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HOME HEALTHCARE AND REMOTE PATIENT MONITORING

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41.1 INTRODUCTION

The *Internet of Healthcare Things* is the theme for Connected Health Symposium 2015 for *Internet of Things (IoT) in Healthcare*. As we are all in the evolution phase for the devices that communicate through wireless technology, there are a lot of lessons to be learned with real-world Healthcare usage scenarios.

The application of IoT in the Healthcare (Figure 41.1) can be classified as follows:

- Critical care
- Follow-up care
- Preemptive care
- Monitoring
- Diagnosing
- Treating

At the time of writing this chapter, we were still evaluating the reliability of IoT in Healthcare, and still Healthcare industry is evaluating the use of IoT Device to treating patient in real world. The Clinical usability sometimes does not fulfill the Healthcare services outcome, for example, why would I need a wireless device that is not reliable in the hospital? I can use an existing wired Medical device that is reliable. Assumption is that it is dangerous to put an IoT device to treat Critical care

Internet of Things and Data Analytics Handbook, First Edition. Edited by Hwaiyu Geng.

Companion website: www.wiley.com/go/Geng/iot_data_analytics_handbook/

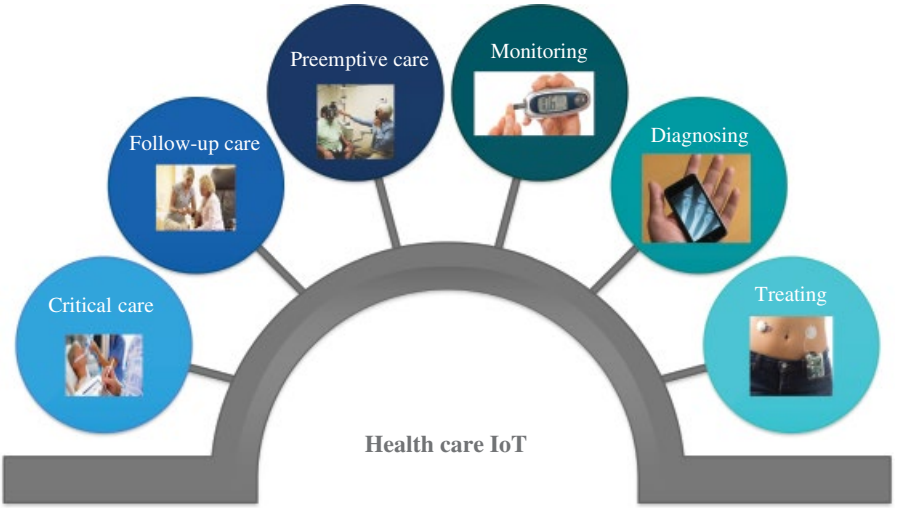

FIGURE 41.1 Application of IoT in healthcare. © University of Utah TeleHealth Services.

patients. We can send home IoT devices for follow-up care for patients by getting their biometric Data. Using IoT medical device, getting biometric data can be used as Preemptive Care approach for and create change in patient's Life Style. We have to identify the class of IoT application and prove the use case. Certain usability can be only performed through wireless IoT Devices for tracking a moving person or object. In this case we cannot tether device with a wire attached to a person or an object to monitor. The application of IoT for different class has to be based on the Use Case. The Use Case has to have a basic need or critical need. Technical possibilities and hurdles can be evaluated. When setting up an IoT device in a Hospital environment, it has a lot of challenges. The Hospital may have some or all of the ambulatory division, inpatient, Emergency, specialty, pharmacy, rehabilitation, Laboratory, and so on. The IoT application varies from monitoring patient, to biotest sample tracking, to nurse practitioner spending time with patients.

41.2 WHAT THE CASE STUDY IS ABOUT

CASE STUDY 1

Out of these classifications we chose to start with simple and less intrusive case study like tracking patient's movement in University of Utah Hospital physical medicine and rehabilitation (PM&R) (Figure 41.2). There are different kinds of patients who come to PM&R facility for treatment such as patients who are mentally not capable but physically strong enough to walk within the hospital premises, and there are some occurrences that patients wander off to the street and even to freeway. It is not viable to lock the patients undergoing therapeutic treatment

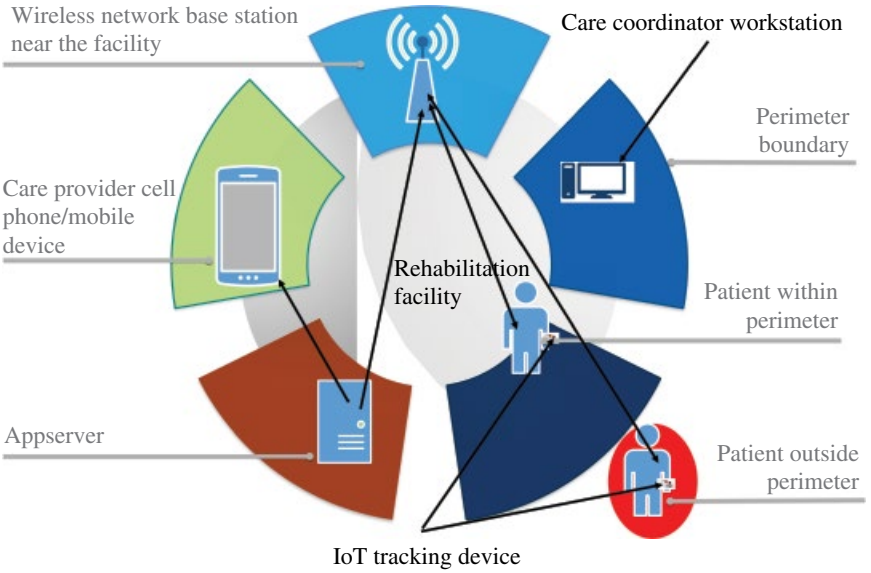

FIGURE 41.2 IoT patient tracking system diagram. © University of Utah TeleHealth Services.

into a confined room or area. So we need to track a patient with a lightweight device, and network should be capable to pick up the device chirps (emitting message) to care provider and alert them through their phone or other devices. Using this approach patients can move around freely within the facility but with constantly monitored performance.

41.3 WHO ARE THE PARTIES IN THE CASE STUDY

The following are members who participate in the case study. An organizational chart is shown in the succeeding table with their responsibilities.

Role	Specific Role Name	Responsibilities
Care Provider	Physician	Diagnosing and treating patient
Care Provider	Nurse practitioner	Patient care
Technical strategist	IT person	Coordinating, implementing, and assisting in planning
Project manager	Program manager	Manages overall project development
Care coordinator	Nurse manager	Oversee any patient notification
Network engineer		Set up perimeter and security with network
Network vendor		Provides networking hardware tools
Device vendors		Any vendor provides I/O device

- Physician, Nurse Practitioner, and so on
- Network Engineer
- Technical Strategist
- Project Manager
- Care Coordinator
- Network Vendor
- Device vendor

A road map with timeline is also shown in the succeeding table.

Solution	Implementation Timeline
Patient tracking	2016–2017 University of Utah fiscal year
Nursing time spent on tracking	2016–2017 University of Utah fiscal year

41.4 LIMITATION, BUSINESS CASE, AND TECHNOLOGY APPROACH

Currently, there is no mechanism to track a patient; moreover, there is limitation in Ethernet Wi-Fi and Bluetooth in the Hospital perimeter. The device cannot emit its presence after certain distance due to limitation in network capability or some dead Spots. So the simple tracking device sends tiny packets of data. So we need Ultra Narrow bandwidth and dedicated network for IoT devices. A very lightweight IoT device wearable in patient's Wrist.

41.5 SETUP AND WORKFLOW PLAN

Equipment

1. Base station which transmits and receives IoT device Messages should be installed on the Roof of the nearby facility so that it has better coverage.
2. IoT device is put on the Patient's wrist (Figure 41.3).

The IoT sensor devices are worn on patient's wrist during the therapy period. The devices will constantly emit message to base station about the location of patients. The Network operator-provided Base station will establish an Ultra Narrow Bandwidth that is dedicated for IoT devices. So the patient wearing IoT devices on boot-up will communicate with network (Ultra Narrow Bandwidth base station) pre-programmed frequency and message. This is publish/subscribe model, so the devices registered to the network, and only it can send a message by communication token established by Business Support System.

All the Device to Antenna are Radio Links. There are very few network operators in this unlicensed Bandwidth. Assume the security (tampering, resending messages,

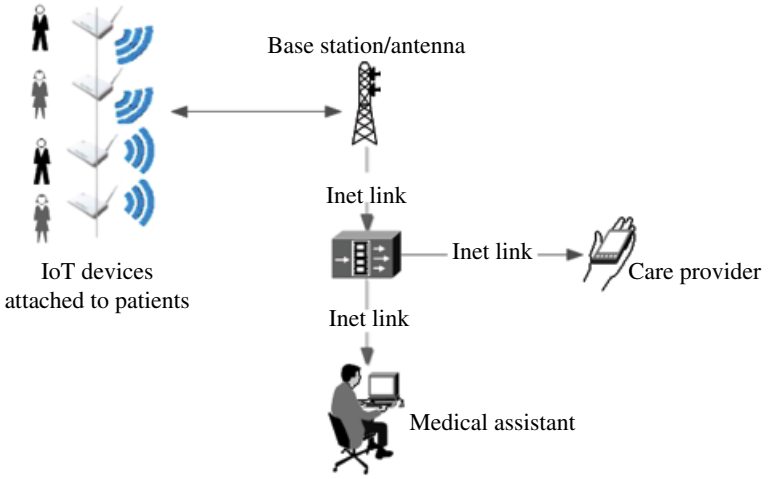

FIGURE 41.3 Patient tracking system using IoT sensor devices. © University of Utah TeleHealth Services.

integrity of messages, no open-inbound port listening, authentication, authorization) of the IoT devices is taken care of.

Classification is crucial to manage the ecosystem of Healthcare IoT devices (Figure 41.4). For example:

- Device Type = Tracker, Temperature, and so on
- Device Group = Medical
- Device Type Related to Business Support System = To track Patient movement
- Device taking a communication token in Business Support System Order = Communication Token for Device Group and Device Type

41.6 WHAT ARE THE SUCCESS STORIES IN THE CASE STUDY

1. The prepilot exercise points out the person's movement from room to room or location to location, and we can see that the status is Web portal dashboard. This feature can help the care coordinator to actively locate the patient movement.
2. There is no issue in network proxy settings for the Bluetooth listeners.
3. Using commercially available consumer-friendly wearable devices will be welcomed by Healthcare community.

Note: Due to Hospital-wide Network Wi-Fi is enabled. This project is reevaluated to use Wi-Fi 5G bandwidth replacing all Bluetooth frequencies.

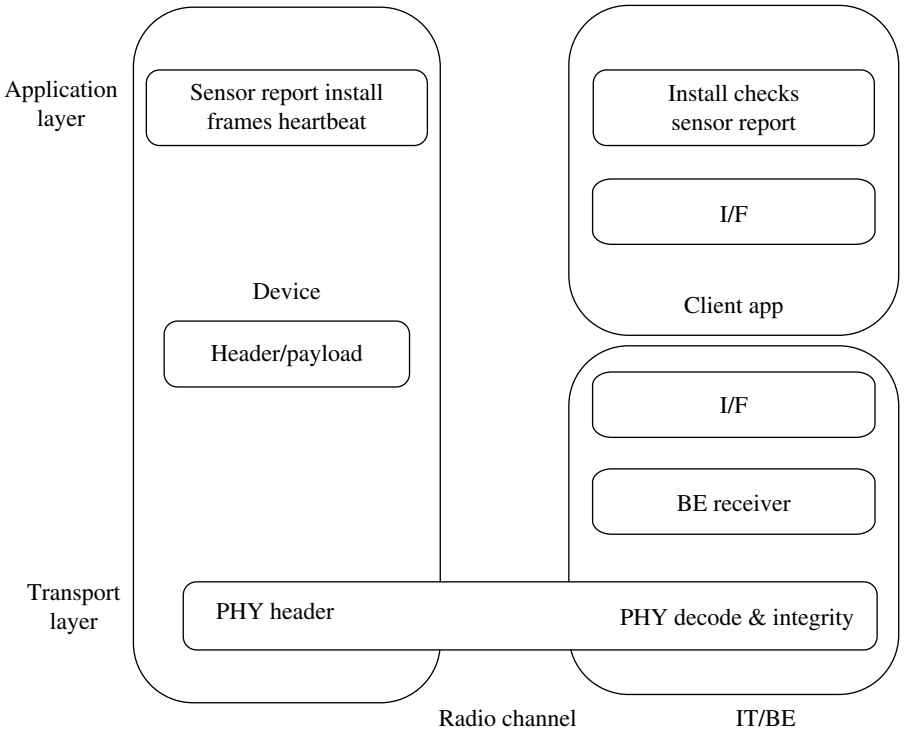

FIGURE 41.4 Healthcare IoT devices and classification. © University of Utah TeleHealth Services.

Serendipity Finding 1

When this demo of the solutions caught the attention of our orthopedics clinic operations director, we found that this can be applied to operational efficiency. He mentioned the typical current workflow of the department.

1. Patient checks in the front desk.
2. Patient is given a tablet for survey.
3. Patient is taken to X-ray by technician.
4. Nurse practitioner takes vitals.
5. Doctor checks the patient details.
6. Doctor meets the patient face to face.

The current workflow process has delays between the next steps. This is due to lack of patient location awareness. They perform action only when they see the patient, and it involves actual person monitoring and notifying. Alert and notification is missing in real time. So this patient tracking solution can be used to alert the care coordinator to move the patient to the next step and avoid waiting time. So the patient

will be able to see the physician ASAP. This is a good candidate for patient satisfaction. So this is another potential pilot with IoT.

Serendipity Finding 2

Second doctors want to find how much time the MA/Nurse spends with Spinal cord-injured patients and Quadriplegic patients. This information helps the department to better allocate resource and capacity management.

Currently, IoT devices have potential opportunities for the following:

1. Send home Bluetooth-enabled medical devices with Gateway. This gets instant biometric readings from patients and update in the patient and nurse portal.
2. In patient setup will also benefit from continuous reading of vitals using IoT devices without any wire tangled.
3. IoT Compression suite having electromyography sensors (EMG) will provide real-time and recorded-time muscular activities, heart rate, and respiration.
4. IoT Shoe Insole provides real-time Gait, Symmetry, Jump details of Rehabilitation patient. These details give care providers information to adjust the physical therapy exercise for patients.
5. Ingestible pills through IoT technologies provide medical adherence, tracking, and so on.

41.7 WHAT LESSONS LEARNED TO BE IMPROVED

- The latest IoT devices in Healthcare and evolution are ongoing. Currently, Skin patch biometric devices which are also noninvasive are going to be the future within couple of years (current year 2015). So adoption of these devices is essential, and interface with the mainstream Healthcare application is crucial.
- When IoT Healthcare devices come to the market (like consumer-related step monitor, sleep monitor, and heart rate monitor), it is necessary to communicate with the provider (Physician, Nurse, etc.) for multifactor diagnosis. They are the sole authority on the decision-making process. Since the patient empowerment is necessary from home perspective, physician empowerment on clinical setup is crucial. Data generated with IoT medical devices/sensors fed to the smart applications can provide rapid preliminary diagnosis and provide prescription conjunction with provider.
- With this explosion of IoT devices, there should be very effective implementation governance for secure and solid integrity of data delivery to be taken care of for successful Healthcare.

Figure 41.5 shows IoT components in a Digital Health Ecosystem. The Digital health ecosystem starts with IoT Devices at the bottom. Those devices provide a wide range of information on biometrics, laboratory sample tracking system, health and

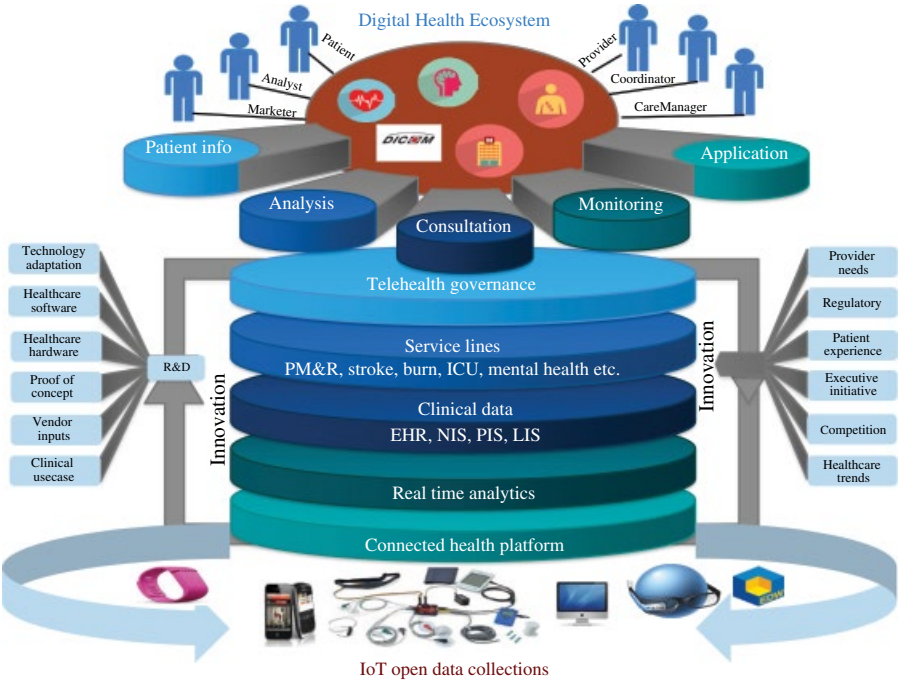

FIGURE 41.5 Digital health ecosystem with IoT components. © University of Utah TeleHealth Services.

wellness devices (wearables), and so on. They are connected to a health platform and move upward by applying analytics and workflow. The information that reaches to clinical data EHR, NIS, and so on will be more actionable data or decision-making data. This actionable data can be available to different service lines like PM&R, Stroke, and so on. The whole deployment will be notified and tracked by Telehealth team to facilitate Telehealth calls. The whole Telehealth system's goal is to automate the process and notify the critical actions to take place. This process will be constantly influenced by R&D on the one hand and innovation on the other hand. The top figures consist of care provider, patient, and other actors. These actors use the appropriate action tools (DICOM for seeing patient's MRI) to provide care. For example, the action tools and IoT data at the bottom can provide shared decision making on certain ailments. The patient's insole sensors provide data on patient rehabilitation exercise adherence, and the MRI provides patient improvement after the surgical procedure.

FURTHER READING

http://mobihealthnews.com/ (Accessed January 19, 2016).
http://www.telehealth.com/ (Accessed January 19, 2016).
https://digitalhealthsummit.com/ (Accessed January 19, 2016).
https://www.wearable-technologies.com/ (Accessed January 19, 2016).