

# Usage of Agent Technology for Distributed Medical Services Support

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**Abstract:** Typical health systems don't adequately address the complexities in the modern health context in an efficient manner. Necessarily dynamic and distributed nature of the health environment requires being adaptive to the changes taking newer decisions accordingly to co-evolve with the situation, which best would be enable using the common space provide in the Multi Agent Technology to build effective interaction among associated parties. Therefore this paper presents a better approach in delivering assistance for the health service seekers enabling enhanced accessibility to medical services streamlining the health care process adapting emerging technique of Multi Agent Technology which best would be deal with the complex nature of the health context enabling the self adaptation necessarily with the dynamically changing instances. Mainly system follows the message-request-resource-ontological model which comprises of three main agent modules respectively for the channeling, medical tests and pharmacy services which activates necessarily based on the incoming requests and derives necessary conclusions through effective communication, coordination and negotiation. Finally selecting suitable parties covering the health domain successful evaluation was carried out to access the level of success gained at the end.

## 1. INTRODUCTION

In recent years health care plays a vital role in each and every human beings' routine since effective management of health needs causes to increase the healthy long living and the wellness which has identified as a major theme for the next five to ten years which is based upon growing knowledge of the trends from a population health, health promotion and disease prevention perspective [7]. Modern health care environments become very complex and encompass a vast number of entities including doctors, patients, health centers that are characterized by shared, distributed and heterogeneous information sources requiring increased collaboration and coordination of activities in order to provide integrated care when and where needed [13]. In a developing country like Sri Lanka, there is high demand for increased accessibility of healthcare services due to inadequate service availability to cater the increasing demand. Any individual often have varying health needs while evolving with the time and needs are so dynamic and complex necessarily requiring adaptive to the changes taking newer decisions accordingly to co-evolve with the changes. As well context itself has causes to lot of uncertainties interconnecting ubiquitous health resources distributed around individuals increasing the complexity of accessing

to health services in an effective manner [14]. Hence there is a necessity of addressing the issue of offering medical services support, since current approaches made in the domain do not adequately provide the services that generally required by health care professionals for better decision making and for the patients themselves in accomplishing their health needs in an easy, efficient manner effectively utilizing their own valuable time.

So since everyone has to play the role of patient in the life span, Smart-Health, Distributed Medical Services Support System is to provide an easy, effective, interactive mean to assist humans in meeting their health needs on selected health services while assembling the scattered health records to enhance the efficiency of medical services offered to individuals enhancing entire medical decision making process utilizing human time effectively with the use of emerging Agent Technology. There are number of dynamic health needs that an individual encounters in their day to day life since no one exists in the world without falling ill. So Smart-Health is designing to provide assistance only in selected health services including health personnel channeling, health personnel, center finding and medical purchasing which can be further expanded to all dynamic health needs.

The rest of the paper organizes as follows. In section two depicts the current state of the medical services while section three details about the technology adapted in Smart-Health. Multi Agent Technology based medical assistance system's design view is presented in the section four while how the design converted in to a successful solution is detailed in the section five, implementation section. Finally the Evaluation and Conclusion of the solution is presented respectively in coming six and seven.

## 2. CURRENT STATE OF THE MEDICAL SERVICES

Nowadays, with the explosive growth of health needs of human beings most of the research focuses have gone towards in health context in finding best ways of delivering quality health services to individuals increasing efficiency in the health care processes and practices. As a result of that in recent years, the dramatic increase in the use of information technology for healthcare has resulted in much innovative research on e-Health applications [9] and some of the related efforts details below.

### 2.1 HeCaSe

As a better agent based approach which allows modeling real entities in the medical domain, HeCase [5] has developed as a prototype solution in finding better means of delivering healthy services. HeCaSe is an agent-based system that provides medical services to its users especially to the citizens or the visitors of a city. This multi-agent system contains agents that have information about the medical centers, departments and doctors of a region. According to the designed architecture there are numbers of agents to offer the requested service in the region including *Personal Agent (PA)* to provide graphical user interface to the user, *Broker Agent (BA)* to provide gateway between personal agents and other agents. As an agent based approach this system tries to improve the quality of life in the citizens.

## 2.2 MPAEX

This is a dynamic and distributed approach to the hospital patient scheduling problem, in which patients can have multiple appointments that have to be scheduled to different resources. MPAEX [12] is targeting at achieving efficiency in hospital environment with Effective scheduling algorithms that causes to decrease waiting-lists significantly, while increasing hospital efficiency Problems in typical health cycle that any patient moves along has been taken in to the consideration in coming up with a better approach for the problem.

As Fig.1 shows in this approach any patient walking into a doctor's office becomes part of the "health care cycle": if a medical problem is suspected, a number of actions will be scheduled to diagnose the exact nature of the problem and/or a treatment plan is scheduled. Central in the health care cycle is the doctor treating the patient: the doctor first requests diagnostics or treatments, and upon completion, the results and patient return to the doctor. In the consult, the doctor then decides what activities must take place next.

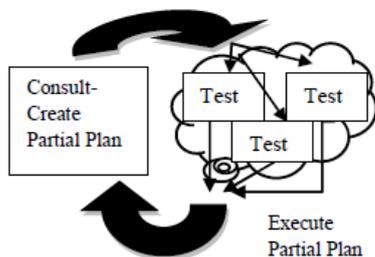


Fig. 1: Partial typical health cycle

## 2.3 Hospital patient scheduling. By Paulussen et al.

This is a Multi agent system (MAS) prototype which has been developed for hospital patient scheduling [3]. Since this is an agent based approach patients and ancillary units

represents as patient agents and resource agents. Due to the scarcity of resources in the market place there are set of patient agents compete for treatment appointment. To deal with increasing demands resource agents auction off the time slots corresponding to their capacity and time slots are assigned to the patient agent with the highest bid whenever a resource gets free. Each individual patient agent assesses the benefit of a treatment as the price, it is willing to pay for it and the running rationality behind this is that patient agent who gains the highest utility from a specific time slot is willing to pay the highest price for it. The priority of the patients is determined by their health conditions and health state dependant cost functions use to specify individual worth of patient agents. The implementation of the prototype has been carried as a layered approach which comprises of three main layers namely coordination, hospital and infrastructure layer

## 2.4 Merits of Smart-Health

According to the carried out literature survey it is possible to identify that most of the researches have undertaken in the domain with the usage of various Artificial Intelligence techniques. Though the scenario is like that there are demerits too which the Smart-Health is attempting to overcome. Though there are varieties of health services that individuals require no such system has taken integrated effort to deliver assistance to the users to cover much of those user needs and instead those have attempted in one particular health problem. MPAEX, HeCaSe reveals that fact in the better manner.

Smart-Health is making advanced effort than identified researches because this takes an integrated approach to cover increased number of health needs of users to deliver increased assistance to many health issues via a single interactive application make users satisfy their needs in an effective way. This enable users to satisfy health needs of medical physician channeling through better management of waiting lists and times improving the scheduling and efficiency of available resources , taking medical tests from best service offering health center through maximizing use of scarce resources, medicine purchasing through easy means by reducing unnecessary costs and time which people typically incurred in wandering around the health cycles.

## 3 TECHNOLOGY BEHIND SMART-HEALTH

Any Successful invention is backed by successful technologies to make the invention a worth effective one. So this section details about the technological adaptation in Smart-Health to deliver successful health assistance to human beings which is essential in the today's context

### 3.1 Agent Technology

Agent Technology, especially the Multi Agent Technology plays a vital role in Smart-Health since health context provides a better instance of complex environment

as emphasized in the Pregogine's complexity science. In simpler terms an agent [16] is a software program that works for the master activating and deactivating which necessarily, disappearing when the job is over causing for effective resource consumption and can possess some of the human capabilities such as intelligence, autonomy, reactivity, and pro-activity. Further the agent has to use reasoning to achieve its goals and build interactions with environment to learn from the environment. Agent has sensors to perceive its environment and actuators to act on it as shown in fig 2. With that interaction reasoning process is taken place in emerging intelligence required to solve complex problems [6].

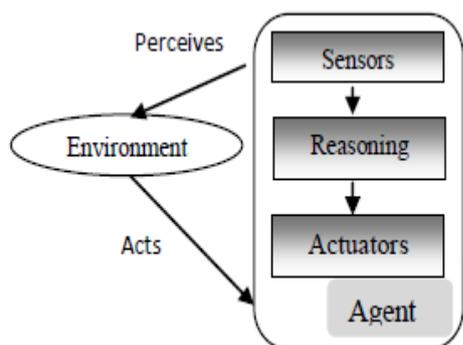


Fig. 2: Agents interaction with environment through actuators and sensors

Health care context is so complex, uncertain and distributed because there are number of interconnected entities like doctors, patients, health centers which needed to be interacted in a dynamic fashion in achieving the assigned tasks [4]. As well the environment is itself dynamic and unpredictable where entities need to co-evolve with the dynamic nature of the environment to achieve efficient health care process with increased coordination and communication for effective involvement with the changes. With the scarcity of healthcare resources has created a complex instance where multiple requests for the same resource and multiple resource variations to satisfy a single request which can be derive potential solutions through agent technology that couldn't be solved otherwise. Agent technology provides a novel and well suited approach in the development of integrated health care systems mainly because its characteristics are well suited in the development of such systems and it is ideal for devising a solution for such a complex environment.

### 3.2 Web Technology

Since user interaction is highly required in health care applications to get the precise requirements of users web technologies assist in coming up with interactive mean of building user interactions. Developments carry using the software .Net Framework 3.5 which is a very newer innovative web development technology. Apart from that

there is a dramatic improvement in speed for AJAX-enabled websites. AJAX [18] which stands for Asynchronous Java script And XML enables to build highly responsive and interactive web applications by doing more in the browser. AJAX gains its popularity by allowing data on a page to be dynamically updated without having to make the browser reload the page. So to deliver maximum user friendliness to users adopt AJAX technique along with web development techniques as a mean of getting higher interaction between users and the system.

### 3.4 Ontology

Any system requires domain knowledge or task related knowledge to perform the relevant tasks especially in the agent based system. Ontology [19] plays the key role in representing knowledge and that typically carries knowledge in terms of set of concepts within a domain and the relationships between those concepts. Ontology can be disguise in variety of ways either as an XML file, Database or simply a text file. In the case of health domain in make agents workable need to provide the domain knowledge to carry out the necessary operations. For instance to diagnose a disease need domain knowledge on which symptoms cause to which disease and to make appointments for a particular doctor need the knowledge on which places doctor offers the service and in which duration and on which days. So all those required knowledge is presented using ontology. With the ease of use in XML in ontology implementation, XML [20] and databases become parts of ontology to deal with the purpose of modeling knowledge as ontology, in the Smart-Health.

## 4 DESIGN OF SMART-HEALTH

Smart-Health is a web application aiming at delivering user assistance in satisfying their health needs via an interactive, effective mean since easy accessibility to health services at single location has become an emergent need in the modern health context with the explosive expansion of the health context. Since lack of efficient mean of obtaining health services to satisfy health needs Smart-Health presents a better approach to enhance individuals' health decision making process via an interactive, time effective pathway of health service assistance.

For the design and implementation simplicity overall system has been designed as a composition of set of modules which can be implemented independently. Basically on the top level view there are three core modules namely Agent Modules, Web Interface Module and the ontology module. Agent Modules plays the vital role in this system since the system is an agent based system which designed as a swarm of agents which communicate with each other to derive the conclusions for the certain health situations.

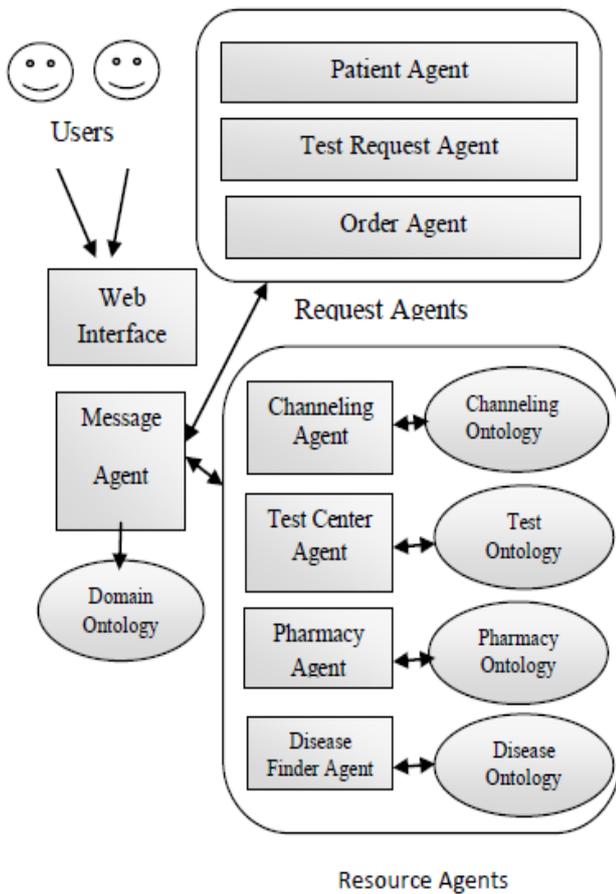


Fig 3: Top level Agent Architecture

#### 4.1 Agent Module

Agents play the key role in the Smart-Health in providing user assistance in medical services via an interactive mean. Since web module plays in the front end agent modules plays vital role in the backend. Within this module, follows the concept of request-resource-message space concept and has identified set of request agents separately who make the requests and set of resource agents that are capable of making offers for the received requests. As the top level agent architecture on fig. 3 illustrates, channeling, medical test, pharmacy agents acts as the resource agents while patient, test request and order agents acts as the request agents. Mainly Agent Modules can be categorized in to three main sub modules namely channeling, medical test and pharmacy module.

##### Channeling Module

This is one of main modules of Smart-Health application which aims at providing assistance for the individuals in channeling medical personnel. This is an important module because each individual require interaction with physicians in their day to day life for various kind of diseases and they have limited options of channeling them because busy routines of medical personnel have limited

time to serve to their patients since there are number of patients looking for the same service at the same moment. This module enables user to find disease based on the symptom if the disease is unknown, Find doctors who are capable of handling the disease of the user, Find where particular personnel offer the service, Make online appointments for the selected doctor to satisfy user's health need & Drop already taken ones, etc. At the doctors' side doctors' can enter consultation information at the consultation time referring to the complete health log maintaining and can recommend test, issue prescriptions where patients can perceive those through their own health profile. As well when the user dissatisfied with the suggested physician s/he can reject the suggestion for a new decision and by the way adapted solutions derive to satisfy the changing user needs.

Though top level view illustrates as a simple module inside view of channeling module as in the fig 4., and it follows multiple requests multiple resources instance because there are two main scenarios, where multiple requests (patients) to channel the same doctor at the same time and multiple resources (doctors) to offer the same service at the same time.

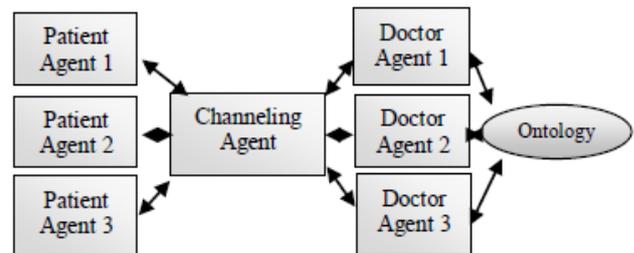


Fig 4: Agent Interaction of Channeling Module

##### Medical Test Module

There are number of medical tests to be performed in the case of confirmation of disease and to lead to effective treatment process. Hence this module aims at providing user assistance on issues related to the accessibility of medical test finding most efficient path way.

This module enables users to, Find medical centers which can be performed the assigned medical test, Get best center which can satisfy the user health issue, Make available the test reports for the evaluation in users health profile notifying users at the generated time of the reports indicating the disease status and At the medical test personnel's side can generate reports based on the specimens collected while getting the disease conditions appeared in the reports. Meanwhile whenever a physician recommends a test user is notified with that giving best medical test center suggestions to make user life easier. Like in channeling this also follows multiple requests-multiple resources model in dealing with the tests.

### Pharmacy Module

Whenever user consults a doctor typical case is where user gets a prescription with the required medicine to take for the minimizing impact of the disease. So user has a requirement of purchasing the assigned medicines because they know the wellness of their life increases only if they adhere to the instructions. So this module deals with that health issue of users by providing assistance in purchasing medicines either with the prescription or not because there are cases people looking for medicines like thyroxin for the identified lifetime disease even without prescriptions. This module enables users to, Find pharmacies which provide the required medicines with available quantities, Find the best matching pharmacy that can cater the need, Make online purchasing of the required medicines from the identified pharmacy, Get typical information like where a particular pharmacy is located at. As well, whenever physician issues a prescription that notification sends to the user along with the best available pharmacy which user can purchase the prescribed medicines. Like in channeling this also follows multiple requests-multiple resources model in dealing with the pharmacy handling.

#### 4.2 Web Interface Module

Web interface module is the module which makes interactions with users in acquiring user requests and delivers the best services to satisfy the requested health need. This is designed in a manner users can express their health needs and build interactions in an easy means without taking much effort. Really easily understandable web design has carried out to make user task easier and effective achievement of health needs in an easy mean.

#### 4.3 Ontology

Entire knowledge representation need is achieved via this Ontology module and plays a key role in the Smart-Health because system fails to perform as required without this module. Since medical context is a complex area basically has designed domain ontology to include medical domain information in a structured manner including diseases, symptoms, typical therapies, treatments, medical tests, general ranges, risks, etc. That is accessible to all agents and designed in a manner agents can access to domain ontology when necessarily. Additionally for the special tasks performance task based private ontology has been designed to enhance the success of the tasks performance. For instance for channeling purpose has designed individual ontology including information related to process and manage user requests for appointments and to manage health personnel information that cater the user requests. For other tasks like pharmacy management, medical test management too has designed separate ontology to structured, meaningful management of information respectively information related to available pharmacies, medicines available in those pharmacies and laboratories available, medical tests facilities available in those laboratories.

## 5 IMPLEMENTATION OF SMART-HEALTH

Since system mainly comprises of web interface module, agent modules and ontology module implementation follows the three tiered architecture due to the increased flexibility and maintainability achievable by the usage. Typical three tiered architecture has illustrated in the below fig 5. In the layered architecture implementation carries in three main levels.

1. Presentation Layer (Web Interface Module)
2. Business Logic Layer (Agent Modules)
3. Data Access Layer (Ontology Module)

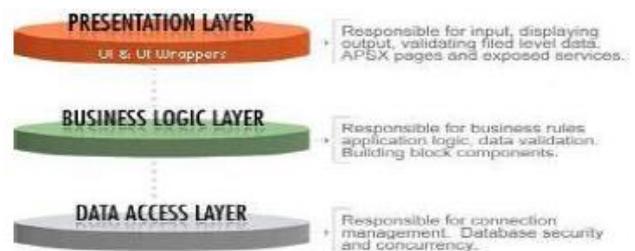


Fig 5: Three Tiered Architecture

#### 5.1 Presentation Layer –Web Interface Module

This is the front end layer which is comparable with the web interface module. This is the top most layer in the layered architecture. Implementation of the web interface module is carried out using .Net Framework to come up with interactive web interfaces to interact users to get precise health requirements and to deliver better assistance to them. Visual Studio 2008 Integrated Development Environment uses to develop the web interfaces.

#### 5.2 Business Logic Layer- Agent Modules

This is the middle tier of the three tiered architecture and deals with entire processing logic of the system. This is comparable with the Agent Modules of the system because entire processing logic is carried out through the communication takes place among set of agents. Agent Implementation including all the resource, request agents and message agent is carrying out using the Boris.net utility since that is compatible with .Net framework. Since the tasks that each agent has to perform different from each other internal processing of each agent has implemented separately. Communication, coordination, negotiation all aspects are implemented in to agents using that agent toolkit and C# uses to carry other necessary processing logic. Different set of interaction process carries in different agent modules to meet the specified needs through communication passing among agents via a common message space shared and through coordination self adaptation ensures with the dynamic nature.

### 5.3 Data Access Layer –Ontology Module

Though this is in the lowest level in the layered architecture, plays a key role in managing all the data sources acting as the knowledge base to perform the necessary processes. This is comparable with Ontology module and implementation is carrying out mainly using the XML. Since XML is extensible it facilitates the creation of custom structures which is efficient in the application and due to the complexity of the context ontology also become a complex one hence that needed to cover various aspects required in various kinds of needs.

## 6 EVALUATION OF SMART-HEALTH

Any system's success/failure is identifiable through proper evaluation mechanism so better evaluation plan was carried out in Smart-Health to assess the level of success gained. Initially since implementation followed modular approach Unit Testing along with Functionality Testing was conducted to get the unit level testing. In there each individual module including web module, agent module were tested for the expected functionality. After ensuring individual components functioning well Integration Testing was carried out to check how well the modules functioning after the integration. At the final level fully system testing plan has designed using basically two user groups. One user group is the patient category who is looking for the service and the other party is the personnel which actually being in the health field (e.g. Doctors, laboratory personnel, pharmacists). From the personnel in the field get the level of accuracy of the results generated, for instance level of accuracy in getting the disease based on the symptoms, level of accuracy in finding the disease status in a report. From the patient category that doesn't being in the field use to assess the accuracy of the results, suggestions that presents to them and how much efficiency has gained through the integrated medical service delivery.

## 7 CONCLUSION & FURTHER WORK

In recent years health care plays a vital role in each and every human beings routine since effective management of health needs causes to increase the healthy long living and the accomplishment has become crucial as everyone has to play the role of patient at least a day in the life span. Hence, there is a necessity of addressing the issue of offering medical services support, since current approaches made in the domain do not adequately provide the services that generally required by health care professionals for better decision making and for the patients themselves in accomplishing their health needs in an easy, efficient manner effectively utilizing their own valuable time. This paper has addressed the underlying need through a web based solution which adapted the Agent Technology which best fits with the dynamic,

distributed, uncertain environment presents in the health context in deriving successful conclusions, outcomes through effective coordination, communication and negotiation effectively being adaptive to the dynamic nature to co-evolve with the changes. Through the evaluation it indicates that that the solution has reached a success which can be further expanded to cover all varieties of the individual health needs enabling health service seekers obtain better pathway for the health need accomplishment integrating all the health parties to streamline the overall health care process enhancing the overall significance of the solution.

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