Demo: EarnArdui – A Wireless Sensor Network Testbed for Water Pipeline Monitoring

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Abstract

We present EarnArdui, a wireless sensor network testbed for water pipeline monitoring. This system enables to test our water pipeline monitoring system in real world. The proposed setup provides us with an insight understanding of the physical behavior of the system. The testbed consists of two components: a water distribution laboratory setup and a wireless sensor node prototype to gather data from sensors and send it to a base station. In this paper, we give an overview of the distribution system components including pipes, valves, taps, sensors, nodes, etc. We also, illustrate the deployment, usage and the operation mode of a typical sensor node for leak detection.

Keywords

Wireless Sensor Network,Water Pipeline Monitoring, IoT, Sensor Node

1 Introduction

In recent days, there has been a significant growth of the Internet of Things (IoT) and a great interest to smart environments including smart home, smart city and smart water. This is pull resulted in an increasing demand on Wireless sensor Network (WSN) research and development. Water Pipeline Monitoring (WPM) especially leak detection and localization is one of the crucial applications. Leakages in water pipes are very common. They causes several environmental and economic losses [3]. Investigation in this field still limited by the lack of standard databases. This and other limitations drive the need to construct special technology to generate datasets. Moreover, existing software simulators could cover either WSN systems or water distribution system behavior [6]. Consequently, testbeds present an essential step to overcome this lack. They allow researchers to understand the phenomena in realistic way, i.e., a step between the mathematical model of simulations and the unpredictable changes in the real world. In this context, we present in the proposed demonstration, EarnArdui, a testbed for water pipeline monitoring [1]. A canalization setup and a sensor node prototype are constructed in order to make different experiments and visualize the solution of leak detection in real constraints.

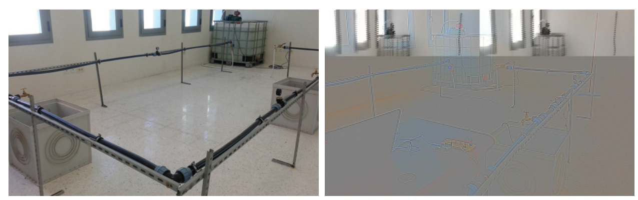

Figure 1. Distribution System Setup

2 Distribution System Setup

To design a water distribution system testbed, several parameters such as the pipe material and its size,the reservoir size, the setup size, valve form, pump capacity and design,etc should be considered. The enumerated parameter have been studied and a laboratory distribution system setup have been designed in our research center in order to test the EarnArdui system. Figure 1 shows a rectangular section composed of approximately 25 m long 32 mm external diameter polyethylene pipes. These are low cost pipes that could support up to 12 bar of pressure and offer high resistance and insensitivity to chemical and electrical corrosion. Commonly, the plastic pipes are increasingly used all over the world. The setup consists also of two valves in order to vary the pressure. A 1000 m^3 reservoir is used as a water source. To control the upstream and downstream boundaries, we use two flow meters. An electric pump with 1 hp motor is employed to provide up to 6 bar of pressure. The supports are designed to have variable heights that we will explore in the future to see the effect of this variation on the pressure and to test our algorithm in varied conditions. Finally, to induce leaks, two garden taps are used.

[1] This Demonstrator is part of a EARN project that aims to develop an Energy Aware Reconfigurable Wireless Sensor Node architecture for Water Pipeline Monitoring.

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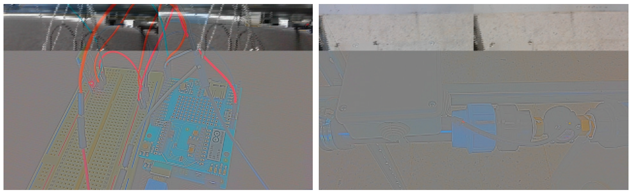

Figure 2. Sensor Node Prototype

3 Node Architecture and components

WSN consists of a number of nodes which work and communicate cooperatively to inspect and monitor various phenomena. In our setup, we monitor the flow in water pipeline. A detailed description of the system is given in our previous work [5]. The choice of the sensor components is a critical step for accurate and efficient results. A typical sensor node is composed of three units aside from the power unit:

- **Sensing Unit:** This unit is in charge of collecting data from real world. In this work, a YF-S201 Hall Effect Water Flow Sensor [8] has been utilized. It measures the quantity of water moved through it. The accuracy of this sensor is about +/- 10 % and the flow rate vary from 1 to 30 liters per minute. This sensor is widely employed due to its pulse-based mechanism that allows low power consumption.
- **Processing Unit:** The processing unit is the brain of the system. It manages the different components of the node and perform the processing tasks. We have used Arduino Uno microcontroller [1]. In fact, Arduino Uno is low cost, easy-to-use and flexible. Consequently, it facilitates and speeds up the prototyping task.
- **Communication Unit:** Typically a transceiver, the communication unit carries out data transmission. A HC-06 Bluetooth transceiver [2] is used in this demo. The Bluetooth communication [4] is designed for low cost and low power. It is suitable for a wireless short range data transmission.

This components are gathered and connected using cables to build the mote prototype as shown in Figure 2. This prototype is used to collect flow data and detect leaks induced by garden taps.

4 Experimental results

Leak detection has been a concern during the last years to prevent water wast. Countless equipment and software programs have been tested in the literature [7]. The WSN adoption for pipeline inspection and monitoring is a recent research field. A mass balance method has been used in this testbed. As a matter of fact, in a steady state and based on the mass conservation principal, the flow curves are approximately equals. When a leak occurs, the difference between the inlet and outlet flow exceed a threshold which is known experimentally. A LED has been used to sign the leak occurrence as demonstrated in Figure 3.

Figure 4 shows the difference between data shapes before and after leak occurrence. The green line shows steady state conditions (i.e. when there is no leaks). The red and pink lines illustrate the flow shape measured by sensors situated before and after leak position.

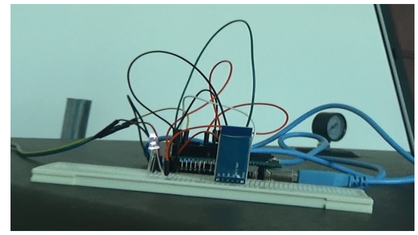

Figure 3. Leak detection using the sensor node prototype

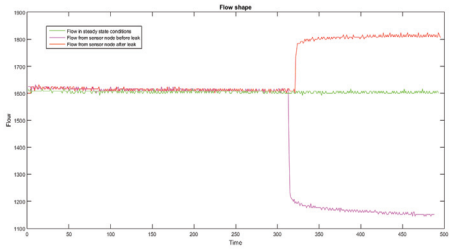

Figure 4. Flow shapes before and after leak

5 Conclusions

A testbed has been built for WSN water distribution system in order to get experimental data and catch a well understanding of real phenomenon. Leaks have been successfully detected using the proposed setup. Currently, we are working on enhancing the prototype in terms of size and components, testing other sensors and inspect the testbed in different conditions.

6 Acknowledgments

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7 References

[1] Arduino. Arduino/genuino uno description.

[2] Guangzhou HC Information Technology Co., Ltd. *Product Data Sheet*, 4 2011. Rev. 2.2.

[3] O. Hunaidi and W. T. Chu. Acoustical characteristics of leak signals in plastic water distribution pipes. *Applied Acoustics*, 58(3):235–254, 1999.

[4] O. Javeri and A. Jeyakumar. Wireless sensor network using bluetooth. In *Advances in Computing, Communication and Control*, pages 424–432. Springer, 2011.

[5] F. Karray, A. Garcia-Ortiz, M. W. Jmal, A. M. Obeid, and M. Abid. Earnpipe: A testbed for smart water pipeline monitoring using wireless sensor network. *Procedia Computer Science*, 96:285–294, 2016.

[6] S. Kartakis, E. Abraham, and J. A. McCann. Waterbox: A testbed for monitoring and controlling smart water networks. In *Proceedings of the 1st ACM International Workshop on Cyber-Physical Systems for Smart Water Networks*, page 8. ACM, 2015.

[7] A. M. Obeid, F. Karray, M. W. Jmal, M. Abid, and M. S. BenSaleh. Towards realisation of wireless sensor network-based water pipeline monitoring systems: a comprehensive review of techniques and platforms. *IET science, measurement & technology*, 7, 2016.

[8] YIFA the plastics Ltd. *Data-sheet,Prodcut Introduction*.