Design and Implementation of Web Information System for Asthma Attacks using Raspberry Pi

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Abstract—As the main target of this paper is to develop a flexible system characterized by a low-cost wireless sensor network that assures robust and continuous monitoring of air quality in order to prevent the asthma attacks and other respiratory attacks. At the same time it permits to establish correlations between the air quality parameters, physical parameters and the Appearance of respiratory diseases such as asthma, lung cancer and other respiratory attacks as part of environment medicine approach. The wireless sensor network includes a set of sensing nodes with ability to measure environment parameters like temperature, relative humidity, carbon monoxide among others and to send processed information to a smart coordinator such as the Raspberry Pi which is the new controller which is able to load the information on to the web. This paper presents a web information system and a wireless sensor network for indoor or outdoor air quality monitoring with application in asthma trigger factors assessment. Referring to software, a client application that uploads the measured data to a remote air quality server through Internet was designed and implemented. The primary processing is done by the smart coordinator that transmits the processed values of air quality parameters including alarms to a web based information system. Referring the web based information system it assures the human machine interface, the users being capable to receive alerts, and to visualize the data associated with wireless sensor network, and to monitor network status. Alarm will be generated when the temperature, humidity and CO is greater than or equal to the boundary limit set and gives status it’s abnormal.

Key words: wireless sensors networks, air quality, asthma assessment web based information system

I. INTRODUCTION

The work presents a wireless sensor network and information system for air quality monitoring and periodic respiratory exams that is employed to extract relations between the air quality and respiratory disease such as asthma. The data provided by the WSN may be published using a web based information system the information being accessed by users that can be alerted about the poor air conditions. Focussing on web based information system that process and publish the data received from air quality WSN the developed system prototype that can be used to help medical researchers to analyse extended amount of experimental data contributing to limit the asthma spreading and asthma attack occurrences based on measurement of the indoor and outdoor air quality conditions. Activities such physiotherapy that are commonly performed in indoor with people characterized by limited health can be well organized by personalized air conditions that can contribute to reduce the recovery times.

Wireless sensor networks (WSN) are used in a huge variety of sectors and industries, one of the important fields of application being expressed by WSN for outdoor and indoor air quality monitoring including temperature, relative humidity but also the concentration of the gas pollution such is presented in. Additionally the WSN are used in agriculture related to the irrigation and crop monitoring, and also in healthcare as part of cardiac and respiratory activity monitoring nodes.

In the new era of information technology, the people spend more time indoor considering their activities related work or leisure, indoor air quality conditions can affect directly the respiratory condition of the people. Thus, breathing air characterized by poor air quality will imply to bring air pollutants deeply in lungs, which causes serious damage to the respiratory tract. At the same time long term polluted air exposure can trigger new cases of asthma. Air pollutants also negatively and significantly harm lung development, creating an additional risk factor for developing lung diseases. At the same time the respiratory disease developed on young people are increasing, the asthma being one of the illnesses that is nowadays more frequent on children and teenagers. To investigate the relation between the indoor air quality and respiratory diseases, the measurement of gases concentrations such as CO, NO2, PM10 and physical parameters such as temperature and relative humidity are carried out. The air quality guidelines promoted by World Health Organization, highlights the relation between asthma disease occurrence and factors such as smoking, mustiness, nitrogen dioxide.

The usage of Wireless Sensor Network (WSN) to monitor outdoor and indoor air quality is reported by different authors. However such solutions can still be considered limited regarding the flexibility and the possibility to include specialized measurement nodes based on accurate respiratory monitoring instruments as part of the deployed network. Regarding the WSN the autonomy represents an important issue. To have an optimal choice of wireless communication protocol it requires performing set preliminary studies regarding the necessities of distributed measurement system and to investigate the solution already proposed in the field. In this case can be mentioned air quality monitoring network based on Wi-Fi or Bluetooth that are relatively low cost solution, with high data rate transfer but high power consumption. In the latest times Bluetooth low energy and ZigBee protocols become the chosen solution for environment monitoring applications. At the same time the ZigBee wireless networks prove to be better succeed cause by greater flexibility, the lower consumption and the range.
II. WIRELESS SENSOR NETWORK

In order to give a better perception of the implemented architecture for air quality monitoring, in Figure 1 are presented the main hardware and software element.

Fig. 1: Distributed system for air quality a) indoor distribution of WSN

In Figure 1 on the left side are represented the border-router connected through the Ethernet port to the embedded PC (Raspberry Pi) working as the smart coordinator, which receives IPv6 frames within IEEE802.15.4 frames and forward them through Wi-Fi to the PHP server. Second smart coordinator architecture expressed by Raspberry Pi and Zigbee coordinator of sensor network is expressed on Figure 1.a right side.

A. Sensing Nodes:
The implemented WSN includes sensing nodes of JN5139-EK030, characterized by temperature and relative humidity measurement capability through the usage of Sensirion SHT11. Additionally a set of sensors NO2, O3 and PM10 are used to provide information used for air quality index calculation according to the relations provided by “Agência Portuguesa do Ambiente”. The analog inputs of each nodes are used to acquire the values from air quality index sensors. For each wireless sensor node the sampling rate associated with analog channel is programmed in order to assure good accuracy of air quality parameter calculation, also following guidelines of air quality index which defines the minimum number of samples needed to an efficient calculation. The choice of the sampling rate is performed considering also the general requirements of higher autonomy for WSN nodes.

Referring to the communication between sensor nodes and coordinator, in the first approach it is based on 6LoWPAN. Messages are sent between the wireless network of a 6LoWPAN system as IPv6 packets which are compressed and embedded in IEEE 802.15.4 frames. An important issue is whether the compressed packet is still too large; 6LoWPAN fragments the compressed packet for transportation in two or more frames. The layer also decompresses the packet extracted from a received frame. Alternatively, in the second approach the communication protocol (RS232) uses frames consisting in KVP transactions.

B. Routers and Gateway:
In this section are mentioned other network components, like routers and smart coordinator / gateway. The routers, that besides routing also include sensors of air quality, are considered regarding the network size. Thus to extend the WSN coverage (extend the number of monitored rooms) these elements are the key to support the big distances between sensing nodes (end devices) and smart coordinator. This element gathers all data from sensing nodes and sends them through Ethernet (with UDP protocol), or RS232 (depending chosen approach) to the client of network. For the implemented WSN architecture that includes a smart coordinator, the “local client” of network is a Raspberry Pi computer which runs a java application that will be detailed later in this document.

III. SYSTEM SOFTWARE

In our software system we have a web service with client – server architecture. A web server based in PHP provides a minimal set of services, maintaining the security of system. This project was designed for indoor and outdoor networks, thus a geographic information system was considered and was built above client application. A block diagram is presented below (Figure 2):

Fig. 2: Communication and protocols of system

A. Client Software:
The java client application was designed to send data to a database and to receive data from coordinator through UDP protocol or RS-232. The implemented application permits a highly robust response even if the client does not have internet connection at the moment. So, for this situation, the client application will save data received from nodes to a file and when the application could connect it will send data to the server database.

B. Server Software:
In the server side there are a set of services which will be consumed by java client and a site which provide an user interface that can be accessed wherever. In order to provide
a global system, where everyone can access, it was needed a bridge between local client (java app) and “world”, this bridge is materialized by a web service. Using a free library PHP, NuSoap, we have WSDL file from our PHP functions. WSDL is an XML-based language for describing Web services and how to access them; it can be easily interpreted by diverse languages, which does not limit the information system only to java client, new client applications can be developed.

IV. CONCLUSION

A wireless sensing network indoor and outdoor to monitor the air quality in relation with trigger factors detection associated with asthma attacks was developed. To support data representation and alarm generation a graphical user interface was developed such as a website. As important part of the system java application makes a bridge between the wireless sensor network and the database through Internet connectivity. Data from respiratory tests, imported using the developed java application permits to analyse the relationship between asthma and air quality. The presented solution is useful to prevent asthma and other respiratory diseases in indoor spaces. The information can be accessed anywhere which allows the users to know elements about risk condition for their respiratory health.

REFERENCES


