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Internet of things in medical applications with a service-oriented and security approach: a survey

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Abstract In recent decades, Internet of Things (IOT) has been widely used in the communication of equipment and resources. An important and appropriate application of this technology includes medical devices and resources. With the aid of this technology, the services provided for the end user for example, the patients admitted to the hospital will have greater speed and accuracy. Further, in the necessary care of chronic diseases or extensive applications like services for the elderly or applications requiring momentary knowledge on a large scale and in the online form, using this technology is undoubtedly a great help to better do the job. In this paper, attempts have been made to investigate the Internet of Things in the field of medicine with a service-oriented and security approach and make different comparisons concerning the works conducted, researchers, success, development of Internet of Things in health care systems in terms of empowering the technologies and various applications of Internet of Things in the medical industry and report the results. Ultimately, the opportunities and challenges ahead in the use of Internet of Things in medical applications and health field have been stated.

Keywords Internet of things · Healthcare systems · Service-oriented architecture · Security · Smart gateway

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1 Introduction

Recently with the advances in electronics and computer networks, different ideas have been proposed regarding the communication between different devices and in various forms and with different abilities and intelligence. According to the concept of device to device telecommunications technology, Internet of Things is the epitome of the free flow of information among a large number of computers embedded in various devices with the aid of Internet as a kind of two-way communication [1]. The term "Internet of Things" was raised for the first time by Kevin Ashton in 1982 [2]. As an advanced communication between different devices that can cover many applications and allow for more complete human interactions with the virtual environment, Internet of Things has found its application in almost every field [3]. Numerous medical problems have led to the strong need to receive online information with high precision and security due to the increasing rate of the elderly population and the need for long-term and complex medical obligations on one hand and the increasing growth of human demands which requires more advanced technologies on the other. For example, medical rehabilitation services as a relatively new topic have faced the following great challenges in its growth process to be extended in extensive applications: 1) Long treatment period; 2) the need for the patient's convenient access to rehabilitation services; 3) decreased access to rehabilitation resources due to the increased demand [3]. As a way to deal with these problems, Internet of Things is recommended. Besides, in rehabilitation applications which should have the possibility to be provided at all times and in all places of smart cities, Internet of Things has managed to play a significant role. Compared with the traditional methods of rehabilitation in which equipment and services are provided in a hospital in a centralized form, Internet of Things allows for providing services and equipment in various locations and at

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different times with minimum delay and maximum flexibility for faster treatment of patients [4, 5]. Song et al. [6] have carried out a study on the workflow of computer-aided Healthcare. They define the features of workflow for the common activities of Healthcare and present a summary of the characteristics and requirements of the workflow. In the health and medical sector, many processes have been formed based on the Internet of Things including the following: Control and monitoring of Healthcare, interoperability and security ,acquisition of medical services ,exploring the effects of medicine interactions , industrial environments, public transportation devices ,and many other instances. Thus, with regard to all these cases and in a general overview, a promising future is estimated for the products of medical technology based on the Internet of Things [7]. But it is evident that in a technology with this extent of application and given the sensitivity of some applications, if the security of this technology is not fully developed, Internet of Things will remain the same as the initial form and will never grow [3]. In this research, the application of the Internet of Things in the field of health and medicine with a security and service-oriented architecture approach has been examined. Commercial companies provide Healthcare systems such as Aurora, Medseek and Palm portals and web-based-health systems and phones, but none of them presents all the functions that a health care system provides based on the Internet of Things and service-oriented architecture.

2 An introduction to the Internet of Things

The word whose creator put its name on it with hesitation and even the name of Mr. Ashton's article was formed like this: "Maybe I'm wrong, but I'm almost certain about the term Internet of Things" [8]. Mr. Ashton together with his colleague, Mr. Brock, launched the Automatic Identification Center in Massachusetts with the help of that system moving objects were possible to be tracked.In 2002, America's National Science Foundation (NSF) published a report about aligned sciences in which it focused on the use of nanotechnology in the information and communication technology [9]. Additionally, in the report by the International Telecommunication Union (ITU) in 2005, it was suggested that the Internet of Things be integrated with the technologies of objects identification, wireless networks, sensors, embedded systems and nanotechnology [10]. The tendency to the Internet of Things technology has vastly increased over time. In 2009, a national center for studying the Internet of Things was established in China and after that, more than 90 cities in this country based their strategic decisions and policies on developing the use of the Internet of Things and making smart cities and many companies developed their activities based on the smart city [9].

3 IOT applications in the health and medical field

As shown in the tables below, numerous activities have been performed based on the Internet of Things in the field of health and medicine. Figure 1 display the scope of scientific activities on average based on the statistics on the number of articles registered in the journals and conferences of two major publications and Table 1 has described the important applications. As can be observed in Fig. 1, the frequency of the publication of articles has been increasing in the recent years and this increase is growing dramatically. Conference papers normally reflect new scientific works and indicate that in the process of the growth of scientific articles, a great leap will be seen in the year 2014 onwards; that is, scientific journals will publish much more articles in this regard in the coming years.

In Figs. 2 and 3, framework and architecture of using the Internet of Things in Healthcare have been provided [13].

4 Healthcare systems and devices

Today, a large number of smart Healthcare systems and devices based on Internet of Things are commercially available. These products have divided Internet of Things into different tasks including the monitoring of patients, establishing contact with doctors, improving the performance of medical rehabilitation and so on [24]. Cybercare model has originated from the term of medical care in cyberspace [25]. This model transfers Healthcare from hospital to home and from treatment to prevention of disease. Indeed, transition of Healthcare provisions from a hospital model towards a distributed network model leads to reduced treatment costs, improved treatment results, facilitation of access to services, and increased security and satisfaction of patients and medical staff. Cybercare model benefits from technology for more efficient medical service through a distributed network. For example, we can refer to wearable sensors and mobile phones to connect the patients with specialists and uploading one's medical information in the shortest time interval. Cybercare model has been recently in the process of implementation in the US and around the world (see Fig. 4)

4.1 Smart healthcare systems

A smart Healthcare system usually includes intelligent sensors, a remote server and a network. This system is fundamentally able to provide multidimensional care and suggestions for the treatment of patients [24]. Wireless body area networks (WBANs) technology has numerous applications such as establishing contact in airlines or space crafts, monitoring and dealing with patients in their homes (Healthcare transferable to houses), baby care, establishing connection between household tools and monitoring athletes and sport analyses [26].

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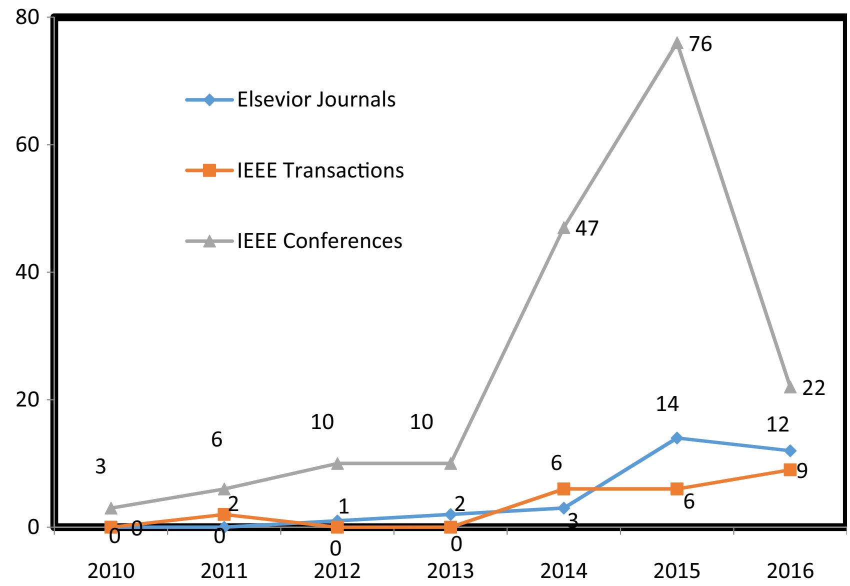

Fig. 1 Frequency of the publication of scientific articles in the field of Internet of Things in the journals and conferences of two major publications

The most important application of WBANs is in the field of Healthcare. In fact, WBANs are able to provide an intermediate for disease diagnosis, remote control and supervision of individuals' physiological data and drug prescription in hospitals and also help in the rehabilitation of patients (see Fig. 5) [27]. In Future, it will be possible to continuously monitor the patients remotely by the medical staff and send medical instructions to them, whether they are in their homes or in hospitals or elsewhere [26].

The following table has briefly examined the technologies applied for empowering the Internet of Things (Table 2, 3, 4 and 5).

5 Big data management

Implementation of Healthcare systems based on Internet of Things is founded upon large data collected from hospitals, rehabilitation centers, society and homes. The information related to objects is updated in real time. Data transfer may occur simultaneously among hundreds or thousands of objects. Theoretically, all information must be stored in servers [24]. As a main component in the Internet of Things, cloud computing has attracted the attention of many individuals, whether in the industry sector or academic sector [35]. Cloud computing is a model to create comfort and access to a demanded network for a source shared by configurable computing resources [36]. For instance, Kanagaraji [37] has introduced the use of cloud computing to implement the picture archive and communication system (PACS). PACS refers to a computer system which is applied for the operation of medical images and their storage and distribution and then display of these images. Electronic images and reports are transmitted digitally via PACS. Use of this system causes to eliminate manual and traditional methods. A PACS system consists of four main components: The method of imaging such as MRI, a secure network for transmitting patient information, workstations for interpreting and retrieving medical images and long-term and short-term archives for the storage and retrieval of medical images and reports. Combination of PACS systems with web technology causes that these systems transmit medical images and interpretations and related information more efficiently and in a timely manner. This system removes physical and temporal barriers associated with traditional methods of retrieval, distribution and display of medical images. Indeed, remote access enables several specialists to concurrently observe similar information. Figure 6, [37], shows the implementation of a cloud-based

Table 1 IOT applications in the field of health and medicine

Application	Objective	Ref.	Technologies	Description
Healthcare	Rehabilitation, reducing the problem of limited resources, dealing with the increasing elderly population	[11–20]	RFID,WAN,MMS, SMS,	Figures 2, 3
Smart Healthcare	Providing multi-dimensional and smart care along with suggestions to treat remote patients	[21–23]	Wearable clothing Google-Health, Withing-Device, Nike + fuelband,	

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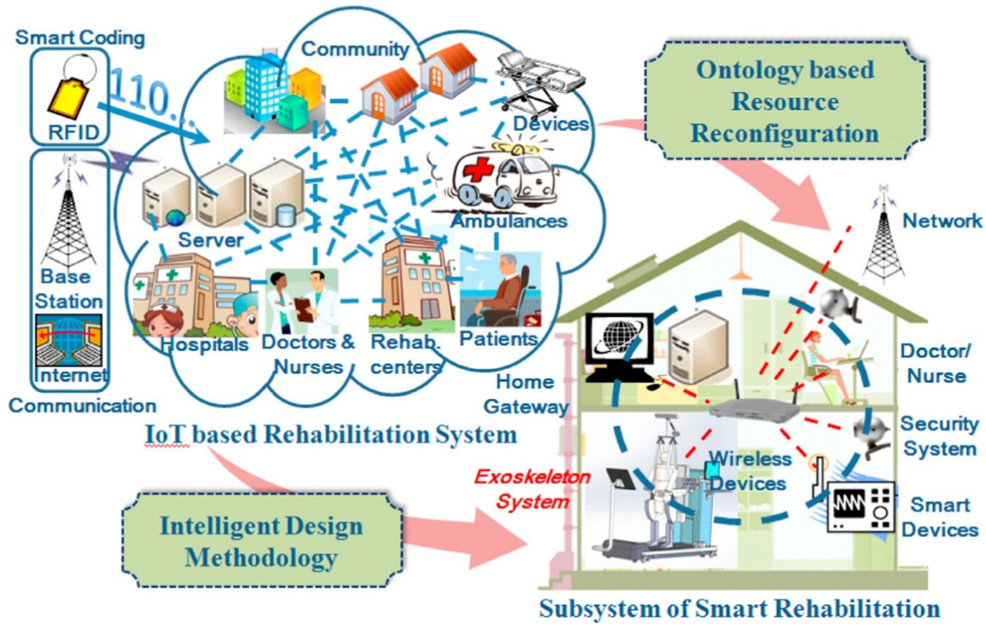

Fig. 2 Framework of IOT-based smart rehabilitation system [13]

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PACS system. Such a system stores medical images in the cloud so that hospitals can have access to the details of these images through Virtual Private Network (VPN) and public use of Internet. Thus, cloud computing provides computations, software, data access and storage services which do not require the knowledge of end-users from a physical location and also configuration of systems that send services [38].

6 Service-oriented architecture

The number of nodes in the IOT-based Healthcare system can reach up to thousands and even millions of nodes. Since all networked devices must be compatible, service-oriented architecture (SOA) has been considered as a promising solution in this case [39].In the service-oriented architecture, each device is independent and its function is clearly determined through standard interfaces. The cooperation between a device and other devices can be quickly re-set in order to implement a new task for other demanded services. Service-oriented architecture offers a great help in sensor networks which support the modular design, interoperation and software reuse. Under the service-oriented architecture, standards that support interoperation, including XML standards (extensible markup languages), Simple Object Access Protocol (SOAP) and Web Services Description Language (WSDL), allow for interoperability for different platforms as services are implemented in different programming environments.Various research teams have found the applications of service-oriented architecture in electronic Healthcare systems. For example, Kart and his

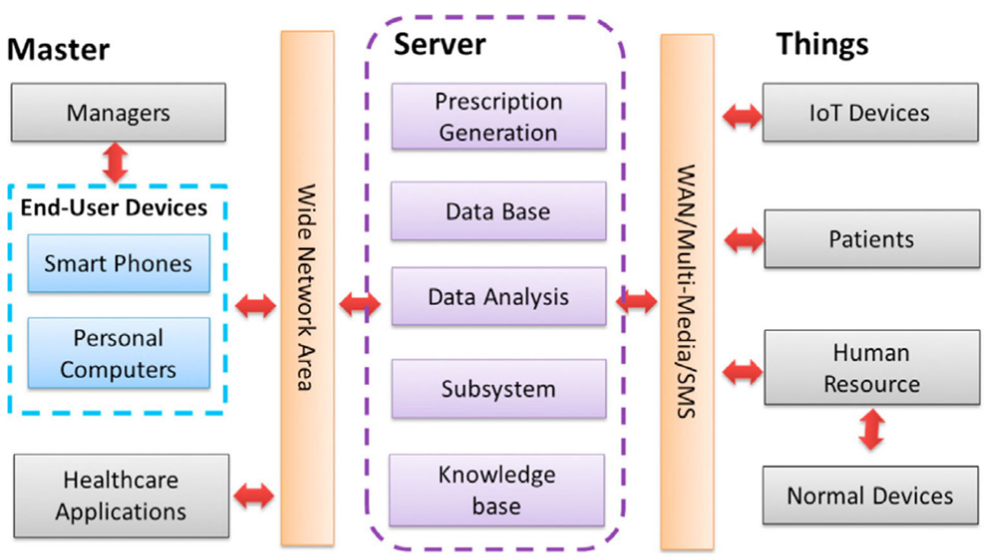

Fig. 3 Architecture of IOT-based smart rehabilitation system [13]

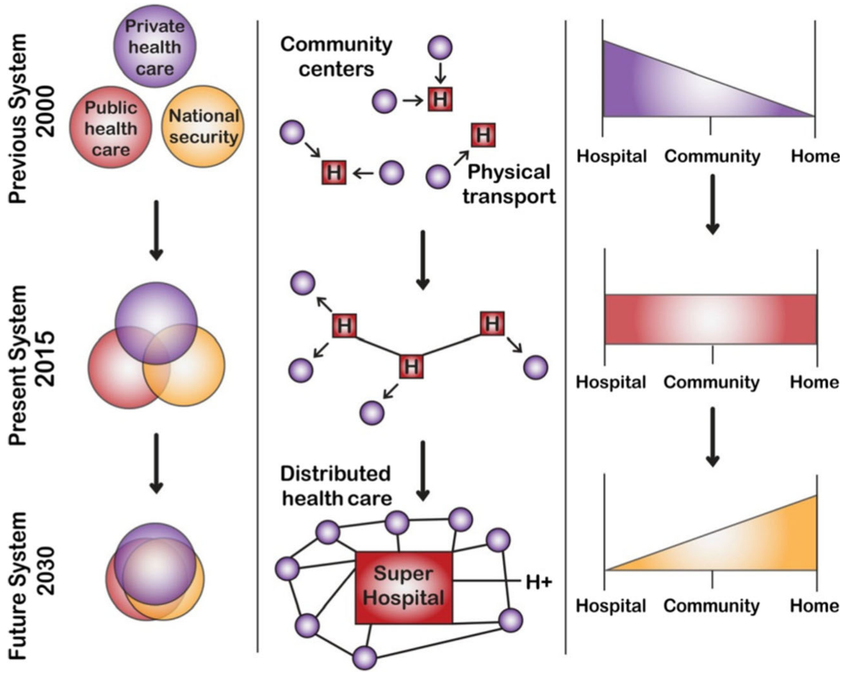

Fig. 4 How Cybercare will make the health care system evolve over time. 1. In 2000, the bulk of healthcare was centered in large hospitals, to which patients were transported often over long distances and at large expense.2. In 2015, health care has been distributed away from central hospitals, with more care provided in community clinics and at home through telemedicine and wearable sensors. The network helps to integrate the functions of private and public health care and national security (the healthcare network also functions in disasters or acts of war) 3. In 2030, Cybercare will have enabled the bulk of care provision to happen at home, with only "super hospitals" remaining for very specialized services. The functions of private and public health care and national security almost completely overlap [25]

colleagues advocate the use of service-oriented architecture as a basis for design, implementation, development, retrieval and management of services in distributed Healthcare systems [40]. Since the development of distributed systems on a large scale such as electronic Healthcare systems is difficult because of the complex and concentrated nature, service-oriented architecture facilitates the development of such systems by supporting the modular design, program integration, interoperability and

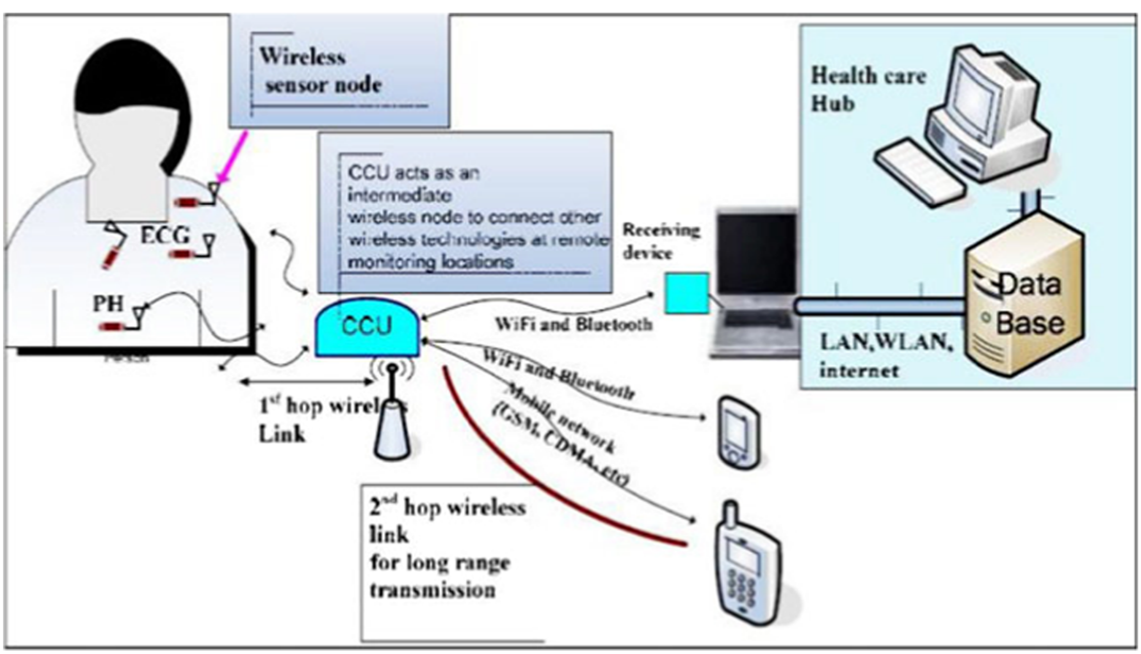

Fig. 5 Medical applications of WBAN [27]

Table 2 Empowering the Internet of Things in a glance

Empowerment	Key words	Description	Future works	Ref.
Identification	Unique Identifier (UID) Open source Software Foundation (OSF) Distributed Computing Environments (DCE) Global Unique Identifier (GUID)	Since a large number of devices are used in the Internet of Things, it is necessary to allocate a unique identifier to each device in order to make possible the identification and determining the identity and location of that device among other devices.	1- Specifying more efficient location based on a global identifier. 2- More secure identity management using advanced encryption techniques. 3- Providing a world map to search for services under the Internet of Things.	[24]
Short distance communication technology	Bluetooth, RFID, Wi-Fi, IrDA (Infrared Data Association), UWB (Ultra Wide Band), ZigBee	Table 3 compares the technologies used in this section.		[14, 24, 28, 29]
Determining the location	Real Time Locating Systems (RTLS), Global Positioning System (GPS), Direction Determination System (Beidou), Local Positioning System (LPS),	Some of the technologies have limitations in medical works. For example, in places that are covered or in the presence of tall buildings ,GPS does not work well. So, it is necessary to get help from LPS or combine it with other wireless communication technologies.	Developing the methods of determining the position using short distance communication technologies	[11, 24, 30–32]
Sensor	Heart rate (HR), blood oxygen (SPQ2), pulse oximetry device (measurement of blood oxygen and pulse) and many instances, some of which are shown in Table 4.	Sensor technology helps the doctor be well aware of the patient's physiological parameters on a continuous basis and from any distance and this effectively helps the patients' improvement process.	Wireless sensor technology can be highly effective in data collection without the need for storage and with the least energy possible. In the future, we need to develop this technology and also the issue of energy consumption in them.	[24, 33, 34]
Service-oriented architecture	SOA	Since the number of nodes in the Internet of Things can be too much and all of them should be compatible with each other, service-oriented architecture can be a good solution for the Internet of Things. Hence, one of the cases that will be discussed in detail in this paper is service- oriented architecture.		

software reuse. In the work done by Kart and his colleagues, a distributed electronic Healthcare system has been described which uses the service-oriented architecture as a basis for design, implementation, execution, retrieval and management of Healthcare services. The electronic Healthcare system developed in the article by Kart supports the physicians, nurses, pharmacists and other healthcare professionals as well as patients and medical devices for monitoring the patients (see Fig. 7). Multimedia input and output along with text, image and speech make this system more user-friendly than the electronic Healthcare systems of that time [40]. Healthcare requires advanced solutions that have been designed and implemented using advanced technologies and encourage Healthcare professionals and patients to accept new trends so that they can improve the presentation and delivery of Healthcare. Multimedia input and output especially graphics and speech cause the system to have less resemblance to a computer and to be highly attractive for the users who are not much familiar with computers. Kart believed that for the future development of his work, he should develop his system among medical technicians and pharmacy staff in addition to doctors and nurses. Further, he should equip his device with other ancillary devices that use service-oriented architecture and Internet of Things; for example, a device that can provide information about drugs and their doses and warns about the interactions between drug administration, an example of which is the Epocrates Rx system [41] or drug delivery devices like e-pillboxes which monitor regular and timely use of medicines [42].Omar et al. [43] in their article have described a pilot electronic medical monitoring system in which the service-oriented architecture has been applied as a platform for the development,

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Table 3 technologies applied for near communications have been compared with each other [24]

type	Bluetooth	RFID(NFC)	WI-FI	IrDA	UWB	ZIGBEE
Rate	2.1Mbps	106 K to 424Kbps	1 M to 300Mbps	14.4Kbps	53 M to 480Mbps	20 K to 250Kbps
Band	2.4GHz	13.56Mhz	2.4G,5GHz	850 nm to 900 nm	31.G to 10.6GHz	868M to 2.4GHz
Distance	20-200 M	20 cm	50 m	0-1 m	0-10 m	10-75 m
Network nodes	8	2	50	2	/	65,000
Security	128bit AES	TIP	SSID	IRFM	High	128bit AES
Power(m W)	1–100	<1	>1000		<1	
Cost	2–5$	<1$	25$		20$	5$

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detection, integration, management and retrieval of electronic medical services. Omar and Taleb-Bendiab have particularly used the service-oriented architecture combined with grid computing technology for a sensor and actuator framework such that it monitors the patient's health condition and provides feedback. The proposed electronic Healthcare system consists of the services that include patients, nurses and pharmacists as well as monitoring devices while their structure focuses in particular on the use of monitoring medical devices. One of the research topics under consideration is how to solve the problems of conceptual interoperability increased by the use of heterogeneous medical information systems. Indeed, these systems apply different standards to provide similar information. In their article, Shaikh et al. [44] have emphasized the importance of service-oriented architecture for telemedicine applications. Their proposed system is based on designed web services that are accessible through any person related to the system via a server. To continue their work, they tended to work on semantic interoperability which is the automatic interpretation of data from system to system. They sought to resolve this issue by using service-oriented architecture and their own design. This goal was achievable through service-oriented architecture using web services. Figure 8 shows a brief review of the structure designed by Mr. Shaikh . [44], This structure comprises three main layers. The Internet layer acts as a presentation layer in the system which includes the representation of the system logic. Web server is placed between the Internet layer and firewall so that the server communicates with web services and application server (software) when needed. The middle layer contains the software and database server together with all the modules installed in the system. This layer is a channel of communication between the application server and its modules. Moreover, this layer plays an important role in the sharing of information in the required time. The database server communicates with the application server through a specific module

Table 4 Different samples of sensors for various physical signs [24]

Signs	Sensors
Temperature	A thermistor: It is suitable for measuring the temperature of the body which can be placed as a tissue in the body; for example, smart clothes for children containing a thermometer.
Breathing	Plethysmography (volumetric): It is suitable for measuring the respiration. New fibers and coatings which change by stretching.
Heart rate (electrocardiogram)	A wearable electrode that is in contact with the skin and can calculate the heart rate and ECG.
Weight: Measures	Establishing communication between weight and a home computer via a wireless tracking
Skin	It identifies the concentration of potassium and sodium in one's sweat.
Galvanic reactions	It can identify the levels of concern in individuals. It was formerly used as the lie detector.
Blood flow (SPQ2)	A light source which is applied to measure the color change that reflects oxygen in the bloodstream. Also, pulse and heart rate can be identified by using it.
Glucose test	Blood characteristics may be analyzed which requires an invasive test like blood sampling from the finger for diabetes testing which is common among diabetic patients.
Muscle contractions (EMG)	A wearable electrode similar to ECG electrode (electrocardiogram) which can show the muscular condition.
Motion analysis	It requires a combination of different sensors, such as speedometer (accelerometer), gyroscope and surface electrodes for muscle contractions (EMG) and so on.

Table 5 General comparison of the recent articles in the field of Internet of Things in the health area

Ref.	The problem posed	Objective	Methodology	Achievements	Challenges
[50]	The elderly and the weak cannottake care of themselves	Clinical care data collection using the Internet of Things	Applying different sensor networks and ubiquitous sensor network using the ultrasonic receiver	1. Ultrasonic receiver can also receive the elderly's activities at home. 2. There is no need for a person who constantly collects and analyzes the medical data.	There is a need for an infrastructure of the service layer that can easily be damaged.
[51]	The problem of the gateway between Healthcare devices and monitoring systems	Creating a sensor network that removes the distance between the Internet and different medical applications using the smart medical box	Using AODV for data transfer from the sensor clothes which can transmit the individual's biological signals to the smart medical box in an online form	Optimality in the field of energy, scalability, interpretability, reliability	It is expensive
[51]	Receiving the sensed information and locally analyzing it are difficult.	Seamless transition using mobile gateway architecture in the Internet of Things	Using the smart gateway for the codes of applications	It is optimal in terms of cost and can be privatized for each patient.	Only the data that can easily be compressed can be transferred with the help of RedBox.
[52]	Creating a reliable tracking system in health care	Keeping track of all personal and medical records	By applying EPC and RFID, we use burnt information to automatically keep track of the signal that has been stored as a key in ONS server.	Security, privacy, reliability and return on investment	Hack tracking can be used to disrupt the medical information.
[53]	Unknown diseases which have no treatment kill millions of people.	We use online information by employing Arduino boards.	Data collection using digital sensors and online health Java protocol.	Smart laboratory, reduced bureaucracy, monitoring and take home health facilities	All data cannot be transformed into audio data in order to be sent to myself in an online form.
[54]	Patient data is usually sent to the doctor without security and usually with replacement.	Internet of Things has been used to stop the delay and transmit without pain.	Sample-based perspective, using service-oriented architecture	Care at lower cost, with more advanced and more scalable systems	
[55]	Healthcare is not possible to be provided for remote places.	Maintenance of the program and sharing of the information	Low-power direct current converter, low-power amplifier, high analog power	Faster improvement, flexible	Non-stationary application
[56]	Receiving the sensed information and locally analyzing it are difficult.	Sensors are worn on a dress in the form of network.	We apply WANDA by using ECG, EMG signals.	Reduced costs, contribution to the future instances	It cannot be personalized; materials used in the sensor can cause skin sensitivity.
[57]	Access to a patient is often risky and if we encounter an unfavorable case, we may make wrong decisions.	Using combined profile structure, cryptography, stenography to ensure the security of patient data	A public key encrypted by its function and network of body sensors, and monitoring oneself	Safe, simple to use	Expensive
[58]	A disease takes root and many doctors cannot provide any help.	Using diagnostic tools that enable us to know our physical shortcomings	Automated systems perform data prioritization by collecting with the help of network architecture	It is fully automated and solves almost every treatment problem.	It needs smart network and smart calculation system

and stores and fetches (reads) the requested information. Details of the system design by Mr. Shaikh include a structure based on which service-oriented architecture can be easily developed and integrated with other remote treatment programs (similar and dissimilar). This issue refers to the existing information gap, i.e. the interoperability between two or more remote treatment systems. This design includes software and a structure that is easily extensible and can exchange information with many telemedicine networks in order to solve the problem of stability.In the article by Begum et al. [45], a general study of the published scientific documents has been provided with an overview of the articles published by

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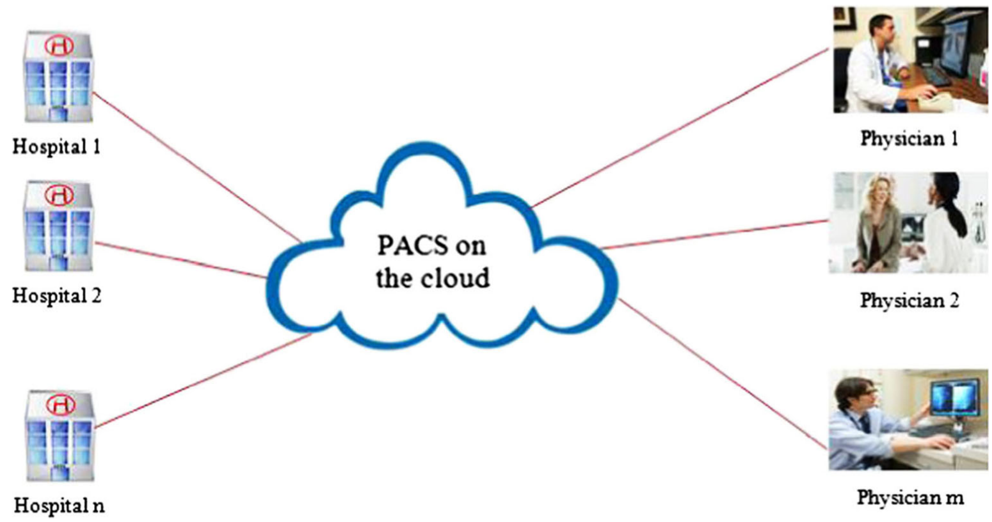

Fig. 6 Proposed cloud service for medical image exchange and management [37]

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researchers and with a focus on the methods applied in Healthcare using Internet of Things, such as wireless health monitoring, ubiquitous Healthcare, electronic Healthcare, Healthcare systems for the elderly and some security procedures for Healthcare applications. Also, in the study by Sre [46], a general overview has been presented on what has been published about the Internet of Things in the field of health. Mad [47] has investigated the remote monitoring in Healthcare with the aid of GPS and RFID technologies. Additionally, Hin [48] has referred to the concept of Healthcare based on the Internet of Things on LTE-Femtocell network and has provided two-stage architecture based on Android and task prioritization. In the article written by San [49], the recent articles have been reviewed. In a general comparison, recent articles in the field of Internet of Things in the health area can be compared as follows:

7 Security

Security and privacy are particularly important issues for Healthcare. A mass of information technology (IT) and increased demand for information about medical care systems are always considered as a risk for lack of patient privacy [59]. Hence, all the efforts made to protect privacy should efficiently and effectively identify possible threats. On the other hand, it should be determined which cases exist to ensure the protection of individual privacy and what information and resources should be considered for timely operations against threats [59]. For example, modern advanced applications for Healthcare to overcome the underlying constraints regarding the transmission of the quality of Healthcare services and increase the potential of telemedicine and modern Health services such as medical services through mobile phone (mHealth) are very appropriate. But concerns about maintaining patient privacy and protecting medical information are two fundamental issues regarding the proper use of electronic medical services, especially through mobile phone (m Health) [60]. Digital data theft and misuse of information are on the top of different fields and there is a fundamental need for strengthening the security systems of digital data in order to prevent data theft and data misuse [60].Use of service-oriented architecture is important for the strengthening of such policies. Therefore, some of the works done in connection with electronic Healthcare systems have focused on the security issue [61].In the article by Rahimi et al. [62], a safe

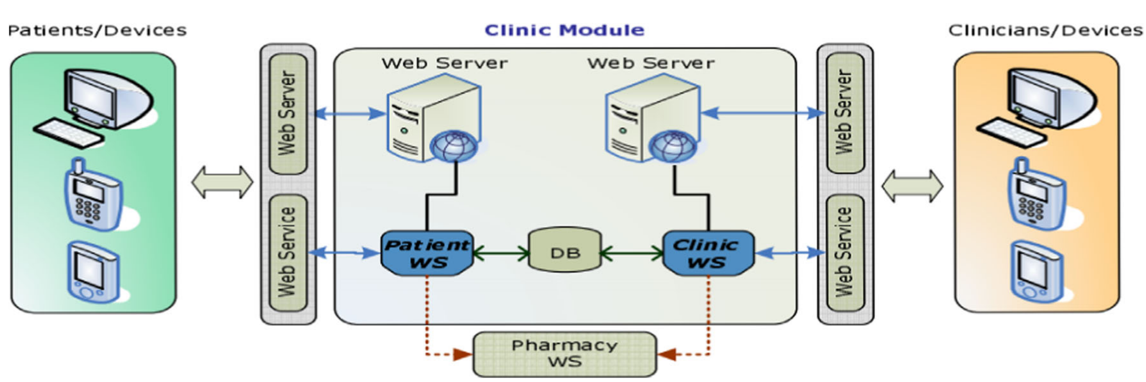

Fig. 7 A schematic representation of the system proposed by Kart and his colleagues [40]

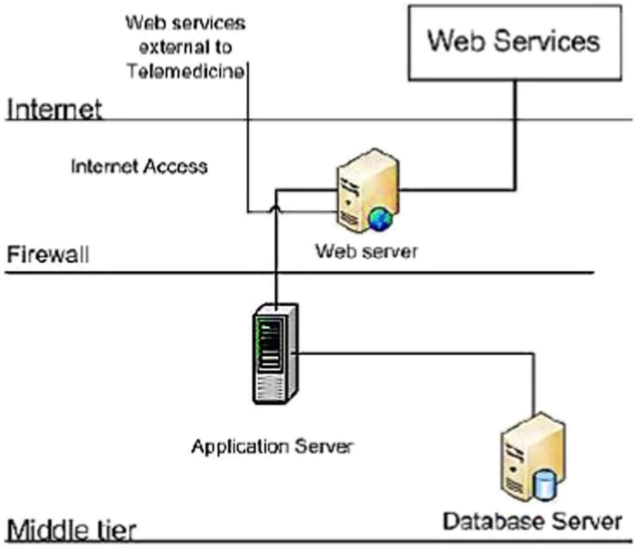

Fig. 8 Diagram of the designed program structure [44]

and efficient authentication and authorization architecture has been developed in the field of health care based on the Internet of Things. Security and privacy of the patient's medical information are very important for acceptance and widespread use of the Internet of Things in health care. Secure authentication and authorization of a remote specialist doctor have been the main focus of that article. Considering the limited sources of medical sensors, the use of conventional encryption in healthcare based on the Internet of Things is impossible. Besides, gateways in the existing Internet of Things have only focused on unimportant works without reducing the challenges of authentication and authorization. In the work by Rahimi et al. [62], a remote end-user authentication and authorization are done by distributed smart electronic health portal in order for the medical sensors to be unencumbered to do things with greater efficiency and as a solution for the security of the Internet of Things, certificate-based DTLS handshake protocol is employed. The proposed authentication and authorization architecture has been tested by developing a sample healthcare system based on the Internet of Things. The provided architecture is safer than the most updated identity-based centralized architectures because it uses a more secure key management scheme between the sensor nodes and smart gateways. Additionally, the impact of DoS attacks is reduced due to the distributed nature of the architecture. CodeBlue is one of the most famous research projects of Healthcare that has been developed in Harvard sensor network laboratory [63], in which several medical sensors are embedded on the patient's body. This technology is expected to play an effective role in the emergency care within the hospital and response to rehabilitation disasters and traumas. The writers of CodeBlue acknowledge that IOT-based medical applications need security. However, security of this technology has been entrusted to future research works. Lorincz et al. [64] has proposed elliptic curve cryptography (ECC) in the study by Kob [65] and TinySec in the article by Karlof [61] as an effective solution for the security of CodeBlue. But after all this time, this solution has not been actually implemented yet. Kambourakis et al. [66] have explained several attack and security threats models related to the CodeBlue project. To create end-to-peer compatible network security from several independent network domains, different types of conventional end-to-end security protocols have been recently provided, among which Datagram Transport Layer Security (DTLS) is one of the most appropriate protocols [67]. In this respect, Hummen et al. [68] have provided an implementation of representation architecture based on a route-off representation service provider. But their architecture cannot be extended to a multi-domain infrastructure. Considerable attempts have been made in designing gateways for one or more specific applications and architectural layers. Finally, Rahmani et al. [69] presented a smart e-health gateway called UT-Gate to bring artificial intelligence to ubiquitous Healthcare systems based on the Internet of Things. This gateway is smart in that they have the ability to autonomously perform local data storage and process it for learning or decision-making in distributed networks due to internal processing power and storage capacity in gateways. A smart gateway can quickly produce preliminary results and decrease the volume of cloud telecommunications of servers and yet create greater security through compression techniques.In the article written by Rahimi et al. [70], a tandem security scheme was proposed for mobility enabled healthcare Internet of Things. Their suggested scheme was composed of the following three parts: 1) A secure and efficient authentication and authorization architecture for the end user based on DTLS handshake certificate; 2) safe tandem telecommunications on the basis of session resumption; 3) robust mobility based on interconnected smart gateways. Smart gateways act as a middle layer processor. In the proposed scheme, this layer creates constant mobility without the need to reset the layer of devices. Their suggested scheme has the highest set of security features compared to the similar works found in articles. Their work is admirable relative to other works either in terms of energy or memory and is significantly better.In a study, Cvi [71] classified the risks involved in the security of the Internet of Things. In this article, it has been suggested and demonstrated that as the risks of the whole architecture should be seen, the risks related to the technology of individual architectural layers should also be considered independently.

8 Conclusion and future studies

In this paper, a review of the studies conducted on the issue of Internet of Things application in the field of medicine with a focus on security and service-orientedness was carried out.

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Numerous articles have proved that Healthcare necessarily needs to move towards using Internet of Things. Good works have been performed on the initial formation and organization of the Internet of Things. In addition, some works have been conducted on communication protocols. In scientific research, scholars have come to the conclusion that service-oriented architecture is one of the best options for the Internet of Things in the medical field due to the benefits mentioned in the text. Over time, scientific research has gradually moved towards the use of service-oriented architecture in the Internet of Things. Furthermore, it should be noted that in this sensitive area, data security is very important. Thus, some works have been performed on security which was mentioned above. But what is manifest in almost all of these articles in this field is the need for much broader research on the security in service-oriented architecture and Internet of Things and it can be almost said that a safe, cheap, convenient and comprehensive method has not yet been created. But since the audience of this technology is from all segments of society, those tools are successful in future that are cheap, convenient, resistant to common functions and most importantly, very safe.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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