Smart Medical Systems Based IoT: Exploring the Relationship Between Essential Algorithms and Service Orientation

Ahed Abugabah[1*]

[1*] Professor, College of Technological Innovation, Zayed University, Abu Dhabi Campus, UAE.
ahed.abugabah@zu.ac.ae, Orcid: https://orcid.org/0000-0002-3181-5822

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Abstract

This study examines the most recent research publications that focus on the Internet of Things (IoT) in medical systems including health monitoring, fitness programs, etc., as a consequence of the IoT's explosive growth in these areas. The monitoring efficiency of IoT-based healthcare systems has been the subject of much study. In this paper, we go into the architecture of the Internet of Things, namely the cloud-integrated systems. As accuracy and power consumption are major issues in the Internet of Things, studies that aim to enhance the efficiency of healthcare systems that rely on the IoT are highlighted. This research also provides a thorough examination of the strategies used for data management in IoT-based healthcare systems that make use of cloud services. The benefits and drawbacks of the IoT-based healthcare system are discussed, as well as its performance. Studies often have a high percentage of success in identifying multiple symptoms and making illness predictions. When it comes to keeping tabs on the health of the elderly population, the Internet of Things-based healthcare system developed specifically for them is an effective answer. Existing systems have many drawbacks, including high power consumption, limited resources, and security concerns brought on by the use of several devices which are discussed in the paper.

Keywords: Health Monitoring, IoT-based Medical Systems, Cloud-integrated Systems, Illness Predictions.

1 Introduction

One of the most influential communication paradigms of the 21st century, the Internet of Things (IoT) has gained a great deal of academic attention. Connecting sensors, vehicles, homes, and appliances (among many other input-output numerous objects) to the internet paves the way for users to share information, data, and resources (Balasundaram et al., 2023). In recent years, technologies such as IoT sensors, tablets, wearable devices, etc. have become indispensable for monitoring health. The information gathered by these gadgets is not only beneficial for real-time health monitoring by individuals but helps in improving overall well-being and managing health care expenses among other benefits (Bollimuntha & Murugan, 2023). Wireless Body Sensor Networks (BSNs) are networks of worn sensors that may collect data and send it elsewhere. When data is collected from a number of sources, it's preferable to employ multi-sensor fusion to eliminate any inaccuracies and provide high-quality fused data (Islam & Bhuiyan, 2023). Vital health conditions including heart rate (HR), respiratory rate (RR), electrocardiography (ECG), body temperature (BT), body position (BP), and blood pressure (BP)

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*Corresponding author: Professor, College of Technological Innovation, Zayed University, Abu Dhabi Campus, UAE.

are often monitored by wearable sensor nodes placed inside a wearable body area network (WBAN). WBAN has several uses outside of the medical field, including environmental monitoring (Parvez et al., 2023; Ahmed et al., 2023). These kinds of apps may be particularly helpful for enhancing users' awareness of potential dangers in their immediate vicinity. The term "wearable technology" refers to the incorporation of electronic components into everyday objects, such as wristbands, wristwatches, eyeglasses, and smartphones. Health monitoring gadgets help you save time and get better treatment. As an added bonus, long-term data collection is possible with wearable devices, which is much superior to a single medical exam regarding general health. Several measurements, however, are required to keep an eye on the health concerns. The data used to derive these metrics comes from a wide variety of health-tracking gadgets and mobile apps that constitutes what we can call IoT-based smart medical systems (IoMT) (Islam & Bhuiyan, 2023). It is also being put to use as an electronic health application (E-health app) for things like medical alerts and early diagnosis. Smartphones have become an integral part of most people's lives, and now they may be equipped with sensors to track vital signs (Reddy et al., 2020). This sensor-based surveillance system collects information from hospital rooms and diagnostic tools, then uses this information to streamline and automate healthcare management (Narmatha & Banuchitra, 2020). In this way, IoT-based smart medical systems have the potential to reshape the way healthcare services are delivered, making them more efficient, personalized, and accessible. At the core of these advancements lies the concept of service orientation, which refers to the approach of designing systems around services that can be independently deployed, invoked, and managed.

Service Orientation Architecture in IoT-based Smart Medical Systems or Internet of Medical Things (IoMT)

Service orientation is a design principle that has been widely adopted in the development of complex systems. Service-orientation architecture (SOA) is a business-IT-aligned methodology in which applications rely on available services to help them perform their tasks. A service, as the name suggests, is a self-contained, reusable software component that a service provider provides and that service consumers use (Wu et al., 2015)]. Service orientation in healthcare systems involves breaking down functionalities into modular services that can be independently deployed, invoked and managed. These services may include data management, patient monitoring, diagnostics, treatment planning, electronic health records, and more.

Service-oriented architectures enhance interoperability, flexibility, and scalability in IoT-based smart medical systems, allowing seamless data exchange and adaptability to new technologies (Heinzl et al., 2009; Saranya et al., 2021). These architectures enable personalized healthcare, real-time data analysis, and cost efficiency, enabling healthcare professionals to make informed decisions based on vast amounts of data generated by IoT devices. Additionally, service-oriented architectures optimize resource allocation, reduce redundant functionalities, and minimize development costs. Also, the services supplied to the end user, like patients admitted to the hospital, will be quicker. Furthermore, services for the elderly or applications needing instant information on a wide scale and in the web form, using this technology is unquestionably a tremendous assistance (Javdani & Kashanian, 2018). Recently, cloud computing has been utilized to manage healthcare data because it allows for the pooling of resources and the early detection of difficulties with storage, parallel processing, and security. Cloud computing and service-oriented architecture go hand in hand (Raines, 2009).

Cloud-based service orientation in healthcare involves the utilization of cloud computing technologies to deliver medical services and manage health-related data (Sonya, A., 2022). The essential algorithm plays a pivotal role in facilitating the integration, deployment, and management of various cloud-based services to optimize the healthcare system's performance and enhance patient care.

The service-oriented architecture relies on the essential algorithm to enable different services to interact with each other in a smooth and effective manner. An algorithm is a set of rules or a step-by-step procedure used to solve a problem in a certain way (Stephens, 2019). The essential algorithm is crucial to the success of healthcare systems that use this architecture as it enables interoperability, flexibility, and adaptability. This, in turn, enables medical facilities to seamlessly integrate new services, personalize patient care, and respond quickly to changing healthcare demands, leading to better patient outcomes and a more efficient healthcare delivery system. In this paper, we aim to examine the relationship between the essential algorithm and service orientation in IoT-based smart medical systems by conducting a comprehensive review of the available literature.-

Objectives

The present paper focuses on

1. To overview the existing IoMT (IoT-based Medical System) system in terms of the network.
2. To discuss layer-wise taxonomy of the IoMT system with in-depth classification of various layers and their subsets.
3. To provide an in-depth survey of IoMT services and application areas.
4. To address the core technologies for IoMT that are taking smart healthcare to the next level.
5. To address various challenges and issues of IoMT systems

2 Literature Review

When it comes to dealing with dire situations like automobile crashes, heart attacks, etc., medical personnel are heroes. In most emergency situations, physicians only have access to the patient's vitals and cannot make a proper diagnosis until further information becomes available. This might lead to treatment processes and procedures being rushed, which can be dangerous for the patients. If physicians had all the necessary medical information before making a treatment plan, it would improve the patient's prognosis and likelihood of a full recovery. In the study by Balasundaram et al. (2023), Multi-Model IoT (MMIoT) devices were used to track and record vitals from several areas of the body at once. The healthcare data included both signals and images obtained from MMIoT gadgets. Automatic data analysis is performed using the U-Net model and the LSTM model. the processing of the data was done by the server in the MMIoT network. A 5G network was tested as a means of connecting all medical IoT devices. In order to correctly categorize the health abnormalities, the output from the U-Net and the LSTM is filtered via a thick layer. It would not only help but also teach doctors how to confidently manage both rare and common instances in the future. If the greatest tools are used, it may increase the standard of care and save lives.

Though, the development of a wide range of medical equipment and sensors for the benefit of patients is going on the need of medical personnel are still needed for the treatment in outlying regions and chronic diseases. One such chronic disease now considered as an epidemic is diabetes which is rapidly expanding across the globe. The paper by Bollimuntha & Murugan (2023) details a method for remotely monitoring glucose levels in people with diabetes using infrared (IR) sensors and an Arduino-UNO board, with the ability to communicate monitoring results via text message to a medical professional, upload data to the cloud, and display readings on an LCD screen.

The Internet of Things cloud-based technologies allow for remote patient monitoring and assistance. Yet, in the current context, making healthcare systems more environmentally friendly has not received a lot of attention. In the article by Islam & Bhuiyan (2023), an interactive user interface built on top of state-of-the-art technology and an integrated framework for eco-friendly healthcare was presented. The system's scalability and performance-to-cost ratio were guaranteed. This interface was built so that patients could transmit health data to physicians through wearable sensors, and the doctors could get this information in real-time. They used Hierarchical Clustering Algorithms to classify and examine the data. The overall outcome of the study was to improve the interactive healthcare experience for all users.

Wireless technology is being advanced to facilitate the distribution of healthcare to underserved areas. Prototypes of the electronic health record (EHRs) of the future provide doctors with a complete picture of their patient's health. The research by Parvez et al. (2023) looked at healthcare for the elderly in rural India and proposed a system called the Rural Smart Healthcare System (RSHS). With the help of IoT, medical devices may share data with one another and with medical professionals. It's revolutionary because it changes the way healthcare is delivered without sacrificing quality or cost. The advent of cloud computing and large amounts of data has revolutionized medical technologies. Cloud computing is distinguished by its scalability, speed, and reliability. Smarter, Internet-connected products and consumer goods are being developed with the help of cloud computing. In addition, the use of computerized medical record-keeping systems is commonplace. The future success of healthcare companies is greatly aided by continuous engineering. They are linked to computers and other gadgets online everywhere. Every hospital, clinic, and gym should be committed to improving its patients' health and well-being. Improvements in efficiency, accuracy, and access to treatment are only some of the outcomes of IoT's use in the healthcare industry. The healthcare industry has lately shifted its attention from the development of automated scientific procedures and the digitization of medical records to the study of big data. Better healthcare for providers may be possible with the use of cloud-based data. Connected medical equipment gathers data from vital signs and images. Correct diagnosis calls for probing cloud computing and the Internet of Things. It provides accurate data for use in health management. Incredible, in-the-moment data is gathered by smart systems. The security of the open-source technology used in the cloud computing environment varies.

In the paper by Ahmed et al. (2023) telemedicine's resource networking architecture is founded on the Internet of Things (IoT). By combining resource management pools of Internet of Things (IoT) devices and communication channels to establish a dependable corporate ecosystem of smart cities, Augmented Intelligence (AuI) enhances the present telemedicine framework. They proposed a new method for recommending telemedicine resources by combining artificial intelligence and the Internet of things. In order to provide an informed suggestion based on telemedicine services, the framework collects data from the pre-existing eHealth infrastructure of smart cities and the telemedicine environment of the IoT. Enterprise Management System (EMS) was the foundation of the proposed framework for eHealth services. The proposed framework for Augmented Intelligent Telemedicine (AITel) assumes a 94.83% accuracy from AI-assisted telemedicine, and it would establish a trustworthy ecosystem for recommending resources in order to construct a robust healthcare system for far-flung patients, communities, and facilities.

Network Configuration or Topology of IoTMS

The topology of IoTMS would refer to the network architecture and design used to connect various devices, sensors, and applications in the medical or healthcare industry. This enables the seamless transfer of data and information between devices and systems, ultimately improving patient care and outcomes. It includes a wide variety of steps, such as determining the devices' physical setup, activations, and overall strategy. The network is a group of disparate medical gadgets linked together by way of a consolidated server. Wires or wireless technology might be used for the link. By collaborating in the same area of application to carry out preset or predetermined activities, these smart health devices create the topology (Miyamoto et al., 2020). Many medical devices may be part of this infrastructure, all of which work together to complete their assigned tasks through the network. These lines of communication allow for the recording of the data transfer and response. The service providers are linked to these avenues of communication (Nivedha et al., 2020). To put it another way, we may say that a number of service providers are responsible for overseeing these lines of communication. These providers maintain the integrity of the communication system by providing essential services and safeguards. Since this information is part of an individual's electronic health records, the IoHT network must be secure so that private data is not leaked. Service providers collect data from a wide variety of medical devices, evaluate that data, and then make that analysis and data available to the proper authorities or user. The sensors, activities, and processes of sensor-based devices make up the standard IoHT structure.

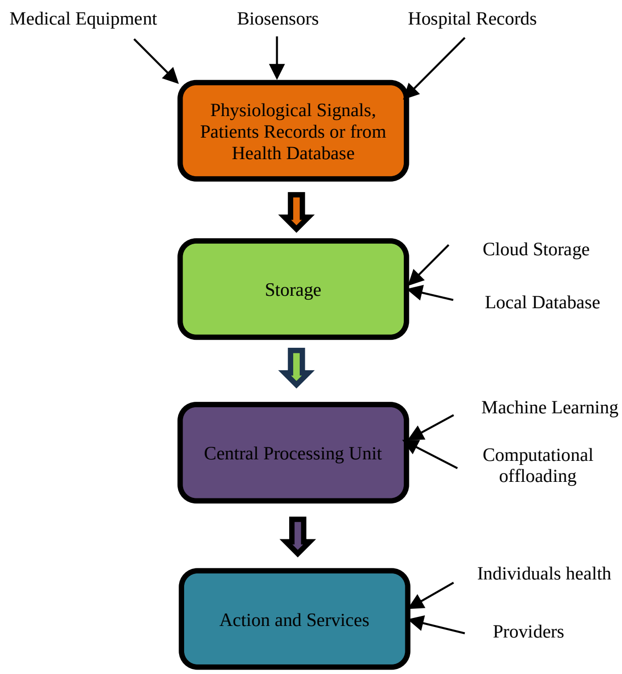

Figure 1: IoTMS Architecture

As shown in Figure 1, the data in this core network architecture is gathered via the use of smart or sensor-based devices. Data sources include things like hospital electronic records, smart devices, wearable sensors, biosensors, and medical equipment. These elements come from the health database, patient records, and psychological signs. A local or cloud-based database stores a replica of the message and its accompanying data whether the message originated from a device or was extracted from medical records (Stephens, 2019). The data is then sent to the CPU, which is responsible for the calculation and subsequent result finding. Machine learning algorithms or computation offloading techniques are used to carry out the computation. When the calculation is complete, the result is shared with the healthcare professional or the patient. Because of the potential for significant harm to both the smart healthcare system and the individual's health, it is essential that appropriate security mechanisms be in place at all levels, from the sensing or collecting level data to the service level.

Key Algorithms and Framework for IoTMS

Internet of Things (IoT) technology offers enormous promise in the healthcare sector. Intelligent medical treatment and facility management are both facilitated by this. In addition to addressing the problem at hand, it has the potential to fulfill requirements for medical health information, medical equipment and supplies, and smart administration and monitoring of public health safety (Nivedha et al., 2020).

The Internet of Things (IoT) is a network of devices that can listen to, analyze, and monitor physical objects from a distance. The algorithmic connective tissue between computers enables sensor and smart sewing machines to talk to one another. The middleware layer is crucial for IoT implementations in IoT data processing. There are many different types of IoT systems, such as smart grids, cities, homes, farms, communications networks, etc. The IoT's three-tier structure is predicated on conceptual and communication "layers." Middleware and enterprise applications are added to this broader category (Lu et al., 2019). The IoMT has mainly three layers as demonstrated in figure 2 and are mentioned below:

1. **Perception layer**: This layer identifies the sensory and bodily apparatus. The perception layer sensor system first locates the item by pointing, and then it detects it and gathers data about it. Depending on the sensor, one may get data on factors such as temperature, motion, location, wetness, vibrations, distance, speed, chemical changes, and so on. The data is subsequently sent on to the next level of processing. Data is sent from this layer through the node to the processing network layer.
2. **Network Layer**: Sometimes referred to as the "Broadcast Layer," its primary function is to facilitate communication between several servers, IoT devices, and other nodes in a network. Acquire information transmitted by sensors and record it. Infrared, Bluetooth, ZigBee, Wi-Fi, UMTS, and 3 G are all viable options for the communication system. The data from the core is sent to the working layer's front end via the middleware layer, which in turn receive the data from the network layer.
3. **Middle ware Layer**: It’s a connecting link between various components of IoT devices responsible for their inter-communication which were originally not meant to be communicating. It is also known as processing layer which holds the massive quantity of data acquired from the network layer. As a service layer between the two data storage levels, database communication & resource management must take the blame. It is related to Big Data and cloud computing because of its ability to handle massive amounts of data.
4. **Application Layer**: The provision of application-centric services to end users is a crucial function of this layer. This is due to the fact that the layer in question has application layers that make direct contact with the user. Tell the woman whose earrings you're trying to identify that you have a fever and would need her contact information. This is the layer responsible for relaying information to the user through flu-related text messages sent to their smartphones.
5. **Business Layer**: The whole Internet of Things business ecosystem is managed by the corporate layer. Users are able to make better decisions with its aid. A person with a fever, for instance, may provide information on the nearest medical facility.

3 Wearable Devices

Accessories, include bracelets, ornaments, patches, hats, t-shirts, bands, and spectacles The "actual body" may be accounted for in the design of wearable processes. This apparatus has been used to get in touch with the individual’s sickness and health monitoring and to transmit the collected data to the central and internal research facility. Wearable gadgets, machine buildings, and displays are the three components. Metrics like as calories burned, distance walked, heart rate, blood pressure, and the length of time spent exercising might all be gathered by means of such wearable technology. This has a huge impact on these gadgets and is, of course, incredibly powerful, since they are primarily used to track users' physical well-being. Below is the list of few wearable gadgets (Guo, 2017):

Pulse Oximetry: Throughout the cardiac cycle, the device measures the change in blood flow to the skin to determine the amount of oxygen saturation in the body. An image detector and LEDs are housed inside the pump oximeter, which is then attached to a finger or an ear. Infrastructure is evaluated by red light reflected into or carried by humans. Oxygen saturation was determined by comparing the concentration of hemoglobin with its degree of deoxygenation. It is used to calculate the heart rate as Photo Plethysmo Graph (PPG).

Electrocardiography (ECG): Uses a waveform to keep an eye on the heart's electrical activity . The development of automated methods for calculating ECGs using wireless sensors is nowadays an on-going development in the field of IoHT. ECG devices are attached to the human chest and the readings are then recorded through IoT devices.

Blood Pressure (BP): It is the pressure exerted by the blood on vessels during circulation in human body and is measured by using sphygmomanometer which consists of a cuff, a manometer and a stethoscope. There are three methods to measure BP; by palpating the pulse, by listening Korotkoff sounds through a stethoscope, and by recording oscillations caused by pressure in the cuff. The new age digital BP apparatuses are now being developed with sensors that measures the oscillations or vibrations caused by rushing of blood into the arteries. which pushes its walls

Electromyography (EMG): The study of muscles relies on analyzing the electrical impulses produced by them. The electromyogram (EMG) is the spatial-temporal DRM for electric signals. As a result, the EMG signal is a practical tool for keeping tabs on muscular activity in humans.

Electroencephalography (EEG): The electroencephalogram (EEG) represents mental processes. The Electroencephalogram (EEG) data collection, wireless communication, analogue signal synchronization, and low-level real-time signal processing capabilities of the Wireless Intelligent Sensor (WISE) are all made possible by its low-frequency control.

The Internet of Medical Things (IoMT) is an emerging field of study that bridges the healthcare sector with the IoT infrastructure. This system allows for remote, round-the-clock monitoring of patients. Integrating and improving communication between caregivers and patients is a primary goal of this system (Balasundaram et al., 2023). As wireless sensor networks can collect data from a wide range of dispersed sensors, they find widespread usage in remote sensing applications. Because to its widespread adoption and increasing utility in recent years, the price of this technology has dropped dramatically. Energy efficiency, however, is the primary challenge this technology must overcome. This is because turning off the equipment when there is no activity is a key responsibility (Bollimuntha & Murugan, 2023). With block chain technology, medical records may be kept confidential. Medical records are safe and secure because to this technology. Due to the delicate nature of health information, protecting its secrecy and authenticity is crucial. This is made possible by the use of blockchain technology to the field of medicine (Islam & Bhuiyan, 2023). The data in block chain systems is not managed by relying on reliable third parties. Blockchain technology ensures the safe transfer of patient data to medical professionals and academic institutions. In addition, this method allows for adequate scalability of the confidential medical data (Parvez et al., 2023). There is a dire need for smart health care systems due to the convergence of IoT and the medical sector. The technology helps monitor patients with conditions as varied as heart disease, brain damage, etc. Smart health care systems have significant hurdles, chief among them the need to minimize energy usage and computing complexity (Ahmed et al., 2023). The analysis of data from the Internet of Things is a common use of soft computing methods. With the right algorithms, these methods may assist infer previously inaccessible information from large datasets (Elkahlout et al., 2020).

Several vision-based, wearable, and embedded sensors are used to gather data in smart health care systems. Many algorithms based on artificial intelligence and machine learning are used to analyze the data gathered by these sensors (Reddy et al., 2020). These algorithms simulate the way the human brain does calculations, which aids in making good choices. The information obtained from these sensors is analyzed using big data methods. The acquired data is kept in the cloud, where the calculations are also done (Narmatha & Banuchitra, 2020). Machine learning methods, such as k-means clustering (Elkahlout et al., 2020), support vector machine, etc., are used to process this data. Careful attention is required while working with electronic health record (EHR) data, since even a little change may have far-reaching consequences. Electronic health record data should be encrypted before transmission to protect the data's integrity. Most often, electronic re-encryption is employed to protect this information so that no outsider may read it or change it (Nawaz, 2020). The volume of health information shared through the cloud is growing at a pace of 20–40% annually. Surgery may now be performed remotely thanks to the Internet of Things' incorporation into the medical field. Instructors from from all corners of the globe are used (Sowjanya & Dasgupta, 2020). This facilitates the use of medical professionals from all over the globe, whose insights might be invaluable during life-or-death procedures. One of the most significant ways in which the Internet of Things positive impact on healthcare. Moreover, with the help of remote monitoring systems, patients may be tracked in real time, and alerts can be sent to caregivers immediately. As a result, humans are no longer needed to intervene constantly.

4 The Proposed IoT-based Remote Health Monitoring Architecture

Care for the elderly must include the provision of a comfortable, convenient, and secure place to live. Anyone living in such a setting will be alerted to and prepared for any number of potential incidents, including accidents and medical emergencies. In the case of an accident, a smart, automated house may switch on the lights or shut off the water supply to the sink to avoid potential flooding. Context sensors may be used to monitor the room's surroundings and regulate the temperature accordingly, or to guarantee that the medicine cabinet remains unlocked at all times. Using the same channels, their loved ones and caregivers may have access to the same information and resources. For example, a design was proposed for monitoring diabetic patients by Rghioui et al. (2020) (Figure 3). In addition, a number of service-based applications are listed in Table 1.

OpenHAB is proposed as the middleware to combine various home automation systems into a unified platform for interacting with sensors and actuators, which would help address some of the problems with the conventional "vertical" home automation system. Popular home automation protocols like Z-wave, KNX, and Insteon are only few of the many that are now supported by openHAB software. In the future, openHAB is intended to support a wide variety of protocols.

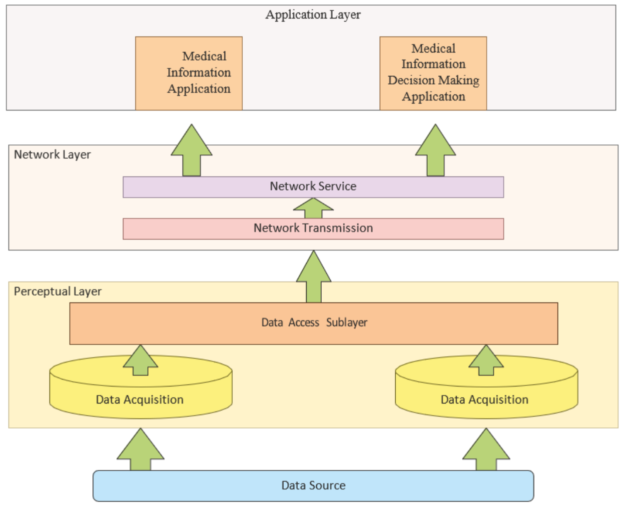

Figure 2: IoMT (Internet of Medical Things) Architecture Overview (Adopted from Srivastava et al. (2022)

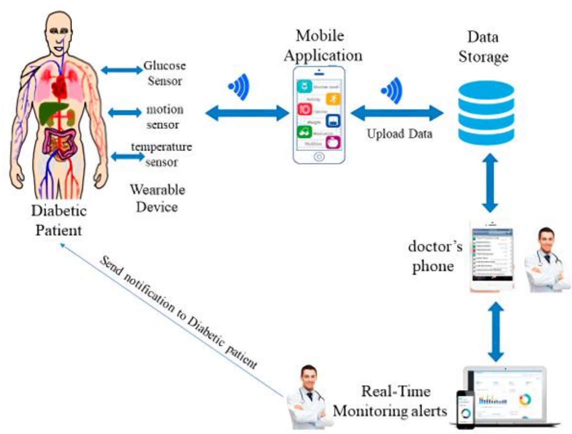

Figure 3: Home Care Example (Rghioui et al., 2020)

Table 1: IoT Applications in Healthcare

IoT Application	Description
Smart Hospitals	IoT devices can be integrated into hospital infrastructure to improve patient care, optimize hospital operations, and reduce costs (Schweizer, n.d.).
Medication Management	IoT-enabled medication dispensers can remind patients to take their medications, track their medication history, and alert healthcare providers of any potential issues or concerns (Ahmad et al., 2020).
Fall Detection	IoT sensors can detect falls and alert healthcare providers, allowing for quick response and potential lifesaving interventions (Karar et al., 2022).
Ambient Assisted Living	IoT devices can monitor and assist elderly or disabled individuals in their homes, providing increased safety, security, and independence (Ghorbani et al., 2023)
Health and Wellness Apps	IoT-enabled apps can provide personalized health and wellness recommendations based on user data, such as diet, exercise, and sleep habits (Lam et al., 2022; Erdeniz et al., 2018).

5 Relationship between Essential Algorithms and Service Orientation in IoT-based Smart Medical Systems

Smart medical solutions based on the Internet of Things need both core algorithms and a focus on providing a service to end users. The goal of the service-oriented design methodology is to create independent components that may be combined and reused in any number of contexts. On the other hand, "essential algorithms" are the foundational mathematical or computational procedures used in making sense of data gathered from IoT gadgets.

Data analysis and decision-making skills are enabled by integrating critical algorithms as services in a service-oriented architecture, which is the connection between these two ideas in IoT-based smart medical systems. With the help of machine learning algorithms, for instance, healthcare practitioners and patients may benefit from the analysis of patient data gathered through IoT devices.

IoT-based smart medical systems may also benefit from service orientation's capability to reduce complexity by decomposing otherwise overwhelming workflows into more manageable subprocesses. Data processing and analysis may be made more effective and scalable, and the integration of crucial algorithms and other system components can be simplified.

Care professionals are able to make better judgments and offer more individualized and efficient treatment for patients thanks to the Internet of Things (IoT)-based smart medical systems that include crucial algorithms and service orientation.

Data acquired by IoT devices requires essential algorithms, which are the underlying mathematical or computational processes required to make sense of that data. Information like as trends, patterns, and anomalies may be gleaned from the data using these algorithms, allowing for the generation of actionable insights that can guide clinical decision-making and lead to better patient outcomes. Machine learning algorithms, statistical algorithms, and signal processing algorithms are all examples of fundamental algorithms utilized in IoT-based smart medical systems.In contrast, service orientation is a method of designing that prioritizes independent, independently deployable services that may be combined and reused in a variety of contexts. By decomposing large, complicated processes into simpler, more manageable services, service orientation may help keep Internet of Things-based smart medical systems under control. In order to provide more effective and scalable data processing and analysis, these services may be readily connected with other system components, such as crucial algorithms.

Many advantages may be gained when Internet of Things (IoT)-based smart medical systems combine important algorithms with a service orientation.

- Data processing and analysis have become more precise and time-saving.
- Improved timeliness and individualization of healthcare decisions
- Improved ability to handle complex processes and systems
- greater design and implementation scalability and adaptability
- Data privacy and security are enhanced as a result of tighter administration of data transmissions.
- For IoT-based smart medical systems to be developed and implemented effectively and efficiently, it is necessary that core algorithms and a service orientation be integrated.

6 Conclusion

This article presents a comprehensive analysis of the current state of the Internet of Things (IoT) healthcare ecosystem, including an IoT healthcare framework, a smart healthcare system, and its logical architecture. By the use of sensors, mobile and smart networks, cloud computing, and sophisticated algorithms, a smart healthcare system may gather medical data from which doctors can draw treatment and diagnostic suggestions. We break down the rollout of the IoT-based healthcare system into its component parts and provide information on each one. To combat the existing security issues in the Internet of Things (IoT), a homomorphic method using a scrambling matrix was created. As the Internet of Things (IoT) continues to grow, we can expect our healthcare system to continue to expand.

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Declarations

The author declare that all works are original and this manuscript has not been published in any other journal.

References

[1] Ahmad, S., Hasan, M., Shahabuddin, M., Tabassum, T., & Allvi, M.W. (2020). IoT based pill reminder and monitoring system. *International Journal of Computer Science and Network Security*, *20*(7), 152-158.

[2] Ahmed, S.T., Kumar, V., & Kim, J. (2023). AITel: eHealth Augmented Intelligence based Telemedicine Resource Recommendation Framework for IoT devices in Smart cities. *IEEE Internet of Things Journal*, *10*(21), 18461-18468.

[3] Balasundaram, A., Routray, S., Prabu, A.V., Krishnan, P., Malla, P.P., & Maiti, M. (2023). Internet of things (IoT) based smart healthcare system for efficient diagnostics of health parameters of patients in emergency care. *IEEE Internet of Things Journal*, *10*(21), 18563-18570.

[4] Bollimuntha, M., & Murugan, K. (2023). Design and Implementation of an Interoperable IoT Based Health Monitoring System for Diabetes. *In IEEE 5th International Conference on Smart Systems and Inventive Technology (ICSSIT)*, 386-390.

[5] Elkahlout, M., Abu-Saqer, M.M., Aldaour, A.F., Issa, A., & Debeljak, M. (2020). IoT-Based Healthcare and Monitoring Systems for the Elderly: A Literature Survey Study. *In IEEE International Conference on Assistive and Rehabilitation Technologies (iCareTech)*, 92-96.

[6] Erdeniz, S.P., Maglogiannis, I., Menychtas, A., Felfernig, A., & Tran, T.N.T. (2018). Recommender systems for IoT enabled m-health applications. In *Artificial Intelligence Applications and Innovations: AIAI IFIP WG 12.5 International Workshops, SEDSEAL, 5G-PINE, MHDW, and HEALTHIOT, Rhodes, Greece, Proceedings 14*, 227-237. Springer International Publishing.

[7] Ghorbani, F., Ahmadi, A., Kia, M., Rahman, Q., & Delrobaei, M. (2023). A decision-aware ambient assisted living system with IoT embedded device for in-home monitoring of older adults. *Sensors*, *23*(5), 1-21.

[8] Guo, J. (2017). Smartphone-powered electrochemical biosensing dongle for emerging medical IoTs application. *IEEE Transactions on Industrial Informatics*, *14*(6), 2592-2597.

[9] Hamlaoui, S., & Weber, A.S. (2020). The Internet of Things (IoT) in Tunisian education and healthcare: prospects and barriers to improved educational and medical outcomes. *In IEEE International Conference on Informatics, IoT, and Enabling Technologies (ICIoT)*, 603-607.

[10] Heinzl, S., Seiler, D., Juhnke, E., Stadelmann, T., Ewerth, R., Grauer, M., & Freisleben, B. (2009). A scalable service-oriented architecture for multimedia analysis, synthesis and

consumption. *International Journal of Web and Grid Services*, *5*(3), 219-260.

[11] Islam, M.M., & Bhuiyan, Z.A. (2023). An Integrated Scalable Framework for Cloud and IoT Based Green Healthcare System. *IEEE Access*, *11*, 22266-22282.

[12] Javdani, H., & Kashanian, H. (2018). Internet of things in medical applications with a service-oriented and security approach: a survey. *Health and Technology*, *8*(1-2), 39-50.

[13] Karar, M.E., Shehata, H.I., & Reyad, O. (2022). A survey of IoT-based fall detection for aiding elderly care: Sensors, methods, challenges and future trends. *Applied Sciences*, *12*(7), 1-15.

[14] Lam, C., Milne-Ives, M., Harrington, R., Jani, A., Helena van Velthoven, M., Harding, T., & Meinert, E. (2022). Internet of things–Enabled technologies as an intervention for childhood obesity: A systematic review. *PLOS Digital Health*, *1*(4).

[15] Lu, S., Wang, A., Jing, S., Shan, T., Zhang, X., Guo, Y., & Liu, Y. (2019). A study on service-oriented smart medical systems combined with key algorithms in the IoT environment. *China Communications*, *16*(9), 235-249.

[16] Miyamoto, K., Hashimoto, K., Kasaoka, M., & Kakumu, M. (2020). Wearable sensors corresponding to various applications in medical/healthcare field. *In IEEE 27th International Workshop on Active-Matrix Flatpanel Displays and Devices (AM-FPD)*, 115-118.

[17] Narmatha, K., & Banuchitra, M. (2020). Privacy Enrichment Model for IoT Based Healthcare System. *In IEEE International Conference on Computing and Information Technology (ICCIT-1441)*, 1-5.

[18] Nawaz, M., Ahmed, J., Abbas, G., & Rehman, M.U. (2020). Signal analysis and anomaly detection of IoT-based healthcare framework. *In IEEE Global Conference on Wireless and Optical Technologies (GCWOT)*, 1-6.

[19] Nivedha, K., Priyadharshini, R., & Swetha, G. (2020). IoT Based Real Time Healthcare Monitoring System and Visualization. *In IEEE International Conference on System, Computation, Automation and Networking (ICSCAN)*, 1-6.

[20] Parvez, S.J., Babu, S.S., Farook, S., & Baraneedharan, P. (2023). Analysis of the Effect of IoT-based Wearables in Healthcare Applications. *In IEEE Third International Conference on Artificial Intelligence and Smart Energy (ICAIS)*, 137-146.

[21] Raines, G. (2009). Cloud computing and SOA. *MITRE*, *white paper*, *Oct*. https://www.mitre.org/sites/default/files/pdf/09_0743.pdf

[22] Reddy, J.E.P., Bhuwaneshwar, C.N., Palakurthi, S., & Chavan, A. (2020). AI-IoT based healthcare prognosis interactive system. *In IEEE International Conference for Innovation in Technology (INOCON)*, 1-5.

[23] Rghioui, A., Lloret, J., Harane, M., & Oumnad, A. (2020). A smart glucose monitoring system for diabetic patient. *Electronics*, *9*(4), 1-18.

[24] Saranya, A., Kottursamy, K., AlZubi, A.A., & Bashir, A.K. (2021). Analyzing fibrous tissue pattern in fibrous dysplasia bone images using deep R-CNN networks for segmentation. *Soft Computing*, 1-15.

[25] Schweizer, E. (n.d.). How IoT Delivers Better Patient Care and Optimizes Healthcare Facility Operation. https://uk.insight.com/content/dam/insight-web/en_GB/Buy/shops/apc/How-IoT-Delivers-Better-Patient-Care-and-Optimizes-Healthcare-Facility-Operation-998-20001481_A4.pdf

[26] Sonya, A., & Kavitha, G. (2022). A Data Integrity and Security Approach for Health Care Data in Cloud Environment. *Journal of Internet Services and Information Security (JISIS)*, *12*(4), 246-256.

[27] Sowjanya, K., & Dasgupta, M. (2020). Survey of symmetric and asymmetric key management schemes in the context of iot based healthcare system. *In IEEE First International Conference on Power, Control and Computing Technologies (ICPC2T)*, 283-288.

[28] Srivastava, J., Routray, S., Ahmad, S., & Waris, M.M. (2022). Internet of Medical Things (IoMT)-based smart healthcare system: Trends and progress. *Computational Intelligence and Neuroscience*, 1-17.

[29] Stephens, R. (2019). *Essential algorithms: a practical approach to computer algorithms using Python and C*. John Wiley & Sons.

[30] Wu, Z., Deng, S., & Wu, J. (2015). Service-oriented architecture and web services. *Service Computing-Concept, Method and Technology*, 17-42.

Author Biography

Dr. Ahed. Abugabah is a Professor in Information Systems. He currently works at the College of Technological Innovation at Zayed University. Before joining Zayed University he worked in higher education in Australia where he received his degrees in information systems. His research interests include Information Systems, Enterprise Applications and Development, Machine Learning & Data Mining in Healthcare, Information Systems and RFID in Healthcare.