Drinking Safe Water Using Wireless Sensing Technologies

By Ronak Sutaria

Introduction

Clean drinking water is the very essence of life. It has been affirmed by the world health organization that 'the human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses' [1].

Contaminated and unsafe drinking water leads to a host of infectious diseases such as diarrhea (including cholera), malaria, arsenic poisoning, and skeletal fluorosis, among many others. In 2002, over 1.1 billion people lacked access to safe drinking water, of which nearly two-thirds live in Asia. It has also been found that of the 1.8 million people who die of diarrheal diseases every year, over 90% are children under five, mostly in developing countries. A large majority of these people typically do not have the necessary timely information or the technical knowledge to detect the impurities in the water they are drinking.

Basic chemical sensors are available that can detect, in real-time, the presence of ionic contaminants like pH, Chloride, Fluoride, Arsenic, Lead, Iron, etc. This article explores the application of ubiquitous and pervasive technologies for the detection, dissemination and routing of information and

for alerting the end-user of water contamination in real-time using wireless sensor networks.

Impurities in drinking water can cause significant harm to the environment and to those who consume it. Water contamination occurs due to both point (single point of entry) and non-point (pollution due to contamination of the surrounding land) sources of pollution. Some of the key water pollutants found in India are Fluoride, Arsenic, Iron, Nitrate, Salinity, Heavy Metals and Pesticides [2]. In Bangladesh between 28 and 35 million people consume drinking water with elevated levels of arsenic. Skeletal fluorosis is said to affect over 25 million Indians due to fluoride laden drinking water from borewells dug in the earth [3].

Wireless sensor networks based real-time solutions can assist in solving this critical problem using technology which is simple to use and which can still be effective on a large scale. This article discusses some of the key challenges that need to be addressed in any given practical solution, the existing wireless sensing technology available to implement such a solution at a prototype level and finally the current state of research in the related issues. In the following section, a real world scenario of a dense urban environment is discussed where conventional detection and dissemination techniques have failed and where this particular wireless sensing solution can make a significant impact.

Detecting Impurities in Water Distribution System of a Dense Urban Environment

Cities with large slum settlements have a unique set of challenges in providing clean drinking water to the urban poor and slum dwellers. Dharavi in Mumbai, India, spread over 217 hectares, is one of Asia's largest slums and is home to between 600,000 to one million people. The city's water distribution system runs through this urban slum settlement where leaks occur regularly in the water pipelines that carry drinking water to several other parts of the city. The image in the beginning of the article shows a drinking water pipeline surrounded by slum dwellings, garbage, human waste and the people living in those settlements.

The conventional techniques for detecting water qualities in dense and large urban areas involves taking periodic water samples at the source and sending the sample to chemical labs for analysis. One of the vulnerabilities and limitations of this process is that there can be tampering/ modification/manipulation of the data collection process as well as the lab analysis that is done on the samples collected. The tampering is at times done by the small-scale industries in these urban slum settlements whose low-cost and low-quality operations forces them to blatantly ignore the various waste disposal standards and regulations.

In 2002, over 1.1 billion people lacked access to safe drinking water, of which nearly two-thirds live in Asia.

This problem can be overcome by deploying hundreds, if not thousands of low-cost wireless sensors along the entire water distribution system. A unique contribution of a wireless sensor based solution would be the realtime sampling and detection of the water quality. The distributed nature of the wireless sensors would also make it easier to detect both point and non-point based pollutants.

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A UbiComp solution using wireless water based chemical sensors

A project at the Department of Chemistry at the Indian Institute of Technology, Bombay [4] has created a low cost rugged and tropicalized sensors which can simultaneously detect ionic contaminants like pH, Chloride, Mercury,

Figure 1: A Variety of Sensor Modules (Credit: CC Jabstarr)

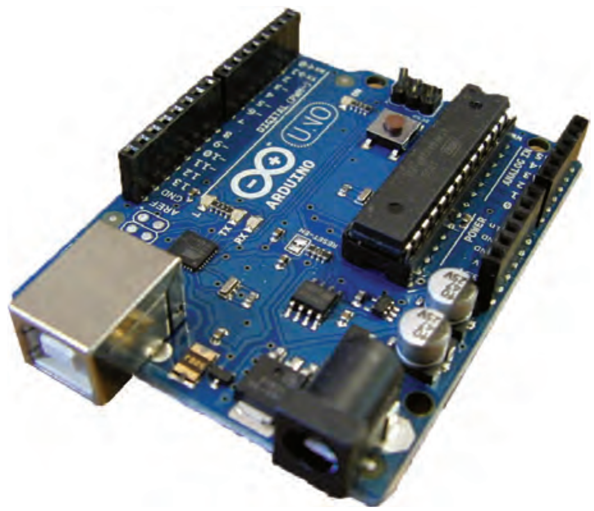

Figure 2: An Arduino Uno Board (Credit: CC Creative Tools)

Fluoride, Arsenic, Lead, Iron, etc. In the field of nano-technology, a large number of research universities have been building microfluidic devices called "lab-on-a-chip" where many of these chemical sensors have been specifically designed for detecting water pollutants [5].

While the stationary chemical sensors can provide information to the person operating the sensor devices, an IP (Internet Protocol) based, multi-hop mesh networking solution, such as the one provided by the Arch Rock PhyNet Technology [6] can provide significant flexibility and a tighter integration between the physical world and the networked world.

An IP based Web services solution using these wireless water quality sensors could help create a sensor networking platform or substrate, which can then allow other end-users/developers to query these large-scale sensors and build meaningful applications using this substrate.

The data collected from all these sensors can also be made available to the end-user via IP enabled devices or via SMS to mobile-phones. In addition, small digital displays can be attached to the drinking water faucets or taps from where people consume water. These displays would be getting their data from all the distributed sensors and hence can co-relate the data to identify the extent and severity of the water contamination.

Related Research Work

A number of university and industry based research groups have begun working on and built initial prototypes to address some of the issues involved in building a practical solution. University of Minnesota researchers [7] are building a network of wireless sensors that are non-mobile and positioned at key points near ponds and streams to measure besides other factors - turbidity, salinity, pH and nitrate levels. Another real world research funded project by the European Commission, BMT Group and researchers at University of Essex [8] are building mobile robotic fishes that are equipped with tiny chemical sensors to find the source of potentially hazardous pollutants in the water, such as leaks from vessels in the port or underwater pipelines. A prototype has also been built by researchers at the Carnegie Mellon University's Living Environments Lab [9] where they have developed a low cost, non-invasive method for detecting water flow in a pipe. They have also suggested a solution to detect water quality using easily measurable properties of water such as temperature, pH and light attenuation.

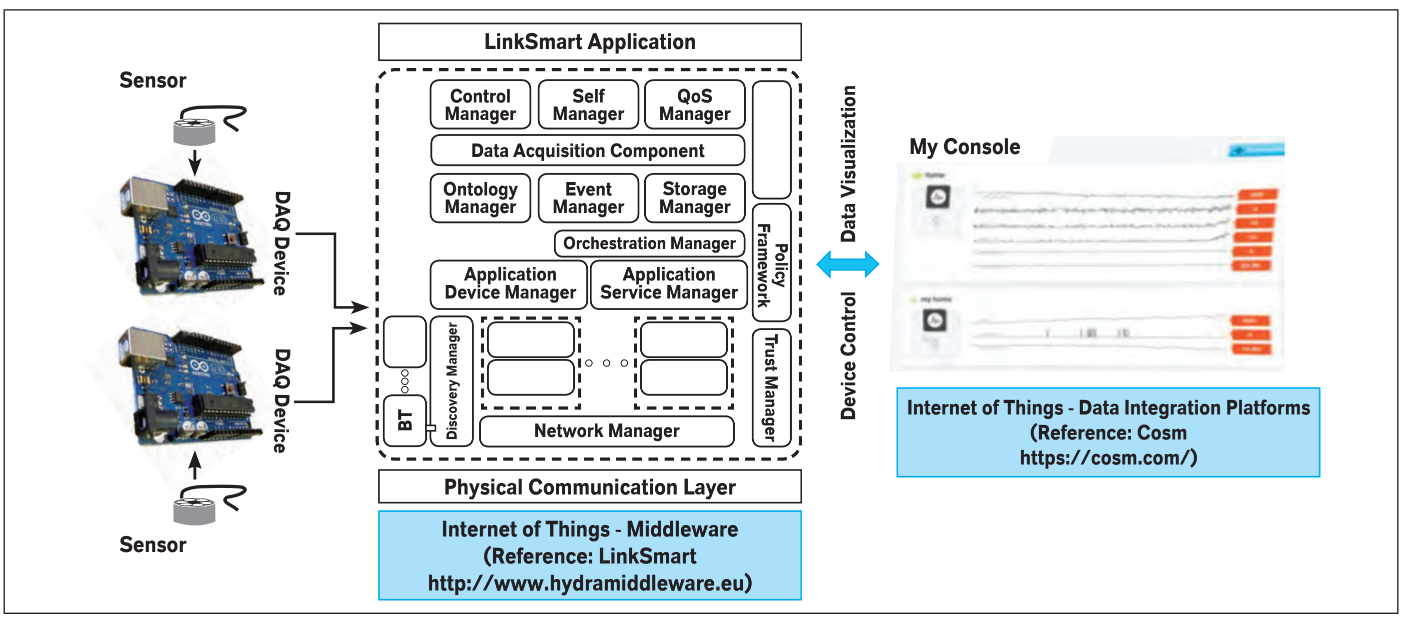

Figure 3: A High Level Diagram of a Data Acquisition Architecture Involving the Technologies Mentioned in the Article

Figure 4: Japanese Radiation Feeds from Failed Robot & Safecast (Additional Examples Data Feed, Shigeru's Geiger Counter)

Conclusion

The intent of this article is to explore the application of UbiComp technologies to address issues that affect the urban poor, children and those who are not directly benefitting from the technological progress of the "developed" world. A real world scenario of the problem is discussed and the current technological innovations that can assist in solving the problem are mentioned. Finally, a survey of the current state of the art research is given.

Citations

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About the Author

Ronak Sutaria is currently a principal researcher in MindTree Labs. He has a background in large-scale internet applications and payment security related technologies. For the past four years, he has been solely focusing on pervasive computing related technologies and has a passion for researching at the intersection of human life, the planet and emerging technologies. His area of research focus is on wireless sensing technologies and solutions, also covering applications in smart water grids. He is based in Mumbai, India.

Author Acknowledgements: The author would like to thank Malay Thaker of Arch Rock for providing valuable suggestions for building a practical solution using sensor networking technology. Thanks are also due to Ricky Robinson of NICTA for discussions regarding an UbiComp substrate.

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