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Healthcare Information System Architecture Based on Internet of Things, Big Data and Agent Technologies

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Abstract*—As a result of having access to high-speed wireless Internet and smart phones, many patients have started to use mobile applications and monitoring health devices to manage various health needs and to provide real time health data. User devices and healthcare information systems and their components can be integrated by and communicated via the Internet of Things (IoT). As a result of such integration huge volume of data will be produced by health and healthcare information systems at a remarkable rate. One objective of this study is to explore the opportunities of using big data analytics in healthcare information system to significantly improve the decision making process, enhance capability to offer services to patients and resolve major national challenges in healthcare such as predicting epidemics, patients follow up, etc. This work describes a conceptual design of an e-healthcare system, which implements big data analytics, intelligent agent technology and IoT for highly distributed applications in healthcare environment. Intelligent agents play a critical role in the integration as well as providing correct and timely information for diagnostic, treatment, etc. Agents work on behalf of human actors taking care of routine tasks, thus increasing speed and reliability of the information exchanges.

***Index Terms*— Agent Technology, Internet of Things, Mobile Applications, Wireless Technology, Big Data.**

I. INTRODUCTION

Enormous amounts of health and healthcare related data have been generated within healthcare organizations as a result of recent advances in information and communication technologies. All actors and all types of devices in the healthcare information systems (HISs) produce data. Smartphones and high-speed wireless Internet allow patients and healthcare staff use monitoring devices and various mobile applications to handle diverse health needs and provide access to real time health data. All these devices, both users' and components of healthcare organizations, can be integrated via the Internet of Things (IoT). This, in turn, will result in production of huge volumes of data by health and healthcare information systems at an outstanding rate, both unstructured and structured. Moreover, new technologies allowed significant increase of data processing speed and development of new methods of optimization which cause advances in healthcare data analytics, thus data conversion into information and knowledge also speed up which significantly benefits the decision making process. All this results in enhanced capability to offer services to patients and is helping to resolve major national challenges in healthcare. Healthcare information is mobile by nature, given that medical professionals at different locations need patient's information in order to improve efficient care, diagnostic, and minimize medical errors.

Current systems cannot efficiently process large amounts of patients' data, while in some circumstances it might mean difference between life and death. What we need now is an efficient data processing approach satisfying real-time response requirements for critical health situations. High speed wireless computing has capability to reduce the cost and improve the quality of healthcare. Proposed architecture uses IoT to connect doctors, hospital staff, patients, and other components of healthcare organization systems, including medical equipment, smart devices, etc., into a unified healthcare system. Such system will provide high efficiency, wide coverage, low cost, availability and reliability of services; where vital patients' data, for example, heart rate and blood pressure, will be collected, processed and transmitted by mobile devices in real time. Application of this real-time analytics to these huge volumes of data will help to make better decisions, optimize operations, monitor current conditions and respond accordingly which is especially important in cases of remotely monitored patients with chronic ailments or in homecare.

Due to the wide diversity of the HISs and their components (different vendors, platforms, infrastructure, system architecture, and databases), current systems experience complications with regard to inadequate integrity and interoperability among different healthcare systems and their composite parts. Interoperability, for example, facilitates communications between these systems for sharing information, improving availability [1]. Healthcare staff requires access to patient data across

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these systems to provide an adequate care. Information flow between various systems must be properly managed which is adding to the complexity of HISs, thus interoperability in HISs now is a requirement rather than a feature.

This work presents a comprehensive solution to the HIS architecture based on big data, agent, and IoT technologies, employing wireless communications. The proposed model also considers the interoperability and integration problems within such HISs, which leads to more efficient access to different healthcare systems, allows acquisition of patient's medical data (lab results, radiological data, etc.) and monitors information from multiple mobile sources, thus improving patient's care. The concerns of the healthcare administration on information technology as a means to cut costs and improve quality of healthcare also have to be taken into considerations. To be cost-effective, system has to use the existing information and communication technologies developed for support of and already in use in health and health-related fields: health education, health observation, health literature, and especially healthcare services, to preserve investments in already existing e-health information systems. Developers should be able to add new features to assure that needs of ever growing user mobility will be satisfied and to provide intelligent assistance to users. to improve healthcare locally, regionally and worldwide.

List of other objectives include providing access to healthcare services and health information the same and at the remote primary healthcare centers, helping parties involved to interact efficiently among themselves (by transferring routine tasks from humans to software agent) and within the information systems. Access to mobile distributed healthcare systems will facilitate medical staff access to a service and assure collaboration between different healthcare actors from anywhere in and around the healthcare organization and improve efficiency of health information acquisition.

The remainder of this paper is organized as follows. Background on Big Data, IoT, and agent technologies are discussed in section 2. Section 3 presents literature review and related work. Section 4 will introduce the overall framework of the proposed healthcare information system.Discussion of the proposed system is presented in section 5. The conclusion and future work are in Section 6.

II. TECHNOLOGY OVERVIEW

The features and benefits of the essential components of the proposed distributed mobile healthcare environment are big data, IoT, and intelligent agents are described below.

A. Internet of Things (IoT) Technology

A network of physical objects or "things" which are embedded in electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data, is referred to as Internet of Things (IoT). IoT objects can be sensed and remotely controlled across existing network infrastructure, with possibilities of more direct integration between the computer-based systems and physical world, which leads to economic benefits, improved accuracy, and efficiency. "Thing' are provided with a unique identifier through its embedded computing system and capable of communication and sharing data with other "things" within the existing Internet infrastructure. By expert estimations by 2020 the IoT will include around 50 billion objects; significant part of IoT-related technology (40%) will be health-related, higher than any other category, which represent a $117 billion market [2].ThusIoT impact on medicine will be perhaps the most important, and personal, effect.

Any of devices such as biochip transponders, heart monitoring implants, DNA analysis devices, can be referred as "things" in the IoT sense. With the help of different existing technologies they gather useful data and then the data is transmitted between other devices. Amounts of data are generated on various locations and amass very fast, thus making the need to better indexing system, storing and processing such data very urgent.

Implementation of healthcare IoT system is based on the integration of Wireless Sensor Networks (WSNs), radio-frequency identification (RFID) systems, and intelligent technologies. RFID and wireless data communication technology are necessary to create a network covering everything. Smart devices, embedded medical devices, RFID tags and readers, sensors, etc., have to be incorporated into the healthcare network. They will interact with each other via unique addressing schemes, and have networking, processing, and storing capabilities. All the medical objects will have embedded sensors as a consequence of advances in sensor technology. All this will lead to the generation of huge amounts (big data) of health data which require storage, processing and presentation in easily interpretable and efficient form. As long as people and various objects are online, they can use any network, communicate with each other in real time, connect anywhere and anytime with anything and to any service [1]. Other necessary composites are data modeling, processing, data warehouse, and communication technologies [3]. Major wireless technologies, such as wireless personal area network (Bluetooth), wireless metropolitan area network (WiMAX), are wireless local area network (Wi-Fi), and satellite network (GPS), wireless wide area

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network (3G/4G mobile networks), will be used to build wireless sensor networks within healthcare organizations.

Fig. 1 shows a typical structure of a RFID based sensor network built of wireless low-end RFID sensor nodes generating data (tags) and high-end RFID sensor nodes retrieving data from the low nodes. Collected data are sent to readers (mobile static nodes), from there - to wireless low-end computational devices (base stations) where a certain amount of processing performed on the sensor data. Then Through the internet (or other network) collected data sent to high-end computational servers for further processing and there data will be stored and shared.

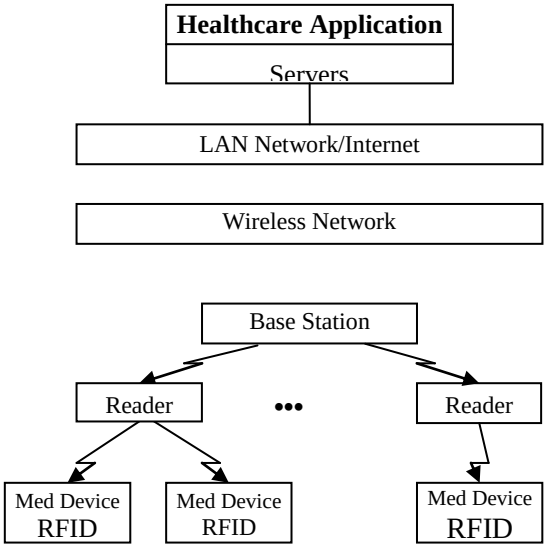

Fig 1. RFID-based Healthcare network

B. Big Data

Continuous advances in the Internet, mobile computing, and digital technologies resulted in a virtual explosion of data. Estimated volume of information in 2012 was over 2 zetabytes, and by 2020 will be up to 35 trillion zetabytes [4]. Economist Intelligence Unit Survey [5] estimated the data volume of 75% of European utilities will grow by 25% over the next three years. Reference [6] states that most of the data in the world (90%) has been created in the last two years alone.

Such an outstanding growth of data demands the development of new methods for designing, managing, maintaining, presenting, and analyzing the resulted information and knowledge on all levels of management, where it's going to be used. There is an urgent need for finding efficient ways for establishing patterns and trends in aggregate big data and applying that knowledge to business problems in the real-world. It's necessary to study the underlying enabling technologies to optimize the handling of big data within systems and organizations in more competent fashion.

Categories of healthcare analytics have been defined as:

1) Descriptive analytics that tries to understand what is happening in the healthcare organization and underlying causes of such occurrences;
2) Prescriptive analytics used to determine what is more likely to happen in the future based on statistical and data mining techniques; and
3) Predictive analytics intention is to examine existing trends and forecasts and use this information for decision making with intent to offer a decision or a recommendation for a specific action.

Big data analytics can boost capability of HISs to offer healthcare services to their patients and provide intelligent assistance in resolving major national challenges in healthcare, natural disasters, economy, etc.

C. Agent Technology

In order to accommodate integration of a variety of existing medical subsystems into an effective distributed support system a number of information technologies have been used. HL7 (Health Level Seven) [7] offered a solution for exchange of medical data. It supplies standards for integration, exchange, and management of healthcare data. The main objective of H7 is to make interoperability among heterogeneous healthcare applications simpler. Its specifications define how a HL7 compliant software package is implemented and used, and provide a set of message-based transactions between existing healthcare applications.

But, as been observedin real-life situation, integration just at the standards level simply is not enough. Others provided solutions which attempted to attain HISs interoperability using agent based architecture in combination with the HL7 standards as means of interoperability implementation in healthcare systems [8]-[9].

Agents are executable software, small in size, reusable; capable of executing autonomous tasks and providing needed support for lightweight computations. They are intelligent, have the ability to predict users' needs and adjust to these needs, can make suggestions to a user and learn new techniques. An agent can derive the learning process using data from a user's response and from an assessment of previous performance; it has some control over its actions and not always have to wait for commands. To achieve prescribed goals agents can act upon their own initiative and adapt their behaviour as the environment changes.List of actions include cooperation with other agents, ability to

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coordinate their actions, migrate from server to server in heterogeneous networks, interact with stationary services and other resources on each visited server to accomplish its mission, communicate to anticipate, adopt and plan tasks. Its behaviour is built of desires, beliefs; its interactions depend on the place function of an entity contained by an agent-based system.

Two parts comprising a mobile agent are: the code composed of the instructions defining the intelligence and behaviour of the agent, and the agent's current state of execution. Platforms available for development and operating agent applications are D'Agents, JADE [10], Voyager, JACK [11], Fargo, AgentBuilder [12], Aglet [13], etc. The active agent platform on all mobile devices, JADE-LEAP (Java Agent Development Framework-Lightweight Extensible Agent Platform), is an agent-based runtime environment which aimed towardsresource constrained mobile embedded devices and is an excellent choice for our IoT e-healthcare system. JADE and JADE-LEAP support the following tasks: creating, deleting, starting, and migrating of agents; agent administration, agent communication while using executing environment to pass messages between agents, errors announcement.

D. Related Work

A lot of studies have been conducted in this area, but little research was done to find effective ways to leverage the big data and IoT for a purpose of creating meaningful information from e-healthcare information systems. Reference [14] describes the big data access issues and analytics of multiple sources of healthcare data. The challenges and benefits of medical IoT and big data have been discussed in [15]. Analysis of a big data collected from IoT of some sport-oriented healthcare application was presented in [16], and security and privacy issues of data gathered through IOT healthcare information have been studied in [17].

This research intention is to integrate all the existing healthcare subsystems and medical devices by developing an effective agent-based distributed decision support system implementing IoT and Big data. There has been a growing interest to application of agent-based systems in healthcare [18] -[22]. It has been attracting a lot of interest, mainly due to the fast growing size and complexity of medical systems and pressing need of their efficient management in distributed environment. Medical systems are becoming more distributed and complex arrangements of multiple individual systems. Thus the task of the efficient management of such distributed environment becomesextremely important. Large number of possible solutions to this problem of managing distributed systems has been proposed. However, the most promising choice is using mobile intelligent agents. In [23] a framework for integration of medical information resources using agents and XMLwasdeveloped. The noteworthy features shared by these e-health applications are: dynamic management of distributed resources, accessibility by remote e-health actors corresponding with the characteristics of software agents, and loosely coupled heterogeneous systems [24]. Systems employing multiple agents can be beneficial for the recognition of Health Agents and diagnostics applications. A multi-agent system providing support for patients searching for HL7-aware healthcare system that detects healthcare service providers delivering requested e-healthcare services was recommended in [25]. The issues of scalability and interoperability in heterogeneous e-health environments were addressed by [26], wheretheadoption of a FIPA2000 standard with implementation of agent technologywassuggested.

III. The Framework Architecture of Proposed Healthcare System

The proposed system major tasks are: transmitting obtained data, prediction, detecting and identifying diseases. A general overview of the proposed healthcare system is shown in Table I. The structure of the proposed healthcare IoT system consists of three layers: application, network and acquisition.

Application layer main functions are collecting and storing data; healthcare data analytics to produce value-added services; displaying an interface healthcare IoT to actors and analysing information received from an acquisition layer according to different needs.

Subsystems of the application layer include the following:

1) Healthcare Data Analytics:
   - Secure access to information of a patient as needed, in a convenient for the healthcare staff form;
   - Real-time access to clinical data of a patient across healthcare systems; patient's data analytics to gain insight and achieve organizational transformation.
   - Timely updating patient information in time to make fast and effective decisions.
2) Hospital Information Management Subsystem: patient registration, lab services, wards, help desks, pharmacy, etc.
3) Intelligent Clinical Support Subsystem: processing received information and sharing it through the interface with other subsystems for better decision making (consultations, diagnosis, prescriptions, etc).

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4) Information Collection and Monitoring Subsystem: merging data from different subsystems and presenting in a suitable format to end users.

The responsibilities of the network layer are reliable and secure transmission and processing of the data coming from acquisition layer. High-speed wireless IP services for mobile devices are provided by GPRS. Any standards, such as Bluetooth, Zigbee, IEEE 802.11, etc., may be employed for wireless communication channels used by the devices.

Various sensors and mobile medical devices gather and transmit real-time medical data via smart terminals, WSN, cameras, RFID, etc., which constitute physical layer. It serves as a source of all types of information collected from the devices. Layer's main functions are monitor objects, collection of real-time information from IoT sensors, and transfer data to the network layer. Wireless sensors are low cost, low power consumption, capable of distributed processing and self-organization devices and thus very appropriate for utilization in IoT HISs for real-time medical information gathering. Mobile agents deliver data collected by wireless devices to the backend system.

Some new medical devices are by now equipped with sensors and GPS, that could be connected with the wireless sensor, capable of sending and receiving medical information to the control and monitoring centers via the satellite communication facilities at any time.

IV. DEVELOPMENT OF AN AGENT-BASED HEALTHCARE INFORMATION SYSTEM

As number of heterogonous devices within the healthcare system using IoT increases, the challenges attaining complete interoperability of these heterogeneous devices is becoming more urgent. The major issue is the interoperability between different protocols, standards, resources types, heterogeneous hardware, database systems, software, and data formats.A convenient tool for handling these issues that can provide means for communication among such devices and handle the IoT interoperability is mobile agent technology.

Carrying their data and execution states mobile agents can migrate between networked devices, ableto communicate with other agents. A collection of such collaborating among themselves agents, with some degree of autonomy or independence is a multi-agent system.

Applying agent technology in healthcare is relatively new approach. Agent technology is perfectly fitted for distributed systems like HIS due to its autonomy, configurability, scalability, and flexibility.

Layers	**Subsystemsandtheircharacteristics**			
Application	Healthcare Data Analytics	Hospital Information Management	Information Collection& Monitoring	Information Services
Network	Internet,WiFi, 3G/4G	WiFi, 3G/4G	WiMax	GPS, GPRS
Physical	RFID	RFID Reader Mobile agent	WSN Mobile agent	Smart Terminals Mobile agent

Table I. Healthcare IoT

Even if the address of destination medical device is unidentified, agents still can be used to pass messages across networks. This infrastructure allows interconnection of large variety of heterogeneous devices, where each type represented by its own intelligent agent providing its functionality as a service, collecting information and responding to others' requests.

An agent comprised of its set of rules and knowledge base, might be able to competitively or cooperatively coordinate with other agents, assume different responsibilities, and play different roles. Each healthcare actors will have an assigned to it agent, with specified tasks and predefined behaviours that corresponds with their roles in the e-healthcare and follows the rules based on the requirements of their owners.

A number of e-health applications, such as diagnostics, smart emergency and smart hospital applications, tele monitoring, quality aging e-services helping elderly people, and etc., can definitely benefit from use of agent technology [31]

The advantages agent-based healthcare information system:

1) Software agents will undertake routine and many non-routine tasks of their actor;
2) Actors may receive and transfer data anytime and anywhere via their mobile devices;
3) All transactions are saved systematically to maintain the system's audibility;
4) Simple user-friendly device management and devices connection functions;
5) Extraction of valuable knowledge is performed on data received from different platforms and agents using rich analytics;
6) No changes to the functionalities and features of current HISs are necessary.

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A. Types of Agents

Different agent types, such as intelligent (problem-solving agents), interaction (Interface Agent), communication (Mobile Agent), and device agent (RFID-Sensor Agent), will be implemented in the proposed e-healthcare system.

Main Types of IoT Healthcare agents are:

1) *Interface Agent (IA):* provides user-friendly interactive interface for user assistance in carrying out required tasks, like filtering retrieved information from queries, etc. Its responsibilities are returning feedback to other participants, presentation of results generated by other agents, and sending user requests to the appropriate agents.
2) *Monitor Agent:* monitors the system contingency situations detection and triggers appropriate actions to react to some tag reading events on behalf of a smart traffic object, for example in emergency cases.
3) *RFID Agent:* reads from or writes to RFID tags. After reading a tag, this agent performs proper operations, according to the retrieved from the tag data, and handles a single task on behalf of a smart object of the corresponding RFID, and may migrate to different platforms at run time, if necessary.
4) *Mobile Device Agent:* provides support for mobile medical devices. Middleware enabling mobile device agents to use effectively adaptive servers in their medical network environment. An actor's medical interests are represented, worked towards, and communicated by an agent. Healthcare organizations are strongly dependent on mobile links to access patient information at the point of care. Mobile devices will help to ease this dependence, reduce the cost and improve the quality of healthcare.
5) *Sensor Agent:* responsible for receiving and processing data from the associated sensor; and storing or passing it somewhere as required.
6) *Electronic Health Record agent (EHRA):* Electronic Health Record (EHR) represents an integrated database storing patient's relevant digital information (radiology images, textual, audio and waveform data, ECGs, and other media content) generated during the healthcare process. It usually shared across the different healthcare settings in digital format with nurses, physicians, and other medical staff.
7) *Home Patient Agent (HPA):* is installed with the patient's premises software for monitoring remote patient's conditions, providing temporary advice, handling routine of healthcare activities, transmitting the abnormal cases data to the mediator, and sending urgent alerts to doctors in the emergency cases.
8) Telemedicine agent (TA): Telemedicine is a precious tool in healthcare that has the ability to enhance health care delivery for patients in rural areas, leads to faster delivery of medical services, helps keep patients satisfied, and facilitates training programs for medical and non-medicalstaff.

Healthcare Mediator: The healthcare mediator represents an integrated unit made up useful healthcare transactions. Actors must interact in order to complete healthcare transaction successfully. Healthcare mediator delivers health services to remote or local patients and acts as the communication link between multiple agents of medical staff and patients.

V. DISCUSSION

The major contributions of proposed framework are development of an agent-based HIS architecture to support an efficient data flow between different healthcare systems and enhancing the design with big data and IoT. In the proposed architecture, multiple mobile agents interact to transport information between various distributed components, thus providing flexible dissemination architecture. The agents are able to interoperate with dissimilar subsystems without having to be modified for each type of data platform, to query database servers, and store retrieved information locally over a period of time. There is no need for writing customized interfaces to provide translations between components; using the proposed approach eliminates that obstacle. The system can determine patients' current status, foresee future diseases, and issue some real-time information that helps physicians choosing correct action based on analytics results of collected real-time medical data.

Implementation of the proposed architecture can significantly improve the quality of healthcare services. The main benefits are:

1) Easy access: implementation of agents for connecting of applications and data facilitates an easy access to the HIS data and records generation. Interoperability among different HISs is guaranteed by an agent-based platform, thus ensuring the high availability and reliability of the systems.
2) Human actors and agents interact via an interface that allows the actor to create new agents and monitor their activities in real time.
3) Mobile agents are employed to minimize patient's data transport delays on the network, including multi-media content.
4) Helps the healthcare authorities to develop comprehensive healthcare policies.

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5) Reduced healthcare cost is the result of the effective communication and sharing of data, information, and knowledge among healthcare staff.
6) Helps hospitals in monitoring the activities and study of the effectiveness.

VI. CONCLUSION AND FUTURE WORK

The intent of this research paper is to develop flexible and scalable intelligent framework architecture based on IoT, big data and agent technologies for enhancing highly distributed mobile healthcare services where all data transactions are done by agents improving availability, efficiency, and response time. Such a system will help improve patients' mental health and lifestyles in general and possibly avoid chronic illness. The healthcare processes could be simplified and improved with the strong support of such infrastructure; sharing up-to-date patient information in real time, providing specialized healthcare professionals with the right information at the right time, and making healthcare processes more efficient across a hospital system will improve the overall quality of healthcare.

The overall contributions of this research are introduction of agent technology and IOT into healthcare system to assist medical actors in their work, to enhance treatment procedures, diagnostics capabilities, recommendations and prescriptions; and definition of agents' cooperation techniques for a distributed mobile medical environment. Cost effectiveness of its implementation is another major contribution achieved by use and adaptation of already existing healthcare services and information sources. Modifications of medical actors' business processes and changing their behaviour are required in order to benefit from utilizing the proposed system and new technologies. This approach will improve the productivity of the medical professionals and the quality of healthcare in general.

The future work will focus on the security issues of this architecture. Security in mobile environment is an important issue as personal health data must be confidential. There should be a mechanism to protect the data moving among agents from outsiders' malicious agents.

REFERENCES

[1] D.Singh, G.Tripathi, and A. J. Jara, "A survey of Internet-of-Things: Future Vision, Architecture, Challenges and Services", IEEE World of Forum on Internet of Things, 2014.

[2] H. Bauer, M. Patel, andJ. Veira,"The Internet ofThings: sizing up the opportunity [Internet] New York (NY): McKinsey &Company"; Available from: http://www.mckinsey.com/industries/high-tech/our-insights/the-internet-of-things-sizing-up-the opportunity.[cited at 2016 Jul 1].

[3] B. Xu, "Key IOT Technology and Application Research", Applied Mechanics and Materials, vol. 543-547, pp. 3411-3414, 2014.

[4] FIIB MAC, marketing analytics,"A Whole New Way of Thinking: The Big Data Revolution",[Online] Available: http://www.fiib.edu.in/mac/? tag= analytics-conference, September 2013

[5] C.Eaton, T.Deutsch, D.Deroos, G. Lapis, andP. Zikopoulos, "Understanding big data: Analytics for enterprise class Hadoop and streaming data", San Francisco, CA, McGraw Hill, [Online] Available: http://www.ibm.com/software/data/-bigdata, 2012.

[6] R. H.Bajaj andP. L. Ramteke, "Big Data – The New Era of Data", International Journal of Computer Science & Information Technologies, vol. 5, no. 2, pp.1875-1885, 2014.

[7] Health Level Seven (HL7). http://www.hl7.org.

[8] M.Miranda, G.Pontes, A.Abelha, andJ. Neves, "Agent Based Interoperability in Hospital Information Systems", Int. Conf. BioMedical Engineering and Informatics, pp 949-953, 2012.

[9] M. Miranda, M. Salazar, F.Portela, M.Santos, A.Abelha, J.Neves, at. el., "Multi-agent Systems for HL7 Interoperability Services. Procedia Technology" 4th Conf. of Enterprise Information Systems – aligning technology, organizations and people, pp 725–733, 2012.

[10]Telecom Italia Lab, Java Agent DevelopmentFramework,http://jade.tilab.com/.

[11] Agent Oriented Software Limited (AOS), JACKDocumentation, http://www.aosgrp.com/products /jack/documentationand instruction/jack documenttation.html.

[12] Acronymics. Inc.AgentBuilder,http://agentbuielder.com/.

[13] IBM, Aglets, http://www.trl.ibm.com/aglets/.

[14] Y.Yesha, V. P. Janeja, N.Rishe, andY. Yesha1, "Personalized Decision Support System to Enhance Evidence Based Medicine through Big Data Analytics", IEEE International Conference on Healthcare Informatics, 2014.

[15] D. V. Dimitrov, "Medical Internet of Things and Big Data in Healthcare", Healthc Inform Res.,vol. 22, no. 3,pp.156–163,2016 Jul;

[16] R. Cortés, X.Bonnaire, O. Marin, andP. Sens, "Stream Processing of Healthcare Sensor Data: Studying User Traces to Identify Challenges from a Big Data Perspective", The 6th International Conference on Ambient Systems, Networks and Technologies (ANT-2015), vol. 52, pp. 1004-1009, 2015.

[17]Abinaya, Vinoth Kumar, Swathika, "Ontology based Public Healthcare System in Internet of Things (IoT)", 2nd International Symposium on Big Data

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 6, Issue 5, November 2016

and Cloud Computing (ISBCC'15), Procedia Computer Science vol. 50 pp. 99 – 102, 2015.

[18] Z.Yaowen, X.Wei, and H,Yuwan, "Research on Healthcare Integrating Model of Medical Information System Based on Agent", Int. Conf. Computational and Information Sciences,pp. 622-625,2010.

[19] K.Miller and G.Manning, "Towards a distributed mobile agent decision support system for optimal patient drug prescription", 3rd Int. Conf. Innovative Computing Technology (INTECH), pp. 233 – 238,2013.

[20]L.Cardoso,F.Marins,F.Portela,M.Santos,A.Abelha,and J. Machado, "The Next Generation of Interoperability Agents in Healthcare", Int. J. of Environmental Research and Public Health, pp. 5349-5371,2014.

[21] M. K. Moghaddam, M. Shojafar, M.R.Nami, and H.Rashidi, "An Efficient Multi-agent System for E-health Functionalities", Int. J. Software Engineering and Its Applications, pp. 23-34, 2013.

[22] K.Zarour& N.Zarour, "A Coherent Architectural Framework for the Development of Hospital Information Systems", Applied Medical Informatics, pp. 33-41, 2012.

[23] S.Zheng, W.Li, X.Peng, H.Zhao, and C.Zhang, "Research on Integrating the Healthcare Enterprise Based on Multi-Agent", Int. Conf. Computer, Mechatronics, Control and Electronic Engineering (CMCE), pp. 493-496,2010.

[24]T.N.Minh, P. Fuhrer, and J.Pasquier-Rocha, "Enhancing E-Health Information Systems with Agent Technology" International Journal of Telemedicine & Applications, pp. 1-13, 2009.

[25] P.De Meo, G.Quattrone, and D.Ursino, "Integration of the HL7 Standard in a Multi-Agent System to Support Personalized Access to e-Health Services", IEEE Trans. Knowledge and Data Engineering. vol. 23, no. 8, pp. 2144-1260, 2011.

[26] C.J.Su and T.W Chu, "A Mobile Multi-Agent Information System for Ubiquitous Fetal Monitoring", Int. J. Environmental Research and Public Health, pp. 600-625, 2014.