivery of goods. The activities are different in their nature: they work with various data, have different tasks and constraints. At the same time, they are interrelated to ensure the achievement of the ultimate goal of maximizing the enterprise's profit. This makes the chain very difficult to manage; being successful in one of its areas does not necessarily guarantee the improvement of the overall performance. Designing an effective decision-support system for SCM has become crucial in recent years. With the advent of e-Commerce and in a global economy, SCM systems have to be able to deal with the uncertainty and volatility of modern markets. In such systems, the ability to learn and adapt to new conditions in the environment is of paramount importance.

2. Decision Support System (DSS)

DSS technology has been rising and flourishing since 1970s. Classic DSS is comprised of components for sophisticated database management ability, powerful modeling functions, and simple user interface that enable interactive queries, reporting, and graphing functions, the design of DSS involves helping decision-makers face with semi-structured and unstructured problems. DSS has grown over the periods and today a DSS includes data warehousing, On Line Analytical Processing (OLAP), data mining, Web-based DSS, collaborative support systems, and optimization-based DSS. A Web-based DSS refers to a computerized system that delivers decision support information through a web browser to someone who needs it. When a user sends requests on a website, this system passes the requests to a database server which generates the query result set and sends it back for viewing. A Web-based DSS serves incessantly with data warehouses and OLAP, but web database architecture should be able to handle a large number of concurrent requests when the number of users increases. This may help facilitate collaboration between the supply chain members, so Web-based DSS is chosen as the DSS architecture in this study. Generally there are five types of Web-based DSS: data-driven, model-driven, communication-driven, knowledge-driven, and document-driven DSS. Data-driven DSS help managers organize, retrieve, and analyze large volumes of relevant data using database queries and OLAP techniques. Model-driven DSS use formal representations of decision models and provide analytical support using the tools of decision analysis, optimization, stochastic modeling, simulation, statistics, and logic modeling.

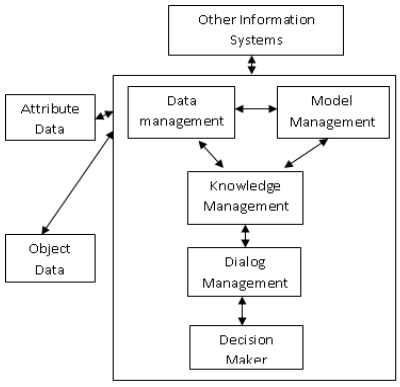

Fig 1 Decision Support System Model

- A Model Driven DSS uses various models such as statistical model, simulation model or financial model for decision makings. So, decisions are based on models.
- A Data Driven DSS emphasizes access to and

manipulation of a time-series of internal company data and sometimes external data to aid decision makings. So, decisions are based on analyzed data.

3. Data Mining

The information systems management sets the attention to the importance of data and on activities of selection that are finalized to the individualization of those data. Currently, even rather simple business monitoring system can bring a huge quantity of data to the attention of enterprise managers among which not all is of critical importance, even though the monitoring systems tend to underline the more useful data. Therefore, there is a need to develop a synthesis process that underlines the critical information that can aid business decision making. To this end, it is useful to build:
- A data warehouse - a data store that contains information which is extracted by other
Systems used by the firm and make it accessible to business customers
- Various data mart - a specialized data warehouse which is used by the department or a
Group of business customers for special requirements
The information, apart of being easily accessible it also has to be useful. In between data
Acquisition and data use, there is an interval process, which allows error correction, essential data extraction, as well as extraction of permanent data from provisional one. The monitoring process of internal and external activities of an enterprise has as a result the development of enormous information database. The information extraction is a rather complex activity and at the same time of great interest. The way to solve the problem stated above is to follow Data Mining (DM) activities, or rather "the efficient discovery of valuable, non-obvious information from a large collection of data[2]." This brief definition expresses accurately the DM meaning, which emphasizes two terms: 'discovery' and 'efficient.' In the above definition, discovery states that the DM procedures focus on the automated detection of facts and relationships existing among data. The main idea that underlies this concept is that the large quantity of raw data presented by the enterprise is analyzed by the DM algorithm in order to extract valid information... DM is implemented through six different activities[3], all based on the extraction of meaningful information:
- Classification
- Estimation
- forecasting
- grouping for affinity or associative rules
- clustering
- Description and visualization

The process of DM is articulated through three principal phases. The first one consists of the preparation of the data, or rather the selection, the purification and the pre-elaboration under an expert's guidance. The second phase consists of further data elaboration, data compression and transformation, to extraction of valid information easier, even though it is not directly noticeable. The third phase consists of the analysis, which is in the evaluation of the DM output, with the purpose to verify the knowledge domain and determine the importance of the facts produced with the use of the DM algorithms. The DM procedures can be implemented through different techniques and formalities. Among all, the most appropriately elaborated in resolving business problems are: Neuronal Nets, techniques of Case-Based Reasoning (CBR), Intelligent Agents (IA).

4. Case-Based Reasoning (CBR)

Over the last few years an alternative reasoning paradigm and computational problem solving method has increasingly attracted more and more attention. Case-based reasoning (CBR) solves new problems by adapting previously successful solutions to similar problems. CBR is attracting attention because it seems to directly address the problems outlined above. Namely:

- CBR does not require an explicit domain model and so elicitation becomes a t ask of gathering case histories,
- implementation is reduced to identifying significant features that describe a case, an easier task than creating an explicit model,
- by applying database techniques largely volumes of information can be managed, and
- CBR systems can learn by acquiring new knowledge as cases thus making maintenance easier.

The CBR Cycle

The processes involved in CBR can be represented by a schematic cycle (see Figure 2). C BR is typically as a cyclical process comprising *the four REs*:

- RETRIEVE the most similar case(s);
- REUSE the case(s) to attempt to solve the problem;
- REVISE the proposed solution if necessary, and
- RETAIN the new solution as a part of a new case.

A new problem is matched against cases in the case base and one or more similar cases are *retrieved*. A solution suggested by the matching cases is then *reused* and tested for success. Unless the retrieved case is a close match the solution will probably have to be *revised* producing a new case that can be *retained*.

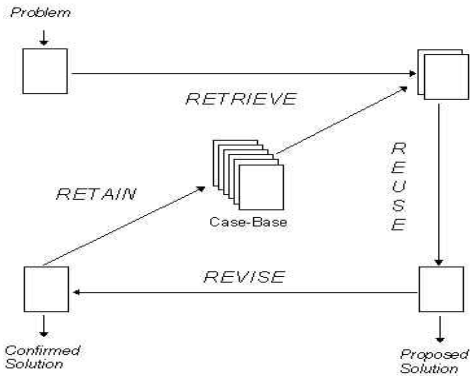

Figure 2 The CBR Cycle

This cycle currently rarely occurs without human intervention. For example many CBR tools act primarily as case retrieval and reuse systems. Case revision (i.e., adaptation) often being undertaken by managers of the case base. However, it should not be viewed as weakness of CBR that it encourages human collaboration in decision support. The following sections will outline how each process in the cycle can be handled.

5. Multi-Agent systems

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuator.

Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment, and by doing so realize a set of goals or tasks for which they are designed

Intelligent agents are software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in so doing, employ some knowledge or representation of the user's goals or desires.

Agents are social bile in the sense that they interact with other agents (and possibly humans) via some kind of agent-communication language;

Agents are reactivity that is; agents perceive their environment and respond in a timely fashion to changes that occur in it;

Agents are pro-active in a way that agents do not simply act in response to their environment; they are able to exhibit goal-directed behavior by taking the initiative.

Agents have the capability of Learning in a sense that an agent has to change its behavior based on its previous experience.

Agents are Mobile which enables an agent to transport itself from one node of a network to another.

Agents are communicative /cooperative so that they can communicate / cooperate with other agents when they really need to complete the job.

Agents are generally designed with a specific purpose in mind. They do one or perhaps several tasks very well, but aren't often designed as a jack-of-all-trades. If agents must perform more tasks, we can either increase their complexity (which increases the development effort), or we can make them work co-operatively.

For cooperation between agents to succeed, effective communication is required. We can view a co llection of agents that work together co-operatively as Multi-agent System or a small society, and for any society to function coherently we need a co mmon language and communication medium.

This language and communication medium is critical for cooperation between agents. Imagine how ineffective software agents would be if they worked in isolation - unable to interact with their peers.

Multi-agent system has been given a m ore general meaning, and it is now used for all types of systems composed of multiple autonomous components showing the following characteristics

- each agent has incomplete capabilities to solve a problem
- there is no global system control
- data is decentralized
- computation is asynchronous

Multivalent has the following features:

- Dividing functionality among many agents provides modularity, flexibility, modifiability, and extensibility.
- Knowledge that is spread over various sources (agents) can be integrated for a more complete view when needed.
- Applications requiring distributed computing are better supported by MAS.
- Agent technology, then, provides the ultimate in distributed component technology.

6. Case Based reasoning system and Multi-agent systems

Multi-Agent System technique is employed in CBR system for the purpose of retrieving, reusing, adapting the cases in CBR System. This section explores a framework that integrates the multi-agent and case-based reasoning techniques to support the dynamic and problem-oriented knowledge sharing among supply chain members. The framework is characterized by differential knowledge sharing levels depending upon the applications as well as the knowledge creation and reuse based on the previous knowledge in the problem area. It also provides a new tool for the field of inter-organizational knowledge management.

The CBR system retrieves cases relevant to the present problem situation from the case base and decides on the solution to the current problem on the basis of the outcomes from previous cases CBR System based on MA system consists of the following main agents:

Retriever Agent

When a new problem is entered into a case based system, a retriever decides on the features similar to the stored cases. Retrieval is done by using features of the new cases as indexes into the case base.

Adapter Agent

An adapter examines the differences between these cases and the current problem .It then applies rules to modify the old solution to fit the new problem

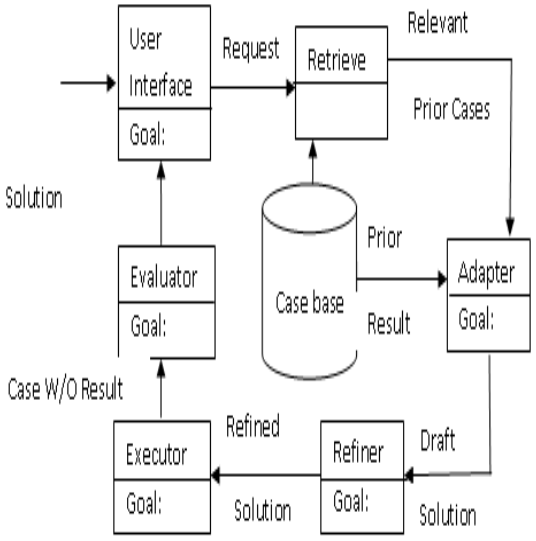

Fig 3 Multi-Agent based CBR System

Refiner Agent

A refiner critiques the adapted solution against prior outcomes. One way to do this is to compare it to similar solutions of prior cases. If a known failure exists for a derived solution, the system then decides whether the similarities are sufficient to suspect that the new solution will fail.

Executer Agent

Once a solution is critiqued, an executer applies the refined solution to the current problem.

Evaluator Agent

If the results are as expected, no further analysis is made, and the cases and its solution are stored or use in future problem solving. If not, the solution is repaired.

7. Data Mining and Multi-Agent System

Intelligent agents represent an important opportunity to optimize knowledge Management. Agents and data mining can work together to achieve required target. In this section data mining agents perform various functions of data mining. It is increasingly significant to develop better methods and techniques to organize the data for better decision making processes. In a competitive world, modern organizations focus on locating, storing, transferring and efficiently using their own information in order to better manage their intellectual capital. Main focus is to find methods and techniques to organize huge data provided by transactions or other activities and to extract useful patterns, relations, associations from data etc. In different applications, it is necessary to know what to do, when and how to do it, in order to complete the pre-established tasks for the proposed objectives, by means of self-decision systems. These systems are known in literature as agents. Intelligent agents act robustly in a flexible, open environment. Knowledge discovery process can be assisted by agents in order to increase the quality of knowledge and to simplify the main processes of identifying patterns from huge data volumes. Intelligent agents and data mining share the same objectives in order to assist decision making process.

Agents, i.e. special types of software applications, have become increasingly popular in computing world in recent years. Some of the reasons for this popularity are their flexibility, modularity and general applicability to a wide range of problems like data filtering and analysis, information brokering, condition monitoring and alarm generation, workflow management, personal assistance,

simulation and gaming. Intelligent agents can help making computer systems easier to use, enable finding and filtering information, customizing views of information and automating work. The concept of knowledge is very important in data mining. In order to get the correct knowledge from the data mining system, the user must define the objective and specify the algorithms and its parameters exactly with minimum effort. If the data mining system produces large number of meaningful information by using a specialized data mining algorithm like association, clustering, decision trees etc., it will take more time for the end- users to choose the appropriate knowledge for the problem discussed. Even choosing the correct data mining algorithm involves more time for the system. A solution for this problem could be an intelligent system based on agents. Data mining and intelligent agents can make a common front to help people in the decision making process, to elaborate decisional models and take good decision in real time.

The following Agents are employed in Data Mining:

Data mining agent: - A data mining agent is a software program built for Pre-purpose of finding information efficiently. It is a type of intelligent agent that operates valuable information to find the relationship between different pieces of information. It is a type of agent to detect major trend changes
GOAL: - DMA finding suitable new pertaining information efficiently

Filtering Agent:-A Filtering agent filter required information; it will check contents and attachment task both include in On End Of Data Filters (smart screen, intelligent content filtering, file filtering ,Multiple AV Scan)
GOAL: - Searching message and check filtering reinforcement.

Information Agent:-An individual or company that is charged with explaining the various transaction of another party to anyone who need to know EXAMPLE: - the delivery of a security by a seller and its acceptance by the buyer
GOAL: - Delivery of commodity to give or keep information

User Interface Agent: - The user interface is the space where interaction between humans and machines occur effectively and control of the machine feedback from machine, operate making decisions.
GOAL: - Interaction between human and machines operate all levels

Office Agent: - According to portal, office agent will choose information where it finds suitable. Different types of office agent occur; they work and uses are totally different. It depends on functioning values and does their own business. It is very purposeful ordinal nature of point.
GOAL:-According to work through this agent altering as per work nature.

Workflow agent:-the workflow agent can be configured for polling on demand processing. when configured for polling, the workflow agent periodically polls (quires) in the database work queue for batches of task to be processed. Workflow depends on polling
GOAL: - priority techniques use to analyze workflow

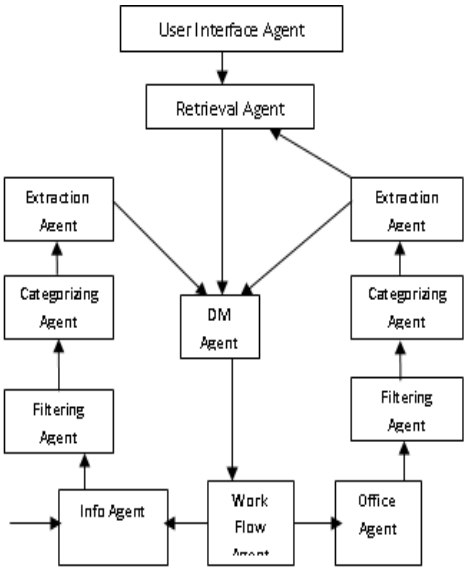

Fig. 4 Multi-Agent System based Data Mining

Interface Agent: - Interface agent to be a program that can also affect the objects in a direct manipulation interface, but without exploit instruction from user. The interface agent reads input that the user presents to the interface and it can make changes to the objects the user sees on the screen.
GOAL: - Defining of objects it depends on input and output

Extraction Agent:-Extraction agent extracts set of information regarding object and is used its dilute for any such information for further needs. Any information fetch it explain every criteria of objects. Collect complete information about the concept. It shows object detailed in well-mannered

GOAL:-Launch every bit of information in detailed manner

Categorization Agent:-Categorization agent classified terms in-lieu of format. Such subject have separate category in various form; which category is valuable for any instance and it follow that event summarization.
GOAL:-three level of category maintain (high, middle, low) it perform under based

Retrieval Agent:-In retrieval agent retrieve information which one has been extracting. Whether this agent executes information using data sets and visualization effects etc. it will display exactly induced information as well. Such functional value used in this format for retrieving procedure
GOAL: - Execute information according to demand specification

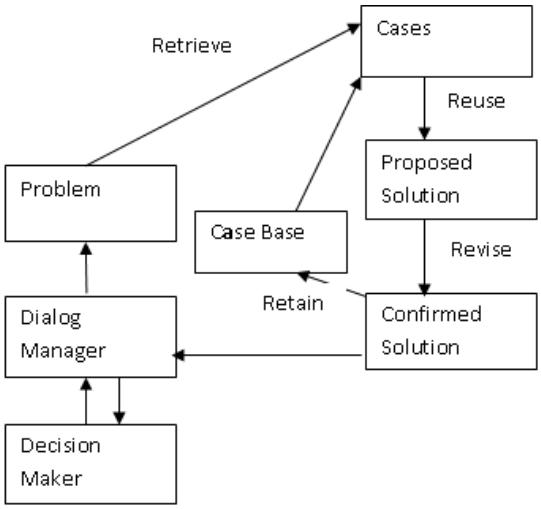

Fig. 5 **CBR based Decision Support System**

8. Decision Support System based on Case Based reasoning System

Using CBR systems for decision-aiding has a certain intuitive appeal because such man-machine collaboration in decision-making can be mutually beneficial. A CBR system can help overcome some of the limitations of case-based reasoning by humans. For example, it can augment a decision-maker's (DM's) memory by providing access to a large collection of cases, rapidly recalling the most relevant cases, and aiding the decision process through appropriate critiquing. In return, the DM can assume greater responsibility for the use of cases, i.e., the adaptation of prior cases to the current decision. While humans have been observed to be fairly good at adapting cases, these adaptation procedures have proven to be the Achilles heel for many CBR systems. Another new paradigm which is generating interest is the use of CBR systems to stimulate innovative decision- making and enhance learning about the decision situation in a DM. Such learning oriented CBR systems can be viewed as symbiotic systems in which the human DM and the CBR component play mutually complementary simulative roles in the decision-making process. By exploiting prior problem solving experiences stored within cases in the case library, CBR can provide the opportunity to emphasize the creative divergent aspects of learning such as metaphorical thinking and lateral stimulation. Prior research in such new paradigms for CBR systems has been limited and has lacked adequate conceptual bases. This section augments CBR systems being used as integrative conceptual framework for the design of DSSs. CBR systems are learning oriented and aim to enhance learning in the DM about the decision situation and the decision process. Each type of a CBR system is suited to a particular organizational decision environment and CBR systems can be seen to be evolving from conventional to decision-aiding and simulative in nature.

9. Multi-Agent System based Decision Support System

The main work in this section is to propose a new architecture for a multi-agent based DSS. DSS consists of the following agents:
a) Contractors interface agent, b) client interface agent, c) coordinator agent, d) report agent, e) database agent.

The whole architecture is depicted in Figure 6. The overall DSS agent architecture consists of three high-levee modules: a) interface module, b) process module, and c) knowledge module. The interface module deals with is publicly visible to other agents and users (consultants and clients). It provides mechanisms for interacting with the agent and supports inter-agent communication and collaboration. The process module and knowledge module are restricted only to the agent that is, other agents or users cannot directly manipulate the contents of these modules without access privileges. The process module contains methods and heuristics that implement a variety of functions and processes using which the agent can respond to requests from other agents or users. Thus, the process module basically provides the services and computations that may be necessary in solving a particular problem. The knowledge module contains domain-specific and domain-independent knowledge relevant to problem solving. The detailed design of the three above-mentioned DSS agents, in terms of the three high level modules, is described section 8.

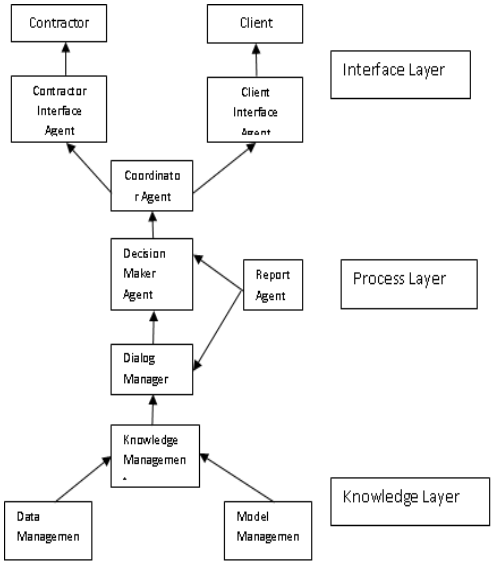

Fig 6 Multi-Agent based Decision support System

10. Decision Support System and Data Mining

DATA Mining is concerned with finding patterns in data which are interesting and valid. Numerous data mining algorithms exit , including the predictive data mining algorithms which result in classifiers that can be used for prediction and classification , and descriptive data mining algorithm that serve other purposes like finding of association clusters etc . .

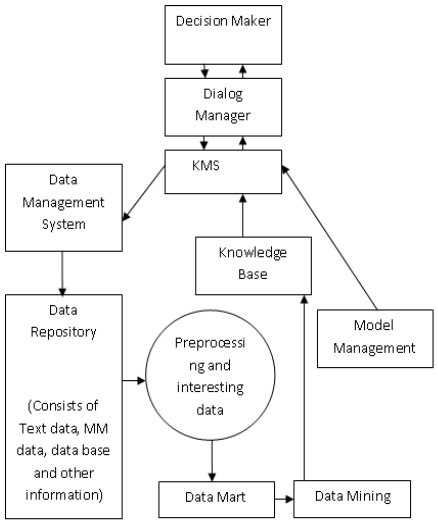

Fig 7 Decision Support System and Data Mining Model

whereas Decision Support System is concerned with developing systems aimed at helping decision makers solve problems and make decisions. Their main characteristics are that they incorporate both data and models; are designed to assist managers in semi-structured or unstructured decision making processes; support, rather than replace, managerial judgment and are aimed at improving the effectiveness of decisions. In this section we try to integrate DSS and DM and present a model. The framework consists of two layers in which first layer the request for quarry is handles by dialog manager which passes the quarry to knowledge management system (KMS). KMS selects the data/information from DM and the required model from Model Management system and process the quarry and sends back to decision maker.

11. Decision support system, Case Based reasoning and Data Mining Model

Decision support System uses both Data mining and Case Based reasoning. Depending upon the quarry from decision maker that Dialog Manager sends quarry to CBR system or DM system.

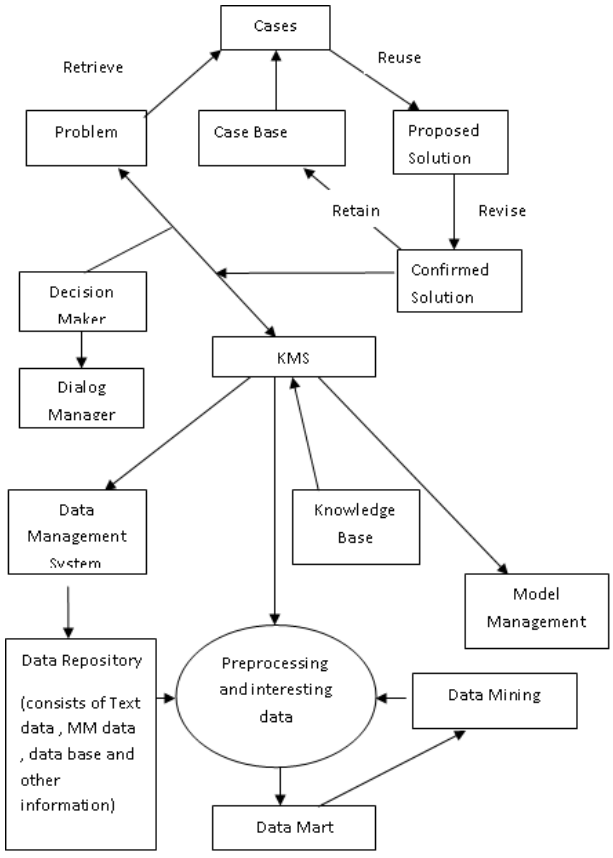

Fig.8 Decision Support System using Data Mining and CBRS Model

12. Multi-Agent System based Decision Support system using Data Mining and case based Reasoning

The Coordinator agent takes the quarry from clients through User Interface Agent and passes it on to the Decision maker Agent which in turn passes it on to Dialog Manager. The dialog Manager interprets the quarry and it sends it to either Data mining system or CBR System. The solution will be sent through Dialog Manager to Report agent who will return to Decision manager.

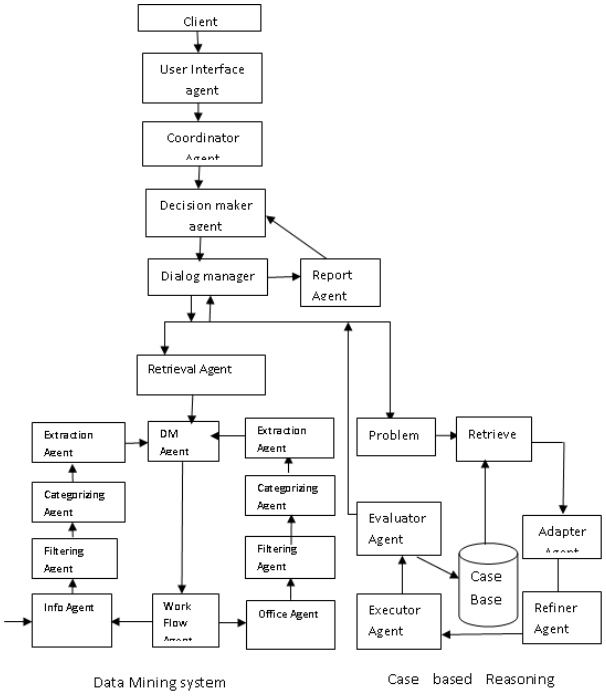

Fig 9 Multi-Agent based Decision Support system Using DM and CBR

13. Application of MAS based DSS using DM and CBR in Supply Chain Management

Agent technology has become the most popular tool for designing distributed SCM systems as it provides an adaptable and dynamic way for managing separate links within the chain. Unlike centralized approaches, agent-based SCM systems can respond quickly to changes and disturbances (either internal or external) through local decision making. Another advantage of designing the SCM solution as a multi-agent system (MAS) is that it a llows different tasks within the SCM to be separated and explored both independently and in relation to each other. The main problem which sellers are facing when managing their supply chains is of deciding on the details of offers to be made to customers: which prices to set, how many items, when and to whom to sell in order to increase port, and when to sell available stocks without being penalized for late deliveries at the same time? The ability to predict market prices is crucial for developing better selling strategies. Agent characteristics, like autonomy, abilities to perceive, reason and act in specialized domains, as well as their capability to cooperate with other agents, makes them ideal for use in electronic trading environments. Similarly, agent technology provides a natural way to design and implement efficient intelligent systems for SCM, where information is distributed and each link of the process is both self focused and dependable on other links. Applications of agent technology for designing SCM DSS allow developers to achieve the following:

- Distribution of data, resources and control over them;
- Effective collaboration, communication and negotiation among separate entities
- Coordination of information how;
- An integrated and united framework, which is task independent;
- Resolution of distributed constraint satisfaction problems within supply chains.
- MAS based DSS in SCM can perform well in the process of selection of suppliers

14. Conclusion

Among the advantages of using intelligent agents, one may mention higher work efficiency, meaning that user saves time, as agent work autonomously and more effectively, as they can search and filter huge amount of information, which would be impossible for humans. This opens new approaches for researchers in combining data mining with intelligent agents. This paper proposed a multi-agent work flow based system in order to automate the complex processes. The proposed system is characterized by the advantages of autonomy; mobility and collaboration of different agents in order provide simple and fast solution. Using agents as data mining and CBR techniques, also as decision makers to make the system more robust and quick in resolving issues in any complex situation. When it comes applying the proposed system, various considerations are too incorporated in to it . The activities are different in their nature: they work with various data, have different tasks and constraints. At the same time, they are interrelated to ensure the achievement of the ultimate goal of taking effective decisions. This makes the system very difficult to manage; being successful in one of its areas does not necessarily guarantee the improvement of the overall performance. Designing an effective decision-support system for any application especially SCM has become crucial in recent years. With the advent of e-Commerce and in a global economy, SCM systems have to be able to deal with the uncertainty and volatility of

modern markets. In such systems, the ability to learn and adapt to new conditions in the environment is of paramount importance. This open up a n ew area of research to build more robust systems.

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