

# Use of Internet of Things (IoT) in Healthcare : A Survey

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## ABSTRACT

In today's world of connectivity, with the advancement of Internet of Things (IoT) all entities are connected to each other by some communication means. The Internet of Things for the medical equipment will produce data that can go a long way in not only increasing equipment efficiency, but also patient health. The Internet of Things (IoT) is increasingly being recognized by industry and different services mainly in healthcare. This paper describes the various Internet of Things (IoT) enable devices and its practices in the area of healthcare for toddler, children, chronic care, monitoring of critical patients, operation theaters and medicine dispenser.

## General Terms

Documentation, Design, Human, Standardization

## Keywords

IoT, Sensor, Healthcare

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## 1. INTRODUCTION

Present approaches used for monitoring a patient in hospitals are time consuming. With the advancement of communication protocols built in IoT system it is possible to design a research prototype for real time monitoring of patients. This prototype will be facilitating with direct patient physician interaction.

Now a day with the increasing use of sensors by medical devices, remote and continuous monitoring of a patient's health is becoming possible. This network of sensors, actuators and other mobile communication devices, referred to as the Internet of things – Medical Devices (IoT-MD)[1], is on the edge of revolutionizing the functioning of healthcare industry. This connected relationship between doctor and patient leads to a connected healthcare environment which promotes the quick flow of information and enables easy

access to it. Improved home care facilities and regular health updates to clinicians reduce the chance of redundant or inappropriate care, improve patient care and safety, and reduce overall costs of care. The IoT – MD provides an environment where analysis can be done on real time data promoting an evidence based medicine system [1].

## 2. MOTIVATION

Improving the efficiency of healthcare infrastructures systems is one of the most challenging goals of today's society. The need of delivering quality care to patients while reducing the healthcare costs is a main issue. Recent advances in the design of IoT technologies are stepping stone towards development of smart systems to support and improve healthcare system. The IoT is the Internet of Things, where sensors are connected to the Internet, which collect data for analysis to make our world more interconnected

and intelligent. A common person carries on average one or two mobile devices nowadays. Hence, by taking advantage of the increasing presence of mobile devices the cost of equipment can be reduced significantly in many industries like healthcare

### **3. IOT DEVICES IN HEALTH-CARE**

The Internet of Things could be a game changer for the healthcare services. It is transforming healthcare industry by increasing efficiency, lowering costs and put the focus back on better patient care. In this section we are going to list down some IoT enable devices those can be used by Healthcare sector.

Remote monitoring translates into a greater number of patients worldwide having access to adequate healthcare. Data is captured via sensors, complex algorithms analyze the data, and medical professionals can wirelessly access the information and make diagnoses and treatment recommendations. Patients can also be monitored around the clock so that subtle changes are detected and drug intoxication is avoided. We have categories these devices depending on their use

1. Internet of Things for Toddlers 2. Internet of Things for kids 3. Internet of Things for chronic care 4. Internet of Things for Motion detection and body motion reconstruction 5. Internet of Things for Man-down and personal emergency response systems (PERS) 6. Internet of Things for guidance in Surgery 7. Internet of Things for Healthcare mobility aids including wheelchairs and scooters

#### **3.1 Internet of Things for Toddlers**

##### *3.1.1 Mimo*

Developed by Boston startup Rest Devices, the Mimo smart baby onesie monitors the respiration, skin temperature, body position, and sleeping and activity levels of infants through an embedded turtle-shaped sensor. Data is transferred to cloud can be tracked back on mobile or PC. This device is basically useful for working parents. [8]

##### *3.1.2 Milk Nanny*

Toddlers are given milk made from milk powder. Proportion of power and water should be same always otherwise it affects babies divagation

system, The world's first fully-automatic smart formula machine makes fresh, warm baby milk in seconds — consistently and precisely — all with the press of a button. More conveniently, it can be controlled right from your phone [8].

##### *3.1.3 TempTraq*

TempTraq is the only 24-hour, Bluetooth-enabled thermometer that continuously senses and records a child's temperature in the form of a soft patch. That comfortable wearable then sends real-time information to a caregiver's mobile device.[8]

##### *3.1.4 Smart Diapers*

Researchers at the University of Tokyo have designed a super-thin sensor that can go inside diapers to inform caretakers when it's time for a change. In addition, these Smart Diapers allow parents to simply and unobtrusively screen for UTIs, dehydration or developing kidney problems [8].

#### **3.2 Internet of things for Kids**

##### *3.2.1Swimband*

Designed for personal aquatic safety, iSwimband is a portable and effective anti-drowning system that works in pools, lakes and rivers to ensure child water safety. The device is worn as either a headband or wristband and uses a built-in sensor to detect when it has been submerged for a user-defined length of time. If that threshold is reached, it sends an alert to a companion iOS app via Bluetooth up to 100-feet away[8].

##### *3.2.2 Sleep Monitoring*

Good sleep is a sign of good health. Sleep monitoring system provides comfortable and natural sleep environments. It tracks different parameters like blood pressure, body temperature, movement of the body, movement of all joints etc. [9]

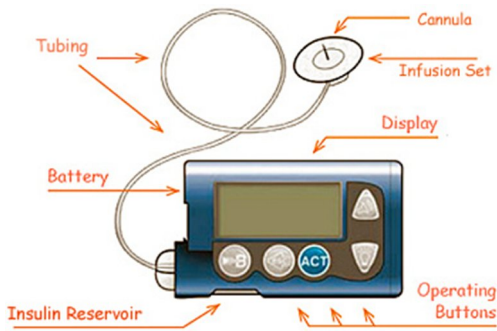
#### **3.3 Internet of Things for Chronic care**

Wearable devices are getting enough attention because many including those with chronic illness are deriving genuine benefit from them. The push

buttons on the devices can immediately send out alerts for emergency medical help

### 3.3.1 Implantable Medical Devices (Pacemakers, Defibrillators And Neuro-Stimulators)

#### 3.3.1.1 Insulin Pump

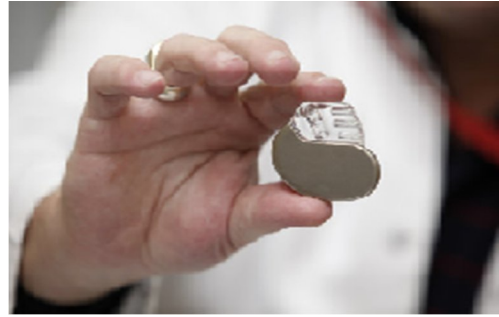


**Figure 1 Insulin Pump**

Insulin pumps are cell-phone-size devices used to deliver preprogrammed and user-adjusted doses of insulin. As a health benefit, the insulin pump helps to improve blood glucose (BG) control and correct high and low BG levels. People are using insulin pumps to achieve their target A1C level. According to the United Kingdom Prospective Diabetes Study (UKPDS), tight control of blood glucose in people with Type 2 diabetes helps to delay or prevent the development of microvascular complications such as retinopathy (eye disease), nephropathy (kidney disease), and neuropathy (nerve damage). Simply using an insulin pump is no guarantee of tight blood glucose control, of course, but studies have shown that pumps can help people to achieve control that is at least comparable to (and possibly better than) that of people on insulin injection regimens[3].

#### 3.3.1.2 Pacemaker

A pacemaker is a medical device implanted under a person's skin, with wiring going down to his heart, helping regulate abnormal heart rhythms. In modern western societies the fitting of pacemakers and implantable cardioverter defibrillators (ICDs) is growing rapidly.

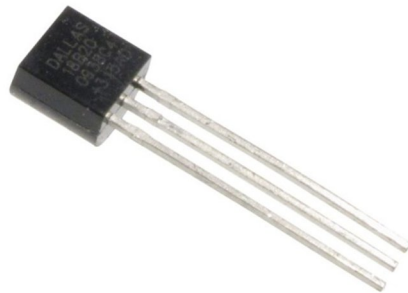


**Figure 2 Pacemaker**

Devices of this type control heart rhythm and, if necessary, send an appropriate response to make the heart beat at the right rhythm. They also record heart activity patterns when abnormal heart rhythm is detected. This information is periodically checked and monitored by a doctor to plan future treatment. To do this, the information is transmitted in wireless mode to an external device. At the moment this communication is carried out in hospitals[13].

#### 3.3.2 Temperature Measure

A thermistor will do a good job of measuring the temperature of whichever surface it is in contact with. If that surface is the skin on a human's body, then that temperature will be accurately reported. NTC thermistors are most often used for healthcare devices and are manufactured from the oxides of transition metals and can operate over the range of  $-196^{\circ}\text{C}$  to  $1000^{\circ}\text{C}$  [4].



**Figure 3 Temperature Sensor**

#### 3.3.3 Breathing CO

It's important to be aware of the dangers and identify any appliances in your surrounding that could potentially leak carbon monoxide (CO).

Install a carbon monoxide alarm, as this will detect a leak in your surrounding and give out a high-pitched noise when gas levels are high. They are available from hardware stores. However, alarms are not a substitute for maintaining and regularly servicing household appliances. Incorrectly installed, poorly maintained or poorly ventilated household appliances – such as cookers, heaters and central heating boilers – are the most common sources of carbon monoxide. Blocked flues and chimneys can also prevent carbon monoxide escaping, allowing it to reach dangerous levels [6].

### **3.4 Internet of Things for Motion detection and body motion reconstruction**

Wearable motion tracking system tracks a patient's body segment movements and these movements can be represented on the reconstructed human model. Based on the human model, rotational angles of involved upper extremity joints (elbow and wrist) and lower extremity joints (hip and knee) correlated with two symptoms (of resting tremor and bradykinesia) are estimated. Whenever there is need to track activities of patient in ICU this system is the most useful.

### **3.5 Internet of Things for Man-down and personal emergency response systems (PERS)**

#### *3.5.1 Blood Pressure Measurement*

The tonometer is one of the most important medical devices from home to hospital. But existing tonometer has drawback that it has to apply high pressure on the artery and it can give one's blood pressure no more than 5 consecutive checks. Thus the existing tonometer cannot be applied on 24 - hours continuous blood pressure measurement for hypertension patient in usual life. The traditional method which known as Kortokoff method measures patient's blood pressure by using air pressure cuffs and stethoscope sound [5]. Today's doctors still check patients blood pressure with this method. According to the development of information technologies, automatic electronics tonometer is widely used in home and hospitals since it is handy and has lots of usability. As it adopts oscillometric method, a sort of advanced

Kortokoff method, and also has the same problem that it has fatal step to stop the artery completely as like the traditional tonometer . [5]

### **3.6 Internet of Things for guidance in Surgery**

In operation theater doctors requires checking different reports or x-ray. Google Glass aids in a higher percentage has successful surgeries, and having such immediate and close access to the data helps to confirm doctors their decisions during surgery. [9]

### **3.7 Internet of Things for Healthcare mobility aids including wheelchairs and scooters**

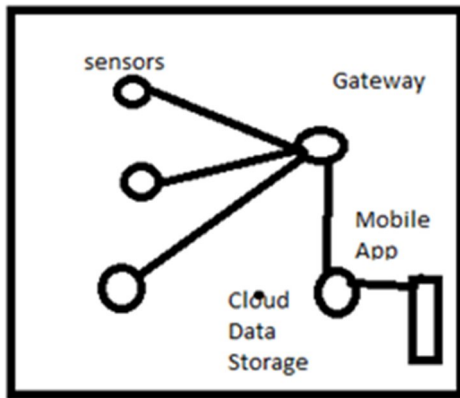
Pathfinder wheel chair and stretcher will be very helpful. They will be operator less and accurate.[10]

### **3.8 Medicine dispenser**

Studies show the consequences of patients not taking medications according to doctor's orders can be serious, especially in older patients. An automated pill dispenser is now available that brings together wireless M2M and IoT as well as mobile phones. The magic of the device is that the powered pillbox is equipped with a secure M2M Bluetooth module made by Gemalto (the Cinterion PHS8 smart card) that provides a 24/7 automated wireless link from the pill box to the patient, doctor, family member and medical alert monitoring center. The sensor-based dispenser monitors medication usage (open and close) and sends that usage information over the wireless network to a central server. [11]

## **4. Comparison of all IoT enable Healthcare Devices**

All these devices communicate with user mainly using mobile app. Data generated by these devices get save on a cloud. Cloud can public or private. As shown in figure 1. All sensors collect data and transfer it to gateway. Gateway is responsible for transferring data to cloud. Sensors are having very less memory. They cannot store data. At cloud data get process and responses get transfer to end user on his/her mobile phone



**Figure 4 Communication network of different Sensors**

All devices those they are discussed up till now are compared in this section. Comparison is carried out based on who can use that device? What is its battery life? Is it a cloud base system? Detail Comparison is given in table 1.

**Table 1. Comparison between IoT enabled Healthcare device**

Device	Who use?	can IoT Device	Battery Life	Response Time	Cloud connectivity
Mimo	Toddlers	yes	Depends on use but not more than 1-2 yrs	Depends on Internet Speed	yes
MilkNanny	Toddlers	yes	Depends on use but not more than 1-2 yrs	Depends on Internet Speed	yes
TempTraQ	Toddlers	yes	Depends on use but not more than 1-2 yrs	Depends on Internet Speed	yes
Smart Diapers	Toddlers	yes	Depends on use but not more than 1-2 yrs	Depends on Internet Speed	yes
iSwimband	Kids	yes	Depends on use but not more than 1-2 yrs	Depends on distance between nodes	yes
Sleep monitoring	Kids	yes	Depends on use but not more than 1-2 yrs	Depends on Internet Speed	yes
Insulin Pump	Diabetic Patient	yes	Fix 1-2 yrs depends company	Depends on Internet Speed	yes
Temperature Measure	anyone	yes	Fix 1-2 yrs depends company	Depends on Internet Speed	yes
Motion detection and body motion reconstruction	patient in ICU	yes	Fix 1-2 yrs depends company	Depends on Internet Speed	yes
Man-down and personal emergency response systems	anyone	yes	Fix 1-2 yrs depends company	Depends on Internet Speed	yes
Blood Pressure Measurement	anyone	yes	Depends on use but not more than 1-2 yrs	Depends on Internet Speed	yes

## 5. CONCLUSION

As the survey carried out it is observed that many devices are coming up in the market from different organization that uses IoT technology for remote monitoring of patient. All above mention devices work on different standards and principles. Putting a wealth of complex devices together is problematic on several levels. One in particular involves standards. IoT will rely on even greater standardization of communications protocols in the future for medical devices.

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