Transaction and Performance Analysis of Clinical Diagnosis System: A Novel Scheme using Multi Agent System

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ABSTRACT
Now days it is a true fact that the concept of telemedicine revolutionized the health-care paradigm to a great extent. But, still there were many other aspects which could be further improved to make the healthcare facility more enhanced and easy. Keeping this in mind, the concept of Multi Agent System (MAS) was introduced in the health care system later. In our previous research paper, we proposed Clinical Diagnosis System (CDS), an advanced scheme of agent-based healthcare and medical diagnosis system. Using the knowledge base and. collaborative as well as co-operative intelligent agents and residing on a multi-agent platform, that CDS provides a communicative task-sharing environment. In this paper we describe the CDS model first and then analyze the performance of each and every transaction of that model through Petri net modeling to show the multi-user collaborations in dynamic and distributed environment.

Keywords
Telemedicine, Multi Agent System, Clinical Diagnosis System, Knowledge base, Agent Transaction, Petri net.

1. INTRODUCTION
After the independence India has achieved excellence in science and technology and successes fully implemented them in diff erent domains in order to improve life of a common man. But we have not yet reached to a very satisfyable position in terms of accessibility in healthcare. Technological paucity and poor economic condition [1] are the major concern. Beside these issues a major portion of the population of our country resides in the remote areas [2], where proper health care and community medical services are almost beyond the reach of the people. The conventional medical and healthcare system cannot give them proper chance to get appropriate services. The problem is due to acute scarcity of medical practitioners as well as proper infrastructure. Keeping the healthcare problems in mind we have tried to give focus on that technical infrastructure development. Generally technical infrastructure means the practitioners, tools, medicines and modern technology based platform. After the manifestation of the concept"Tele-medicine" [3], it will revolutionize the health-care paradigm to a great extent. It is true that with the advancement of tele-medicine, many major problems of the prevailing system were removed. But, still there were many other aspects which could be further improved to make the health care facility more enhanced and easy. And Multi Agent System is considered as the best and most appropriate technology that can be used in the development of applications in healthcare paradigm where the presence of multiple agents, heterogeneous and loosely coupled components, the data management in a dynamic and distributed environment and multi-user collaborations are considered the most pertinent requirements for healthcare system. The idea of model based diagnosis[4] in MAS platform proved its utility in this context. In our previous work [5] we have proposed a new multi agent system (MAS) oriented intelligent diagnosis scheme called Clinical Diagnosis System or CDS. That very system can take care of the initial check up of the patient, do the treatment and generate the solution or report for the patient very easily. In this paper we have mentioned the working concept of CDS briefly and then we have analyzed the individual transactional performance of that CDS through petrinet modeling.

2. SIGNIFICANCE OF USING MAS
Now a days agent based system is one of the significant areas in the field of software engineering. Agent and multi agent system can be defined in many ways. As per Michael Wooldridge [6], an agent is a computer system that is capable of independent action on behalf of its user or owner. In other words, an agent can figure out for itself what it needs to do in order to satisfy its design objectives, rather than having to be told explicitly what to do at any given moment. And a multi agent system [7] is one that consists of a number of agents, which interact with one another, typically by exchanging messages through some computer network infrastructure. In the most general case, the agents in a multi agent system will be representing or acting on behalf of users or owners with very diff erent goals and motivations. In order to successfully interact, these agents will thus require the ability to cooperate, coordinate, and Prepare negotiate with each other, in much the same way that we cooperate, coordinate, and negotiate with other people in our society. Multi agent system can be formed with several autonomous entities (agent) which posses their own problem solving abilities to solve a complex problem.MAS expert system [8] can be chosen as the best alternative. Residing in diff erent sites those agents can join with others with a strong interdependence [9].In MAS the knowledge is also distributed in various locations and the problem in the domain may be decomposed in diff erent sub problems. If we analyze the

medical diagnosis and health care system, we can see that the knowledge is required for solving a problem is spatially distributed.For example, diagnosis of general diseases diff ers from eye, or cardiology section. Each specialist doctor uses their own knowledge to solve the problem. Tests are carried on to some diff erent location with the help of some diff erent set of knowledge. Giving solution to a particular case involves better coordination between diff erent individuals with their diff erent skills and functionalities. It is obvious that medical diagnosis system is a complex system and there is no straightway software engineering standardization. A multi agent based system may be a better approach at that place.

3. CORE CONCEPT OF CDS

In Clinical Diagnosis System [5], an agent called User Agent (UA) is responsible for taking the user inputs i.e. symptoms from the patients with the help of a user interface. The user interface helps the practitioner or any person engaged in taking the symptom to feed the input as measured form and observation. Duty of this UA is to take patient symptoms in the form of raw data. The UA takes the raw input, and to apply some analysis method upon those data with the help of Master Agent (MA) to convert it to knowledge. This analysis is done with the help of the user interface i.e. the patient symptom form. That knowledge is stored in the Global Knowledge base (GKB). Role of the Master Agent (MA) is to select a specialist doctor agent (SDA) for handling the particular case and handover the case to that specific specialist doctor agent (SDA). The MA has the responsibility to give the task and to provide the proper knowledge from the Global Knowledge base (GKB) to the specialist doctor agents. For each SDA, there is individual local knowledge bases (LKB) associated with them. After having the solution, SDA will give the solution to the Master Agent (MA) and that solution will be stored in the Solution knowledge base (SKB). A report agent will be responsible for generating the report after getting the final instruction from the master agent. For instance, if a patient will come with symptoms such as high fever with convulsion, headache and weakness etc, the person will take those symptoms with the help of the user interface i.e. the form. User agent will help the person to refine the queries. After getting the queries or symptoms in the measured way, those inputs will be converted to knowledge and will be kept to the Global knowledge base. That knowledge will tell the master agent that the symptoms are likely to be of malaria. Then on the basis of that knowledge, the master agent will select the proper doctor agent. MA will also help SDA to access the global knowledge base. That SDA will then give the proper solution. That solution will also be kept in the Local knowledge bases of each SDA. After getting the particular solution for a particular case, that solution will be stored in form of knowledge at a diff erent knowledge base called Solution knowledge base (SKB). A

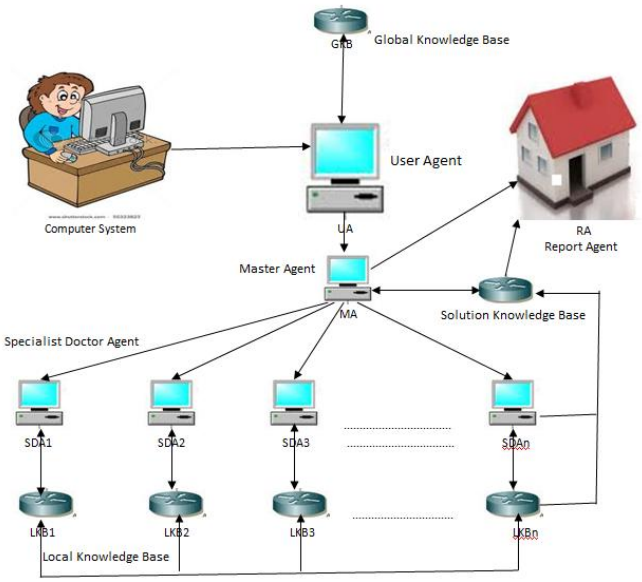

Fig.1 Proposed schematic diagram of the Clinical Diagnosis System (CDS)

Report Agent (RA) can access this know ledge base for generating report with the help of MA.

4. PETRI NET

In the field of multi agent system agent modeling is a very important task. To clarify the interaction as well as the transaction between agents we need an efficient modeling technique. We know that agents can be modeled using various techniques such as finite state automaton, Petri net modeling [10] etc. Petri net modeling is very much efficient to model concurrent processes. And in our CDS we can see many tasks are performed by a single agent at the same time. So we need to model parallel processes. Therefore we have followed Petri net modeling. In their research field failure handling in multi agent system, Varakantham, Gangwani and Karlapalem, three marvelous scientists have analyzed the petrinet modeling for multi agent system very efficiently [11]. In our paper we had taken the modeling assumptions and using the generic Petri net model we have tried to analyze each and every transaction of CDS. Actually petrinet is a graphical and mathematical formalism which is gaining popularity in recent years as a tool for the representation of complex logical interactions (like synchronization, sequentiality, concurrency and conflict) among physical components or activities in a system[10].As a graphical tool petrinets can be used as a visual communication aid similar to flow charts, block diagrams, networks. In addition tokens are used in these nets to simulate the dynamic and concurrent activities [12] of systems. As a mathematical tool, it is possible to set up state equations, algebraic equations and other mathematical model governing the behavior of the system [13]. Generally it consists of places (P), transitions (T), and some arcs. The arcs are used to connect P and T. Each and every transaction is done to change the place i.e.: the current position of the transactional state of the agent. Some tokens are also used to model the states.

5. ASSUMPTON AND TERMINOLOGY

To understand any Petri net model specially the generic Petri net model, we have to recall some basic terminologies of agents or some basic features of an agent like belief, desire, intension, task, capability, commitment etc. Belief means what an agent believes about itself and about its environment [11].Desire

means the willingness to complete the task. Intension is the grade in which the agent wants to end up the task. Task is the mentioned work to be done by an agent. It consists of a set of atomic actions. Commitment means the agent's obligations towards the environment and to itself [11]. In our work in this paper we had taken the generic Petri net model as a medium to analyze the tasks of our proposed Clinical Diagnosis System (CDS).Here we assume the transaction medium rather the communication medium of that multi agent system (CDS) is message. After getting the task or after getting the request to do a specific task the agent checks its own capability. And if it has the capability to do the requested task, it tries to meet the commitments received. Every message is composed of the following fields: Sending agent (SA), Receiving agent (RA), Message ID (MID), Response ID (RID), Action (ACT) and content (CNT) of the message.

6. GENERIC PETRI NET MODEL

In the Generic Model of an agent Fig. 1 Varakantham, Gangwani and Karlapalem tried to test all the event states of an multi agent system. In this model task isolation is an important feature. Each isolated task is divided into some transactions. And before starting the action to complete the task the agent must go through some specific predefined states. In this model an agent is initially in a waiting state (P0). That means waiting for some message. After receiving a message the agent goes to P1 state through transition T10. In P1 state it checks the response ID (RID). If this response ID is not equal to zero then it treats the message as a response message and through transition T2 it goes to the action place P5 directly. If the response ID is zero it means that this is a new message or a request message for performing a task. Then the agent goes to the place P2. In P2 the agent checks whether it has the capability to perform the task (or action) that it has received in the message. Checking the capability involves checking if the beliefs of the agent allow it to take up the task or not. If the agent does not have the capability it sends a negative response message to the sending agent and goes to the end place P7. If it has the capability, it moves to the place P3.This state is the commitment making state. Here the agent gives the acceptance of the commitment to the agent that sent the message and moves to the place P4. From P4 it goes to the action (necessary to perform the task for the commitment) place P5.In the model P5 is taken as a single place to avoid complexity. A variable

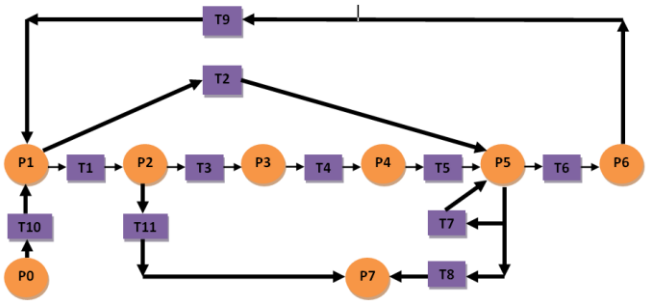

Fig.2 Generic Petrinet model

(ActionNum) is associated with the P5 indicating the action each is about to execute in the sub-task if more than one action can be performed in that place. The initial value of this variable is set to 0.Whenever the agent entersP5 state ActionNum is incremented. After completion of P5 the agent moves to the place P6.In P6 it transmits the message to the receiver. After the task is complete it goes to the end place P7.

7. TRANSACTION ANALYSIS OF CDS THROUGH GENERIC PETRINET MODEL

Using the above model we can easily describe the transactions made by each agent in CDS. In this context we will analyze the role of User Agent (UA) [14] first. At the very beginning the User Agent (UA) stays in P0 state. In this state it receives a message (m1) (from the computer interface agent or CI agent(we are here assuming that the interface is also an agent) and moves into P1 state through transition T10.In P1 state the UA checks the RID of the message (m1).If RID is not equal to zero then it seems to be an old message, means an old transaction and it goes to P5 state directly using T2 transition. If RID is equal to zero then T1 is activated and it moves into P1 state. In P2 the UA checks whether it has the capability to perform the ACT or not. If capability is negative then it sends a negative message to the computer interface (CI) and goes to the end place P7 through T11.If it is capable enough to do the task then it goes to P3 through T3.In P3 it gives the acceptance of the commitment to the CIA and moves into P4 through T4.After analyze the task (here clinical data) it moves to P5 through T5. As P5 is the action place the task is performed here. The variable Action Num is incremented here to make a count of total task. After completion of the task it moves into P6 and sends message to CIA through T6.In P5 one loop (T7) is there to execute recurrent tasks(if needed).In P6 it sends a message through T9 to the receiver agent and update the status of the just completed task at P1. Finally T8 transaction shifts the agent to the end place P7.In P7 it waits for new task again. Like the above concept the roll of MA, SDA and RA can be properly explained.

8. PERFORMAANCE TIME ANALYSIS OF CDS

The total performance of CDS depends on the participated agents performances. It is the summation of all individual performances of the CDS member agents. In this paper we have tried to analyze the performance of the CDS in aspect of time only. We have classified time T in five categories. They are Tw, Tmsg, Tchk, Tmo and Tact. The summation of all kind of time is assumed as the performance time or PT . Tw is the waiting time of an agent. Though it is not an active time (i.e. it does not affect the active computational time of the system) still we have considered this time as this is a mandatory metric to measure the performance of the system. Tmsg is the time required to transmit messages by the participated agents (we have already assumed that message is the communication medium of the system). Tchk is the time to check and analyze any massage or any state. Tmo is the movement time from one event to another event by an agent and Tact is the main computational time to solve the specified task of an agent.

TABLE I. STATE AND TRANSACTIONS OF GENERIC PETRI NET MODEL

P0: Waiting state.
P1: Received message.
P2: The message is a request for a task.
P3: Agent has the capability.
P4: Commitment accepted.
P5: The task sub-petrinet.
P6: Message handling.
P7: End place.
T1: If the message is a request for a task.
T2: Checking if this is a response to an earlier message.
T3: Check whether the agent has the capability for doing the task.
T4: Agent sends commitment accepted message.
T5: Starting the task.
T6: Want to send a message.
T7, T8: Execution of actions.
T9: Sending message.
T10: Receiving message.
T11: The agent does not have the capability to do the task.

TABLE II. PERFORMANCE TIME CALCULATION FOR UA

1. Waiting time in P0 = t_{w1}
2. Movement time for transition T10 = t_{mo1}
3. Checking and analyzing the RID of the massage m1 = t_{chk1}
4. Time for T2(If RID = 0) = t_{mo2}
Or,
Time for T1(If RID = 0) = t_{mo3}
5. Capability checking in P2 = t_{Chk1}
6. Time for T3 (if capability is positive) = t_{mo5}
Or,
a. Massage sending time to CIA (if capability is negative)=t_{msg1}
b. Time for T11 (if capability is negative) = t_{mo4}
7. Commitment massage sending time to CIA = t_{msg2}
8. Movement time for transition T4 = t_{mo6}
9. Movement time for transition T5 = t_{mo7}
10. Action time in P5 = t_{act1}[assuming no recurrent action is there]
11. Movement time for transition T6 = t_{mo8}
12. Movement time for transition T7 = t_{mo9}
13. Massage sending time to CIA T9(after completion) = t_{msg3}
14. Movement time for transition T8 = t_{mo10}
So the total performance time of UA $T_{UA} = t_{w1} + \sum_{1}^{10} t_{mo;i} + \sum_{1}^{2} t_{chk;i} + \sum_{1}^{3} t_{msg;i} + t_{act1}$
Hence we can have the total performance time $P_T = T_{UA} + T_{CIA} + T_{MA} + T_{SDA} + T_{RA}$

Here in this CDS we have introduced five types of agent (In the core concept module the details are discussed already).Excluding the Specialist Doctor Agents (SDA) the total numbers of participated agents in CDS are fixed. So the size of the MAS depends on the number of Specialist Doctor Agents. The total performance time is therefore the summation of the total time taken by CIA, UA, MA, SDA and RA. Here we have shown the detail time calculation of UA. The calculation technique is same for the rest individual member agents of CDS.

9. CONCLUSION AND FUTURE WORK

In this paper, we have analyzed the transaction based performance time of our proposed Clinical Diagnosis System (CDS) model. To reduce the complexity of this paper, we have taken time as the only parameter in case of performance analysis of CDS. But so many performance parameters are there which are very important to measure the performance of MAS. Like number of agents, occupied memory, dependencies etc. In future correspondence we shall try to cover up all for the proposed scheme.

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