2021 5th International Conference on Information Systems and Computer Networks (ISCON)
GLA University, Mathura, India. Oct 22-23, 2021

Expert Decision Support System for Donor Identification Using Multi-Agent System

J. Dhiviya Rose
School of Computer Science, University of Petroleum and Energy Studies (UPES),
Bidholi, Dehradun. INDIA 248007. ORCID : 0000-0003-2933-4226
dhiviyanelson@gmail.com

. S. Christalin Nelson
School of Computer Science, University of Petroleum and Energy Studies (UPES),
Bidholi, Dehradun. INDIA *248007*.ORCID: 0000-0002-1526-6765
christalinnelson@gmail.com

Rohit Kaushik
Student, School of Engineering, University of Petroleum and Energy Studies (UPES),
Bidholi, Dehradun. INDIA 248007
kaushikrohit2001@gmail.com

2021 5th International Conference on Information Systems and Computer Networks (ISCON) | 978-1-6654-0341-2/21/$31.00 ©2021 IEEE | DOI: 10.1109/ISCON52037.2021.9702412

***Abstract*— Convalescent Plasma (CP) therapy is an efficient method in the treatment of COVID-19 patients who either have a weak immune system or who are early in their illness. The notable setback for the implementation of the CP therapy lies in understanding the availability and spatial distribution of plasma donors. A multi-agent-based expert system is proposed in this paper to identify a suitable plasma donor in a short span and also in an efficient manner. Moreover, the issues with blood banks are twofold in connection with uneven intra-state and interstate distribution and lacuna of necessary facilities like the Component Blood Separation Units (CBSU) and Apheresis. The proposed expert system would remove the barriers of non-uniform distribution of blood banks and facilities across the country, and will provide a suitable solution to overcome the pandemic using multi-agent systems if implemented systematically.**

Keywords*— *Multi-Agent Systems, Blood Bank, JADE

I. INTRODUCTION

The continual reduction in the cost of computing, network components, and the trend of automation and delegation of the task to the computer has initiated a lot of research innovation in the field of Artificial Intelligence. On this path, the intelligent agents invented with the merging concepts of AI and distributed computing advantages opened the path of Multi-Agent systems to achieve a coordinated job [1]. Wooldridge has defined software agents as an intelligent object that has features of autonomy and better ability to demonstrate the human interest [2]. The distributed computing features have enabled us to work with the goal of cooperating, coordinate, and negotiate to achieve and solve any problem toward's social awareness. Russell and Norvig identify each agent has to be identified with the parameters like Performance measures, Environment, Actuators, Sensors [3].

Software agents have programmed software objects capable of autonomous behaviors acting to achieve a specific goal. A multi-agent system (MAS) is a group of heterogeneous agent works cooperatively towards a common goal. [4] describes a multi-agent system (MAS) as a mannered collection of individual software agents that can interact and communicate with each other that holds its degree of independence, autonomy to make decisions with social ability. MAS systems work in an environment E, with a collection of agents A = {a1, a2,….. an} acting with specified rules that govern the interaction and targets individually. Reasonably, these agents collaborate to solve complex problems. The bundle of interacting intelligent agents provides some computational packages to achieve some degree of integrity and able to cooperate, compete, communicate, act flexibly, and manage control over their behavior with a range of their objectives.

As there are so many challenges that have hindered plasma donation due to the fear of COVID 19 among the patients, it will be good if the targeted audience capable of plasma donation is identified using some expert system and mentored. The various study claims that the blood banks are not uniformly distributed across the country and lacks in the facility also[5]. At this outset of a real need, a self-manageable and coordinated expert system was proposed and tested in this paper which can help the plasma donors' and the hospital to find the exact donor with ease. The proposed system detailed in this paper helps in the Identification of the Donor to the nearby locality using Multi-Agent System. Each patient who's cured is been pinned with the location by an agent and each hospital agent has a track of the count. A search agent finds the optimum solution of the list of the optimal donor as shown in figure 1.

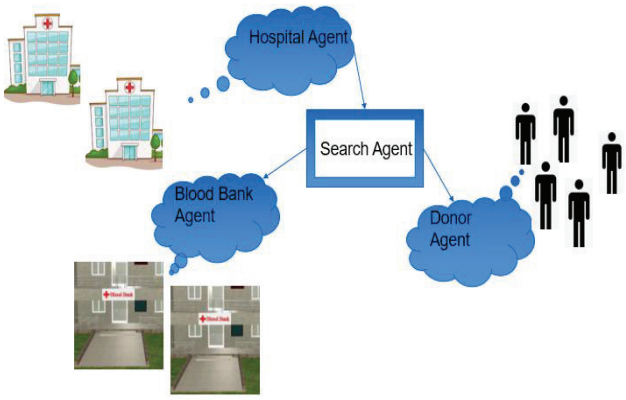

Fig. 1. Interaction of Agents in the proposed system

II. BACKGROUND STUDIES

MAS applies to various disciplines to identify and solve various dynamic changing environments. The property of an agent like autonomy, goal-oriented, social ability, and pro-activeness with the benefits of various implications like negotiation, bidding, compromising made the system more flexible and adaptable. The studies undergone in various application streams of MAS are as follows.

© IEEE 2022. This article is free to access and download, along with rights for full text and data mining, re-use and analysis.
Authorized licensed use limited to: R.M.K. Engineering College (An Autonomous Institution). Downloaded on August 30,2023 at 05:14:46 UTC from IEEE Xplore. Restrictions apply.

A. MAS in Industry Domain

In electrical engineering, MAS is applied for security monitoring, remote sensing, adaptive defense systems, power system restoration, and automation. The property of flexibility, robustness, and expandability connotes the ability of MAS to deal with the dynamic though situations accurately. Khan et. al. proposed a system where MAS is applied for power generation and the grid is formed in a decentralized effective adaptable way[4]. Management of electrical power generation and supervision in his model is managed with the help of MAS. In another research, the author develops a system for scheduling projects where MAS is used to solve the conflicts that arise due to resource shortages[6]. He claims agents as a robust technology to handle unforeseen demands and a perfect real-time large-scale decision-maker. Boudoudouh proposed a system where the distributed energy consumption is checked [7][8] and MAS has been an important element to meet the following requirements like heterogeneous environment having various capabilities and nature, intelligence and pro-activeness in decision-making, scalability by enhancing the components and Self-adaptive ness. Eddy et.al. depicts an intelligent energy market using MAS where the auction technologies were used[8]. The energy buyer and seller helps to perform the load balance attaining a price-driven demand scheduling. Zhou et.al. Discussed a shared scheduling environment for scheduling. An optimal schedule is generated in a coordinated and cooperative manner by the various agents in the system[6]. A constrained project scheduling algorithm using MAS where optimization techniques are used to find the proper schedule with some fitness functions and the scheduling is achieved [9].

B. MAS in Logistics Management

Pontevedra discusses how agents are used in a self-management manufacturing environment [10]. This system using MAS in automation demonstrates the metric of latency and network failure. Khayyat claims the use of agent technology in supply chain management has yielded to just-in-time and request, efficiency, and accuracy in the collaboration that takes place between various commodities in the logistics chain[11]. The social ability of the agent is controlled by the Game theory where both the buyer and seller are benefitted. Jabeur discusses a smart logistics system with an assurance related to the distribution of products to anytime anywhere customers [12]. The BDI property of the agents has proved to be the best in the area of logistics risk management and concurrent availability of the services. He addresses the risk as to the product of event occurrence and severity of the event in the overall business. He has identified the key components of smart logistics includes sensing, identification, localization, processing, and auction. McFarlane pointed the increase in supply chain logistics due to the challenges like uncertainty, efficiency, variability, and availability. Intelligent logistics has proved customer flexibility with compromised optimal feasibility[13].

C. MAS in Health care Domain

Currently, the health care industry is the main sector, which is adapting towards new technology to solve the day-to-day real-time needs. The greatest challenge faced by the healthcare industry includes all-time availability, the tradeoff between cost and services, waiting time of the patient, lack of scheduling the resources, etc. On discussing with the patient journey within the hospital lots of unlively organizational aspects play a very important role that has a direct impact on lively human emotions. Lee claims few issues like overcrowding, boarding and communications are the few barriers in some emergencies [14]. Due to a lack of proper management of organizational components, the healthcare domain has lost its value of care, concern, and trust on both sides of customers, the patients, and the services people in hospitals. The resources deal with the help utility function and auction mechanism of the MAS system. Agents are used to keeping track of resource availability and patient schedules. The coordinator agent has been designed with the task of preparing the plans. Reid has suggested a system, which has increased the independent lifestyle for the elderly by increasing their trust and reducing their stress and cost [15]. This discusses the usage of MAS towards telecare for patients by combining the wireless sensor network with body networks. Agents became a natural choice because of their capability to suit in a distributed environment well and they are capable of coordinating with each other, which works well in a dynamic environment. The social abilities of agents help to realize adaptiveness and dynamism by interacting with each other to reach their own goals has proposed a composite system where various components like pharmacy, laboratory, consultation services, ambulance, etc. are treated as the resources and various agents coordinated to form a minimal schedule [16].

III. System Architecture

The problem of interest in this paper is formulated by defining a set of autonomous heterogeneous agents interacting with each other to achieve the task. The responsibility of various agents is listed as follows with the coordination among them.

Hospital Agents: The environment has Hospital Agent (H1……Hi) will responsible for maintaining the details of patients who are hospitalized and keep track of the patient's mid-stage of the treatment of Covid-19. Each hospital system has a hospital agent running which will be responsible for the following

- Keep track of the patient history like the number of days the patient is admitted to the hospital, name, age, medical history
- Take the appropriate rank from the search agent which suits it.
- Take the plasma.
- Giving plasma therapy to the patient.
- Maintaining a record of the data of the patient (stage of covid-19, personal details), data from search agent(name and other necessary details of plasma donated either from plasma bank agent or from donor agent), and state of patient after giving plasma therapy.
- Provide a certificate of donation to the donor agent (i.e. date).
- Provide a certificate of recovery to the patient who is now recovered (i.e. date).

Authorized licensed use limited to: R.M.K. Engineering College (An Autonomous Institution). Downloaded on August 30,2023 at 05:14:46 UTC from IEEE Xplore. Restrictions apply.

Search Agent: The search agent's primary task is the identification of suitable donors. The search agent is responsible for

- Act according to the request made by the hospital agent to search nearby plasma available at a certain time.
- Processing on the data of the donor agent and bank agent who are eligible for donation (i.e. if plasma is there in stock of bank and if the donor is ready to donate).
- Calculate rank according to the best match found for a particular hospital to give plasma of recovered patients based on distance and expected time to deliver.
- If two or more hospitals request at the same time then calculating rank and giving the best match according to distance, expected time of delivery, and critical state of the patient(i.e. no. of days the patient is admitted).

Plasma Bank Agent: The Plasma Bank Agent (P1……..Pi) will responsible for maintaining stock and responsible for proper replacements and keeping its data (plasma stock, bank name) at the search agent database.

Donor Agents: The Donor Agent (D1-----Di) is a mobile agent that is generated by the hospital agent during the discharge of patients and keeps a record of recovered covid-19 patients like personal details, medical certificate of recovery from covid-19, and the date the patient is recovered. The various functionalities of these agents include

- Alerts them when they can donate the plasma (according to the date the patient is recovered, medical health) , they are ready to donate and keep their record in another database as eligible donors.
- Update regularly the data of eligible donors.
- Keeping this data in the search agent database.

IV. Experimentation and Results

For real-life scenario and testing the efficiency of the system, we think of the problem as a grid model where all the agents except search agent (within the hospitals) as randomly allocated on the grid to make it seems as practical. The agents were simulated using the Java-based agent development framework JADE for testing. The GUI model grid is used for the representation of the following Agents.H1---Hi of hospital agents, P1---Pi of Plasma bank agents, and D1---Di of Donor agents). The simulation platform in JADE as shown in figure 2 is constructed and found the time taken to find the optimal plasma donor is in milliseconds.

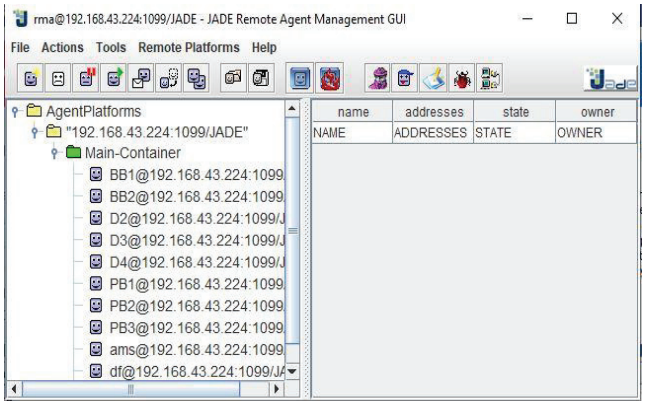

Fig. 2. Simulation in JADE

In this experimentation model, we have assumed that there are 4 hospital agents, 4 plasma bank agents, and 9 donor agents. For this every time this grid model will change for the testing of the system. The distance between the positions of different agents is calculated by the distance formula used in coordinate geometry. For example, H1 coordinates are 1,1 and P2 coordinates are 5,2 so the distance between the H1 and P2 is $\sqrt{(5-1)2 + (2-1)2} = \sqrt{17} = 4.12$ units, which in real life can be done using API maps. Rank will be calculated as distance+ expected time. The lower the rank higher the priority for selection. For example rank 7 will be given more priority than rank 10. For calculation of actual rank, the key parameter is no. days the patient is admitted in the hospital.

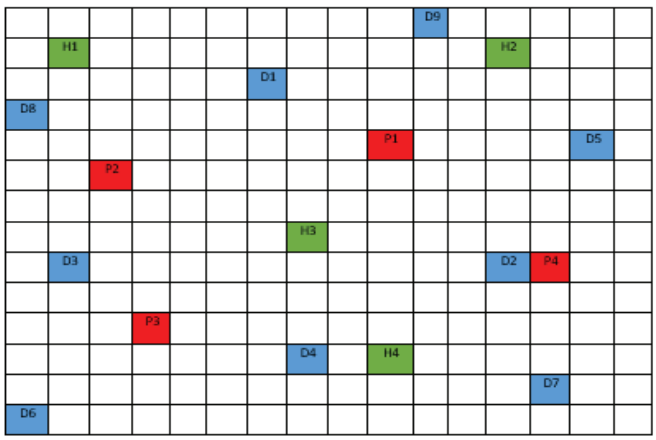

Fig. 3. Simulation Grid Output

Different functions name used for the experimental setup includes newS() for maintain the new stock,next() for next date management,CER() to issue certification date. The code like S for stock availability and R is used for R for ready to provide plasma in case of donor. The function calcrank() is used to calculate rank, rank() to give an actual rank by calculating the distance with geographical identification from the mobile app using the function time() and distance(). The treatment, plasma donation are maintained by the functions dplasma() and tdetail().The grid output simulated is shown in the figure 3.

Authorized licensed use limited to: R.M.K. Engineering College (An Autonomous Institution). Downloaded on August 30,2023 at 05:14:46 UTC from IEEE Xplore. Restrictions apply.

TABLE I. BDI SYSTEM FOR DIFFERENT AGENTS

Agent	Beliefs	Desire	Intention
Hospital	Hospital name [H1--Hi] Location(coordinates) [x,y] Contact info. [xxxxxxxxxx] o Patient Database [P1----Pi] containing o Condition of patient (eligible for p.therapy) [C] o Days the patient is admitted [xx] o Patient contact info. [xxxxxxxxxx] o Patient address [x1,y1] o Donor address(either bank or donor agent) based upon rank (for bank)[x2,y2], (for donor agent) [x3,y3]	Admit a patient Check to give plasma therapy or not Request to search agent for the list of nearby plasma donors Call the donors based upon the best rank it found o Give plasma therapy o Record treatment details(recovery or not) o Provide certificate(i.e. date) of recovery o Provide certificate(i.e. date) of donation o Maintaining record	o If C is Y tell search agent as your hospital name and location o Ask search agent to achieve calcrank() o Tell donor agent to achieve dplasma() o OR o Tell plasma bank agent to achieve dplasma() o Give treatment details tdetail() o Maintain record record() o Tell donor CER() DD,MM,YYYY]
Search	Source[other agents]: o Hospital name [H1----Hi] o Location[x,y] o Source[self]: o Bank name[P1---Pi] o Location[x2,y2] o Donor name[D1---Di] o Location[x3,y3]	o Find eligible donors (i.e. banks and donors agents) o Finding distance of all eligible donors form a particular hospital o Find estimated delivery time o Calculate rank o If the rank matches with other hospitals calculate actual rank	o Check eligibility of donors and process all other things on these only o Compute d() o Compute t() o Calculate calcrank() o Calculate arank()
Plasma Bank	o Bank name[P1--Pi] o Location[x2,y2] o Contact info. [xxxxxxxxxx] o Stock [S]	o Maintain stock o If donated plasma update stock	o Tell search agent about [S] status o If received CER() compute newS() o Calculate[S] according to newS()
Donor	o Donor name[D1---Di] o Location[x3,y3] o Contact info. [xxxxxxxxxx] o Ready to donate [R]	o If ready to donate or not o Calculate next time to donate [DD,MM,YYYY]if received a certificate from hospital o Check if both dates next time to donate and today's date match o And ask if ready or not	o Tell search agent about [R] status o If received CER() compute nxtd() o Check for date o Update [R] status

V. CONCLUSION

During this second wave of COVID pandemic, this proposed Expert Decision Support System for Donor Identification Using Multi-Agent System can help the patient and the hospitals to find optimal plasma donors in India. At this juncture, the proposed system can be a good solution to bridge the gaps of non-uniform distribution of blood banks and their facilities in various states across the country regions of urban and rural areas. This system will promote if extended to regularize the blood plasma bank distribution uniformly. The proposed system can be extended by applying various optimization algorithms for finding the more optimal donors in times of critical crisis.

REFERENCES

[1] A. Dorri, S. S. Kanhere, and R. Jurdak, "Multi-Agent Systems: A Survey," *IEEE Access*, vol. 6, no. April, pp. 28573–28593, 2018.

[2] M. Wooldridge, *An Introduction to MultiAgent Systems, 2nd Edition*. 2009.

[3] S. Russell and P. Norvig, *AI - A modern approach*. 2009.

[4] M. W. Khan, J. Wang, L. Xiong, and M. Ma, "Modelling and optimal management of distributed microgrid using multi-agent systems," *Sustain. Cities Soc.*, vol. 41, no. May, pp. 154–169, 2018.

[5] D. Rose, "Social Challenges and Opportunities in Blood Bank Distribution in India : A Literature Review," pp. 1–5.

[6] Y. Yawen Zhou and J. Liu, "A multi-agent genetic algorithm for multi-period emergency resource scheduling problems in an uncertain traffic network," in *2017 IEEE Congress on Evolutionary Computation (CEC)*, 2017, pp. 43–50.

[7] S. Boudoudouh and M. Maâroufi, "Multi agent system solution to microgrid implementation," *Sustain. Cities Soc.*, vol. 39, no. March, pp. 252–261, 2018.

[8] Y. S. Eddy, S. Xun, Y. S. F. Eddy, S. Member, H. B. Gooi, and S. Member, "Multi Agent System for Distributed Management of Microgrids," vol. 30, no. 1, pp. 24–34, 2014.

[9] X. Zheng and L. Wang, "A multi-agent optimization algorithm for resource constrained project scheduling problem," *Expert Syst.*

Authorized licensed use limited to: R.M.K. Engineering College (An Autonomous Institution). Downloaded on August 30,2023 at 05:14:46 UTC from IEEE Xplore. Restrictions apply.

Appl., vol. 42, no. 15–16, pp. 6039–6049, Sep. 2015.

[10] V. Pontevedra, "ScienceDirect ScienceDirect ScienceDirect ScienceDirect IMPlanner-MAS : A Multiagent System for Distributed IMPlanner-MAS : A Multiagent System for Distributed Manufacturing Process Planning Manufacturing Process Planning Costing models for capacity optim," *Procedia Manuf.*, vol. 26, pp. 1242–1254, 2018.

[11] M. Khayyat and A. Awasthi, "An Intelligent Multi-agent Based Model for Collaborative Logistics Systems," *Transp. Res. Procedia*, vol. 12, pp. 325–338, Jan. 2016.

[12] N. Jabeur, T. Al-Belushi, M. Mbarki, and H. Gharrad, "Toward Leveraging Smart Logistics Collaboration with a Multi-Agent System Based Solution," *Procedia Comput. Sci.*, vol. 109, pp. 672–679, Jan. 2017.

[13] D. McFarlane, V. Giannikas, and W. Lu, "Intelligent logistics: Involving the customer," *Comput. Ind.*, vol. 81, pp. 105–115, 2016.

[14] H. K. Lee, S. Member, J. Li, A. J. Musa, P. A. Bain, and K. Nelson, "Modeling and Analysis of Patient Transitions in Community Hospitals : A Systems Approach," pp. 1–14, 2017.

[15] M. Reid, "Multi-Agent System Applications in Healthcare: Current Technology and Future Roadmap," *Procedia Comput. Sci.*, vol. 52, pp. 252–261, Jan. 2015.

[16] H. Jemal, Z. Kechaou, M. Ben Ayed, and A. M. Alimi, "A Multi Agent System for Hospital Organization," *Int. J. Mach. Learn. Comput.*, vol. 5, no. 1, pp. 51–56, 2015.

Authorized licensed use limited to: R.M.K. Engineering College (An Autonomous Institution). Downloaded on August 30,2023 at 05:14:46 UTC from IEEE Xplore. Restrictions apply.