An Empirical Study of Internet of Things Integration with Healthcare Centre for Improving Quality of Service

Varsha Dubey Upadhyay[1], Nitika Vats Doohan[2], Naresh Menaria[3]
Research Scholar Computer Science, PAHER University, Udaipur, India
Computer Science Department, Medi-Caps University, Indore, India
Department of Mathematics, PAHER University, Udaipur, India

(E-mail: dubeyvarsha46@gmail.com)

***Abstract*—** Internet of Things (IoT) is an amalgam of technologies that support seamless integration between physical and digital worlds. Unprecedented advances in IoT related technologies witnessed. In the meantime, healthcare units show consistently developing requirement for pervasive computing hat enhance quality of life and well-being of humans. In the wake availability of wearable devices, sensors and smart devices that are used in healthcare units, it is a significant leap forward if there is integration of healthcare units with IoT. This article reviews the current research on IoT, present technologies in healthcare industries, and provides information on factors impacting IoT usage in healthcare service. This paper makes an empirical study of IoT integration in healthcare units to ascertain the insights that can lead to make strategic decisions. The key contribution of this article is to present the significance of IoT integration with healthcare infrastructure, change management, and the possibility of enhanced QoS in healthcare units

***Keywords*—** *Healthcare units, Internet of Things (IoT); Integration of IoT; Quality of Service (QoS); Change management*

I. INTRODUCTION

This study is about the integration of IoT technology with healthcare units for improving QoS. IoT is the ultimate technology that exploits inter-disciplinary technologies to realize a dream network of things that connect physical world with digital world for maximizing benefits which could not be imagined otherwise. Using Radio-Frequency Identification (RFID) physical objects can have ability to have identity and participate in integration with digital world. IoT According to Xu et al. [22] the rapid development of IoT paves way for leveraging emergency medical services in healthcare domain with innovative approach in data collection, integration in an inter-operable fashion. With emergence of cloud and mobile cloud technologies, it became evident that wireless body area networks used in healthcare domain can participate in IoT for massive deployment of pervasive healthcare applications that are truly real time. The goal of this exploration is to research the application of IoT and related technologies to improve healthcare services.

The present study focused on the technologies pertaining to identity, Global Positioning System (GPS), patient-centric approach, need for cloud, Service Oriented Architecture (SOA) software design, need for distributed programming framework for analytics, standardization, real time monitoring of health, use of mobile cloud computing, sensors, security, Virtual Private Network (VPN), tele-health, privacy, IoT middleware, , Cyber-Physical Systems, and the QoS in healthcare units with the integration of IoT. To this effect the primary data is collected and interpreted with quantitative analysis. The paper is composed with various distinctive to be specific section 2.Literature review, 3. Methodology, 4 outline Results, 5. present Discussion and section 6 summarize Conclusion.

II. LITERATURE REVIEW

Xu et al. [22] opined that the utilization of IoT within healthcare and other domains deliver outcome as exponential growth of data. Managing such data and having ubiquitous approach to data access is challenging. Rahmani et al. [18] focused on gateways that are used to bridge between sensor network and Internet as part of IoT. These gateways are used to provide services like embedded data mining, local data processing in real-time and local storage at higher level. Shah [20] opined that big data is invariably associated with IoT as the IoT produces voluminous data that needs to be processed. Li et al. [14] provided an overview of IoT that is used for

information sharing, support and strategic decision making. Danzl et al. [7] studied rural health can need for QoS and Quality of Experience (QoE) to minimize health issues. Tsai et al. [21] discussed about meta-heuristic algorithms pertaining to healthcare including challenges and issues there in. Paschou et al. [17] focused on Health IoT (HIoT). The related technologies identified for realization of HIoT include wrist-worn devices, heart rate monitors, pulse oximeters, glucose monitors, and stethoscopes. Ahmed et al. [3] provided an overview of IoT integrated with health infrastructure for monitoring. Gyrard et al. [12] stated the significance of semantic web to realize the needs of IoT and Web of Things (WoT). They said that semantic technologies provide benefits like ease of interconnection, deducing new knowledge, interoperability. Mettler and Raptis [15] on the other hand provide challenges like include security, knowledge empowerment and privacy in such integrated systems. Dijkman et al. [9] proposed a business model framework with IoT that can be used for different domains including healthcare. Catarinucci et al. [6] RFID is a low-power and low-cost technology which includes devices, named tags for participating in computations is sending information to RFID readers. Hiremath et al. [13] presented architecture for Wearable IoT (WIoT). The WIoT is made up of three major components (1) gateways (2) wearable sensors (3) cloud. Datta et al. [8] threw light into the possibility of personalized health services in smart homes. Addo et al. [1] opined that privacy and security play vital role for sustainable IoT growth in healthcare sector. Al-Majeed et al. [5] studied the possible usage of IoT to realize home tele-health. Guo et al. [11] opined that IoT can help to obtain embedded intelligence for medical services.

Ashan et al. [4] studied the functionality of middleware used for IoT and said that it works as interoperable services to integrate heterogeneous applications. Ahmad et al. [2] focused on CPS and WoT in expansion of the usage of IoT to realize smart cyber society. Sakr et al. [19] proposed a CPS for comprehensive data analytics and healthcare monitoring. In the context of big data produced by healthcare integrated IoT systems, their study assumes importance. From the literature it is understood that there are different aspects such as technologies associated with IoT and healthcare units. This paper investigates the role of IoT integration in improving QoS of healthcare units.

III. METHODOLOGIES

The research methodology used in this study includes multiple approaches. Figure 1 shows conceptual overview of the proposed methodology. Secondary research is carried out by reviewing literature

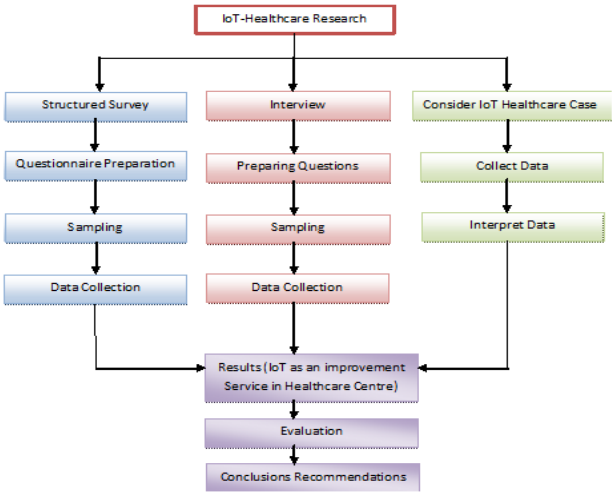

Fig. 1, Outline of research process

As shown in Figure 1, the research process outline is presented. There are three means in which data is collected. They include structured survey, interview and case study of healthcare unit to which IoT is integrated. They include secondary research, case study and primary research methods such as structured survey and interview. The results of these approaches are interpreted in order to have conclusions on the application of IoT in healthcare units and the impact. The data collection method here is questionnaire used as part of structured survey using online website Surveymonkey dot com. Interview is the qualitative approach used in this research. It also includes preparing questions, sampling, conducting interview live with participants using online video conferencing tools like GoTo Meeting. Here the data collection process is done with interview. The third approach employed in this thesis for investigating IoT integration with healthcare unit for improvement in QoS is case study. A case study is identified where a real world healthcare unit has already been integrated with IoT. Then the case is studied to ascertain benefits of using IoT with healthcare infrastructure, its limitations and security issues. These three approaches provide insights that are interpreted in order to conclude and provide possible directions for future research.

The sample size for structured survey is 150. It does mean that around 150 people participate in the survey. The sampling is made using random sampling method. The participants for the survey method are identified from the healthcare experts such as physicians, technicians and other stakeholders from multiple representative healthcare units in India. With respect

to Interview method, sample size is 25.These human experts are identified from well known healthcare units in India.
The information obtained in this paper sketch from three studies through an online survey, interview and case study. Participants, industry association or Experience of respondents with medical industry range of >1 year to more than 10 years. The age of the respondents indicating the range of 25 to 60 years.

In this research data analysis is done using both quantitative and qualitative approaches. Quantitative analysis is made using SPSS tool which is meant for statistical analysis. Qualitative analysis is made to interpret the results of interview. Other tools used for statistical analysis include ANOVA (Analysis of Variance) and Chi-square test.

3.1 Objective of the research

- To identify and summarize present advanced applications of IoT to improve healthcare services and provide useful insights, recommendations to utilize.

- To analyze the QoS in healthcare domain with respect to application of IoT using structured survey and interview

This research is related to investigation into the integration of IoT with healthcare infrastructure of a healthcare unit to improve QoS. First, it throws light into structured survey which obtains quantitative results. Then it focuses on the Interview method that brings about more qualitative information on the said research area. Afterwards, it continues investigation into the study using a case study. All the above mentioned approaches are included in the methodology of this research

In this research data analysis is done using both quantitative and qualitative approaches. Quantitative analysis is made using SPSS tool which is meant for statistical analysis. Qualitative analysis is made to interpret the results of interview. Other tools used for statistical analysis include ANOVA (Analysis of Variance) and Chi-square test.

IV. RESULT

Post successful data collection through methodologies, SPSS analysis tool has been used to conduct statistical analysis. Analysis output has been diagnosed to arrive on interpretation and results. Reliability point to the degree to which a scale produces steady results. In reliability analysis, the value of coefficient alpha or Cronbach"s alpha is used. According to Nunnally (1978), Cronbach‟s α-value must be higher than 0.7. The retrieved Cronbach‟s alpha is 0.891 as could be seen as below:
Case Processing Summary:
Number of cases - Valid = 150, Excluded = 0, Total=150
a. List wise deletion based on all variables in the procedure.

The industry association or Experience of respondents with medical industry revealed that, 38% of respondents have 1-5 years of experience and equal share of 38% have less than 1 year of experience and 10 % people got rich experience i.e. more than 10 years. The age of the respondents indicating that, 38% of respondents are aged between 25-30 i.e. very young generation people, and 40 % are 31-40 years category followed by 10 % & 11% each in 41- 50 and 51-60 years category. As per KMO test value is 0.795 is greater than 0.7 (KMO test measured sampling adequacy). As per Bartlett's Test of Sphericity, Significant value 0.002 is less than 0.05 which means multivariate normal and acceptable for factor analysis. Both the sampling adequacy and Bartlett's values are statistically valid.

Statistical analysis (Principal component and Varimax) conducted. As a next step, 15 factors tested are NFC, VPN, WSN, Realization of IoT integration, Tele-health, diversity in sensing devices, smart healthcare, SOA, cloud computing, disease surveillance, M2M, privacy, business models, CPS, end-to-end security, IoT as internet enabled technology improve efficiency by connecting to any device in a quick timeframe and capture real time patient data to support health decisions. IoT facilitate automated architecture and ecosystem that can contribute to efficiency while ensuring security measure. The top most influencing factors (2 among tested 15) to *Expected Service Efficiency with IoT:*

1. Machine to Machine interaction is promoted with RESTful web services so as to promote IoT integration with hospitals and smart homes where smart healthcare devices are used by people.

2. Mobility based healthcare IoT with end-to-end security and automated reconfiguration for continuous connection can help in improving quality of services in healthcare centres.

Table 1 & 2 below represent results and interpretation of chi-square test and Regression test respectively. SPSS tool have been used to conduct analysis on the basis of collected data.

Table 1 explain hypothesis, result and derived interpretation of chi-square test

TABLE 1. Chi square analysis results

Hypothesis	Result	Interpretation
H_{01}: There is no significant association between industry experience and their opinion on improvement in QoS with IoT	Significant value .039. (Sig. value is <0.05) Reject null hypothesis	As per physician's opinion, the IoT implementation in Health care will certainly improve the service level to the patients
H_{02}: There is no significant improvement between industry association and their opinion on improvement in decision making process with IoT.	Significant value .000. (Sig. value is <0.05) Reject null hypothesis	As per medical experts opinion, the IoT implementation will improve the decision making process in emergency cases.
H_{03}: There is no significant relation between industry association and their opinion on wearing body sensors will improve patient monitoring system.	Not significant value .074. (Sig. value is >0.05) Accept null hypothesis	As per doctors opinions, wearing body sensor may not improve patient monitoring i.e. the physical checking of patient has more efficient than depending on sensors.
H_{04}: There is no significant association between age of the respondents and their perception on E-Health and M-Health will improve health service	Significant value .032. (Sig. value is <0.05) Reject null hypothesis	As per expert's opinion the E & M-health services are certainly improving health care services to patients.
H_{05}: There are no equal opinions among age of the respondents and their opinion on Wireless Sensor Network will improve patient care.	Not significant value.319. (Sig. value is >0.05) Accept null hypothesis	As per age wise doctors are not accepting WSN will improve patient care they, prefer physical check up is more efficient
H_{06}: There is no significant relation among age of the respondents and their opinion on all stake holders' awareness on IoT will improve the health care service efficiency.	Significant value .000. (Sig. value is <0.05) Reject null hypothesis	all the stakeholders like patients , doctors and nurses , if they have better awareness of using IoT services ,which will obviously improve overall health care services to patients.

Table 2 explain dependent variable, regression equation, result and derived interpretation of regression test

TABLE 2. Regression analysis results

Dependent variable	Regression equation	Result	Interpretation
To improve QoS	To Improve QoS (Quality of Service) = 1.973 +0.445 (Accurate Diagnosis) -0.063 (Accurate care) +0.94 (secure gateway)	Model summary: (R=.872,RSquare =.670, Adjusted R Square =.195, Std. Error of the Estimate =.838). Significant value .004. (Sig. value is <0.05) Hence the adopted model was fit for preset scenario.	The tested dependent variables accurate diagnose and secure gateway factors are contributing positively, and the variables body sensors and Decease surveillance have negative impact.
Effective Change Management	Effective Change Management with IoT = .007 + .09 (Reap Benefits) -. 980 (Middle wear technologies) +.008 (Tele Health)	Model summary : (R=.986a, RSquare=.972, Adjusted R Sq =.972, Std. Error =.164). Significant value .000. (Sig. value is <0.05) Hence the adopted model was fit for preset scenario.	Effective change management by implementing IoT in heath care is possible, if the Tele health facility can be used effectively in health services, better utilization of technology will reap benefits in the form of patient satisfaction, and middle wear technology will have negative impact.

V. DISCUSSION

Exponential growth of data is expected to be produced by IoT according to Xu et al. [22] there is 82% support for this proposition. It reveals the significance of associating IoT integrate healthcare unit with big data processing using distributed programming frameworks. As studied by Lubecke et al. [15] and Addo et al. [1] IoT integration needs privacy and security to have sustainable growth. This proposition has 77% supports. Therefore it is essential to have privacy and security in IoT implementations in healthcare units. Possible realization of tele-health is expected by Al-Majeed et al. [5] for real time healthcare services without time and geographical restrictions. This proposition has 78% supports as reflected in the primary data collected.

Rahmani et al. [18] emphasized the need for usage of sensor devices in IoT networks. This can help in integrating wearable sensors used by patients to get integrated with healthcare infrastructure through IoT. This proposition has 82% which reflects the possible reality of sensors' usage in healthcare units for real-time integration. Dlodlo [10] explored potential applications of IoT including patient centric services in healthcare domain. The research found that 83% participants were in favor of IoT for patient-centric services. According to Catarinucci et al. [6] RFID and RFID readers play vital role in IoT integration to help physicians monitor health of select patients in real time. It has 77% support in the research. It is also linked to possibility of remote health monitoring with 74% support. Indirectly the usage of RFID and wireless technologies enable the possibility of real time diagnosis. This proposition has 75% supports. Rahmani et al. [18] studied eHealth gateway architecture and its need for IoT. This proposition has 77% support in the research.

The Research revealed that the improvement in QoS can be achieved in healthcare unit through IoT integration. Research findings indicate that it is possible to have real time monitoring of patients. Sensor devices associated with a patient can help in providing live or real time information through IoT to hospital infrastructure. This can help in making well informed decisions without geographical and time restrictions. Hypothesis prove that IoT integrated with healthcare units could also improve the decision making process in emergency cases.

The Research provides the insights that importance was given by healthcare organizations to have a standard architecture that facilitate reusable building blocks. Most widely used architectures include mHealth and eHealth. These architectures have their considerations on different aspects of integration. As these are targeted at IoT integration with healthcare units, they play an important role which is consistent with hypothesis. However, they need further refinement to realize sustainable and scalable integration with healthcare infrastructure.

It is revealed from the research that IoT integration has focused more on the patient centric approaches. In fact it is patient centred approach that gives more importance to empathy, effective communication, improved patient care, partnership between physician and patient, and reduce unnecessary costs. With IoT this approach is taken to next level as the patients are monitored closely and with technology innovations it is done real time with affordable cost. This could effectively reduce wastage of time and money and Health care will certainly improve the service efficiency levels to the patients.

It is interesting information from the research, IoT telehealth is significantly contributing in effective change management. Therefore, telehelath is understood to have its growth well in future. Better utilization of technology will also reap benefits in the form of patient satisfaction. Research indicates, accurate diagnosis and secure gateway could play an important role in improving the QoS.

V. CONCLUSION

IoT and its integration with healthcare units for improving QoS is the fundamental focal point of the research. This research paper threw light into the existing work on the usage of IoT in healthcare domain either conceptually or with actual integrations. The review of literature provided very useful insights. The empirical study with the survey method showed different aspects of the technology integration and its benefits for healthcare units besides providing QoS. The research revealed the need for security standards, privacy preservation to ensure that sensitive data is not stolen by adversaries, the utility of different technologies, and the efforts in ehealth (can be recognized as electronic health) and mHealth (can be recognized as mobile health) architectures. Research revealed that security standards, connectivity gateways, the possibility of tele-health, real time diagnosis, and remote health monitoring make the required QoS improvements in healthcare units. It also shows the necessity of identify technologies like RFID, 5G technology, GPS, secure private communications for physicians to involve in real time health monitoring and diagnosis.

REFERENCES

[1] Addo, I. D., Ahamed, S. I., Yau, S. S., and Buduru, A. "A reference architecture for improving security & privacy in IoT applications", Conference on Mobile Services IEEE, pp.65-78(2014).

[2] Ahmad, A., Paul, A., Rathore, M. M., and Chang, H. "Smart cyber society integration of capillary devices with high usability based on CPS", Future Genration computer System ELSEVIER, pp.493-503(2016).

[3] Ahmed, M. U., Bjorkman, M., Čaušević, A., Fotouhi, H., and Linden, M. "An overview on the IoT for health monitoring systems", SPRINGER CHAM, pp 429-436(2016).

[4] Ahsan, M.,Talib, M. R., Sarwar, M. U., Khan, M. I., and Sarwar, M. B. "Ensuring interoperability among heterogeneous devices through IoT middleware ", International Journal of Computer Science and Information Security , pp.251-255(2016).

[5] Al-Majeed, S. S., Al-Mejibli, I. S., and Karam, J. "Home telehealth by IoT ", Conference on Electrical and Computer Engineering IEEE, pp.1-7(2015).

[6] Catarinucci, L., Donno, D. d., Mainetti, L., Palano, L., Patrono, L., and Stefanizzi, M. L. "An IoT-aware architecture for smart healthcare systems", Internet of Things Journal IEEE , pp.515 - 526(2015).

[7] Danzl, M. M., Harrison, A., Hunter, E. G., Kuperstein, J., Sylvia, V.,and Maddy, K. "A lot of things passed me by rural stroke survivors and caregivers experience of receiving education from health care providers", Journal Rural Health, pp.13-24(2016).

[8] Datta, S. K., Bonnet, C., Gyrard, A., da Costa, R. P., and Boudaoud, K. "Applying IoT for personalized healthcare in smart homes" ,Conference on Wireless and Optical Communication IEEE , pp.1-6 (2015).

[9] Dijkmana, R. M., Sprenkels, B., Peeters, T., and Janssen, A. "Business models for the IoT", International Journal of Information Management ELSEVIER, pp.672–678 (2015).

[10] Dlodlo, N., Mofolo, M., & Kagarura, and G. M. "Potential applications of the IoT in sustainable rural development in South Africa", Advances in Information Technology and Applied Computing, pp.180-188(2013).

[11] Guo, B., Zhang, D., Yu, Z., Liang, Y., Wang, Z., and Zhou, X. "From the IoT to embedded intelligence" ,World Wide Web Journal SPRINGER , pp.399–420(2013).

[12] Gyrard, A., Patel, P., Datta, S. K., and Ali, M. I. "Semantic web meets IoT and Web of Things", Conference on World Wide Web Campnion, pp.1-10(2016).

[13] Hiremath, S., Yang, G., and Mankodiya, K. "Wearable IoT concept, architectural components and promises for person centered healthcare", Conference on wireless mobile communication and healthcare IEEE, pp.304-307 (2014).

[14] Li, Y., Hou, M., Liu, H., and Liu, Y. "Towards a theoretical framework of strategic decision, supporting capability and information sharing under the context of IoT", Information Technology and Management Springer, pp.205-216(2012).

[15] Lubecke, O. B., Gao, X., Yavari, E., Baboli, M., Singh, A., and Lubecke, V. M. "eHealthcare remote monitoring, privacy, and security", Conference on Microwave Symposium IEEE , pp.1-4(2014).

[16] Mettler, T., and Raptis, D. A. "What constitutes in health information systems for fostering systematic framework and research agenda", Health Information Journal, pp.148-156(2012).

[17] Paschou, M., Sakkopoulos, E., Sourla, E., and Tsakalidis, A. "Health IoT metrics & methods for efficient data transfer" , Simulation Modelling Practice and Theory ElSEVIER , pp.186-199 (2013).

[18] Rahmani, A. M., Thanigaivelan, N. K., Gia, T. N., Granados, J., Negash, B., and Liljeberg, P., et al. "Smart eHealth gateway bringing intelligence to IoT based ubiquitous healthcare systems", Conference on Consumer Communications and Networking IEEE , pp.826-834(2015).

[19] Sakr, S., and Elgammal, A "Towards a comprehensive data analytics framework for smart healthcare Services", ELSEVIER, pp.44-58 (2016).

[20] Shah, M. "Big data and the IoT." from big data analysis new algorithms for a new society. in: Japkowicz N., Stefanowski J. , SPRINGER CHAMP,pp.207-237 (2016).

[21] Tsai, C. W., Chiang, M. C., Ksentini, A., and Chend, M. "Metaheuristic Algorithms for Healthcare: Open Issues and Challenge" , Computers & Electrical Engineering ElSEVIER , pp.421-434(2016).

[22] Xu, B., Xu, L. D., Cai, H., Xie, C., Hu, J., and Bu, F. "Ubiquitous data accessing method IoT based information system for emergency medical services", Transactions on Industrial Informatics IEEE ,pp.1-9(2014).