A SURVEY ON INTEGRATED METHODS FOR SECURING HEALTHCARE DATA WITH INTERNET OF THINGS

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Abstract: Due to its enormous potential and huge prospective for use, as well as its huge benefits and the huge utility it offers, The Internet of Things concept becomes deeply embedded in today's medical telemedicine system. These systems allow patients to have their health monitored 24/7 from the convenience of their home, either through sensors that gather various medical metrics or wearable devices that send health signals in real-time. The data is transmitted over the internet to a specialized workspace and stored in the cloud for later analysis. This article describes IoT design and architecture to monitor ECG signals that are recorded by patients using an electronic tele-cardiogram that is mobile without the help of a professional in the medical field. In this paper, the most important features of these devices are described in depth, along with how they integrate into their place within the IoT architecture Security concerns that could arise from their use are addressed, such as security integrity, confidentiality, integrity, and authenticity.

Keywords: Internet-of-Things, medical signals, tele-electrograph, Encryption,

I. Introduction

"Health is the best wealth" is a maxim that has remained true throughout the ages. Even though he has the capability of sending rockets to other planets, health issues continue to plague him. Thanks to technological advances in healthcare, modern hospitals are highly advanced and equipped with cutting-edge capabilities for treating various ailments. However, maintaining one's health has become an expensive endeavour and people around the world are spending a substantial amount of money for it. It appears that healthcare services are out of reach for many ordinary individuals. Technology should be utilized to meet the healthcare needs of those who are poor and in need. City dwellers have access to health facilities when they have sufficient funds or insurance coverage, but what happens to those living in rural areas who are unable to afford expensive medical treatments? This is the issue that technology-driven systems must solve. Without aiding the poor and neediest, technology's value as a tool becomes diminished. This sentiment has motivated researchers and academics

to explore the latest advancements in computing technology. This concept began as a way to assist those living in rural areas, opening the door for initiatives such as remote health monitoring something unimaginable just a few years ago.

IoT technology allows the physical and digital worlds to come together. A human being, for example, is physical in nature while a mobile device is digital. These two can be seamlessly intertwined through IoT technology. This is made possible with technologies such as radio frequency identification (RFID), sensing technologies, and sensors embedded in wearable devices, telecommunications networks, the internet, and other connected devices—collectively referred to as IoT devices. On the other hand, cloud computing and its services could offer on-demand storage and computing power with availability, scalability, and fault tolerance. Thus, both cloud computing and IoT are indispensable for remote health monitoring applications. Cloud computing also offers distributed programming frameworks like Hadoop for data storage and management. Unfortunately, research has indicated that the current integration of IoT and cloud technologies in healthcare units lacks empirical validity. When people living in villages who can access local primary healthcare are taken into account, having a comprehensive framework that facilitates remote health monitoring is essential. In this thesis, a framework is proposed that uses IoT and the cloud technology in combination with a physical healthcare center (PHC), so patients can be monitored remotely. Patient vital signs are collected and stored in the cloud, where analytics are applied to produce results accessible to different stakeholders - including doctors - through a mobile application. This chapter summarizes key aspects of this research project while subsequent chapters provide more specifics.

The term "network" is an umbrella term for a collection of computers or devices connected together and capable of sharing data and resources. Before networks were invented, computers operated independently in "isolated mode." Modern advances in computing technology have seen much advancement in networked computing over time.. Interdisciplinary in technology refers to the combination of methods from different fields like computer science and electronics, which allows the IoT to link the physical and digital worlds together. As a result, multiple disciplines and standards from various vendors must come together in order for real-world IoT applications to take off. With these resources in place, many exciting real world IoT uses are being realized. Precision agriculture, for instance, utilizes various technologies to determine the necessary inputs for crops and when they

should be given. Making the right decision at the right time can have a major effect on productivity while helping eliminate waste. Precision agriculture is only one example of the many IoT applications. Other potential uses include smart homes, healthcare monitoring, smart cities, intelligent transportation systems, and inventory tracking - just to name a few. By integrating IoT into different applications, businesses can reap many rewards from its potential. IoT technology facilitates communication among devices; Machine-to-machine (M2M) communications can now take place without human intervention. Utilizing sensor networks for data collection and analysis, it becomes possible to make informed decisions based on this collected information. IoT provides automation and control through M2M communications, where devices and their information can be readily accessed. This enables more sophisticated automation and control methods. Furthermore, the IoT helps monitor applications by anticipating needs ahead of time. M2M reduces time and improves the efficiency of real-world systems with speedier responses. Alongside these benefits, however, the IoT can also help people in their everyday lives, making everything more efficient as well as more effective!

Connected Health Monitoring with IOT Integration

IoT technology offers many benefits to individuals by connecting physical and digital elements. Examples of its uses include precision agriculture, smart homes, smart cities, and intelligent transportation. But its integration with healthcare units could potentially offer even greater advantages to those affected by its presence. People of all backgrounds need access to healthcare. Unfortunately, sophisticated procedures can be expensive and inconvenient for rural populations in countries like India. Since the Internet of Things connects physical from physical objects (like humans) to digital devices like computers, wearable devices offer the potential for real-time monitoring of human health status. This integration is only possible through IoT technology. In actuality, the data gathered by remote monitoring systems are saved in cloud and is accessible through mobile devices. Therefore, cloud computing and machine-centric computing (MCC) are used in combination with the Internet of Things to deliver remote health monitoring services.

Privacy and Security Challenges

Figure 1 illustrates some of the privacy and security challenges associated with IoT applications. Since these involve devices connected together, it is vital to ensure authenticated access to devices because authentication is an important security flaw that

makes IoT apps vulnerable to attack. Also, strict authorization procedures should be implemented; rigorous authorization procedures make sure only authorized individuals are granted access to the resources. The privacy of the IoT plays an important role in the analysis and dissemination of data.

II. Literature Survey

The advent of cutting-edge technologies is having a profound effect on people from all backgrounds. The Internet of Things (IoT) is the result of this convergence, uniting the physical and digital worlds for seamless connectivity. There are countless use cases that will have an immense effect on society when IoT technology is integrated. Healthcare is among the scenarios that have the highest potential impact on people. Monitoring health remotely for people who are unable to pay for traditional healthcare is extremely sought-after. This chapter reviews the literature to determine if remote health monitoring services can be made available by IoT integration into healthcare units. SOA-based IoT messaging as well as cloud storage can have benefits and could be used in the field of healthcare, which includes robot-human interactions as well as cyber security issues related to healthcare IT systems.

Internet of Things Suitability for Healthcare Units

IoT technology enables healthcare applications to access patients' health data at anytime and from any place, providing them with unlimited accessibility and scalability. This accessibility combined with any time, place, or anything capabilities, is one of the key benefits of the platform. Technology facilitates communication among various entities. For instance, it allows interaction between computers as well as between things and objects (T2T) and between things and humans (H2T) and between humans and other humans (H2H). As demonstrated by Dang and colleagues. (14), technology supports this notion. Boyi Xu et al. [2] predicted that applications of IoT in healthcare and other fields will lead to an exponential rise in data volume.

Data management and an all-inclusive approach for accessing data are major hurdles. In addition, it can be difficult to develop strategies for different data formats. Boyi Xu and colleagues [2] conducted research in the healthcare sector using UDA-IoT, a resource-based data access method. They investigated methods and approaches for implementing an integrated healthcare information system that utilizes data gathered from various IoT sources. Boyi Xu and colleagues [2] demonstrated this in their study entitled the Medical

Emergency Decision Support System. Health professionals and their supervisors can take advantage of IoT data sources to make informed decisions, such as alternative rescue models, entities-oriented models, persistent designs that is transition-oriented, an execution system and cloud IoT services for accessing data. With these tools in place, health professionals and their supervisors can leverage alternative models, entity-oriented models, entity-oriented designs, persisting designs with transitional aspects, an execution system, as well as cloud IoT services for data access.

Amir et al. [51] the study looked at gateways as "bridges between sensors networks with the Internet, forming an element in the IoT." They offer features such as integrated data mining and real-time process and more advanced storage at a lower level. Furthermore, the gateway can address various issues, like time connections. Any Place Connection Anything that provides mobile Internet connectivity on-the-go during days and nights—connecting computers (h2h), people and objects (h2t), as well as things and things (t2t). All while maintaining reliability, scalability and efficiency of energy. The study they conducted on the architecture they designed showed that "IoT-monitored health at hospitals could improve the safety, reliability interoperability, as well as cost savings" (Catarinucci and co.). A smart IoT-aware architecture has been suggested to monitor the medical equipment, patients and personnel automatically using RFID tags. Wireless Sensor Networks (WSN) and smart phones are the key components of their design, and a virtual private network (VPN) gives secure remote access to healthcare infrastructure.

Jayavardhana et al. [31] discussed "the vision and future direction in IoT," providing a "schematic outline" to measure, analyze, and visualize data. Oweis et al. conducted similar research, while Unitsung et al. suggested using case studies to illustrate why there is a need for IoT; Maria et al. proposed monitoring food-borne contamination linked with health issues through an Internet of Things system.

IoT brings together industrialists, policymakers, healthcare professionals also benefit from these initiatives, which encompass smart transportation as well as local/community projects like defense remote sensing or intelligent grids, among many other services. Mohak Shah noted the IoT produces vast amounts of data which must be processed. Yuan Li et al. provided an overview of this new frontier in computing, noting its potential to facilitate sharing information and aid decision-making processes. Megan et al. concluded with a call for further research into data mining using artificial intelligence (AI) systems. They examined

how rural health could benefit from Quality of Service or Quality of Experience to help reduce health problems. They emphasized the importance of healthcare technology in education and also the latest technologies that could be used to enhance human quality of living.

Joao Santos et al. [53] have suggested an IoT-driven, mHealth solution that consists of mobile devices as well as health infrastructure which could then be used to build intelligence advisory (IPA). As mobile device usage continues to rise, more IPA applications have emerged within real-life scenarios connected with healthcare fields that provide autonomous data collection such as location tracking, heart rate detection, and fall detection [15]. Chun et al examined "metaheuristic algorithms used in healthcare along with their challenges and issues associated with them" (16 Chun et al).

RFID, wireless sensor networks (WSN), IoT middleware in the cloud, as well as application software according to Amelie and colleagues (2010), these five elements work in synergy to create a successful ecosystem. [22] Highlighted the significance of the semantic web in meeting both IoT and WoT requirements. They highlighted that semantic technologies provide advantages like easy connection, access to the latest information and interoperability. Tobias Mettler et al. (2013) provide more information regarding this issue. But these systems also pose integration issues. Dijkman and al have developed an IoT-based framework to develop business models that could be utilized across a variety of industries - including healthcare - fostering innovative concepts based upon IoT technologies. This will encourage innovative business models that make use of IoT technologies.

Role of Mobile Cloud Computing for Realizing IOT in Healthcare Units

Cloud computing for mobile devices consists of several elements, such as "mobile computing," "cloud computing," wireless networks, network operators, mobile users, and cloud computing service providers. Jiafu Wan et al. explored how MCC can be applied to healthcare services. They further discussed that MCC integration can be achieved through body-area networks, providing wearable devices with real-time access to health data about individuals. Additionally, devices participating in MCC don't need much hardware in terms of memory or processor speed since they can outsource computing and storage to the cloud. Integrating MCC into a wearable device network can provide numerous benefits, such as enhanced user experience and functionalities, efficient performance, patient-centric services,

and increased reliability. Body sensor nodes used by patients form networks with mobile devices in hospitals. The network is then joined to the Internet through the base station or through access points allowing it to connect to mobile and cloud-based servers through the internet. Data stored on servers may contain patient vital signs, which are then analyzed with appropriate algorithms for diagnosis. Physicians then have real-time access to this health information so they can treat patients accordingly. According to Hiremath et al., MCC reduces smart phone battery consumption by outsourcing both storage and processing functions.

Stergiou et al. examined the role of MCC (Media Content Filtering) in IoT and healthcare integration, noting its shortcomings concerning security, connection speed, Mazhar Rathore et al. presented an IoT-based plan for connecting smart cities using big data analysis, with their primary purpose being to provide an IoT solution for hospitals. Urban development initiatives and big data analytics initiatives, as well as smart city development, are all part of their plan.

Role of RFIDIOT-Based Healthcare Units

Amir et al. [51] pointed out that RFID, as well as RFID readers, is a key element in the abstraction of hardware for the eHealth gateway. In the words of Luca Catarinucci et al. [53] [33], "RFID can be described as a power-efficient, low-cost technology that utilizes tags to transmit information onto RFID readers." RFID tags consume no energy and also have a long lifespan, making them suitable as a solution for IoT applications. A different type of RFID is "Ultra-High Frequency (UHF) RFID," which offers additional features such as sensing and calculation. Healthcare facilities that use RFID-enabled sensing have an energy-efficient and cost-effective solution that requires minimal installation work. RFID tags integrate the capabilities of sensing and computing, but they only function within their readers' area; thus, they should not be used to create devices or applications for monitoring patients.

Madanian was a researcher studying both eHealth technologies as well as RFID technology and concluded RFID is a key element in IoT implementation and integration into healthcare networks. An antenna-equipped RFID reader; receiver with RF module; tag; host device or computer (Figure 1); each requires its own specific components.

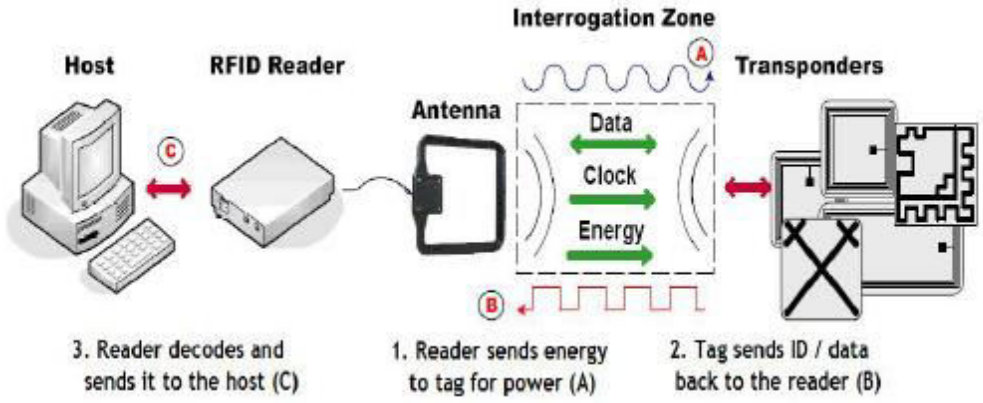

Figure 1: Components of RFID System

Tags are used to uniquely identify objects and transmit data wirelessly. Dynamic tags come with an embedded power source as well as document reading capability, while passive tags lack this feature and have a smaller reading range.

Wearable sensors have emerged as an essential element of the medical industry, collecting vital signs from patients, allowing physicians to make educated decisions. Recently, an IoT-driven system for healthcare management for better healthcare efficiency and outcomes in this space utilizes wearable sensors to collect body data through data analytics; then, this information is processed through predictive models to give clinical diagnoses or prognoses. The system is illustrated in Figure 2.

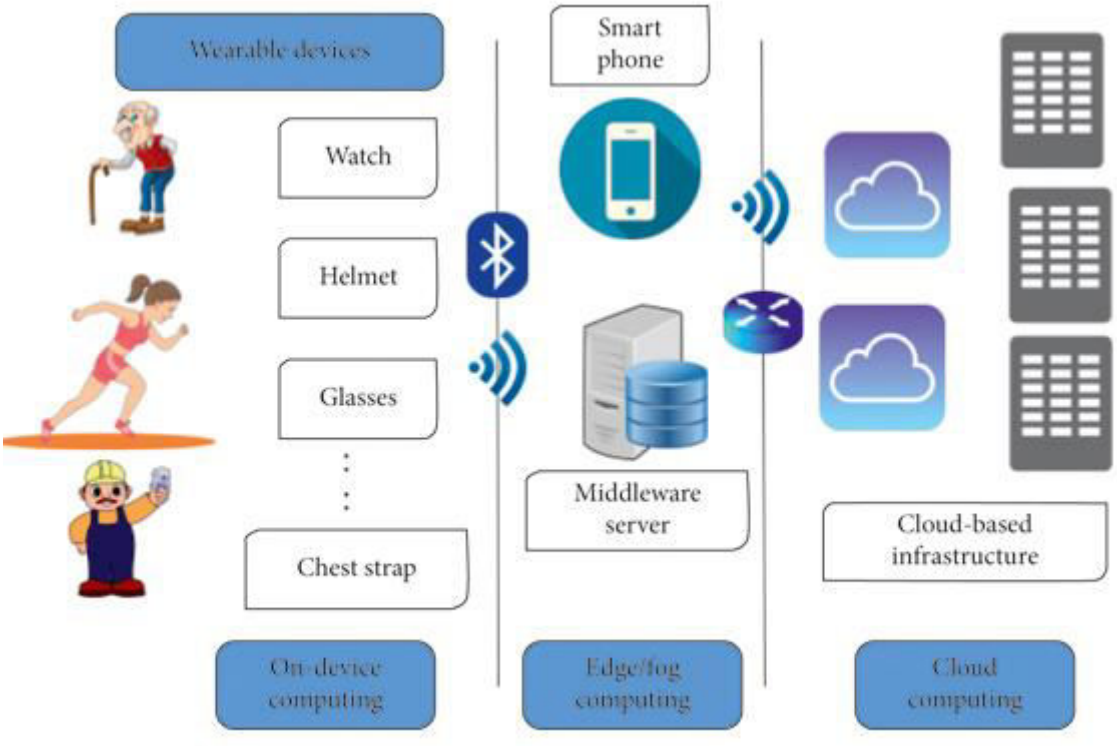

Figure 2: Sensors and data analytics for monitoring Healthcare System

The system utilizes both historical and current data in order to achieve superior data analytics results. This cloud-based diagnosis system utilizes machine learning techniques, which are integral parts of artificial intelligence (AI) and the rapidly developing data science field. Data-driven approaches have long been employed to address real-world problems, including heart disease prediction. According to the literature, various algorithms have been found suitable for this task, all relying on data. Features extraction, feature selection, and feature optimization are essential for improving classification algorithms. Classification algorithms can perform prediction tasks based on the training provided to them; thus, they're known as supervised machine learning algorithms.

Table 1: Implemented methodologies and limitations in literature survey

Joel J. P. C. Rodrigues, Senior Member, IEEE, Dante B. R. Segundo [11]	Enabling Technologies for the Internet of Health Things	A review of techniques based on IoT for healthcare and ambient assisted living, defined as the Internet of Health	this paper can be considered as a source of information for healthcare providers, specialists.

		Things (IoHT)	
JayeetaSaha, Arnab Kumar Saha [23]	Advanced IOT-based Alarm System, Home Automation, and Remote Health Monitoring	remote health monitoring system by offering alarm notification along with prescribed medicine name and dose display	This system needs an appropriate bandwidth since email alert notification and website visit for remote data monitoring through internet depends on the proper bandwidth of internet connection
Liu, Yuehua, Tharam Dillon, Wenjin Yu [39]	When there are severe irregularities in industrial IoT sensor data, noise removal is required.	Nearest neighbor method	Implemented only on limited synthetic data sets. Missing value imputation not addressed.
Deng, Xiaowu, Peng Jiang [42]	A sophisticated outlier detection technique using a one-class support tucker machine as well as a genetic algorithm for large sensor data from the Internet of Things	OCSTuM, GA- OCSTuM	Consumes more time to analyze high-dimensional data

III. Motivation

Motivation Human beings are spending an increasing amount of money on healthcare services. The industry is becoming more advanced and equipped, necessitating that patients

dedicate both time and resources in order to receive care. When patients live in remote places (especially elderly individuals), getting to a healthcare facility and making an appointment can take considerable time. Unfortunately, many cases have occurred where people have died from heart attacks due to lack of access. Technology that is able to monitor the vital signs from a distant location can help save lives and offer better health services. Monitoring health remotely is possible with cloud computing, sensing technology, and technologies like the Internet of Things (IoT). IoT technology - especially for those living in rural areas, will transform the way health services are offered as well as help patients fight dangerous diseases. This is why we are doing this research project.

IV. Proposed Methodology

IoT can be achieved through various existing technologies as well as new standards. Because it connects digital and physical things it should make use of all the available technologies specifically communications technologies, sensing technologies, various types of computers, and the existing digital and physical infrastructure. Organizations can leverage IoT benefits without reinventing their infrastructures by integrating these elements together as shown in Figure 3. When looking at IoT architecture from a higher-level perspective (as depicted in Figure 3), multiple layers are present.

IoT architecture consists of multiple layers. Network layer and sensor connectivity: this covers sensing technologies such as sensors, actuators, and RFID tags. It handles both identification and sensing. Gateway connectivity: the gateway layer wraps all gateway protocols currently in use. Service layer for management: it is responsible for the device's modeling as well as security management, configuration management, and data flow management. More details on these are available in the following sections.

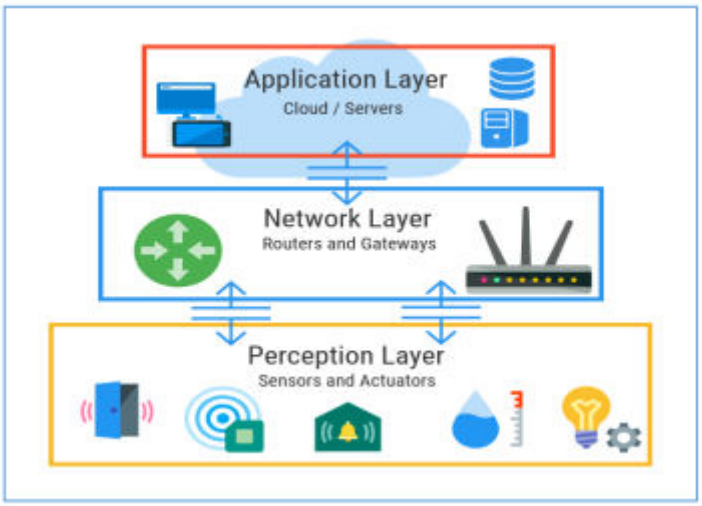

Figure 3: IOT Architecture overview

Healthcare is one of the areas that have a profound effect on people from all backgrounds. To this day, healthcare services continue to evolve with new The "Internet of Things" is the future, an interconnected system connecting digital and physical worlds. By applying these technologies and their applications together, we can achieve a synergistic effect from these innovations. A fusion IoT IoT with healthcare devices can provide unbeatable quality healthcare services. Through IoT as an encompassing technology amalgamation, remote health monitoring becomes possible; this hypothesis guides this research. To this end, this chapter illuminates the IoT's potential for remote health monitoring.

This section lays the foundation to enable remote monitoring of health using IoT technological integration. The article examines the structure of the IoT, its importance across industries, and how RFID tags can be employed alongside sensor networks and microcontrollers to realize this vision.

V. Conclusion

This article outlines a new remote health monitoring system that is IoT-integrated and integrated into the village's primary healthcare center and smart bed, in which patients can wearable devices that was implemented. After conducting empirical research and comparing it to the latest technology research findings, the researchers came to this conclusion: A comprehensive study of the literature was conducted on IoT-integrated health systems. It's given me valuable insight into cutting-edge technologies like NFC, RFID, MCC Wearable devices, and remotely-controlled health systems. In addition, the study offered insight into

SOA-based systems that analyze health data using ECGs, IoT use within healthcare systems, Raspberry Pi use for healthcare system integration, as well as cyber physical systems that have IoT integration and security systems. What are the requirements to implement the IoT integrated system to monitor health remotely at village Primary Healthcare Centers (PHCs) with smart beds that wearable devices are analyzed? An example of an integrated IoT application case involving the use of a smart bed in the PHC located in the village to provide remotely monitored health is suggested.

VI. References

[1].Ji, W.; Xu, J.; Qiao, H.; Zhou, M.; Liang, B. Visual IoT: "Enabling Internet of Things Visualization in Smart Cities". IEEE Netw. 2019, 33, 102–110.

[2].Tanwar, S.; Bhatia, Q.; Patel, P.; Kumari, A.; Singh, P.K.; Hong, W.C. "Machine Learning Adoption in Blockchain-Based Smart Applications: The Challenges, and a Way Forward". IEEE Access 2019, 8, 474–488.

[3].Butt, S.A.; Diaz-Martinez, J.L.; Jamal, T.; Ali, A.; Franco, E.; Shoaib, M. "IoT Smart Health Security Threats". In Proceedings of the 19th International Conference on Computational Science and Its Applications (ICCSA), Saint Petersburg, Russia, 1–4 July 2019.

[4].Nasir, H.; Parah, S.A.; Sheikh, J.; Turjman, F.; Khan, M. "Secure data transmission framework for confidentiality in IoTs". Ad Hoc Netw. 2019, 95, 101989.

[5].Breach Barometer. Available online: https://www.protenus.com/resources/2021-breach-barometer/ (accessed on 12 December 2021).

[6].Gull, S.; Parah, S.A.; Khan, M. "Reversible data hiding exploiting Huffman encoding with dual images for IoMT based healthcare". Comput. Commun. 2020, 163, 134–149.

[7].Muhammad, B.; Ataur, R.; Fahim, A.; Gwanggil, J. "Energy-harvesting based on internet of things and big data analytics for smart health monitoring". Sustain. Comput. Bioinf. Syst. 2018, 20, 155–164.

[8].Gull, S.; Mansour, R.F.; Aljehane, N.O.; Parah, S.A. "A self-embedding technique for tamper detection and localization of medical images for smart-health Multimedia Tools" Appl. 2021, 80, 29939–29964.

[9].Liu, X.; Lin, C.; Yuan, S. “Blind Dual Watermarking for Color Images’ Authentication and Copyright Protection”. IEEE Trans. Circuits Syst. Video Technol. 2018, 28, 1047–1055.

[10].Wahed, M.A.; Nyeem, H. “High-capacity reversible data hiding with interpolation and adaptive embedding”. PLoS ONE 2019, 14, e0212093.

[11].Gull, S.; Loan, N.A.; Parah, S.A.; Sheikh, J.A.; Bhat, G.M. “An efficient watermarking technique for tamper detection and localization of medical images”. J. Ambient. Intell. Humaniz. Comput. 2020, 11, 1799–1808.

[12].Puteaux, P.; Puech, W. Rebuttal: “On the Security of Reversible Data Hiding in Encrypted Images by MSB Prediction”. IEEE Trans. Inf. Forensics Secur. 2021, 16, 2445–2446.

[13].Rinki, K.; Verma, P.; Singh, R.K. “A novel matrix multiplication based LSB substitution mechanism for data security and authentication”. J. King Saud Univ.–Comput. Inf. Sci. 2021.

[14].Hu, R.; Xiang, S. “Reversible Data Hiding by Using CNN Prediction and Adaptive Embedding”. IEEE Trans. Pattern Anal. Mach. Intell. 2021.

[15].He, W.; Cai, Z. “Reversible Data Hiding Based on Dual Pairwise Prediction-Error Expansion”. IEEE Trans. Image Process. 2021, 30, 5045–5055.

[16].Showkat, S.; Parah, S.A.; Gull, S. “Embedding in medical images with contrast enhancement and tamper detection capability”. Multimed. Tools Appl. 2021, 80, 2009–2030.

[17].Hussan, M.; Parah, S.A.; Qurashi, G.J. “Realization of a Reversible Data Hiding Framework using Histogram Bin Shifting for Color Images”. In Proceedings of the Fifth International Conference on Image Information Processing, Shimla, India, 15–17 November 2019.

[18].He, W.; Xiong, G.; Wang, Y. “Reversible Data Hiding Based on Adaptive Multiple Histograms Modification”. IEEE Trans. Inf. Forensics Secur. 2021, 16, 3000–3012.

[19].Kaw, J.A.; Loan, N.A.; Parah, S.A.; Muhammad, K.; Sheikh, J.A.; Bhat, G.M. “A reversible and secure patient information hiding system for IoT driven e-health”. Int. J. Inf. Manag. 2019, 45, 262–275. [Google Scholar] [CrossRef]

[20].A. Doulamis, N. Doulamis, A. Angeli et al., "A non-invasive photonics-based device for monitoring of diabetic foot ulcers: architectural/sensorial components & technical specifications," Inventions, vol. 6, no. 2, p. 27, 2021.

[21].Alraja, Mansour Naser, Murtaza M. Junaid Farooque, and Basel Khashab. "The Effect of Security, Privacy, Familiarity and Trust on Users' Attitudes Towards the Use of IoT-based Healthcare: The Mediation Role of RiskPerception." IEEE Access (2019).

[22].Ma, Ying, Kang Ping, Chen Wu, Long Chen, Hui Shi, and Dazhi Chong. "Artificial Intelligence powered Internet of Things and smart public service." Library Hi Tech (2019).

[23]. C.M. Lolita, R. Roopalakshmi, S.L. Pais, S. Ashmitha, M. Banu, M. Akhila, "IoT-Based Patient Remote Health Monitoring in Ambulance Services". Lecture Notes on Data Engineering and Communications Technologies, pp.421–429, 2018.

[24]. G. Manogaran, R.Varatharajan, D. Lopez, P.M. Kumar, R. Sundarasekar, C. Thota, "A New Architecture of Internet of Things and Big data Ecosystem for Secured Smart Healthcare Monitoring and Alerting System". Future Generation Computer Systems, 82, pp.375-387, 2018.

[25]. A. Nayyar, V. Puri, N.G. Nguyen, "BioSenHealth 1.0: A Novel Internet of Medical Things (IoMT)-Based Patient Health Monitoring System". Lecture Notes in Networks and Systems, pp.155-164, 2019.

[26]. J.J.P.C. Rodrigues, D.B. De Rezende Segundo, H.A. Junqueira, M.H. Sabino, R.M. Prince, J. Al-Muhtadi, De Albuquerque, V.H.C., "Enabling Technologies for the Internet of Health Things". IEEE Access, 6, pp.13129– 13141, 2018.

[27]. J. Saha, A.K. Saha, A. Chatterjee, S. Agrawal, A. Saha, A. Kar, H.N. Saha, "Advanced IOT based Combined Remote Health Monitoring, Home Automation and Alarm System". 2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC), pp.1-5, 2018.

[28]. R. Sundarasekar, M. Thanjaivadivel, G. Manogaran, P.M. Kumar, R. Varatharajan, N. Chilamkurti, C.H. Hsu, "Internet of Things with Maximal Overlap Discrete Wavelet Transform for Remote Health Monitoring of Abnormal ECG Signals". Journal of Medical Systems, 42(11), pp.1-13, 2018.

[29]. S. Patil, Shamshekhar and R. Sunitha, N., "A Novel, Lightweight, and Cost-Effective Mechanism to Secure the Sensor-Gateway Communication in IoT," Cybernetics and Algorithms in Intelligent Systems, pp. 403-412, 2019. 10.1007/978-3-319-91192-2_40.

[30]. Gargees, Rasha S., and Grant J. Scott, "Dynamically Scalable Distributed Virtual Framework Based on Agents and Pub/Sub Pattern for IoT Media Data," IEEE Internet of Things Journal, vol. 6, no. 1, pp. 599-613, 2019.

[31]. Santos, João, Joel JPC Rodrigues, João Casal, Kashif Saleem, and Victor Denisov, "Intelligent personal assistants based on internet of things approaches," IEEE Systems Journal, vol. 12, no. 2, pp. 1793-1802, 2018.

[32]. C. Li and B. Palanisamy, "Privacy in Internet of Things: From Principles to Technologies," in IEEE Internet of Things Journal, vol. 6, no. 1, pp. 488-505, Feb. 2019.

[33]. D. Wang, B. Bai, K. Lei, W. Zhao, Y. Yang and Z. Han, "Enhancing Information Security via Physical Layer Approaches in Heterogeneous IoT with Multiple Access Mobile Edge Computing in Smart City," in IEEE Access, vol. 7, pp. 54508-54521, 2019.

[34]. Dang, L.M.; Piran, M.J.; Han, D.; Min, K.; Moon, H. "A Survey on Internet of Things and Cloud Computing for Healthcare". Electronics 2019, 8, 768.

[35]. Deelip, S.A.; Sankpal, S.V. "IOT based Smart and Secure Health Care System Analysis & Data Comparison". Int. J. Res. Appl. Sci. Eng. Technol. 2020, 8, 394–398.

[36]. Sanjay, S.; Shekokar, N. "Towards Smart and Secure IoT Based Healthcare System. In Internet of Things, Smart Computing and Technology: A Roadmap Ahead, Studies in Systems, Decision and Control"; Dey, N., Mahalle, P.N., Shafi, P.M., Kimabahune, V.V., Hassanien, A.E., Eds.; Springer Nature AG: Cham, Switzerland, 2020; Volume 266, pp. 283–303.

[37]. Hathaliya, J.J.; Tanwar, S. "An exhaustive survey on security and privacy issues in Healthcare" 4.0. Comput. Commun. 2020, 153, 311–335.

[38]. Aceto, G.; Persico, V.; Pescapé, A. Industry 4.0 and health: "Internet of things, big data, and cloud computing for healthcare" 4.0. J. Ind. Inf. Integr. 2020, 18, 100–129.

[39]. Ray, P.; Dash, D.; Salah, K.; Kumar, N. "Blockchain for IoT-Based Healthcare: Background, Consensus, Platforms, and Use Cases". IEEE Syst. J. 2020, 2020, 1–10.

[40]. Nazir, S.; Ali, Y.; Ullah, N.; García-Magariño, I. “Internet of Things for Healthcare Using Effects of Mobile Computing: A Systematic Literature Review”. Wirel. Commun. Mob. Comput. 2019, 2019, 1–20.

[41]. Yuehua Liu; Tharam Dillon; Wenjin Yu “Noise Removal in the Presence of Significant Anomalies for Industrial IoT Sensor Data in Manufacturing”, IEEE Internet of Things Journal (Volume: 7, Issue: 8, Aug. 2020)

[42]. Wu, J.; Tian, X.; Tan, Y. “Hospital evaluation mechanism based on mobile health for IoT system in social networks”. Comput. Biol. Med. 2019, 109, 138–147.

[43]. JayeetaSaha; Arnab Kumar Saha; Aiswarya Chatterjee, “Advanced IOT based combined remote health monitoring, home automation and alarm system”, 2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)

[44]. Chun-Wei T., Ming-Chao C., AdlenKsentini, Min Chen, “Meta Heuristic Algorithms for Healthcare: Open Issues and Challenges”. Computers and Electrical Engineering, pp.1-14, 2016.

[45]. S.F. Khan, “Health Care Monitoring System in Internet of Things (IoT) by using RFID”. 2017 6th International Conference on Industrial Technology and Management (ICITM), pp.1-5, 2017.

[46]. Joao Santos, J.P.C. Joel, Rodrigues Bruno M.C. Silva, Joao Casal, Kashif Saleem, and Victor Denisov, “An IoT based Mobile Gateway for Intelligent Personal Assistants on Mobile Health Environments”. Journal of Network and Computer Applications, pp.1-14, 2016.

[47]. Jayavardhana, B. Rajkumar, M. Slaven, M. Palaniswami, “Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions”. IEEE, pp.1-19, 2016.

[48]. C. Luca, D.D. Donno, Luca M., Luca P., Luigi P., M.L. Stefanizzi, T. Luciano, “An IoT-Aware Architecture for Smart Healthcare Systems”. IEEE Internet of Things Journal, pp.1-12, 2015.