2.1 Introduction

Health or Medical Informatics is the "scientific field that deals with biomedical information, data, and knowledge - their storage, retrieval, and optimal use for problem solving and decision making. It covers almost all areas of basic and applied fields in medical science using modern information technologies notably in the areas of computing and communication (medical computer science)" [Stanford Medical Informatics]. [HCG]

"Information management constitutes a major activity of the health care professional. Medical informatics is the field that concerns itself with the cognitive, information processing and communication tasks of medical practice, education and research including the information science and technology to support these tasks. This is an intrinsically interdisciplinary field with highly applied focus and it also addresses a number of fundamental research problems, planning and policy issues. After many years spent for the development to support the infrastructure of medicine using information system, a new generation systems and tools are developed for physicians and other health care managers and professionals - to support education, decision making, communication and may other aspects of professional activity. [HCH]

In healthcare domain several researches have been made and still there is ample scope of research work. But at some point there is a gap between good infrastructure setup at hospital level and actual working of hospital system, which efficiently tracks all activities carried out at hospital premises like to track records of patient, conversation between patient and doctor, administrative control etc.

Multi Agent system is growing rapidly and it attracts more researchers for research. Healthcare is one of the domains which can take gain of agents. Multi agent systems are suitable for developing healthcare
applications where the use of loosely coupled and heterogeneous components, the dynamic and distributed management of data and the remote collaboration between various users is considered as relevant requirements. [LSA]

Apart from agent technology ontology is also popular in computing community. Ontology along with agent technology plays a vital role for developing applications for healthcare. Healthcare domain is one of the domain where consistent data, maintenance of large volume of data, manipulation of data are required. Ontology is useful for managing consistency between various environments. It is also helpful for building the knowledge base by defining various classes and its properties and dependency. Later on this knowledge base can also be useful for data mining purpose.

2.2 Multi Agent Systems for Health Care

Many documents, specifications, procedures and research materials are surveyed which are readily available in electronic libraries. For carrying out research several systems have been studied based on multi agents and ontology for health care domain. Multi agent system is very useful for developing next generation healthcare services. The following list shows the various multi agent systems with its brief overview which have been developed and used in health care industry. [LSA]

2.2.1 Assistive Living Applications [LSA, LSK, LSL, LSJ]

The integration of smart-home automation is an essential aspect of assisted living for the elderly or for impaired people. Elderly people tend to suffer from at least one chronic disease which requires telemonitoring. Additional age impairments makes difficult of independent living at home and therefore assistance for daily activities
is required. Moreover, the additional context information provided by a smart-home environment enhances a better interpretation of physiological sensor information e.g. whether the patient is running or sleeping has significant influence on the blood pressure. Multi-agent systems are the common denominator of the kinds of use which discussed above and is the reason to believe that they are a key factor for the coherent and successful development of assistive living applications.

2.2.2 CASIS [LSA, LSC]

CASIS is an event-driven service-oriented and multi-agent system framework whose goal is to provide context-aware healthcare services to the elderly resident in the intelligent space. CASIS framework allows remote caretakers such as concerned family members and healthcare providers to closely monitor and attend to the elder's physical and mental well-beings anytime, anywhere. The smart environment interacts with the elder through a wide variety of appliances for data gathering and information presentation. The environment traces the location and specific activities of the elder through sensors such as pressure-sensitive floors, cameras, bio-sensors and smart furniture.

The elder receives multimedia messages or content through TV, mobile devices and speakers. The caregivers may access the elder's health and dietary information through any Web enable device like a Personal Computer (PC) or Personal Device Assistant (PDA). Context-aware computing enables the environment to respond at the right time and the right place to the elder's needs, based data collected. The environment is further equipped with integrated control for convenience, comfort and safety. CASIS is able to inform the status of the elder and performs appropriate actions. For example, upon sensing that the elder has fallen asleep it turns off the TV and switch
telephone into voice mail mode and it plays back all incoming messages when the elder wakes up.

2.2.3 K4CARE [LSA, LSD]

K4CARE is a research project whose main objective was to combine healthcare and ICT experiences coming from several western and eastern European countries to create, implement and validate a knowledge-based healthcare model for the professional assistance to senior patients at home. The main step of the project was to develop a healthcare model to guide the realization of an integrated system of healthcare services for the care of the elderly, disabled persons and patients with chronic diseases.

The interaction between health professionals, computer scientists, technology centers and SMEs has been crucial to define the model and providing detailed information about the selected prototype services. The K4CARE model provides a paradigm easily adoptable in all European countries being all the proposed structures filtered according to national laws.

2.2.4 IHKA [LSA, LSF]

It is a healthcare knowledge procurement system based on the use of multi-agent technologies. This system is based on six different agent types. These types are the user interface agent, an agent to convert the search result into a viable format for passing to the UI agent, a query optimizing agent which optimizes the query, the knowledge retrieval agent that performs the query, the knowledge adaptation agent to adapt the knowledge to the current circumstances and the knowledge procurement agent which if all else fails searches the web for the knowledge. IHKA features autonomous knowledge gathering, filtering, adaptation and acquisition from some healthcare
enterprise/organizational memories with the goal of providing assistance to non-expert healthcare practitioners.

2.2.5 OHDS [LSA, LSE]

It is a system that supports the doctors in the diagnostic, treatment and supervision processes of the evolution of new epidemics based on the exploration of all data pertinent to each case and on the scientific data contained in various professional databases. OHDS combines the advantages of the holonic paradigm with multi-agent system technology and ontology design for the organization of unstructured biomedical research into structured disease information. Ontologies are used as 'brain' for the holonic diagnostic system to enhance its ability to structure information in a meaningful way and share information fast. A fuzzy mechanism ruled by intelligent agents is used for integrating dispersed heterogeneous knowledge available on the web and for automatically structuring the information in the adequate ontology template.

2.2.6 HealthAgents [LSA, LSG, LSF]

It is a research project with the goal of improving the classification of brain tumors through multi-agent decision support over a secure and distributed network of local databases. Health Agents does not only develop new pattern recognition methods for distributed classification and analysis of in vivo MRS and ex vivo/in vitro HRMAS and DNA data but it also defines a method to assess the quality and usability of a new candidate local database containing a set of new cases, based on a compatibility score. Using its multi-agent architecture, Health Agents applies cutting-edge agent technology to the biomedical field and it provides an infrastructure for the so called Health Agents network, a globally distributed information and knowledge repository for brain tumor diagnosis and prognosis.
2.2.7 AID-N [LSA, LSH]

It is a light-weight wireless medical system for triage. The overall goal of the AID-N electronic triage system is to efficiently gather and distribute information on the vital signs and locations of patients in an extremely fault tolerant manner. Typically, monitoring systems like AID-N consist of (i) a central server that medical doctors use to verify the overall conditions of patients and (ii) portable clients—one for each patient—that patients use to send information about their condition. Such instruments delegate to the patient the task of providing relevant data obtained from classical sensors.

Moreover, monitoring devices are not normally capable of proactively operating to autonomously detect anomalies in the conditions of patients i.e. they always need the direct intervention of the patient. Finally such devices are quite general and they are not able to adapt to the very specific needs of each patient. In other words such systems would really benefit from an agent-oriented approach that would support personalization and proactivity.

2.2.8 ERMA [LSA, LSI]

This system has the purpose of providing meaningful diagnoses and intervention suggestions to the healthcare personnel acting on behalf of the patient in the cases of emergency trauma with particular emphasis on types of shock and stabilization of arterial blood gases. This system ERMA is based on a set of agents that act as a collaborative team of specialists to realize the monitoring and diagnostic infrastructure for dynamically collect filter and integrate data and reasoning about them through a hybrid approach of fuzzy logic, causal Bayesian networks, trend analysis and qualitative logic.
2.2.9 Akogrimo [LSA, LSM]

It is a research project whose main goal is the integration of the Next Generation Grids (NGGs) with the next generation networks. The application scenarios of Akogrimo cover smart hospitals, telemonitoring and emergency assistance. The Akogrimo NGGs are able to deal with an environment with rapidly changing context such as bandwidth, device capabilities, and location. Furthermore, the architecture of Akogrimo can be immediately deployed in unlicensed mobile access environments such as hot-spot infrastructures because it assumes a pure IP based underlying network infrastructure. Target users of an Akogrimo healthcare information system are (i) people demanding mobile ad-hoc and pervasive healthcare services e.g. due to emergencies or chronic diseases and (ii) healthcare service suppliers/institutions i.e. stationary or mobile professionals, including healthcare advisors, pharmacies, nursing services, hospitals, emergency service devices and emergency stations.

The reference scenario of Akogrimo covers objective like: (i) early recognition of heart attacks and fast treatment by combining vital parameters monitoring (ii) aberration and emergency detection and (iii) subsequent rescue management. Agents are spread all over in the architecture of Akogrimo ranging from the end-user application i.e. Akogrimo Personal Assistants, to infrastructural agents supporting interactions among personal assistants.

2.2.10 CASCOM [LSA, LSN, LSO]

It is one of the most recent attempts to bring the notable characteristics of agents to e-health. CASCOM is a technology-driven project that brings together three notable new technologies: multi-agent systems, Semantic Web services and peer-to-peer middleware in the scope of mobile and context-aware environments. It finds its
motivations in a healthcare scenario that was ran in many occasions throughout all Europe.

2.2.11 SAPHIRE [LSA, LSP, LSQ]

It is a research project whose goal was to develop a multi-agent system for the monitoring of chronic diseases both at home and at hospital using a semantic infrastructure. The system is capable of deploying and executing clinical guidelines in a care environment including sparse care providers having heterogeneous information systems. The SAPHIRE multi-agent system addresses such challenges through an enabling semantic interoperability environment.

Moreover the success of multi agent systems in e-health applications will be also due thank to the current work on the integration of multi-agent systems with some emergent technologies like e.g. Web services [LSPP] [LSQQ], the Semantic Web [LSV][LST] and workflows [LSW][LSU] that are already and/or will be fundamental components of e-health. [LSS][LSR][LSA]

2.2.12 Domains of Health Care

Multi agents systems are considered as future which efficiently deals with various kinds of problems in health care. An agent based system allows communicating between agents by using interface. The interface will provide different functions like registering patients, checking stock, decision making based on doctors remark etc. The system can be implemented either on web based environment or windows based environment or in both environment. Below list shows some of the domains where it is applicable. [LSB]
Patient scheduling: It schedules the activities performed on a patient in hospital. [LSAA]

Organ transplant management: It helps to co-ordinate organ management and tissue transplants between different medical locations. [LSBB][LSCC]

Community care: It performs all the activities which help to provide a well-organized health care benefits to the various people of communities. [LSDD]

Information access: This domain helps the agents to collect, compile and unite healthcare information available on internet. [LSEE][LSFF] It also provides mobile users with information about the medical locations or the doctors available in a particular town. [LSJJ]

Decision aid systems: This system monitors the status of a hospitalized patient and helps to diagnose the patients. [LSGG]

Internal hospital tasks: It is related to internal activities performed for the hospitals like monitoring the application of medical protocols [LSHH] or controlling the usage of restricted use antibiotics. [LSII]

2.3 Ontology Systems for Health Care

Above study shows various multi agent systems currently working in healthcare domain for various purposes. These systems are using various techniques for implementing the agents. The common technique for implementing agents is web services or service oriented architecture. There are several reasons why researchers prefer service oriented architecture few of them are remote connectivity support,
interoperability, efficient, reusable etc. ontology is preferred with multi agents system for healthcare application.

IEEE defines ‘Interoperability’ as the ability of two or more systems or components to exchange information and to use the information that has been exchanged. [INTA]

'Semantic interoperability' is defined by the National Alliance for Health Information Technology (NAHIT) as “the ability of different Information Technology (IT) systems, software applications and networks to communicate and exchange data accurately, effectively and consistently so providers can use the information as they care for patients.” [INTB]

There are several open source ontologies exist for healthcare and medical projects. Below list shows it with its brief description. [ONTA]

**2.3.1 ARTEMIS Project:** A Semantic Web Service-based P2P Infrastructure for the Interoperability of Medical Information Systems. IST-1-002103-STP It is in early stages of development.

**2.3.2 MII Medical NLP Toolkit:** This is a toolkit for medical natural language processing (NLP). The core engine is general enough to be used in a variety of text processing domains, though the toolkit includes specific support for medical reports and patient de-identification.

**2.3.3 ONTODerm:** ONTODerm is a specialty specific ontology for dermatology to integrate dermatology with medical software systems.

**2.3.4 Medical Language Processing:** This system allows to Natural language processing of free-text clinical documents into XML representation which is accessible by very rich system of categories familiar to clinicians. It is also in a development phase.
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There are also several published ontologies exist into healthcare. Below list shows it. [ONTA]

- Protein Ontology
- Foundational Model of Anatomy (FMA Ontology)
- Systems Biology Ontology (SBO)
- Gene Ontology

2.3.5 Social Security Administration (SSA) Health IT Semantic Interoperability Pilot Project [ONTA] [SEMA]

The Health IT Semantic Interoperability pilot was developed in by the SSA as a proposed proof-of-concept in 2006 for integration of a Health IT and Disability Determination business process. In particular, this business process requires data sharing and processing across various governmental and private sector enterprises such as SSA, VA, CMS, HHS, NARA, hospitals, healthcare providers, insurance providers, legal communities and others.

2.3.6 Artemis Project and the Artemis Message Exchange Framework (AMEF) [ONTA] [SEMB]

This system is developed to provide the exchange of meaningful clinical information among healthcare institutes through semantic mediation. Some of the achievements of the Artemis project include:

- Demonstration of a very robust but highly flexible approach to security and privacy.
- The partnering entities of the Artemis project developed Web services for exposing their existing healthcare applications and patient data.
The Telemedicine and Advanced Technology Research Center (TATRC) within the U.S. Department of Defense (DoD) has initiated the TATRC Natural Language Processing (NLP) Systems Project. The purpose of this project is to design and develop a natural language processing engine that is compatible with Armed Forced Health Longitudinal Technology Application (AHLTA) and is linked to MEDCIN, UMLS and SNO-MED CT ontologies. The goal is to be able to process semi-structured or free text note sections of AHLTA and be able to capture both contextual and structured terms for surveillance and data mining. [ONTA]

Currently much of the documentation is "too structured", forcing providers to use a very hierarchical structure of MEDCIN. There is significant evidence that this method causes significant errors and the result is a documented note which does not accurately capture the essence of the patient encounter. [ONTA] [HCP]

Work by the Center for Clinical Translation Sciences (CCTS) at the University of Texas Health Science Center at Houston may also be of some interest. The CCTS Environment, Documentation and Authorization models enable the system to dynamically and automatically contextualize availability, access, utilization and retrieval of all informational resources governed by the CCTS program and its collaborators through combinations of constraint based on role, investigator, research project or research question. Thus CCTS utilizes Semantic Web technologies not only for integrating, repurposing and classification of multi-source clinical data but also to construct a distributed environment for information sharing and collaboration online with security and privacy of personal data. [ONTA] [HCS]
2.3.7 Medical Ontology Research by Lister Hill National Center for Biomedical Communications (LHNCBC) of the U.S. National Library of Medicine [SEMC]

The increasing availability of online biomedical information has sparked the development of knowledge processing applications. Knowledge processing applications address concept-based indexing and retrieval, question answering, text understanding and data mining. Semantic interoperability is not likely to be found among existing terminologies. The Medical Ontology Research program is working to develop a sound medical ontology to enable the various knowledge processing applications to communicate with one another. Creating a usable ontology requires the definition, organization, visualization and utilization of semantic spaces created form biomedical knowledge processing applications. Defining medical ontology will assist other National Library of Medicine projects provide a well-organized and more complete representation of their biomedical information.

2.4 Traditional System

Several traditional hospital systems have been studied as a part of literature survey. Most of the systems are window based i.e standalone. Very few are web based having limited functionality.

2.4.1 Limitations of Traditional System

Below list shows limitations of such systems:

- No Information of schedule status: System does not provide the facility for checking the status of requested schedule.
- No Reminder facility: When any request is approved for appointment, it does not provide reminder of the schedule to patient.
- SMS is not supported: Reminder or status of schedule is not supported via SMS, as SMS feature is not available.
- Email facility is not provided: Reminder or status of schedule is not supported through Email and Email with auto complete feature are not supported.
- Content Management facility is not provided.
- Patient cannot confirm the appointments: When the request is approved, patient cannot confirm the appointments. Sometimes it happens that though the appointment is confirmed patient is not able to come hence it becomes difficult for doctor to wait for patient and it subsequently leads to wait for other patients also.
- Random password generation is not supported.
- Credential information is not stored into encryption format: Some information is confidential and if the credentials are not stored into the encrypted format then it is easy for attackers or other users to steal the information and make damage.
- Password strength checking is not supported: Earlier system does not give any information for password like it is strong or weak. Normally weak password is easily guessable or breaks.
- Auto number generation with combination of string and number is not supported.
- No news management: In any system current happening is shown in form of news or services. Earlier system does not support it so users can not get the idea about what are the new services or happenings.
2.4.2 **Scope of Research**

Complex situations in health care domain which can be easily managed by MAS which are listed below: [HCD, HCC, HCB, HCF]

- Training and education of healthcare people (e.g. tutoring system).
- Patient monitoring and diagnosis.
- Communication between intelligent agents like Patient, Doctor, Administrator etc.
- Agents that retrieve, compile and organize appropriate medical knowledge sourced from the Internet.
- Co-ordination between hospitals for managing organs transplant.
- The level to which the healthcare agent model is working
- The way in which the model is representing

In this research work 2nd, 3rd and partially 4th complex issues and limitations of traditional system have been addressed.

Now a day at every place computers are used for making the task easier and it provide flexibility for more productive output. There are several day to day activities performed at hospital and it is very necessary to keep the data in such a way that whenever it is required, it can easily available in time.

Hospital activities can be divided into different sections such as management section, administration section and doctor’s activities etc. Each section has its own work to carry out. Sometimes it becomes difficult to manage all these activities, for example if doctor wants to check patients schedule the current date and he also wants to retrieve old patient’s conversation dialog for reference, then it becomes difficult for him to locate such information. Further if administrator wants
some reports of back date in a format then it’s become difficult for him to find such a data.

In multispecialty hospitals various doctors from other hospitals also provides their services. It is rather possible that the location of hospital might be in different city. In such situation if doctor sitting on ahmedabad wants to retrieve the information of patient consultation done in anand then it becomes difficult to find and retrieve the information. The developed system helps the doctor, admin, patient to find their information irrespective of location barrier.

From the hospital activities such issues are identified and based on that web based Multi Agent System is developed using Ontology. The agent performs the assigned task and in several situations the agents communicates with other agents, thus inter agent communication is also implemented.

2.5 Summary

The chapter summarizes various systems developed for healthcare either using Multi agents or ontologies. Overview of various systems has been given. It also discusses missing features in traditional system and scope of the research in healthcare domain.