Wireless Sensor Network Application for IoT based HealthCare System

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Abstract: ***Public healthcare has been paid an increasing attention given the exponential growth human population and medical expenses. Advances in wireless sensor networks and electronics have led to the emergence of Wireless Sensor networks (WSNs). WSNs have been considered as one of the most important technologies that can change the future. These networks consist of small battery-low powered nodes with limited computation and radio communication capabilities. Each sensor in a sensor network consists of three subsystems: the sensor subsystem which senses the environment, the processing subsystem which performs local computations on the sensed data, and the communication subsystem which is responsible for message exchanges with neighboring sensors. WSNs comprise tiny wireless computers that sense, process, and communicate environmental stimuli, including temperature, light, and vibration. This paper will investigate the application of current state-of-the-art of wireless sensor networks in health care systems and will address how WSN concepts are integrated in our electronics engineering program.***

Keywords: Wireless Sensor networks (WSNs) ,Internet of Things (IoT)

I. Introduction

Advances in wireless sensor networking have opened up new opportunities in healthcare systems. Sensor-based technology has invaded medical devices to replace thousands of wires connected to these devices found in hospitals. This technology has the capability of providing reliability in addition to enhanced mobility. In the future, we will see the integration of a vast array of wireless networks into existing specialized medical technology. In the advanced technology enabled world, changes are rapid and the status-quo is constantly disrupted. Internet of Things (IoT) is one such disruption happening right now, which has the potential to change the way healthcare is delivered. There are no standard definitions for the Internet of things, As per the definition, "Internet of Things (IoT) is the network of physical objects that contain electronic embedded technology to communicate and sense or interact with their internal states or the external environment". The IERC definition states that IoT is "A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network." The IoT allows people and things to be connected anytime, anyplace, with anything and anyone, ideally using any path/network and any service [3].

II. Architecture of IoT in HealthCare

IoT is a vision which is still at very early stages, where everyone interprets the vision with their own perspectives. There are three main visions of IoT based on the things, digital and semantic perspectives [6]. All these three perspectives of IoT should integrate with each other seamlessly as shown in Fig 1, for extracting the full benefits of IoT architecture.

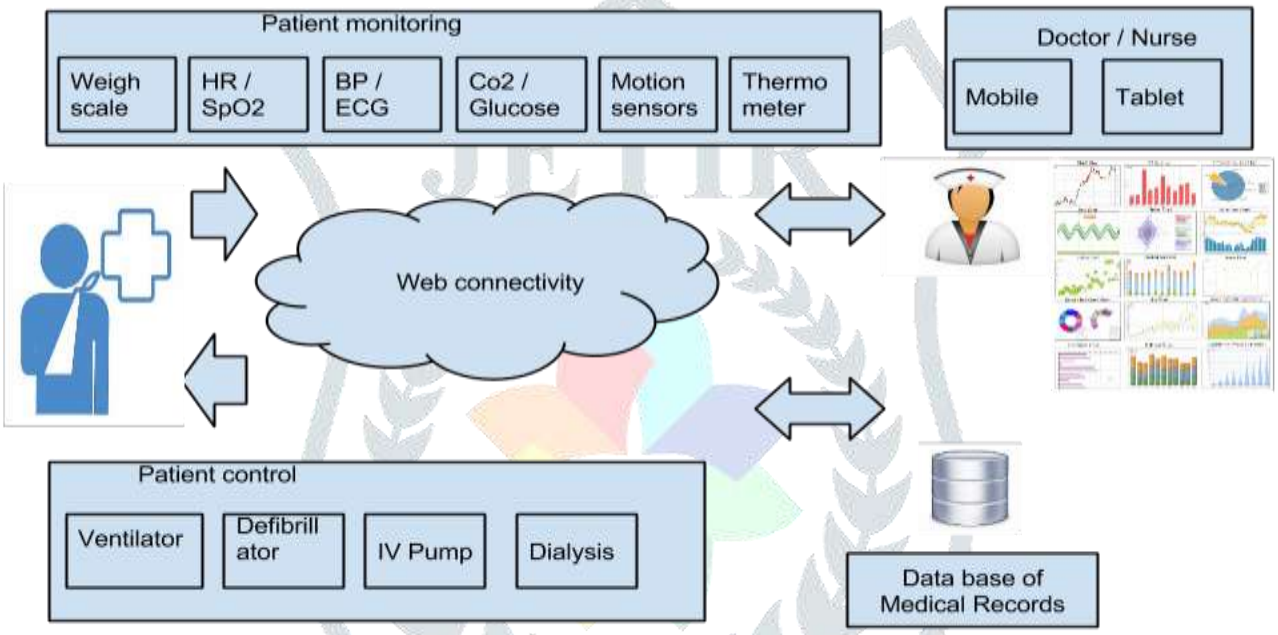
1. Things oriented vision 2.Internet oriented vision 3.Semantic oriented vision

Figure-1: Vision of Internet of Things

1. **Things oriented vision:** This vision provides the perspective that all the real physical objects can have the sensors attached to get the real time information from them. This can be accomplished by the sensors based network of embedded electronic devices using RFID, NFC and other wireless technologies. This vision provides the base for integration of all "things" using different sensor based networks to collaborate and co-exist together.
2. **Internet oriented vision:** This vision provides the perspective that all the devices can be connected through internet and can be described as smart objects. This can be accomplished by using unique IP for each connected object. This vision provides the base for the data integration of all the smart objects, which can be continuously monitored.
3. **Semantic oriented vision:** This vision provides the perspective that all the data collected from carious sensors need to be analyzed for meaningful interpretation. This can be accomplished with semantic techniques, which separates raw data from the meaningful data and their interpretation. This vision provides the base for the semantic integration through the use of semantic middleware.

III. Simplified layout of IoT in HealthCare

Figure-2: Simplified layout of IoT in HealthCare



The sensors help to transform the physical world data (e.g: temperature, pressure, humidity, etc) including human health data (heart rate, oxygen saturation, blood pressure, blood glucose, etc) to the digital world and the actuators transforms the digital data to physical actions (e.g: Infusion pumps, dialysis system, etc). The IoT devices have sensors for receiving signals from the environment for analysis, or actuators for controlling the environment based on the inputs, or both sensors and actuators. These devices connect with each other through internet transfer and cloud storage for communication with similar devices and people, as shown in Figure-2.

IV. Wireless Sensor Network for IoT based HealthCare System

Feature modeling is the best paradigm to choose the feature requirements according to end-user specification. Feature models are tree type structures that consist of common and variable features (alternative, Optional, and OR groups) used to manage the core assets of SPL for high reusability of existing features which can affect low cost and time development of the software applications. The impact of feature modeling on IoT based software applications is to increase the reusability of features [3] and to exchange data that enhances the efficiency of patient care of basic clinical care functions, such as blood pressure monitoring.

Organizations adopt different approaches for the development of IoT applications, such as sequential approach that always starts the development from scratch for every IoT application which requires higher cost and time with quality challenges. Moreover, if minor changes are required or need to be updated then the complete application needs to be changed[4]. Therefore, this approach is not suitable where applications are needed to be developed in less time and with lower budget, such as heat sensors for indoor and outdoor in e-Health.

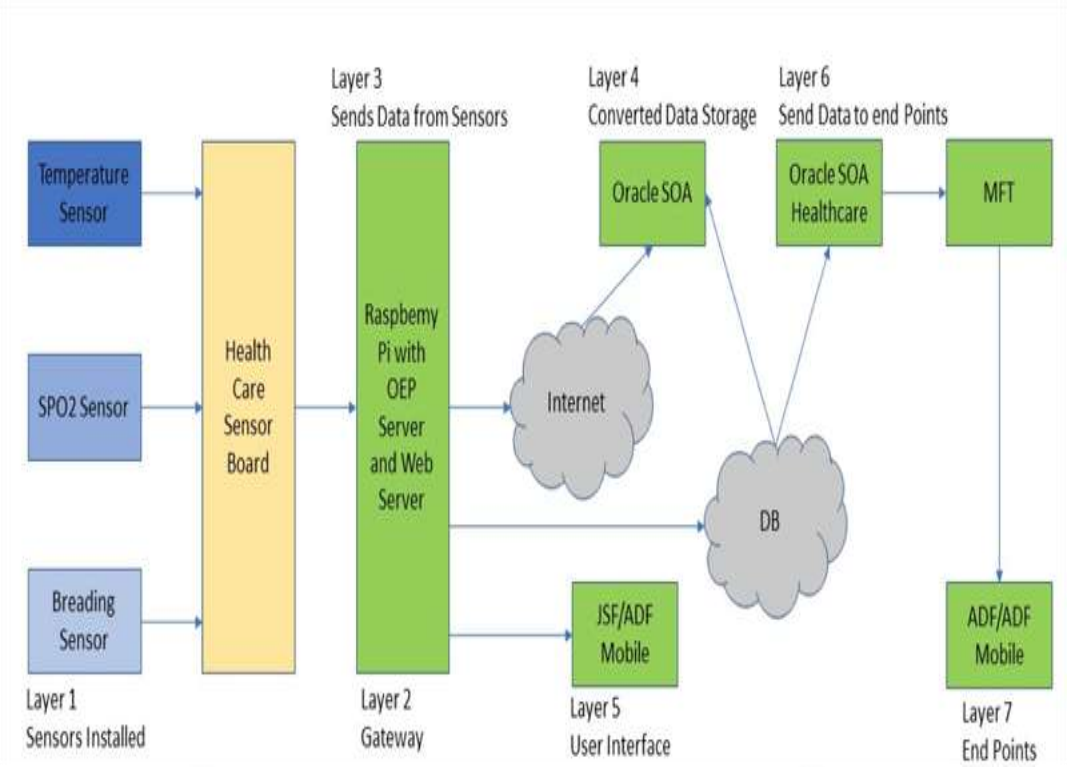


Figure-3: Wireless Sensor Network for IoT based HealthCare System

In this study, we have adopted SPL feature modeling for e-Healthcare IoT-based application to increase the reusability of features by handling variability's, such as alternative (indoor, outdoor sensors), Optional and OR groups features. An e-Healthcare system consists of multiple layers of software, and sensors can be installed on IoT devices, gateway, or at the user interface to present data etc., as shown in Figure-3. However, we are considering the sensors variability's (e.g., layer-1 of the IoT-based e-Healthcare system) with feature modeling. The software application of temperature sensors is different with respect to the environment on same sensor devices[5]. Pulse Oximetry Sensors (SPO2) are used according to performance, quality, and cost savings to measure the pulse rate of diverse categories of patients, such as adults and children[6]. Breathing sensors are used to measure the breathing effects on chest and stomach and are different for child and adult healthcare centers[7].

Temperature Sensors		**SPO2 Sensors**		**Breathing Sensors**	
Thermistors	Low Cost, Minimal BOM	Adult Finger clip	>40 kg	Through-Beam	Large Operating Distance, High Operational
Thermopiles	Non-contact, Wide Temperature Range	Children Finger Clip	10-40 kg	Retro-Reflective	Large Operating Distance
Thermocouples	Wide Temperature Range	Neonatal	1-4 kg	Diffuse Reflection	Small Operational Distance

Table-1: Types of Temperature Sensors for various functionalities of Healthcare System

For e-Healthcare systems, we consider three types of sensors for each sensing such as temperature sensor, SPO2 sensor, and breathing sensor. Table-1 shows the variability's of sensors in different environments and attributes. To develop the software application of these sensors with the environmental selection, we adopted the SPL feature model at the architecture level to achieve high reusability. As per the definition of SPL, these sensors need to be operational with a software application that is called core asset development and for complete e-Healthcare system development, these core assets are reused in various products. Therefore, feature modeling is required to categorize the variability's for each product development.

Figure 2 shows the feature model of e-Healthcare sensors where four variation points indicate the variability's of products. During each application development, these variation points must be satisfied. If any variation point is violated, then application leads to failure at the end-user level. Variation point1 (Vp1) indicates that at least one sensor must be part of the e-Healthcare application, Vp2 indicates that only one temperature sensor can be used, Vp3 indicates that multiple SPO2 sensors can be used general healthcare center (e.g., for adults and kids) and, Vp4 indicates that only one breathing sensor can be used in each product derivation. The purpose of this study is to enhance the reusability of features of e-Healthcare systems with less cost, fast development, and up-gradation of existing systems.

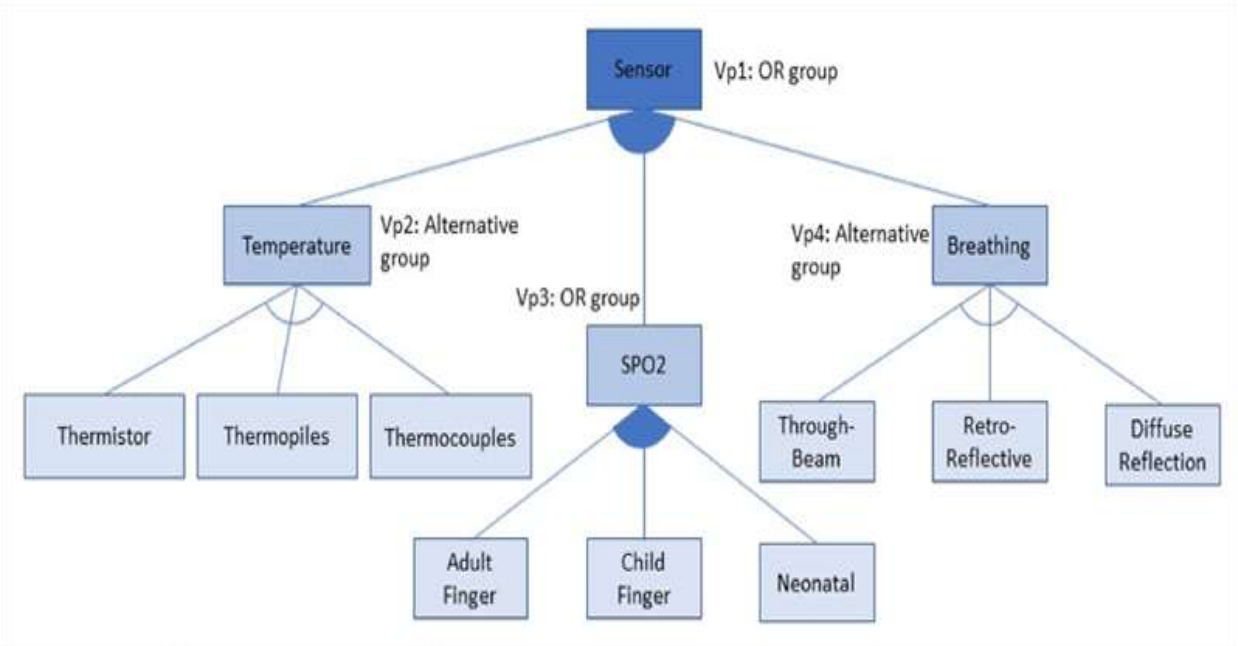


Figure-2: e-Healthcare Sensor Feature Model

Conclusion:

This study revealed that the existing application of WSNs in the healthcare system have some shortcomings that need to be addressed. The WSN research community has done an admirable job of addressing some of the limitations that currently exist for healthcare-related applications; however, improvements are still needed regarding security and privacy issues in addition to further upgrades to wireless communication.

As educators in the field of electronics engineering, it is essential to expose our students to the emerging field of WSNs. As the industry is constantly involved in the development of technology and products to solve issues with WSNs, tomorrow's electronics engineers must be educated on the Wireless Sensor concepts. Wireless Sensor Networks applications in healthcare are being researched and deployed all over world. With the rise of these applications, implications will also arise.

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