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Medical Application Using Multi Agent System - A Literature Survey

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ABSTRACT
In this paper we have projected on the involvement of multi-agent system in medical or health care domain. The objective of this study is to provide future researchers more resourceful and focused review of various research papers in this domain. Multi-agent system is most suitable for healthcare paradigm, as the properties of agent based systems deals with heterogeneous multiple agents. Data distribution and data management in a dynamic and distributed environment with multi-user cooperation, made multi-agent system more significant in this field. The disposition of this paper is classified on the basis of theoretical and application approach. We have tried to cover few relevant papers published on last decade. The main aim of this literature survey is to provide a complete road map on multi agent system based research on medical health care platform.
Keywords **-** agent, health care, medical, multi-agent system, multi user collaboration

I. INTRODUCTION

Agent based system which is a part of Artificial Intelligence, has become a growing area to manipulate and execute simple or complex problems. An agent is a computer program designed to work on behalf of its user or owner. An agent must have the following attributes: a) Autonomous, b) Pro-activity, c) Reactivity, d) Communication, e) Co-operation, f) Negotiation, g) Learning, etc. There are many features of agents, which helps to solve the particular task. An autonomous agent has the ability to adapt and learn from its environment. It can also react whenever its environment changes and also can take decision to fulfill its goals. The combination of multiple agents is known as multi-agent system (MAS). The key idea behind MAS is to form the communication and co-operation between agents, so as they can work together to solve a desired task. The major applications of MAS are in telecommunication, internet, robotic applications and medical domain applications, etc.

The aim of this survey is to set a road map for the future researchers to find the key idea behind the use of multi-agent system in medical domain.

The organization of this paper is as follows. In section 2 we discussed about the background of agent systems and multi agent system. Section 3 we discussed about the involvement of MAS in medical domain. Section 4 describes literature survey of relevant papers. Finally the paper is concludes in section 5.

II. BACKGROUND

The progress of research on artificial intelligence during the mid-1960s and early 1970s led to the evolution of agents in the 1970s. In 1966, Professor Joseph Weizenbaum of MIT wrote the first software agent known as ELIZA [3], which was a computer therapist program, programmed to suggest a conversation and answer many question [4]. In the mid to late 1980s, research began in earnest on multi agent system; researchers understand the concept of organizations and communications between agents. In the 80's and during the 90's huge changes occur in Artificial Intelligence as multi-agent system have replaced single agent as the computing prototype. In 1990s ABM (Agent based Modeling) was expanded within the social sciences. In 1990 large-scale ABM Sugarscape, developed by Joshua M. Epstein and Robert Axtell, which used to model the role of social and cultural development [5]. In 1990s developments there included another famous development, the Carley ABM, developed by Carnegie Mellon University's Kathleen, to explore the co-evolution of social networks and culture [6]. In 2000 Samuelson done a survey over the evolution of agent based systems [7], and In 2006 Samuelson and Macal, they researched on the recent improvements in multi-agent systems [8] [9]. More recently, Ron Sun developed methods for basing agent-based simulation on models of human cognition, known as cognitive social simulation [10].

III. MULTI AGENT SYSTEM IN HEALTH CARE DOMAIN

In recent years agent based systems has become growing approach to solve the limitations in the medical health care domain. Medicine domain is a huge environment distinguished by its common and distributed decisional characteristics and its

management of care, which requires a communication and a complex management between the various medical departments, doctors and patients. The introduction of multi-agent systems into the medical domains make it easy for the management to take its decisions and the actions, and ensures the communication and coordination by minimizing the errors of analysis and treatment, and by improve time required to look for the medical resources, and other medical departments.

IV. LITERATURE SURVEY

In this section we will go through several relevant papers to describe significant applications in the health care domain that have been developed using the multi-agent system. The key idea about each relevant paper is discussed below:

- **Multi agent Systems, by Katia P. Sycara (1998):** [11]

In this article the author presents some of the significant concepts in multi-agent system and the research work related to them. Here the author argued that multi-agent system can be defined as a loosely coupled network of problem solvers that interact to solve problems that are beyond the individual capabilities or knowledge of each problem solver [12]. Here the author tries to show the efficient overall problem-solving logic of multi-agent systems architecture. Rationality was a global property of the multi-agent systems which was measured by the efficiency and consistency of a global solution. But a multi-agent system lacks in global perception, global control or global data. The author in his own work RETSINA, a multi agent infrastructure, shown that each RETSINA agent was a BDI (belief desire intention) type agent [13] [14] that integrates p1anning, scheduling, execution, information gathering, and coordination with other agents [15] and [16]. Here the author proposed the idea of creating software that operates in distributed and open environments, such as the internet.

- **A Road map of Agent Research and Development, by Nicholas R. Jennings, Katia P. Sycara and Michael Wooldridge (1998):** [17]

In This paper they present a survey of study and improvements in the field of autonomous agents and multi-agent systems. The main aim was to find the idea and applications, and to find the interconnection between them. Agents are being used in an increasingly wide variety of applications ranging from Comparatively small systems such as personalized email filters to large, complex, mission Critical systems such as air-traffic control At first sight, It may appear that such extreme1y different types of system can have little in common And yet that was not the case in the key abstraction used that of an agent. It was the naturalness and ease with which such a variety of applications can be characterized in terms of agents that lead researchers and developers to be so excited about the potential of the approach. Indeed, several researchers found that some feature of agents are being not fitted for the solution, and that needs to be stopped, otherwise agent based system will endure a same criticism to that experienced by the AI community in the 1980s [18].

- **Implementation Scheme for Online Medical Diagnosis System Using Multi Agent System with JADE, by Mr. Shibakali Gupta, Arindam Sarkar, Indrani Pramanik and Bauani Mukherjee (2012):** [19]

This paper proposed the concept of online medical service system for internet users. Here they proposed the idea of OnlineDocs.com, where the user can get access to the details of the closest and best health care system like hospital, medical clinic etc. the multi agent based system may works well but, the challenges concerned mainly in five main areas:

(1) Intercommunication between services.
(2) Security of data.
(3) Transparency of environments of different agents.
(4) Interconnection between users and agents.
(5) Synchronization between distributed services.

The standards for agent interoperation was set by, The Foundation for Intelligent Physical Agents (FIPA). Agent Cities was a project, whose target was to construct a publicly available network of FIPA based agent architecture. The final aim of the project was to build a system which could be able to run in all environments, like Agent Cities network. The Message Transport System also called Agent Communication Channel (ACC) [19] was the software module controls the communication within the same platform and the remote platform. This architecture was build using JADE [22] and whenever a JADE platform was launched, ACC module started intercommunication by creating the Agent Management System (AMS) and Directory Facilitator (DF).

- **Multi-Agents System for Medical Diagnosis, by Okba Kazar, Zaidi Sahnoun and Louis Frecon (2013):** [23]

Here the author discussed about the introduction of multi-agent system into the medical fields, which helps the management to take the decisions and actions, and also ensures the communication and coordination by reducing the errors of diagnosis and treatment, and by improving time required to search for the medical resources, and other medical departments. The multi-agent system approach can be used in medical domain mainly for the communication between human and other types of services. Another aspect of using multi-agent system

in medical domain was to build the phenomena simulation of interactions of genes and proteins, which make it possible to reproduce the way in which the patients demand with the treatments.

The appreciation of agent move towards the awareness of a medical application was founded on the supply of the data and the background drive. The medical diagnosis was the different compiling data of different regions; these are mainly divided into two parts: a) symptoms (subjective) and b) The signs (objective). The multi-agent system is mainly developed to serve for the medical field to help the doctors in their diagnosis process. The architecture of the multi-agent system using blackboard control is composed of three elements, these are: a) Agents, b) the blackboard [25], c) the mechanism of control. The objective of this paper was to model a multi-agent system of support to the medical diagnoses. Here they used the approach multi-agent system which composed of three agents, where each agent with a different subject. These agents communicate using the blackboard and which helps to give a final diagnosis. They have noted during recognition of their system that the multi-agent system was currently in growing phase, which helps to communicate between autonomous agents. The possible prospects for their works can be an adjustment so that the system was more flexible for the addition or the removal of an agent.

- **An Efficient Multi-agent System for E-health Functionalities, by Mohammad Kalmarzi Moghaddam, Mohammad Shojafar, Mohammad Reza Nami and Hassan Rashidi (2013):** [26]

Here the author's concentrated on the concept of agent oriented software engineering. The main goal of this agent oriented software engineering was to build process, tools and services for training and maintenance of the agent-based software. To construct and execute multi-agent environments, here they use Jade Technology. Jade was a distributed middleware which was a flexible structure that can easily expand. Jade framework implement agent and a set of graphical tools so as to make agent oriented system design very simple and easy. As jade was completely java based so it can be added to a Library in java language. Following are the several Jade characteristics focused hare:

- Multi-part application;
- Interoperability;
- Having open source;
- Diversity;
- Easy to use mobile software.

Features of E-health like interaction and communication have amplified the necessity of agent abased system. The properties of multi-agent system, which included here:

- Necessity of some domain to multi-agent systems;
- To increase the speed with parallelism;
- Reliability;
- Extensibility,
- Programmer easier.

In recent times, E-health technology [27] developed a way for tele-medical care [28] which was supported by modern digital mass communication media.

Finally this paper tried to study the agent-oriented software engineering and E-Health which provides agent-based system for the hospital by using the agent properties and architecture. Though more improvement is needed in agent technology which causes additional services improvement and to overcome E-health communication challenges.

- **Multi Agent System based Efficient Healthcare Service, by Byung-Mo Han, Seung-Jae Song, Kyu Min Lee, Kyung-Soo Jang, Dong-Ryeol Shin (2006):** [29]

This paper mainly deals with the idea of multi-agent system as a health care system, which composed of medical sensor modules with combinations of wireless telecommunication technology. The projected system comes with various services which include telemedicine in mobile, monitoring patient, disaster management and communication between patients and medical staff. The projected system also provides a computing platform between the BAN (Body Area network) [30] and the supportive system in the hospitals, and communicates with agent network of BAN's PDAs via peers. The communication and message transfer in a hospital was done by the help multi-agent system environment. The JADE (Java Agent Development Framework), a FIPA - certified development framework which was used to develop the multi agent system JADE mainly follows these properties:

- Interoperability
- Uniformity and portability
- Easy to use
- Pay-as-you-go philosophy

Here they also used LEAP (Lightweight Extensible Agent Platform), the most known agent platform for small devices. LEAP becomes an autonomous development branch of JADE under the LGPL license. JADE continues its development towards its monitoring facilities, visualization, ontology's and policies. However, LEAP focus on its lightweight and extensible aspects.

The final objective of this system was to monitor and verify the patient's health by checking their medical report and to provide proficient medical service with the help of medical staff's assistance. JADE can be used to develop multi-agent system for healthcare system and they used the agent platform LEAP for PDA. The future research aspect involves the construction of the mediator between BAN and

hospital domain to implement agents, for more complex computing on PDA.

- **The CMDS Medical Diagnosis System, by Barna Iantovics (2008):** [35]

In this paper they proposed the idea of a medical diagnosis multi agent system called CMDS (Contract Net Based Medical Diagnosis System), which was a hybrid system with human and artificial agent members. The proposed system solves the medical diagnosis problem by the adaptation [36] of the cooperative problem solving method, the contract net protocol [37, 38, 39, 40]. The solution of medical diagnosis problem based on the identified illness (illnesses) and the associated treatment (treatments) which must be applied to cure the illness (illnesses). Different difficulties in the medical diagnoses elaborations are analyzed in [41, 42, 43].

In this paper, a system called Feline [44] which composed of five autonomous agents (expert systems with some proprieties of the agents) capable with medical knowledge was proposed. This paper also proposed a general methodology based on Computer Algebra for creating medical expert systems [45]. This paper also proposed a Web-centric extension to a previously developed expert system specialized in the glaucoma diagnosis. For the implementation of the medical expert systems the CoCoA language is proposed [46]. Here they used Cooperative Medical Diagnosis Elaboration algorithm to show the problem solving abilities of medical agents. Advantages of using CMDS System were that the CMDS medical diagnosis multi agent system can solve medical diagnosis problems using the artificial agents and physicians abilities and capacities. The medical agents (human being and artificial) also can learn autonomously from each other during the problems solution replaying processes. The key idea was to use multi-agent oriented model to solve several health care related problems by merging and expanding different problem solving technologies.

- **A multi agent intelligent environment for medical knowledge, by Rosa m. vicari, cecilia D. Flores, Andre M. Silverstre, Louise J. Seixas, Marcelo Ladeira and Helder Coelho. (2003):** [47]

This paper proposes a multi-agent oriented learning environment aimed at learning using a positive approach to perform diagnostic reasoning and modeling of a domain using AMPLIA [47], which was mainly focused on medical domain. The AMPLIA compares its domain with the one that learner has built; if they are not matched then the environment starts a process in order to encourage the learner to review its model. Here they choose Bayesian network approach to deal with uncertain knowledge. Uncertainty was represented by probability and probabilistic reasoning. The AMPLIA composed of three agents: leaner agents, domain agent and mediator agents. The AMPLIA consist of two phases; that was:

(1) Phase1: AMPLIA Model construction- under which qualitative and quantitative review of the construction is done.
(2) Phase2: Diagnostic hypothesis evaluation, which consists of the evidence input and their propagation into learner's Bayesian network. And it was also based on qualitative and quantitative Diagnostic hypothesis evaluation.

This paper further discussed about investigating the use of Bayesian network in agent's belief modeling and mental states to guide the negotiation process using three cognitive agents(leaner agents, domain agent and mediator agents), two databases(expert knowledge built-in model database and pedagogical strategy database) and the interface module in the AMPLIA architecture.

- **Data warehousing through MAS in the medical arena, by Antonio abelha, Jose machado, Victor Alves and Jose Neves (2004):** [48]

In this paper they proposed an idea of AIDA [49], Agency for Integration, Diffusion and Archive of Medical Information is an agency that offers intelligent electronic workers, commonly known as pro-active agents. This pro-active agent interacts with the various systems by transferring medical information, and thus categorize and saving the information to respond information requirements with the necessary resources to their acceptable and in time execution. Medical Information Systems (MIS) are seen as a way of optimizing the use of the accessible health care communications without resorting to new and costly structure. AIDA offers web based service tools to interact with human agents. Based on these conditions, a Healthcare Information System (HIS) was subjected to in terms of a) Administrative Information System (AIS), b) Medical Support Information System (MSIS), c) Nursing Support Information System (NIS), d) Electronic Medical Record Information System (EMR) etc. Multi-agent system used as a problem-solving via theorem proving i.e., agent based computing has been hailed as a significant breakthrough in prob1em solving, as a new revolution in software development and analysis. The data warehousing [50] [51] for healthcare units for maintaining the data, the documents of everyday operations is done using RDBMS. Data warehousing was there to help manage the system and must also deal with changing worlds or environments. It mainly applied on Radiological information system, Electronic medical board etc.

- **Multi-Agent Systems for Active, Dynamic Activity Areas, by Andreas Schweiger and Helmut Krcmar (2004):** [52]

This paper mainly concerned in the area of health care by care for patients, the reduction of costs and the improved decision making process in the areas of diagnosis and therapy. The multi-agent system was the technology suited for providing solutions to the mentioned problems. In this paper current workings of the German National Science Foundation project ASAinLog are presented. Properties of the health care domain are: Cooperation, Communication and Coordination. The present results of the project ASAinLog shows that agent technology was suitable for the software based realization of active, dynamic activity areas and contributes to the solution of problems of information logistics in the health care domain. Central elements of the proposed solution are active medical documents. Agents perform tasks of interpretation and concatenation of data, arranging access control, controlling complex medical processes, monitoring appointments, associating similar disease patterns, and recommending potential therapies. Agent connectors' support complex, flexible and domain specific relationships for communication, cooperation, and coordination. Software agents act on behalf of their real world representatives.

- **A Hybrid Technology for a Multi agent Consultation System in Obesity Domain, by Rohana Mahmud, Hairul Aysa Abdul Halim Sithiq, and Haryuna Mohd Taharim(2009):** [54]

Here the author presented hybrid architecture of a multi-agent consultation system for obesity oriented health problems. This hybrid architecture composed of an expert system (ES) and an intelligent agent (IA). The author proposed that they will continue to produce and collect biomedical knowledge effectively and efficiently using multi-agent system in the medical domain. The main idea behind this research was to study the capability of hybrid multi agent with expert system which capable of diagnosing symptoms and provide consultation related to obesity problems [55]. Obesity was treated as a chronic non-communicable disease, like diabetes, cardiovascular diseases and cancer. But these are often curable locally if appropriate diagnosis and treatment plans are provided adequately. In the multi-agent system, the service of hybrid technologies 1) pull technology and 2) push technology allows an agent to help efficiently in solving problems and share professional knowledge. The system needs to be correct at any point in analyzing the health and indication of a patient as it deals with patient's life. The proposed multi-agent system was composed with the following components which consist of collection of agents, namely

(1) Diagnosis agent: This was responsible for providing expertise knowledge.
(2) Treatment agent: this agent consulted the diagnosis results and suggests an appropriate treatment plan.
(3) Collaboration agent: it helps to build the communication between the above two agents. The communication was done using two methods which are: a) Image-text mapping and b) Lexical relation ontology.
(4) User interface agent: it will integrate all the knowledge bases of the expert systems in the diagnosis and treatment agents.

The system was available to support users who have obesity problems. This architecture directs the people being aware of the necessity of fitness and good health for long healthy life. However, in future additional work has to be done before applying the commercial multi agent consultation system for obtaining the knowledge [54].

- **Naive Bayesian Learning based Multi agent Architecture for Telemedicine, by Ei Ei Chaw (2013):** [56]

In this paper they discussed about Naive Bayesian machine learning (NBMS) based multi-agent system architecture for telemedicine and simulates a model system for cancer classification. An agent for different medical problem solving consists of different properties:

a) Increased autonomy in operation,
b) Capability of communication,
c) Autonomous learning capability and
d) Capability to interact with the environment.

These properties permit the agents to synchronize with other agents and human during different problem solving. Multiple agents coordinate with each other, balance each other's capabilities, and distribute each other's knowledge to provide good quality services [61]. Telemedicine [57] [58] was the practice of medical health care where the interaction between medical personnel and patients was done via audio-video communication system without the common physical physician-patient interaction. Industry Canada uses telemedicine to provide healthcare services in remote areas [59]. In this architecture three types of agents are used these are:

a) Initial agent: It was an agent which interacts with the user of the system, and it accepts the problem and sends the problem to organizer agent for further processing.
b) Coordinator agent: It was like a broker agent or middle agent, which sends the problem to desired assistant agent based on its own knowledge. It applies Naïve Bayesian learning mechanism for building the agent's knowledge.
c) Assistant agent: These agents actually process the problem. They have own knowledge to process the certain problem. They use Naïve Bayesian classification and are trained with training datasets.

Here they developed the application using the METATEM [60], which was a language based upon the direct execution of temporal formulae. This language was based upon executable logic; the language can be used as part of the design and prototyping of hasty systems. Also, as it uses temporal logic, the language provides a high-level programming detail in which the dynamic Attributes of individual parts can be concisely represented. In this system, each agent has their own different knowledge. It was built on match maker based coordination mechanism Assistant Agents do not need to keep the information of other same level agents. The agents initially know nothing about their environment and learn to coordinate gradually. The chain rule based architecture [56] was built on ring based architecture. Each agent has their own different knowledge. Assistant Agents need to keep the information of other same level agents. Middle agent or coordinator agent keeps the information about the problem and agents' capabilities in the system. Coordinator Agent sends the problem to one of assistant agents (AG) [56]. Comparison between the proposed systems with Chain Rule based system architecture has been performed. The comparison was made on the number of messages, complexity, extendibility, efficiency and processing time. According to these the proposed system architecture was more suitable. But CHA based system was better than the proposed system when the service Provider agent was found directly. However, directly found system was not always occurring. Besides the processing time for CHA system was unstable. Thus the proposed system was better than the CHA.

- **Multi Agent System Based Clinical Diagnosis System. An Algorithmic Approach, by Shibakali Gupta, Sripati Mukhopadhyay (2012):** [65]

In this paper they have proposed an operational algorithm to describe the operations of a hybrid multi agent system based intelligent medical diagnosis system called Clinical Diagnosis System (CDS) [66]. User friendly interface like medical diagnosis system required to be providing high performance, reliability and functionality. The Clinical Diagnosis System consists of several types of agents:

1) User Agent (UA): it was responsible for taking the user or patients inputs.
2) Master Agent (MA): it converts the raw input data collected by UA to knowledge. The knowledge is stored in the Global Knowledge base (GKB).
3) Specialist doctor agent (SDA): it was selected by MA to assign a particular task for solution.SDA was associated with a individual local knowledge bases (LKB) to reach its desired solution.

After having the solution, SDA will give it to the Master Agent (MA) and that solution will be stored in the solution knowledge base (SKB).The proposed agent oriented clinical diagnosis system (CDS) Can takes care of all possible stage of patients which includes patients initial check up, treatment, and report for the patients. Whereas the CDS algorithm was capable to handle the system efficiently. In future the proposed system can be developed and applied to fulfill the demand of the medical scenario in India.

- **A Multi-Agent Learning Paradigm for Medical Data Mining Diagnostic Workbench, by Sam Chao and Fai Wong (2009):** [67]

This paper proposed the model of practical data mining diagnostic which intends to support real medical diagnosis by two emerging technologies - data mining [68] and multi-agent system [69][70]. To fulfill this effort they implemented an intelligent and cooperative diagnostic structure with multi agent approach called i^{+}DiaMAS [71]. i^{+}DiaMAS provides an integrated architecture that includes a variety of preprocessing agents as well as learning agents through interactive interface agent [67]. The data mining systems are only capable of dealing with homogeneous [72] and centralized data. So here they proposed the concept of addition of intelligent agents into a data mining system can perfectly balance the most of existing data mining methods. In this architecture the key idea is to distribute a complex problem among several agents that have the ability to execute in parallel and communicate by sending messages. Overall there are five types of agents which deals with various data mining task:

1) Coordinator Agent (AgCor): it forms the core of i^{+}DiaMAS by coordinating with several agents' behavior. Its breaks a task into sub-tasks and then merge the results from several agents to form the overall response to a task.
2) Data Preprocessing Agent (AgPre): the primary key factor of a successful data mining tool was using the right data [73]. This agent filters the useful data from the raw data by data preprocessing technology.
3) Data Mining Agent (AgDM): it contains a set of learning agents that each of which implements a methodology to diagnose a specific disease.
4) Optimizer Agent (AgOpt): this agent optimizes the learned outcomes from AgDM. The main activity of AgOpt contains:
   a) Pruning: deals with overfitting [74] problem.
   b) Integration: integration task was necessary to assemble the results from different learning modules.
   c) Knowledge presentation: both inputs and outputs of a data mining system must be simple enough to be understood. Visualization and visual data mining play an important role in biomedical data mining [75].

5) Supporting Agent (AgSup): it interacts between users and system, and handles various manipulations regarding data files, such as file operations and format transformations, etc.

Additionally, their agent-based learning approach was experimented in terms of classification accuracy over sixteen bench-mark datasets drawn from UCI repository [76] against two learning algorithms: C4.5 and ITI (Incremental Tree Induction) [77]. Here in data mining agent, they included the i^+ learning module based on i^+ learning (intelligent and incremental learning) algorithms, which makes the decision trees a more powerful, flexible, accurate, and widely accepted model. i^+DiaMAS aim to solve the growing learning problem that in medical domain, through the adoption of multi-agent strategy and data mining methods.

- **Cooperative medical Diagnoses Elaboration by Physicians and Artificial Agents, by Barna Laszlo Iantovics (2007):** [78]

Here the author discussed about Cooperative medical diagnosis systems which used to solve complex medical analysis problems. In this paper, a medical multi-agent system called MAMSM (Medical Assistant Multi agent System) that facilitates the doctor and medical personnel to do their job more professionally and rapidly. The teamwork of the human and artificial belief judgment advances in the diagnostics improvement. The proposed multi-agent system was a composite system which was composed of relatively simple agents. The simple agents can resolve several medical problems which may be unnoticed by the doctor or medical personnel. A medical diagnosis problem represents the description of a patient's illness. The solution of the problem represents the identified illness and the proposed diagnostic to cure the illness. To build these kinds of agent systems some methodologies were proposed, like: HIM [79], GAIA [80] and PASSI [81]. Here they analyze different aspects of the multi agent systems specialized in medical diagnosis. Understanding such systems needs a high-level visual view of how the systems work to achieve some application related purpose. Here the method of visualizing the behavior of a medical multi-agent system based Use Case Maps was projected. Medical expert systems represent comparatively typical applications in the medical diagnosis. Examples of well known medical expert systems are MYCIN [82], GIDEON [83], CARDIAG2 [84], PUFF [85] and CASNET [86]. In this paper, a cooperative MAMAS specialized in medical diagnosis called CMDS (Contract Net Based Medical Diagnosis System*)* is proposed, which was a complex system composed from medical expert system agents that cooperatively solve medical diagnosis problems. The Advantages of these software mobile agents are that they are capable of change their location in the network where they operate. The main disadvantages of the mobile agents are related with their limited Communication capability, protection capability, Intelligence and capability to use knowledge bases in the problems solving. These disadvantages limit the use of the mobile agents for medical problems solving in insecure networks.

- **A Multi-Agent System Architecture for Monitoring Medical Protocols, by T. Alsinet, R. Bejar, C. Fernandez and F. Manya (2000):** [87]

Here they describe the construction of a multi-agent system that used to support and regulate the implementation of health care or medical practice in hospital environments. A medical protocol performs a series event in front of medical diagnosis systems. The work reported here was a part of the SMASH project. SMASH deals with the construction of multi-agent systems to deal with complex problems of distributed nature in hospital environments. The purpose of this paper was to identify a system for the support and management of the execution of medical protocols in hospital environments. They have implemented a user-friendly environment called JAFDIS to graphically represent negotiation processes in multi-agent system based on the concept of dialogical Institutions [88]. Here they discussed about the multi-agent system architecture, which consists of:

- Dynamic location: The system must be available from any point of the Internet (or of the hospital intranet) and allow agents to interact independently of their physical location (the network address).
- Information confidentiality: Agent communications, can involve private information about patients so all message must be sent encrypted.
- Information integrity: The agent system must identify the third party manipulation in order to maintain the information integrity.
- Agent's authentication: To maintain the message integrity all messages will be digitally signed.
- Medical protocols monitoring: The system must supervise all SDA interaction in order to register invalid actions and to support SDA decisions.
- Medical protocols delivery: The system must deliver MP patterns with a suitable format.

They also discussed about 3 types of agents:

1) Certification agent (CA): Agents need their certificates for authenticate messages.
2) Supervisor agents (SA): These agents keep eye on the SDA'S interactions and their validity.
3) Medical protocols server agent (MPSA): It distributes the available MPs to SDA's and also distributes MP specification to SDA's.

Here they also discussed about the communication of the different agents via some communication

interfaces; here they use different network communication protocol stated below:

- Communications are symmetrically encrypted by using the triple DES algorithm to provide confidentiality. The symmetric encryption key was negotiated in every session.
- The negotiation of the symmetric key was performed by using the public key HSA algorithm. This algorithm allows an authenticated communication between the involved agents. Therefore every agent has a public and a private key.
- The public and private keys are generated from the login and password of the agent.
- Two agents transfer one to each other their public key through their certificates.
- A message authentication code (MAC) was used to compute a digest of the plain message. This digest is encrypted wit h the private key of the sender agent.

In future they plan to use this prototype in real hospital environment and also plan to build an agent that will automatically discover the medical history and progress of the patients.

- **Medical Image Segmentation using a Multi-Agent System Approach, by Mahsa Chitsaz and Woo Chaw Seng (2013):** [89]

Here the author proposed an idea, where they design a framework to extract concurrently several objects of interest from Computed Tomography (CT) images by using some priori-knowledge. Their method uses the properties of agent in a multi-agent environment. Firstly, most image segmentation solutions are problem-based Secondly; medical image segmentation methods have limitations because medical images have very similar gray level and texture among the concerned objects. The following properties are represented for a hardware or software-based computer system agent:

1. Autonomy.
2. Social Ability
3. Reactivity.
4. Pro-activeness.
5. Robustness.

The idea of Liu and Tang based on multi-agent system to segment a MRI image of brain. The brain has the four basic elements like as: a) outline, b) branching region, c) enclosing region and d) tumor region. For detecting each four regions, they assign some threshold range. The agent behavior is one of these four types: a) breeding, b) Pixel labeling, c) Diffusion, and d) Decay.

The main improvement of this projected method was that it almost automatic; it works without user interaction in segmenting the image. The most significant benefit of this method was segmenting image into more than two regions in a parallel way.

- **Towards Maturity in Multi-agent Based Remote Patient Monitoring, by Fiaz Majeed, Aslam Muhammad, Rizwan Saleem and Martinez-Enriquez A. M. (2011):** [90]

Here the author proposed the idea of implementing multi-agent system with RPM (remote patient monitoring).The main purpose of this paper was to find weaknesses in present system and propose an idea to improve the system's functionality**.** Recently multi-agent systems have been switched from PC's to mobile technology. So patient at home or road can be treated by the medical staff using mobile technology, the doctors may be alerted about patient condition simultaneously. The GPRS based communication activity is wastage of resource and cost as there is rare communication held between patient and medical staff in multi-agent system. So Short Messaging Service (SMS) was a possible solution which is proposed in this RPM architecture. Features for comparison with existing systems architectures:

- Mobility: The system should keep running in any location.
- Security: The whole system must be centrally controlled.
- Recovery: It should have ability to recover from failure.
- Efficient communication: the information exchange between sender and receiver instantly.
- Updated technologies: It should have the capability to adapt with newer technologies.
- Centralized DB: It maintain a centralized DBMS which secures integrity of data.
- Co-operation: It should maintain the architecture in such a way that agents can easily co-operate.

The main advantages was that it resolved significant problems in the existing multi-agent based RPM infrastructure such as alternative solution for continuous GPRS connection was provided, a way to increase battery life was proposed and data management in the network is resolved in our framework.

Finally, prototype system demonstrates its practical viability. The system work efficiently and securely in the MAS environment.

- **Modeling a massive multi agents system for the knowledge of practices in African traditional medicine, by Ghislain A. Atemezing, Laure P. Fotso, and Alain Cardon (2004):** [91]

African traditional medicine which was strictly bound to the culture of the people was a complex system of treatment in which there was interference of several actors from several domains. It treats disease as a social illness which should be removed from the root. This traditional knowledge was not frequently prepared because it generally passed verbally. The study of ontology shows that several concepts consisted of several categories called

semantic traits [91]. The approach which they proposed the adaptive qualities of the multi-agent system. An adaptive system having ability to develop the sense of the production and the manipulation of knowledge. The adaptive systems with thoughtful action type and its resolution fall into the Scope of a massive multi-agent system (MMAS) [91]. Here the adaptive agents systems applied various types of agents these are:

- Aspectual Agents: These agents are defined from the ontology related to physical aspects observed in the traditional medicine.
- Pregnancy agent: These agents can communicate among them, and can regroup, and also communicate with aspectual agents to guide and modify them to form major behavioral groups.

Here they identify four types of pregnancy agents related to traditional medicine. These are 1) Nuisance Agent (NA), 2) Divination Agent (DA), 3) Protection Agent (PA), 4) Intimidation Agent (IA), 5) Mystification Agent (MA).

- Organization agents: Its action guide the group of aspectual agents to accept a particular structure appreciated globally, taking into account the environment of the system.
- Specific Agents: It also divided into : -
  1) Interface Agents: Used for the filtering of data coming from the user.
  2) Information Agents: Used for the collection of information coming from an existing data base.
  3) Analysis Agents: Used as a pattern matching of the information coming from the sensors of the system.
  4) Geographic Agents: Used for geo positioning for the communication with all the agents involved in this model.

The future aspect of this project was how to produce the artificial environment, as the language in traditional medicine is the one used to exchange knowledge.

- **Use of Ontology-based Multi-Agent Systems in the Biomedical domain, by Maja Hadzic and Elizabeth Chang (2005):** [92]

Here they proposed the design of ontology, called Generic Human Disease Ontology (GHDO). They also design multi-agent system architecture from several different information resources. This multi-agent System uses the common GHDO ontology for query processing, data recovery and information incorporation. The ontology works on different levels of information retrieval such as:

1) It is used to locate and recover requested information.
2) It is used for enabling agents to communicate with each other during the process of information recovery.
3) It is used to examine and manipulate the recovered information.
4) It is used to represent the recovered information to the user in a significant way.

Here they describe four different types of agents and four different phases in the process of problem solving within the multi-agent system. Here they discussed about agent cities, AADCare, BioAgent, Holonic Medical Diagnostic System (HMDS).

- Agent Cities- It was a multi-agent system (MAS) composed of agents that provide medical services.
- AADCare- It was agent architecture [93] comprises several levels of information, a memory, a Communications manager and a human computer interface.
- BioAgent- It was a mobile agent system suitable to support bio scientist during the process of genome analysis and explanation.
- Holonic Medical Diagnostic System (HMDS) - It was a medical diagnostic system. This system combines the Advantages of the holonic paradigm, multi-agent system technology and swarm intelligence in order to realize Internet-based diagnostic system for diseases.

Agent Cities and AADCare are designed as Multi agent architecture, where Bio-Agent and HMDS are systems used as mobile agents. The advantages of this architecture, firstly it allows users on a worldwide basis to intelligently access new scientific information much more rapidly. Secondly, it improves research efficiency and effectiveness. Thirdly, it improves interoperation which make possible to divide a big job among different research teams.

Although they have implemented this system but still lacks in security concerns, testing and validation, and development of user view interfaces, which needs to be developed.

- **Intelligent Scheduling in Health Care Domain, by Srividya Bhat , Nandini S. Sidnal , Ravi S. Malashetty and Sunilkumar. S. Manvi (2011):** [94]

Here they presented this work to construct an agent based information services for mobile users. An agent was distinguished by its property of Situatedness, autonomy and Flexibility. Multi-Agent systems (MAS) were suitable for many medical domains, as it was an upcoming technology that promises to make much easier to design and execute. Here multi-agent system uses java platform to achieve better quality of service. This system schedule the meeting between the patients and the relevant doctors meeting in a professional way for schedule and emergency services. System with above featured properties offers the possibility of lower the cost and Improve the performance of operations by:

- Automating routine tasks.

- Enabling users to complete tasks that would otherwise be very difficult, time consuming, costly or just impossible.
- Adapting to unexpected events or changes in the environment automatically.

Multi-agent system can generate a complex system by a collection of agents, which can have the following ability:

- Social ability: agents have to communicate with each other and their users.
- Reactivity: agents have to perceive their environment.
- Pro-activity: agents not only react on signals, but also take autonomous actions, to achieve a desired goal.

Agents can be classified by their capabilities and method of implementation as given bellow:

1. Collaborative agents: these are autonomous and they interact with each other.
2. Interface agents: it can ask for guidance from other agents and user can also instruct interface agents.
3. Mobile agents: these are agents on the move.
4. Reactive agents: They response to an impulse which can be triggered events and are appropriate for handling sensor data.
5. Hybrid agents: it was the combinations of the above agents.

In future the latest version of JADE, JADE-LEAP v2.4 can be used to achieve better results and consistency than the existing architecture.

- **Communicating Agents in Open multi agent systems, by Terry R. Payne, Massimo Paolucci, Rahul Singh, and Katia Sycara (2002):** [95]

In this paper the author concentrated on the idea of how agents communicate with each other. In multi-agent system, agents often use the services of other agents to perform a desired task. To perform this, agents first have to locate the specific service provider agent and then communicate with it. To interact with a service provider, an agent requires: 1) the service provider agent's interface; 2) the ontology that defines concepts used by the provider agent; and 3) the agent communication language (ACL) [95]. Currently multi-agent system encodes the interface description and the ontology of a service provider, but assumes a common ACL between communicating agents. Many multi-agent systems achieve this through the use of a Middle Agent, such as the OAA Facilitator [96], the RETSINA Matchmaker [97] and the Info sleuth Broker [98]. Agents can be classified as service providers or service requesters, or both, depending on their role within the multi-agent system, or the context in which they are used. Agent Communication Languages (ACLs) such as KQML [99], FIPA [100], and emerging web service communication languages such as SOAP [101] propose the adoption of a common ACL for all agents. Some class of Middle Agents acting as Brokers or Facilitators [96,102] which maintains knowledge of both the capabilities and preferences of different agents and coordinate the communication between them. Another sub-class of Middle Agents was generally known as Matchmakers, Yellow Pages or Directory Agent systems [103, 104, 99, 105]. The matching process is done depending upon the capability description language (CDL) used. Infrastructures such as JINI [106] and UDDI [107] provide class-based or business- based lookup mechanisms to identify registered, distributed services.

Finally formal semantics and ontology specification languages such as the DARPA Agent Markup Language (DAML) [108] are emerging, which support semantic interoperation between agents. Concepts defined in DAML can be readily combined with message templates, thus increasing the flexibility of template based messages, and hence accessibility and interoperability of services within open environments.

- **Decision-making with Trust and Control in multi agent systems, by Chris Burnett, Timothy J. Norman and Katia Sycara (2010):** [112]

Here author argued that in these environments, it was difficult for agents to form a stable trust relationship which was essential for secure communications. Trust was considered as one of the major properties of open multi-agent system (MAS), where agents may be self interested, diverse and deceptive [110][111]. Here they find that agents also use controls to ease the risk in initial interactions. Here they consider three kinds of controls which can be used in the cases where trust is not sufficient. These three kinds of controls are:

1. Explicit incentives: The trustor creates a contract specifying the compensation (in terms of utility) that the trustee will receive, dependant on the outcome [109].
2. Monitoring: The trustor expends additional effort in order to observe the behavioural choices of the trustee [109].
3. Reputational Incentives: The trustor calculates the reputational gain (or damage) that a trustee will experience as a result of good (or bad) feedback being communicated to the society [109].

Here they have proposed a probabilistic trust evaluation model; where in case of risk a trustworthy partner was selected based upon decision-theoretic approach to the risk situation approaches in order to Support decision-making in multi-agent systems.

In future, an approach which aims to overcome the problem of building trust in dynamic environments

[112] [113] still need a base of communications to form generalization.

- **Autonomic Management for Multi-agent Systems, by Nadir K .Salih, Tianyi Zang, G.K .Viju and Abdelmotalib A. Mohamed (2011):** [114]

This paper proposed multi-agent system with autonomic characteristic that completely hides its complexity from users/services. To provide web based service to the users here they used Java Application Development Framework [115] as platform of this environment. The combination of multi agent support system it also provides the following properties like adaptability, intelligence, collaboration, goal oriented interactions, flexibility, mobility and persistence in software systems [114]. A new platform called Agent Oriented Programming (AOP) is implemented here. Being autonomous it can autonomously carry out complex, and often long-term, tasks [115]. A planner section is used to create multiple step scripts or sequences of actions necessary to achieve the high-level goals [116]. The agent design is done using FraMaS advanced behavior wrappers [117], where Agents was mobile. The limitations of multi-agent System were:

1. Individual agent has incomplete information or capabilities for solving the problem.
2. There is no system global control.
3. Data are decentralized, and
4. Computation is asynchronous [118].

So here they included the concept of Bean Generator which is a JADE supported tool that supports message content ontology's for creating agents. There are several languages like be XML, RDF, DAML-OIL, XMI, SQL or UML which was used to signify these ontologies [119]. They have used the jademx JADE add-on, which offers two major abilities: 1) to interface JADE agents with Java JMX (Java Management Extensions) and 2) to unit test JADE agents using JUnit. The construction of a jademx agent can be done programmatically or the XML [115]. They also used OMACS which was a meta model for agent systems. It enables the multi-agent system to autonomously reconfigure at runtime, which deals with unpredictable situations in a dynamic environment [120]. They also introduced MAGE, a powerful development environment for autonomous computing, which supports agent-based requirement analysis, design, development and deployment [121]. Here they mentioned JADE was implemented to provide programmers with the ready to-use and easy-to-customize facilities. They have suggested an agent-Web service that has the properties of both the agent technology and Web services technology and viewed as an independent multi-agent based support system.

- **Towards a canonical framework for designing agents to support healthcare organizations, by John Fox, David Glasspool, Sanjay Modgil, Pancho Tolchinksy, Liz Black and members of the ASPIC project (2006):** [122]

Here the author showed that although multi-agent system is giving promising outcome, but still the design and execution of the agents and their communications varied from one application to another, which has harmful hypothetical and technical consequences. The ASPIC project was subjected to realize the environment of agent systems and survey a standard agent architecture that was hypothetically organized and reused among several applications. The ASPIC project also supports the conclusion and management components of domino model, which includes added abilities to explore new ideas and learning for the improvement of medical diagnosis [122]. The aim of ASPIC project was to develop a software platform in which application developers can generate agents that utilize some properties that are essential for agents to work autonomously in health care organizations which includes the objective management, trouble management and development. The agent architecture that is being developed within the ASPIC project shows that the COGENT simulation package is being used to prototype the ASPIC agent, and initial versions of the CARREL and CREDO applications.

In future they expect the generalization of this agent model in terms of canonical signatures for its core computational functions which are universal to many agent architecture and technologies, as well as providing a theoretical aspect for designing and understand complex multi-agent system.

- **Use and Modeling of Multi-agent Systems in Medicine, by Maja Hadzic, Darshan S. Dillon and Tharam S. Dillon (2009):** [124]

In this paper they represent an ontology-based multi-agent system (MAS) specially planned to retrieve information from human diseases. The human disease ontology is classified into four ways**:** a) disease types, b) Symptoms, c) Causes and d) treatments. Here the MAS consist of four different types of agent:

1. Interface agent: It constructs Specific Human Disease Ontology (SHDO) templates from GHDO, which can be sent to the master and smart agent.
2. Manger agent: It allocates tasks to the different Information Agents.
3. Information agent: This agent retrieves the requested information from huge biomedical databases. And
4. Smart agent: It accumulates and study the information received from Information Agents and assembles the information based on the structure specified by the SHDO template.

Here they proposed an idea of Generic Human Disease Ontology (GHDO)-based multi-agent system, where the agents are sociable means they can be able to communicate with each other in order to cooperate and negotiate with respect to the information, knowledge and services. GHDO is used to develop the Specific Human Disease Ontology template (SHDO template). They used UML 2.1 to represent the social and goal oriented behavior of agent. They used a Composite Structure Diagram to represent the goal driven nature of an agent. The UML 2.1 Sequence Diagram is used to collect and represent the sociable behavior of agents. The different roles of an agent have been represented by the different ports which matched with the ports of the UML 2.1 Composite Structure Diagram.

- **An Ontology-Based Intelligent Agent System for Semantic Search in Medicine, by Jung-Jin Yang (2003):** [125]

Here the author illustrates an ontology based information retrieval agent system in medicine through Bio-related literature database specially MEDLINE. The task of interface agent system was to help patients by examine both existing medical ontology's and its own agent ontology to generate queries in order to get useful and suitable information. Here agent ontology was in the form of the Semantic Web languages. The Semantic Web community deals with these concerns by defining standard mark-up languages like RDF, RDF Schema, DAML+OIL, and OWL [126]. This paper describes the design and execution of a system called OnSSA (Ontology-based Semantic Search Agent) which uses the Semantic Web languages for the systematic recovery of literature in medicine. Here the system supports DAG (direct acyclic graph) based query models to match ranked output recovery with a query by the user. They also analyze the system with a simple query and a query with clinical query option in PubMed, a biomedical search engine and the Ontology part was implemented with DAML+OIL language and OilEd editor was used partly. In addition to the Semantic Web languages, the rest of work is done using Java. They examine both free-text search and MeSH terms for subject heading search separately with a simple query [127]. This task was closely related with another ontology based information retrieval system called MELISA (Medical Literature Search Agent) [128]. The advantage of this system was that, it advances the quality of information recovery and reduces the user's load in information search. Further they will attempt to help user by incorporate patient's profiles to provide related information through user's personal interests and genetic inheritances.

- **An Access Control Scheme for Multi-agent Systems over Multi-Domain Environments, by C. Martinez-Garcia, G. Navarro-Arribas, J. Borrell, and A.Martin-Campillo (2009):** [129]

In this paper they discussed about MedIGS (Medical Information Gathering System) [130], which was a multi-agent middleware for the medical data allocation between hospitals which enables the use of applications in multi-domain environment. Here a distributed access control for MedIGS was presented which proposes a solution with a Minimum impact in the local access control systems of the hospitals based on attribute conversion. MedIGS application had to develop a generic model based on Role-based Access Control (RBAC) [131]. The aim of MedIGS was to provide support for Virtual Electronic Patient Records (VEPR), which is the collection of all the medical documents referring to a given patient among several hospitals. Here they use MAS which is a collection of several types of agents:

a) Collector agents,
b) Document Broker Agent,
c) Remote Broker Agent, etc.

The main idea was to create an attribute mapping between the different domains, through which agents can be interoperable; means an agent working in a foreign domain can access to the local access control policies defined in the local domain. The MedIGS' access control system has two main parts:

1. First is the hospital's access control system, which is supposed to have at least a Policy Enforcement Point (PEP), a Policy Decision Point (PDP) and a set of access control policies (ACP).
2. Second was the MedIGS extension, which consists of an Attribute Management Service (AMS), the attribute conversion policies (Cp) and a local repository of certificates (Crep) [132].

Moreover, it has been described an access control system for the MedIGS scenario, and its integration analysis, which can be easily modified to any multi-agent system in a multi-domain environment.

- **A Multi-Agent Prototype System for Medical Diagnosis, by Qiao Yang and John S. Shieh (2008):** [133]

This paper proposed a model of multi-agent diagnosis helping system (MADHS), which consists of four different kinds of agents: Coordinator, Examiners, Specialists and Joint Decision Maker. This Proposed model is similar to the e-medicine system design presented by Tian and Tianfield [134]. The model and reasoning mechanisms were implemented using Java, Java Agent Development Framework (JADE), Java Expert System Shell (JESS) and NRC Fuzzy J Toolkit. Fuzziness and uncertainty have been integrated into the decision trees to form the reasoning mechanism of agents. JADE supports two Message Transport Protocols (MTPs): IIOP and HTTP. The inter-platform communication mainly

depends on the default settings of JADE i.e. HTTP. JADE has provided several useful tools to develop the multi-agent platform, including Directory Facilitator (DF), Agent Management System (AMS) and Remote Monitoring Agent (RMA) to create distributed Containers and Agents [135].

In Traditional Chinese Medicine (TCM) [136], concepts, terms, rules are often fuzzy; and the facts and conclusions are often uncertain. In order to encode the fuzzy sets, fuzzy rules and to perform fuzzy and uncertain inference, they proposed a fuzzy knowledge-based system MADHS which consists of knowledge representation method, Fuzzy Decision Tree. Here the Fuzzy Decision Tree combined with certainty factor calculation was proposed to deal with fuzziness and uncertainty and to deduce the diagnosis results. A prototype system of MADHS has been implemented according to the presented novel model.

- **An organisation-based Multi Agent System for medical emergency assistance, by Roberto Centeno, Moser Fagundes, Holger Billhardt, Sascha Ossowski, Juan Manuel Corchado, Vicente Julian and Alberto Fernandes. (2009):** [137]

In this paper they represented an application for a real-time Health scenario, the mobile medical emergency management in an urban area. The representation was implemented using the THOMAS approach to open multi-agent system (MAS) based on an executive metaphor. The THOMAS approach platform uses the idea of organization as a key abstraction to build multi-agent system in Real time environment. This approach it provides a way to build Service Oriented Multi-Agent Systems (SOMAS). It defines an abstract architecture, as well as a software platform, where agents interact according to norms and rules put forward by the organizational structure. Their system was based on real-world data provided by the Medical Emergency Service of the Region of Madrid (SUMMA112) [137]. This service handles the medical emergencies, including the transportation of patients to hospitals. A typical medical emergency assistance starts when a patient calls SUMMA112, Asking for assistance. The basic roles within medical emergency assistance processes are:

a) Patient: agents playing role patient represent potential users of medical emergency assistance.
b) Hospital: this role represents a hospital within the organization.
c) Ambulance: agents joining the organization with the role ambulance.
d) Emergency Coordinator: this agent was the main piece in the mHealth organization.

Now the web services used to implement the resources are the following:

a) Emergency Centre Finder: this service finds the responsible emergency co-ordinator for a given location.
b) Medical Record Store: it allows agents to store and retrieve patients' medical history information through the user name and password.
c) Ambulance Finder: This service was able to find an ambulance for a particular patient, taking into account information such as his position, his symptoms, etc.
d) Hospital Finder: The service was able to find a hospital taking into account the patient's position, his symptoms.

The main components of THOMAS approach are the following:

a) Service Facilitator (SF): this component provides simple and complex services to the active agents and organizations.[137]
b) Organization Manager Service (OMS): it was mainly responsible of the management of the organizations and their entities.
c) Platform Kernel (PK): it mainly allows agents to communicate with each other.

They developed their application as an application of the THOMAS abstract architecture, which openly supports MAS. Moreover, the THOMAS platform facilitates the addition of non active entities as web services, following a SOMAS approach. In order to show the system was dynamic, they have implemented a case study based on real data provided by the Madrid Medical Emergency Service SUMMA112.

In future they planned to work more on the dynamic nature of the architecture which decrease the response time and cost. And they also planned to increase the functionality of the application.

- **Virtual Medical Board a Distributed Bayesian Agent Based Approach, by Animesh Dutta, Sudipta Acharya, Aneesh Krishna and Swapan Bhattacharya (2012):** [139]

Here they proposed the idea of medical board in rural areas to provide a sophisticated medical facility. To form this kind of virtual medical board the based Multi-agent based distributed decision support system. Multi-agent system (MAS) based decision support system was a system where number of software agents takes a decision of a given problem collectively. An agent was a computer system or software that can act autonomously in any environment to achieve a purpose MAS. Also two or more agents can communicate or work together to perform a set of tasks or to satisfy a set of goals. Here number of software agents act as group of expert physicians forming medical board. In their system they characterize the knowledge base (KB) of expert agent in the form of Bayesian network. A Bayesian network or Bayes network or belief network was a probabilistic graphical model as medical diagnosis

was a probabilistic method so in our system we use Bayesian network to represent the knowledge base of each expert agent by specifying probabilistic relationships between diseases and symptoms [139].
Ontology [139] was useful for the suitable representation of domain knowledge .The domain specific Ontology contains some rules and methodologies which describe how to take a final decision by determine different problem and argument during group discussion of set a of decision maker. They also proposed an optimization function, minimization of which raises the final decision utility.

- **An Agent-Based Knowledge Discovery from Databases applied in Health Care Domain, by Souad Benomrane, Mounir Ben Ayed and Adel M.Alimi (2013):** [140]

The idea of Knowledge Discovery from Databases (KDD) was a complex, iterative and interactive process to discover knowledge from database. For its implementation, several modules should be developed like:

a) Module for data storage,
b) Module for processing data,
c) Data mining module,
d) Evaluation module,
e) Knowledge management module.

The objective of this paper was to recommend an idea that includes every module to an agent. These agents help the patient to make the most suitable decision by communicate with each other. In this way the process of KDD can be compare to multi-agent system. To prove their approach, they have applied a process of KDD for the fight against nosocomial infections within an intensive care unit (ICU) of a hospital. Technically, they have developed a software tool for decision making support in Java/XML through the agent platform Madkit [140]. The various stages of the KDD process were:

1. Problem formulation: identifying the objectives, defining the objectives and checking the needs.
2. Data retrieval: identifying the information and the sources, checking their quality and accessibility.
3. Data selection: choosing the data related to the requested analysis.
4. Data cleansing: detecting and correcting the inaccuracies and/or errors in the data.
5. Data transformation: formatting the data in preparation for the mining operation.
6. Data mining: applying one or more techniques such as neuronal networks, Bayesian networks or decision trees to extract interesting patterns.
7. Result evaluation: estimating the quality of the patterns extracted, interpreting the patterns' meaning. (8) Knowledge integration (putting the pattern or its results into the company's information system).

Here they represent the functional description of the system by an identification of the five dimensions proposed by A.E.I.O.U. approach. The five dimensions of multi-agent systems: 1) Agents, 2) Interactions, 3) Environment, 4) Organization, 5) User.
Here they discussed about 5 types of agents:

1) Data preparation agent (dpa): It combines three modules these are data selection, data cleansing and data transformation.
2) Data mining agent (da): These agents are applied in order to extract data patterns.
3) Evaluator agent (ea): These agents are applied in order to specify those patterns which represent knowledge based on some defined measures.
4) Coordinator Agent (ca): It was a broker that handles communication among the several agents using the suitable protocol.
5) Graphical Interface Agent (GIA): It allows the patients to analysis the new knowledge discovered by the agents and assign agents to discover new goals.

There are two main advantages of this paper, Firstly, a multi agent based KDD process with a rule agent for mining in medical databases and secondly, the application of the whole proposed model is based on medical databases. In future they proposed to develop an agent for every service in the hospital and select the best communication protocol and algorithm to resolve the local problems.

V. CONCLUSION

In this survey paper we have shown how multi-agent system (MAS) has been incorporated in medical domain to solve various medical diagnosis and related problems. Still there are some advantages and disadvantages of using MAS in medical domain. This survey paper aimed at providing the basic information and medical domain related work using multi-agent system. Here we have provided the review of different types of approach of multi-agent system in medical domain like application oriented paper survey, concept oriented paper survey etc. The future researchers in this field might get help from our survey paper as different varieties of papers are incorporated in this study. The agent based systems also have few disadvantages like, there does not exist any universally accepted health care ontology for generating and analysis of medical or health care information. So it would be hard to communicate between several systems developed in different areas. As sensitive medical information is transmitted between several agents so proper confidentiality measurement is to be done to secure the medical or health care information. Multi-agent system still lacks in implementing intelligent and autonomous agents for mobile devices, such as mobile phones and PDA's, which minimizes the wide use of agent based

systems to access information from anywhere, anytime. Despite these problems still Multi-agent system is an emerging field in medical or health care domain.

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