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# Health Care Systems Using Internet of Things

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**ABSTRACT:** The many uses of the systems and products that connect to the Internet of Things (IoT) are changing business in numerous industries. Patients and providers both stand to benefit from IoT carving out a bigger presence in healthcare. Some uses of healthcare IoT are mobile medical applications or wearable devices that allow patients to capture their health data. Hospitals use IoT to keep tabs on the location of medical devices, personnel and patients. The new trends in health care are gradually progressing with the help of IoT which may make us more health conscious. This paper reviews the concepts, applications and various existing technologies for health care. We have enumerated the difference between those techniques and brief explanation of scope of IoT in personalized health care..

**KEYWORDS**: Energy Internet of things, health care, services, applications, networks, architectures, platforms, security, technologies, industries, policies, challenges.

## I. INTRODUCTION

Nowadays, a promising trend in healthcare is to move routine medical checks and other health care services from hospital to the home environment [2]. With that patients gets health care more easily especially in case of emergencies. Moreover hospitals can reduce their burden by shifting the possible and easy tasks to the home environment. One major advantage is in reduction of expenditure. Patients could avoid the fees charged by hospital each time they went to visit doctor. Therefore, it is urgent that in the near future a trending technology need to be implemented in the health industry to develop advanced health care techniques and technologies and use them for the easy monitoring of patients from anywhere else. Patient monitoring include checking the physical conditions of the patient and their medication details.

The concept of the Internet of Things first became popular in 1999. If all objects and people in daily life were equipped with identifiers, computers could manage and inventory them. The Internet of Things (IoT) is the network of physical objects —devices, vehicles, buildings and other items embedded with electronics, software, sensors , and network connectivity — that enables these objects to collect and exchange data.[1] The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, [2] creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020. With the use of IoT, embedded sensors, tags etc. have developed rapidly. Wearable sensors could be integrated with IoT to get more clear details. An android application could be used along with medicine box to make the system more user-friendly. Incorporation of different technologies at the right time like IoT could make a drastic change in any field especially the medical field. Business.

This paper surveys advances in IoT-based health care technologies and reviews the state-of-the-art network architectures/platforms, applications, and industrial trends in IoT-based health care solutions. In addition, this paper analyzes distinct IoT security and privacy features, including security requirements, threat models, and attack taxonomies from the health care perspective. Further, this paper proposes an intelligent collaborative security model to minimize security risk; discusses how different innovations such as big data, ambient intelligence, and wearables can be leveraged in a health care context; addresses various IoT and eHealth policies and regulations across the world to determine how they can facilitate economies and societies in terms of sustainable development; and provides some avenues for future research on IoT-based health care based on a set of open issues and challenges.

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## II. IOT HEALTHCARE NETWORKS

The IoT healthcare network or the IoT network for health care (hereafter ``the IoThNet'') is one of the vital elements of the IoT in health care. It supports access to the IoT backbone, facilitates the transmission and reception of medical data, and enables the use of healthcare-tailored communications. As shown in Fig. 2, this section discusses the IoThNet topology, architecture, and platform. However, it should be mentioned that the proposed architectures in [13] and [14] can be considered as a good starting point for developing insights into the IoT network.

### A. *The Iothnet Topology*

The IoThNet topology refers to the arrangement of different elements of an IoT healthcare network and indicates representative scenarios of seamless healthcare environments. Fig. 3 describes how a heterogeneous computing grid collects enormous amounts of vital signs and sensor data such as blood pressure (BP), body temperature, electrocardiograms (ECG), and oxygen saturation and forms a typical IoThNet topology. It transforms the heterogeneous computing and storage capability of static and mobile electronic devices such as laptops, smartphones, and medical terminals into hybrid computing grids [15]

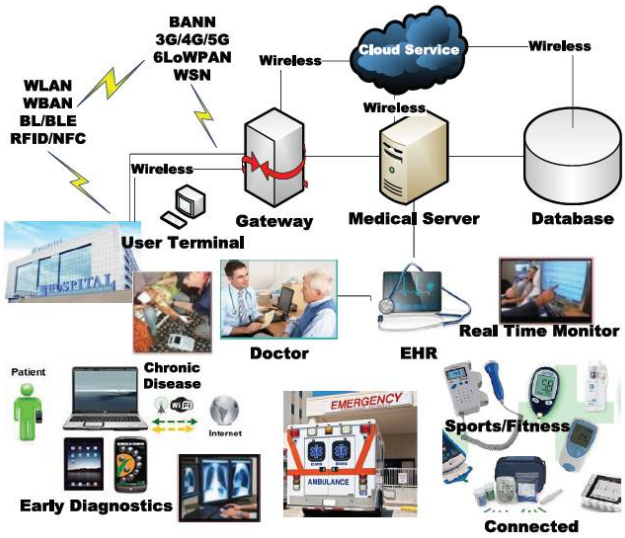


Fig.1. Healthcare trends.

Fig. 4 visualizes a scenario in which a patient's health prole and vitals are captured using portable medical devices and sensors attached to his or her body. Captured data are then analyzed and stored, and stored data from various sensors and machines become useful for aggregation. Based on analyses and aggregation, caregivers can monitor patients from any location and respond accordingly.

In addition, the topology includes a required network structure for supporting the streaming of medical videos. For example, the topology in Fig. 4 supports the streaming of ultrasound videos through an interconnected network with worldwide interoperability for microwave access (WiMAX), an internet protocol (IP) network, and a global system for a mobile (GSM) network as well as usual gateways and access service networks. Similar conceptual structures are found in [16]-[17].

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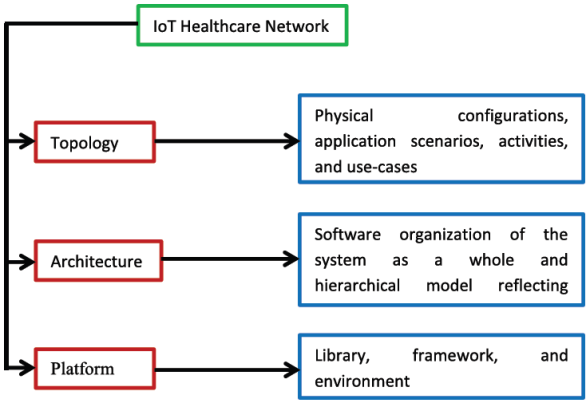


Fig. 2. IoT healthcare network (IoThNet) issues.

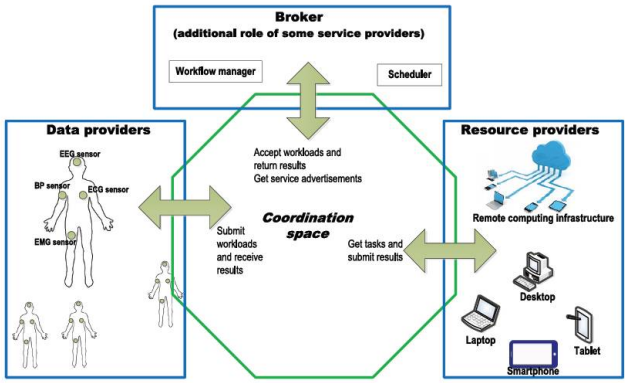


Fig. 3. A conceptual diagram of IoT-based ubiquitous healthcare solutions.

Fig. 5 presents an IoThNet topology showing the role of a gateway. Here intelligent pharmaceutical packaging (iMedPack) is nothing but an IoT device that manages the problem of medicine misuse, thereby ensuring pharmaceutical compliance.

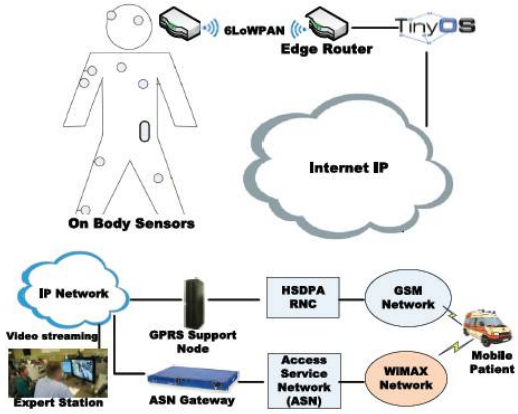


Fig. 4. Remote monitoring in wearables and personalized health care.

The intelligent medicine box (iMedBox) is considered a healthcare gateway with an array of various required sensors and interfaces of multiple wireless standards. Various wearable sensors and IoT devices are wirelessly connected to

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healthcare gateways connecting the patient's environment to the health-IoT cloud, a heterogeneous network (HetNet) that enables clinical diagnosis and other analyses. The gateway itself can investigate, store, and display all collected data [20].

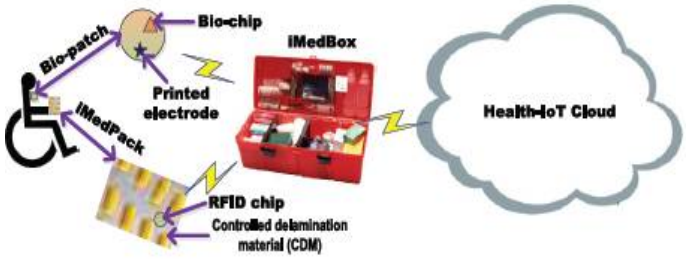


Fig. 5. An IoThNet topology with an intelligent healthcare gateway.

## III. PROPOSED COMPARISON OF EXISTING SYSTEMS

The briefly explains the services provided and sensors used in the each system for patient monitoring.

In [6] Urs et.al proposes an advanced care and alert portable telemedical monitor (AMON), a wearable medical monitoring and alert system targeting high-risk cardiac or respiratory patients. It consists of a wrist-worn device which acts as a communication link and a comprehensive medical center software package.

In [7] Luca et.al proposes smart hospital system for automotive monitoring and tracking of patients, personal and biomedical devices within hospitals and nursing institutes. The system mainly deals with two cases: patient monitoring and management of emergency situation.

In [8] Rui et.al suggests a system for applying internet of things (IoT) for personalized healthcare in smart homes. Continuous monitoring of physical parameters and processing health data makes the system much smarter one. The core functionalities of system are exposed using RESTful web services to the consumers.

In [9] Arif et.al proposes a context aware intelligent wallet for individuals to store their bio-signals and wallet shares the finding with appropriate persons. Special hardware is needed to implement sensor nodes.

In [10] Subhas et.al reviews the existing wearable sensors for human activity monitoring. The system plays an important role for continuous monitoring of physiological parameters especially of the elderly or chronic patient. The survey shows increase of interest in wearable devices may lead to reduce the cost of these devices.

In [12] Shiliang et.al proposes architecture of remote monitoring cloud platform of healthcare information. The system uses a PSOSAA algorithm for medical monitoring and managing application of the hospital information system. This simulated system can improve efficiency about 50%.

In [11] Alok et.al reviews healthcare applications of the internet of things. The IoT based heath care systems are clinical care, which provides continuous automated flow of information about patients and remote monitoring which enables wirelessly monitoring patients.

In [13] Val et.al proposes a body sensor networks for mobile health monitoring. Two approaches: PHM and MobiHealth. The PHM system adopts the policy of local processing, with interpretation algorithms running locally on the mobile system worn by the patient. In contrast the MobiHealth BAN is designed to be inherently a telemedicine system so feature is transmission of data to a remote system or user.

In [14] Media et.al proposes health care monitor system using wireless sensor networks. The main advantage of this system in comparison with previous systems reduced energy consumption, extended communication coverage to increase freedom for enhanced patient‟s quality life.

In [17] Valerie et.al describes a personal heart monitoring application using a smart phone and wireless (wearable) sensors. It was able to detect life threatening arrhythmias locally on a smart phone. System generates alarms and warnings when it crosses thresh hold values to inform the patient.

In [16] Mir et.al proposes Internet of Things (IoT) provides an opportunity of discovering healthcare information about a tagged patient or medical object by browsing an Internet address or database entry that corresponds to a particular Radio-Frequency Identification (RFID) tag. The tags interact with healthcare information system for automating managerial everyday tasks like admission care, transfer and discharge details.

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The major advantages of the Internet of Things in that healthcare organizations can take advantage of1 include the following:

1. Decreased Costs–When healthcare providers take advantage of the connectivity of the healthcare solutions, patient monitoring can be done on a real time basis, thus significantly cutting down on unnecessary visits by doctors. In particular, home care facilities that are advanced are guaranteed to cut down on hospital stays and re-admissions.
2. Improved Outcomes of Treatment – Connectivity of health care solutions through cloud computing or other virtual infrastructure gives caregivers the ability to access real time information that enables them to make informed decisions as well as offer treatment that is evidence based. This ensures health care provision is timely and treatment outcomes are improved.
3. Improved Disease Management – When patients are monitored on a continuous basis and health care providers are able to access real time data, diseases are treated before they get out of hand.
4. Reduced Errors – Accurate collection of data, automated workflows combined with data driven decisions are an excellent way of cutting down on waste, reducing system costs and most importantly minimizing on errors.
5. Enhanced Patient Experience–The connectivity of the health care system through the internet of things, places emphasis on the needs of the patient. That is, proactive treatments, improved accuracy when it comes to diagnosis, timely intervention by physicians and enhanced treatment outcomes result in accountable care that is highly trusted among patients.
6. Enhanced Management of Drugs –Creation as well as management of drugs is a major expense in the healthcare industry. Even then, with IoT processes and devices, it is possible to manage these costs better.

## IV. APPLICATION OF IOT IN HEALTHCARE INDUSTRY

The Internet Of Things (IoT) has been making serious impact on every industry, and wherever this "technology" swept by, you can feel the Midas touch. After the "discovery" of Internet, IoT has been creating waves that not a single business in the world can deny or resist. Those who do will be long left behind as the competition is going to become stronger and tenacious.

As per the reports submitted by the P&S Market Research, there will be a compound annual growth rate (CAGR) of 37.6% in the healthcare Internet of Things industry between the years 2015 and 2020. They claim that this rise could be attributed to the upper hand of remote monitoring healthcare systems that can detect chronic life-threatening diseases

By this we can assume that IoT has taken the reins and people can enjoy personalized attention for their health requirements; they can tune their devices to remind them of their appointments, calorie count, exercise check, blood pressure variations and so much more.

The applications of IoT in the healthcare industry are numerous. Here are six of them:

*a) Real Time Location Services :*

Through IoT, doctors can use real time location services and track the devices used for treating patients. Medical staff may sometimes keep the devices in out-of-sight areas which makes them difficult to find when another medical staff comes on the scene.

Medical apparatus and devices like wheelchairs, scales, defibrillators, nebulizers, pumps or monitoring equipment can be tagged with sensors and located easily with IoT. Apart from real time location services, there are IoT devices that help in environmental monitoring as well (checking the refrigerator temperature, for example).

*b) Predicting the Arrival of Patients in PACU*

With the intervention of Internet of Things, clinicians can predict the arrival of patients who are recuperating in the Post-Anesthesia Care Unit (PACU). They can also monitor the status of patients in real time.

*c) Hand Hygiene Compliance*

There are hand hygiene monitoring systems that would detect the degree of cleanliness in a healthcare worker. According to the Center for Disease Control and Prevention in the United States, about one patient out of every 20 gets infections from lack of proper hand hygiene in hospitals. Numerous patients lose their lives as result of hospital acquired infections.

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The interactions in the hand hygiene monitoring systems are done in real time and if a clinician comes near a patient's bed without washing his hands, the device would start buzzing. And that's not all. The information about the healthcare worker, his ID, time and location will all be fed into a database and this information would be forwarded to the concerned authorities.

*d) Tighten Budgets and Improve Patient Journey*

The healthcare industry has to keep a watchful eye on the budget and at the same time have updated infrastructure to provide better patient experiences. Thanks to the seamless connection between devices that IoT has made possible, it is now possible for the medical staff to access patient information from the cloud as long as they are stored in there.

The goal is to provide quality medical care to patients, and by spending a small amount on IT infrastructure, hospitals can provide good care to patients at affordable rates. IoT aims to provide better patient journey by:

a. Room lighting through personal control
b. Communicate to family and friends through email services
c. Immediate attention to patient needs

*e) Remote Monitoring*

Remote health monitoring is an important application of Internet of Things. Through monitoring, you can give adequate healthcare to people who are in dire need of help. Every day, lots of people die because they do not get timely and prompt medical attention. With IoT, devices fitted with sensors notify the concerned healthcare providers when there is any change in the vital functions of a person.

These devices would be capable of applying complex algorithms and analyzing them so the patient receives proper attention and medical care. The collected patient information would be stored in cloud. Through remote monitoring, patients can significantly reduce the length of hospital stay and perhaps, even hospital re-admission.

*f) Focus on the Research Side of Healthcare*

Protein research and composition analysis benefits from Internet of Things. Through IoT, researchers are able to analyze the accuracy of the equipment, and it rewards them by shortening their workflow through quantitative and reproducible analysis of proteins.

When an infinite array of devices is connected, the healthcare industry is able to provide scalable solutions to its patients. A number of healthcare apps providing cutting-edge personalized solutions are released to them. Here are a few of them:

- Medication Dispensing Device by Philips – so patients will not miss a dose anymore; perfect for elderly patients.
- Niox Mino by Aerocrine – for routine measurements of Intric Oxide in a patient's breath.
- UroSense by Future Path Medical – for catheterized patients to check their core body temperature and urine output.
- GPS SmartSole – this is a shoe-tracking wearable device for dementia patients who have the habit of forgetting things.

## V. CHALLENGES OF IOT HELATHCARE

The following are five challenges of IoT in healthcare that put it at risk of failure.

*a. Lack of EHR system integration.*

While the data that is collected from IoT devices can include a patient's vital signs, physical activity or glucose levels while at home, that information does not typically travel to an EHR system and, in most cases, is not centralized or made easily available to providers. This limits the information's value since it is not always presented to the provider in a clinical context

*b. Interoperability challenges keep IoT data in different silos.*

Patients are likely to collect different sets of data when using different medical devices depending on each device's purpose and, in some cases, the ordering physician. A patient with diabetes may frequently collect glucose levels and report them back to their primary care physician while also potentially capturing data related to their asthma on a separate device, which may be going to their asthma and allergy care provider.

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*c. IoT data alone may not be as meaningful if it is not within the context of a full health record.*

However, Many providers support the collection of meaningful patient data between visits, but this data is only valuable if it can be incorporated and viewed within the context of a full patient chart and timeline. There are still many cases where the data collected from wearables and other medical devices stays locked in the IoT vendor repository or apps, but for a physician, that data may not provide any help unless it is visible within the context of the patient's full record.

*d. Data security causes concerns in the implementation of IoT in healthcare.*

From the time that the data is collected at the device level to the point that it is transmitted over to its final destination, securing that information is critical and is required under HIPAA. But with the lack of common security standards and practices, many health IT professionals have concerns about the risks associated with IoT device tampering and data breaches.

*e. Constant changes in hardware and connectivity technology.*

Patients today need more than one device to capture the different health data their providers need. This can require more than one sensor that, in most cases, is used alongside a hub to which information is pushed that's designed to process the information. These hubs are not always compatible with the different sensors that are available, and having a lack of common hardware or wireless connectivity standards -- such as Wi-Fi, Bluetooth or Z-Wave -- can cause patients to have extensive hardware in their homes, which can be overwhelming and costly.

## VI. CONCLUSION AND FUTURE WORK

Based on advancement in IoT technology, this paper surveys diverse aspects of IoT-based healthcare technologies and presents various healthcare network architectures and platforms that support access to the IoT backbone and facilitate medical data transmission and reception. The several possible IoT based health care networks, its applications and challenges have been discussed. Further we will be elaborating the real time implementation of any of the IoT based healthcare system.

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