IJCSE International Journal of Computer Sciences and Engineering Open Access
Survey Paper Vol.-7, Issue-4, April 2019 E-ISSN: 2347-2693

Evolution of Internet of Things Enabling Technologies in the Field of Healthcare Service

Renuka R. Londhe

Dept. of Computer Science and IT, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur, 413512 India

*Corresponding Author: R. R. Londhe, renu_sanskruti29@rediffmail.com, Tel.: +91-9545226333

DOI: https://doi.org/10.26438/ijcse/v7i4.647652 | Available online at: www.ijcseonline.org

Accepted: 19/Apr/2019, Published: 30/Apr/2019

***Abstract*:** Internet of Things (IoT) is a word used to designate an atmosphere where billions of objects are connected to the internet and are interacting independently. IoT is an innovative prototype providing novel set of services for the future technological inventions. Applications of IoT are unlimited with continuous addition of the cyber-world with the physical world. Smart healthcare system advancement and dissemination has become possible by the convergence of various IoT architectures. In specific, the IoT has been extensively useful to interconnect medical resources and deliver reliable, effective and smart healthcare services to the elderly and patients with a chronic illness. IoT changes the manner in which the facilities are conveyed to the healthcare industry. This paper presents major technologies in IoT-based smart healthcare services. It starts with introduction, definition of IoT, IoT enabling technologies in smart healthcare and IoT challenges in smart healthcare.

***Keywords*—**IoT (Internet of Things); Medical resources; Smart Healthcare; Challenges;

I. INTRODUCTION

Currently, about two billion people around the world use Internet to browse the website, transfer information through emails, access the multimedia content and services, play games for entertainment, use social networking sites and perform many other similar tasks [1]. The Internet usage on worldwide platform for allowing machines and smart objects to communicate, dialogue and coordinate is added giant leap forward in the Internet world [2, 3]. In near future many people will have access to universal information and communication through Internet. With the passage of time, the Internet world has been connected with things and is nowadays being recognized as Internet of things (IoT) [4-7]. As the name illustrates, things are connected thorough Internet by the use of smart communication technologies including Wireless Sensor Networks (WSN) [8], Radio-frequency Identification (RFID) [9], Bluetooth, Near-field communication (NFC), Long Term Evolution (LTE) etc [10-13]. IoT ensued from the evolution of conventional networks that link zillions of devices is currently the talk of every city [14].

The term 'IoT' was invented back in 1999 by Kevin Ashton, in his presentation delivered at Procter & Gamble, linking the innovative idea of RFID in Procter & Gamble's supply chain to the then-red-hot topic of the Internet [15-16]. Whereas the progress in this field started long back in 1832 and is still progressing continuously [17-20].

IoT is concentrated on combinations of several practices including recognizing, detecting, networking, and computing. Rising number of physical objects are actuality associated to the Internet at an exceptional rate appreciating the idea transportation, healthcare, industrial automation, and emergency response to natural and manmade tragedies where human decision making is tough [3, 21-23]. IoT permits an object to see, listen, hear, and communicate together. Accordingly, IoT converts those objects from being usually smart by incorporating its worldwide and universal computing, embedded devices, communication technologies, sensor networks, Internet protocols and applications to improve human life [23].

The growing rate of the aging population has brought about many challenges in healthcare service [24]. For instance, the service of after stroke rehabilitation for the elderly is an emerging challenge, which requires a long-time commitment of medical and human resources. IoT's modest beginnings in healthcare can be traced to the use of remote monitoring, smart sensors and medical device integration as well as activity trackers, wearable biometric sensors, glucose monitors, medication dispensers and smart beds [25-27].

However, even with the massive efforts, there are still many problems to deal with in order to reach the full potential of IoT. This paper demonstrates research articles associated to the field of healthcare using IoT, in order to extract the most valuable content and distinct researches. This paper has been

distributed into five sections. Section I is the introductory in nature, along with the reason for the motivation of this paper. Section II highpoints the fundamentals of IoT. Section III addresses IoT applications in smart healthcare. Section IV addresses IoT challenges in smart healthcare. Section V is the concluding portion of this paper.

II. INTERNET OF THINGS (IOT)

The IoT is an arrangement of interconnected computing devices, mechanical and digital machines, objects, living organisms assigned with unique identifiers (UIDs) and the capability to transfer data over a network without needing human-to-human or human-to-computer interaction [14].

1. Definitions

There is no unique definition for IoT that is acceptable by the world community of users. The definition provided by the International Telecommunication Union (ITU) [28] is:

‘‘*A global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies*”.

According to Atzori and colleagues [29] IoT can be recognized in three paradigms-internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge).

The RFID cluster [30] defines the IoT as:

“*The worldwide network of interconnected objects uniquely addressable based on standard communication protocols*”

The best definition for the IoT would be [14]:

“*An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment*”.

2. IoT architecture

From a technical perspective, the IoT architecture is normally distributed among five layers and is shown in Fig. 1. It consists of perception layer, network layer, middleware layer, application layer and business layer [31].

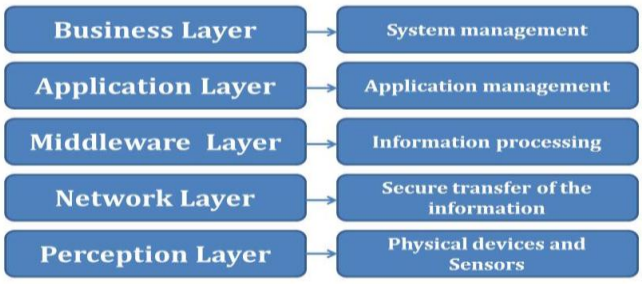

Fig. 1: Five layer IoT Architecture.

III. IOT APPLICATIONS

IoT has an huge prospective for evolving intelligent applications in every sector such as smart transportation, smart home, smart cities, smart metering, smart grid, smart healthcare etc. For instance, there are many IoT applications that have been already successfully implemented; based on overall popularity the major applications of IoT include smart home, wearable’s, smart city, smart grid, industrial internet, connected car, smart healthcare, smart retail, smart supply chain and smart farming [32]. The healthcare industry is in a state of great despair. Healthcare services are costlier than ever, global population is aging and the numbers of chronic diseases are on a rise. While technology can’t stop the population from ageing or eliminate chronic diseases at once, it can create healthcare easier on a pocket and in terms of accessibility. Medical diagnostic consumes a large part of hospital bills. Technology can move the routines of medical checks from a hospital (hospital-centric) to the patient’s home (home-centric). The correct diagnosis will reduce the necessity of hospitalization [33]. The full application IoT in healthcare area is a mutual hope because it allows medical centers to function more competently and patients to obtain better treatment. In this section, we present IoT applications in smart healthcare.

1. Smart Healthcare

Healthcare industry is one of the fastest adopters of IoT. Integration of IoT features into the medical devices paves ways for improving the quality and effectiveness of services. The immense popularity of technology in the healthcare industry has helped the Giants to coin a new term known as Medical IoT. Intelligent devices such as wearable’s and smart phones are amazingly supporting fitness, health education, symptom tracking, and collaborative diseases management on the go. Insights gained by collecting this data from various sources are driving major disruptions of the healthcare world, business processes, and real-time decision-making. Trends suggest that the number of smart healthcare devices being shipped around the world has been on the rise since the year 2015 and is expected to grow up to 161 million by 2020 as shown in Fig. 2 [34].

This section provides an opportunity for academicians and healthcare professionals to discuss current development in the field of smart healthcare technologies and IoT, including progress, application, strategies and policies.

Khowaja et al. [35] have presented the application of Healthcare IoT, services, and people framework with wearable sensor technology to attain the low-cost, easiness, and the pervasiveness for healthcare monitoring along with the integration of services and agents like doctors or caregivers in pain and palliative care units.

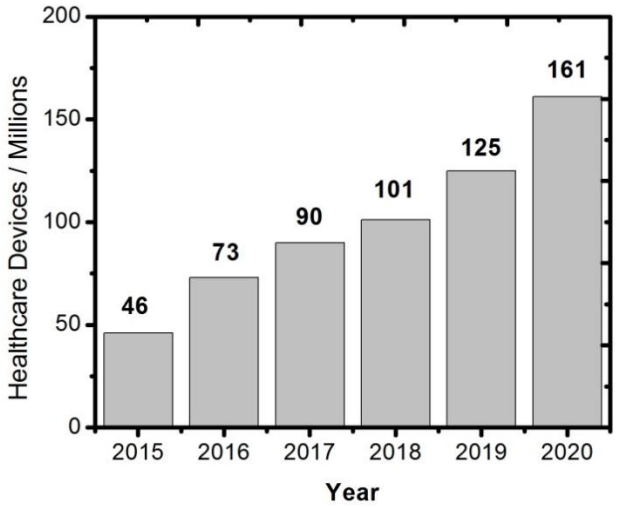

Fig. 2: Trend suggesting rise in smart healthcare devices.

The paper "Internet of Things: A survey of enabling technologies in healthcare and its applications" by Dhanvijay and Patil [4] describes the WBAN based IoT healthcare system and reviews the state-of-the-art of the network architecture topology and applications in the IoT based healthcare solutions. Moreover, this paper analyzed the security and the privacy features consisting of privacy, authentication, energy, power, resource management.

The paper entitled "Applying a mindfulness-based reliability strategy to the Internet of Things in healthcare-A business model in the Vietnamese market" by Tuan and colleagues [27] implicate the approaching process for a startup to build the business model in the field of the healthcare industry.

Martínez-Caro et al. [36] in their paper titled "Healthcare service evolution towards the Internet of Things: An end-user perspective" explored the relationship between patients' capabilities for effective use of ICT and the success of IoT-based healthcare services. The resulting theoretical model for effective use of ICT and the success of IoT-based healthcare services was validated. The validation was based on data collected from a randomly selected sample of 256 users of Internet-based healthcare services provided by the public healthcare system of the Murcia region in Spain. The findings of this research inform future strategies for the implementation of new generations of health and well-being services based on IoT technologies.

Zhang and coworkers [37] in the paper "An inferential real-time falling posture reconstruction for Internet of healthcare things" constructed an approach to reproduce the real-time falls of humans, which uses a triaxial accelerometer and triaxial gyroscope to detect the occurrence of a fall, and an attitude algorithm to estimate the angles of each part of the human body, where Internet of healthcare things collects the information of each sensor, and a Bayesian Network deduces the next action.

The paper "Performance evaluation of a Fog-assisted IoT solution for e-Health applications" by Vilela et al. [38] studied the contribution of the Fog Computing paradigm applied to healthcare, highlighting its main benefits regarding latency, network usage, and power consumption. Based on these parameters, a Fog-assisted health monitoring system is proposed and its performance evaluation and demonstration is carried out. The results demonstrated the potential enhancement of this approach to minimize data traffic in the core of the network because data is analysed locally and, also, enhancing security on health information that can be kept locally, enhancing data security and providing better insights of patient's health status.

The paper entitled "A novel and powerful framework based on neutrosophic sets to aid patients with cancer" by Abdel-Basset and coworkers [24] proposed the implementation of healthcare system based on IoT and fog computing technologies for averting the spread of cancer via early detection, evaluation of disease's symptoms, and also analyzing health data that gathered from IoT through various sensor networks and other smart devices to help healthcare professionals to turn a stream of data into actionable insights and evidence-based healthcare decision-making to improve and enhance cancer treatment.

Zamanifar and Nazemi [25] in the paper "An approach for predicting health status in IoT health care" proposed a method for predicting both ECG sensor data and the most likely health status of the patient, which does not need a common activity recognition method to predict the health situation of the patient. The proposed approach predicts future mobile sensor data and the overall health status of the patient using a hidden semi-Markov model.

The paper "Internet of things (IoT) in healthcare - Smart health and surveillance, architectures, security analysis and data transfer: A review" by Panchatcharam and Vivekanandan [39], displayed the idea of solving health issues by utilizing a recent innovation, the IoT. At long last, the difficulties and prospects of the improvement of IoT-based medicinal service frameworks are talked in detail. This review additionally summarized the security and protection worries of IoT, administrations and application of IoT and smart healthcare services that have changed the customary medicinal services framework by making healthcare administration more proficient through their applications.

Klímová and Kuča [40] in the paper "Internet of things in the assessment, diagnostics and treatment of Parkinson's disease" explored the use of IoT in the management of Parkinson's disease (PD), specifically in its assessment, diagnostics, and

treatment. The findings show that IoT may serve as an appropriate healthcare platform. IoT seems to be efficient, cost-effective and affordable approach in the management of chronic neurological disorders such as PD.

Krishnan and colleagues [41] in the article "An efficient Elman neural network classifier with cloud supported internet of things structure for health monitoring system" suggested two varieties of process namely client side and cloud side. In client side, initially, the EEG signal is obtained from human and is processed with the help of the Hyper analytic Wavelet Transform (HWT) with Adaptive Noise Cancellation (ANC) method.

The paper "Victor Change, Privacy-preserving smart IoT-based healthcare big data storage and self-adaptive access control system" by Yang et al. [42], proposed a privacy-preserving smart IoT-based healthcare big data storage system with self-adaptive access control. This smart healthcare big data storage system is formally proved secure and extensive comparison and simulations demonstrate its efficiency.

Kaw et al. [43] in the paper "A reversible and secure patient information hiding system for IoT driven e-health" proposed a novel high-capacity and reversible data hiding approach for securely embedding EPR within the medical images using Optimal Pixel Repetition (OPR). OPR converts every pixel of the input image to a 2×2 block to facilitate reversibility by ensuring all the pixels in a 2×2 block to have different values. Since a 2×2 block is comprised of 4-pixel elements, which could be arranged in sixteen possible ways; we generate a lookup table corresponding to sixteen possible positions of pixels. EPR hiding in each block is achieved by permuting the pixels of a block according to the four-bit word of secret data, resulting in a histogram invariant stego image. The histogram invariance improved the robustness of the proposed scheme to statistical attacks. A stego image is said to hide embedded data securely, when it provides better imperceptivity for an appreciably high payload. Experimental results showed that average PSNR obtained is 42 dB for payload 1.25 bpp by our scheme, showing its effectiveness for preventing unauthorized access to client's sensitive data.

Saini and Sharma [44] in the article "Review on the Heart Disease Detection Using IoT Framework" have given a review on an IoT framework is given for the prediction of the heart disease. The first part focused on the acquisition of the data using various sensors, second part focused on the data storage using cloud technologies, and third part is about the analysis of the data using various machine learning algorithms.

As discussed above, there are several domains specific IoT based smart healthcare applications.

IV. CHALLENGES

Evolution of IoT has an impact on various aspects of human lives. Therefore, IoT related challenges need to be considered from various aspects such as enabling technologies, services and applications, business models, social and environmental impacts. The main challenges in the implementation of IoT in smart healthcare are:

a) Data security and privacy: The most of the IoT devices lack data protocols and standards.

b) Integration of multiple devices and protocols: Integration of multiple devices also causes hindrance in the implementation of IoT in the healthcare sector.

c) Data overload and accuracy: The data aggregation is difficult due to the use of different communication protocols and standards.

d) Cost: IoT has not made the healthcare facilitates affordable to the common man yet.

V. CONCLUSIONS AND FUTURE SCOPE

In this paper, an overview of the evolution of IoT in the smart healthcare has been provided. IoT in smart healthcare helps in reducing emergency room wait time, Tracking patients, staff, and inventory Enhancing drug management, Ensuring availability of critical hardware. The current study evaluated the importance of IoT technologies with regard to the concept of a smart healthcare. However, more research and in-depth discussions and debates among experts and doctors in fields related to smart healthcare and IoT technologies should be continuously conducted.

REFERENCES

[1] Hanan Elazhary, Internet of Things (IoT), mobile cloud, cloudlet, mobile IoT, IoT cloud, fog, mobile edge, and edge emerging computing paradigms: Disambiguation and research directions, Journal of Network and Computer Applications, Vol. 128, pp. 105-140, 2019.

[2] A. Khanna, S. Kaur, Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture, Computers and Electronics in Agriculture, Vol. 157, pp. 218-231, 2019.

[3] Alem Čolaković, Mesud Hadžialić, Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues, Computer Networks, Vol. 144, pp. 17-39, 2018.

[4] Mrinai M. Dhanvijay, Shailaja C. Patil, Internet of Things: A survey of enabling technologies in healthcare and its applications, Computer Networks, Vol. 153, pp. 113-131, 2019,

[5] M. Muthuselvi, M.A. Abi, V.A. Arthi, M.S. Deivanayagi, "An Intelligent Bus System Based on Internet of Things for Urban Environments", International Journal of Computer Sciences and Engineering, Vol.7, Issue.3, pp.12-18, 2019.

[6] R. R. Londhe, Development of Internet of Things (IoT) and its Substantial Impact in the Field of Smart Cities, International

Journal of Research in Electronics and Computer Engineering, Vol. 7 issue 1 pp.752-757, 2019.
[7] M. Muthuselvi, O. Fathima Thesneem, D. Grace Angeline Hepzibha, M. Indu, "An Internet of Things Based Fire Detection and Fire Alert System", International Journal of Computer Sciences and Engineering, Vol.7, Issue.3, pp.33-38, 2019.
[8] Ilhem Souissi, Nadia Ben Azzouna, Lamjed Ben Said, A multi-level study of information trust models in WSN-assisted IoT, Computer Networks, Vol. 151, pp. 12-30, 2019.
[9] Prosanta Gope, Ruhul Amin, S. K. Hafizul Islam, Neeraj Kumar, Vinod Kumar Bhalla, Lightweight and privacy-preserving RFID authentication scheme for distributed IoT infrastructure with secure localization services for smart city environment, Future Generation Computer Systems, Vol. 83, pp. 629-637, 2018.
[10] I. L. Ruiz, M. Á. Gómez-Nieto, Combining of NFC, BLE and Physical Web Technologies for Objects Authentication on IoT Scenarios, Procedia Comp. Science, Vol. 109, pp. 265-272, 2017.
[11] Matthew D. Steinberg, Christine Slottved Kimbriel, Lieve S. d'Hont, Autonomous near-field communication (NFC) sensors for long-term preventive care of fine art objects, Sensors and Actuators A: Physical, Vol. 285, pp. 456-467, 2019.
[12] Gongguo Zhang, Chaofei Yao, Xiaolin Li, Research on joint planning method of NB-IoT and LTE, Procedia Computer Science, Vol. 131, pp. 985-991, 2018.
[13] M. K. Giluka, T. V. Pasca, T. Priyadarshi, Bheemarjuna Reddy Tamma, Enhanced class based dynamic priority scheduling to support uplink IoT traffic in LTE-A networks, Journal of Network and Computer Applications, Vol. 107, pp. 93-112, 2018.
[14] S. Madakam, R. Ramaswamy, S. Tripathi, Internet of Things (IoT): A Literature Review, Journal of Computer and Communications, Vol. 3, pp. 164-173, 2015.
[15] Kevin Ashton, That 'internet of things' thing, RFiD J., Vol. 22, pp. 97–114, 2009.
[16] S. Huckle, R. Bhattacharya, M. White, N. Beloff, "Internet of Things, Block chain and Shared Economy Applications", Procedia Computer Science, Vol. 98, pp. 461-466, (2016).
[17] https://medium.com/mqtt-buddy/brief-history-of-the-internet-of-things-f00043ae17b5
[18] https://www.linkedin.com/pulse/brief-history-internet-things-hassan-shahzad
[19] https://www.postscapes.com/internet-of-things-history/
[20] https://www.imsindia.com/bank-exam/blog/internet-of-things-worlds-biggest-bot/
[21] B. Afzal, M. Umair, G. A. Shah, E. Ahmed, Enabling IoT platforms for social IoT applications: Vision, feature mapping, and challenges, Future Gen. Comp. Sys., Vol. 92, pp. 718-731, 2019.
[22] Mohab Aly, Foutse Khomh, Mohamed Haoues, Alejandro Quintero, Soumaya Yacout, Enforcing security in Internet of Things frameworks: A Systematic Literature Review, Internet of Things, Vol. 6, Article 100050, 2019.
[23] Parvaneh Asghari, Amir Masoud Rahmani, Hamid Haj Seyyed Javadi, Internet of Things applications: A systematic review, Computer Networks, Vol. 148, pp. 241-261, 2019.
[24] Mohamed Abdel-Basset, Mai Mohamed, A novel and powerful framework based on neutrosophic sets to aid patients with cancer, Future Generation Computer Systems, Vol. 98, pp. 144-153, 2019.
[25] Azadeh Zamanifar, Eslam Nazemi, An approach for predicting health status in IoT health care, Journal of Network and Computer Applications, Vol. 134, pp. 100-113, 2019.
[26] Thomas McGhin, Kim-Kwang Raymond Choo, Charles Zhechao Liu, Debiao He, Blockchain in healthcare applications: Research challenges and opportunities, Journal of Network and Computer Applications, Vol. 135, pp. 62-75, 2019.
[27] M. N. Dang Tuan, N. N. Thanh, L. L. Tuan, Applying a mindfulness-based reliability strategy to the Internet of Things in healthcare–A business model in the Vietnamese market, Techn. Forecasting and Soc. Change, Vol. 140, pp. 54-68, 2019.
[28] ITU work on Internet of things, ICTP workshop, (2015) [last accessed on 01 April 2019]
[29] L. Atzori, A. Iera, G. Morabito, The Internet of Things: a survey, Computer Networks, Vol. 54, pp. 2787–2805, 2010.
[30] Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic, Marimuthu Palaniswami, Internet of Things (IoT): A vision, architectural elements, and future directions, Future Generation Computer Systems, Vol. 29, pp. 1645-1660, 2013.
[31] Rishika Mehta, Jyoti Sahni, Kavita Khanna, Internet of Things: Vision, Applications and Challenges, Procedia Computer Science, Vol. 132, pp. 1263–1269, 2018.
[32] https://iot-analytics.com/iot-2018-in-review/ last accessed on 01 April 2019.
[33] Hodjat Hamidi, An approach to develop the smart health using Internet of Things and authentication based on biometric technology, Future Generation Computer Systems, Vol. 91, pp. 434-449, 2019.
[34] https://www.statista.com/statistics/735810/healthcare-iot-installations-global-estimate/
[35] Sunder Ali Khowaja, Aria Ghora Prabono, Feri Setiawan, Bernardo Nugroho Yahya, Seok-Lyong Lee, Contextual activity based Healthcare Internet of Things, Services, and People (HIoTSP): An architectural framework for healthcare monitoring using wearable sensors, Computer Networks, Vol. 145, pp. 190-206, 2018.
[36] Eva Martínez-Caro, Juan Gabriel Cegarra-Navarro, Alexeis García-Pérez, Monica Fait, Healthcare service evolution towards the Internet of Things: An end-user perspective, Technological Forecasting and Social Change, Vol. 136, pp.268-276, 2018.
[37] Cong Zhang, Chin-Feng Lai, Ying-Hsun Lai, Zhen-Wei Wu, Han-Chieh Chao, An inferential real-time falling posture reconstruction for Internet of healthcare things, Journal of Network and Computer Applications, Vol. 89, pp.86-95, 2017.
[38] Pedro H. Vilela, Joel J.P.C. Rodrigues, Petar Solic, Kashif Saleem, Vasco Furtado, Performance evaluation of a Fog-assisted IoT solution for e-Health applications, Future Generation Computer Systems, Vol. 97, pp. 379-386, 2019.
[39] P. Panchatcharam, S. Vivekanandan, Internet of things (IoT) in healthcare - Smart health and surveillance, architectures, security analysis and data transfer: A review, International Journal of Software Innovation, Vol. 7, pp. 21-40, 2019.
[40] Blanka Klímová, Kamil Kuča, Internet of things in the assessment, diagnostics and treatment of Parkinson's disease, Health and Technology, Vol. 9, Issue 2, pp 87–91, 2019.
[41] Sivakumar Krishnan, S. Lokesh, M. Ramya Devic, An efficient Elman neural network classifier with cloud supported internet of things structure for health monitoring system, Computer Networks, Vol. 151, pp. 201-210, 2019.
[42] Yang Yang, Xianghan Zheng, Wenzhong Guo, Ximeng Liu, Victor Change, Privacy-preserving smart IoT-based healthcare big data storage and self-adaptive access control system, Information Sciences, Vol. 479, pp.567-592, 2019.
[43] Javaid A. Kaw, Nazir A. Loan, Shabir A. Parah, K. Muhammad, Javaid A. Sheikh, G.M. Bhat, A reversible and secure patient information hiding system for IoT driven e-health, International Journal of Information Management, Vol. 45, pp. 262-275, 2019.
[44] K. Saini, S. Sharma, "Review on the Heart Disease Detection Using IoT Framework", International Journal of Computer Sciences and Engineering, Vol.7, Issue. 3, pp.669-674, 2019.

AUTHORS PROFILE

Renuka R. Londhe pursed her Bachelor of Science and Master of Science from S.R.T.M. University, Nanded, India, in year 2002 and 2004 respectively. She is also pursed M. Phil. and Ph. D. in the year 2009 and 2013 respectively. She is currently working as HoD and Assistant Professor of Computer Science at Department of Computer Science and IT, Rajarshi Shahu Mahavidyalaya (Autonomous), Latur. She has published more than 12 research papers in reputed international journals and conference proceedings. Her main research work focuses on Digital Image Processing. She has 13 years of teaching experience and 5 years of Research Experience.

