Anomaly Detection in Wireless Sensor Networks for Precision Agriculture

Hari Prabhat Gupta, Rahul Mishra, and Tanima Dutta fhariprabhat.cse, Department of Computer Science and Engineering, IIT (BHU) Varanasi, India

Abstract—Monitoring of agricultural field using sensors provide valuable information about the the crops to the farmers. The information consists of the real-time pH level, humidity, temperature, etc. Such information is obtained using wireless sensor network which is to be analyzed for predicting the right time of irrigation and amount of water needed by the crops. It is true that this prediction depends on the quality of obtained data. There are several anomalies that can influence the quality of data, such as, battery drainage, communication failure, and faulty measurements. In this paper, we therefore discuss various ways to detect such anomalies to get precise information about the agricultural field.

Index Terms—Agricultural field, mobile sink, sensors.

I. Introduction

Recent technical advancement in sensor technology creates a new era of human-less event monitoring in several dimensions including transport system [1], [2], agriculture [3], health care [5], smart home [6], etc. The agricultural field monitoring using sensors is termed as precision agriculture [3], [4]. Through precision agriculture the farmer through out world are benefited in term of crop monitoring from mo-bile location and periodic irrigation [7], [8] without human involvement. In precision agriculture the sensors are deployed in the agriculture field for monitoring various parameter like soil moisture, temperature, humidity, wind speed [4], [8]. This sensor deployment and data communication from agricultural land to farmer's smart phone forms a Wireless Sensor Network (WSN).

The term WSN is a fabrication of three different terms i.e., wireless, sensor, and network. The term wireless refers to the use of communication technologies like Bluetooth, Wi-Fi, Zigbee, NFC [9], [10] for data exchange. Sensors are small electronic nodes capable of performing sensing, computing and communication between each other and central controlling unit. Network refers to the infrastructure which comprises of computing devices capable of communicating with each other, wired or wirelessly. WSN can also be considered as a scenario of the communication network in which the autonomous sensor nodes are spatially distributed to monitor physical or environmental conditions and exchange their sensing information wirelessly.

The wireless sensor networks are becoming an important part of our ecosystem today. The ubiquitous nature of WSN made wider acceptability and considered as a suitable replacement for wired communication channel in the majority of applications. The various applications of WSN are discussed in Fig. 1. The simplicity, easiness, economical, and reliable performance drive the WSN technology towards the wide area of applications and proven to be the best solution to many problems in the current technological era. Energy efficiency is the key intrinsic property of any industrial system. It impacts more in the case of large-scale applications and difficult-to-access applications, where the energy sources of the system are difficult or even not possible to maintain. In WSN, energy constraints are the prime concern and scarce area of study with the huge research possibilities [11]. WSN consists of several tiny and low-powered sensor nodes communicating with each other to perform sensing tasks. In any application of WSN, network connectivity is considered to be important for measuring the Quality of Service (QoS) of the networks. A network is said to be connected if all deployed sensors in the Field of Interest (FoI) can reach to the base station. A FoI is said to be cover by WSN if entire area comes in the range of a minimum of one sensor node of the network. Since WSN involves the use of battery operated sensors and wireless network, there may be some anomalies inside this system [12].

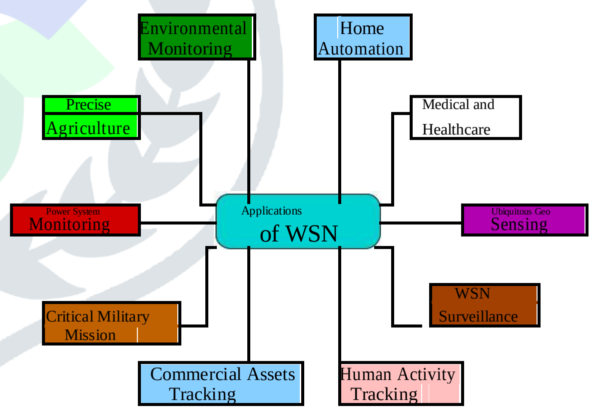

Fig. 1: Applications of WSN in different scenarios.

The precision agriculture system involves several sensors that operate on battery and their local processing on sink node inside the field. The sink node is connected to Cloud and the farmer via internet. The internet connectivity may be lost in area near agricultural field [13] more frequently. The battery operated sensors may stop working due to battery drain. The sensors may also behave wrongly during operation [14]. These anomalies may reduce the performance of precision agriculture system, therefore, these issues must be tackled wisely.

This paper addresses: anomaly detection in WSN for precision agriculture. The main objective is to detect the anomalies in WSN for precision agriculture as soon as possible. The next Section II describes the type of failures in precision agriculture and their characteristics. Section III gives a brief detail of the anomaly detection techniques in WSN that are involved in the precision agriculture. Finally, the paper concludes with Section IV.

II. Type of failures in precision agriculture

The four major failure that might occur inside a WSN for precision agriculture are battery drain result in power loss, loss of internet connectivity, faulty sensor, and sink failure. This section briefly describes these failures.

Power loss problem:

The sensors inside the agricultural field are battery operated and need continuous power for their operation. When the bat-tery power inside the agricultural field is lost, the sensors will stop working. Therefore, continuous monitoring of the battery level inside the field is mandatory for smooth functioning of the precision agriculture system.

Loss of internet connectivity:

In the area of agricultural field there is always a problem of poor internet connectivity and this will hinder alarm generation at the smart phone of farmer. The desired efficiency of the precision agriculture system can be obtained only with the smooth internet connectivity.

Faulty sensors:

Sometimes the sensors are malicious and transmit false value to the sink. This makes the essential decisions for the agricul-tural field faulty. In certain cases, a wrong decision can lead to severe damage to the crops. So, this types of situation should be avoided.

Sink failure:

In precision agriculture there is a sink installed at the edge of the agricultural field which collects the data from all the deployed sensors. Sometimes the sink stops working due to battery failure or some short circuit. This will hamper the performance of the precision agriculture system.

III. Anomalies detection and correction

This section suggests the mechanism of detection and correction of various anomalies that can occur inside the agricultural field. The battery drain problem inside the agricul-tural field is resolved using a power backup alarming system. The backup power starts working after the primary battery is drained and an alarm is generated that secondary battery is in use. Similarly, a backup scheme can be employed for handling the sink problem so that we can avoid the wrong decisions of the sink node. The decision made by the sink must rely upon the previous recorded activities. This will ensure the correct decision making inside the agricultural filed.

The faulty behaviour of the sensors can be avoided by taking values from sensors by comparing the value generated by the sensors with existing records. The values generated by the sensors may also be checked by verifying the values from neighbouring sensors. A small private router based network can be developed for getting liberty from internet connectivity between agricultural field and farmer's location. This is a temporary solution and may not work as properly as internet, but can help in frequent alarm generation.

IV. Conclusion

The paper first present a brief description of use of wire-less sensor network in precision agriculture. The paper also presents various failures that can occur inside the WSN and how they affect the performance of precision agriculture. The later part of paper discusses the anomaly detection and prevention mechanisms. The proposed work will leads to effective utilization of the WSN in the precision agriculture.

Acknowledgements

This work is supported by Science and Engineering Re-search Board (SERB) file number ECR/2016/000406/ES, project entitled as Development of an Energy-efficient Wireless Sensor Network for Precision Agriculture, and scheme Early Career Research Award.

References

[1] M. Benza, C. Bersani, M. D'Inca,` C. Roncoli, R. Sacile, A. Trotta, D. Pizzorni, S. Briata, and R. Ridolfi, "Intelligent transport systems (its) applications on dangerous good transport on road in italy," in 2012 7th International Conference on System of Systems Engineering (SoSE), 2012, pp. 223–228.

[2] C. Dumitrescu, I. M. Costea, F. Nemtanu, I. Badescu, and A. Banica, "Developing a multi sensors system to detect sleepiness to drivers from transport systems," in 2016 IEEE 22nd International Symposium for Design and Technology in Electronic Packaging (SIITME), 2016, pp. 175–178.

[3] T. D. Le and D. H. Tan, "Design and deploy a wireless sensor network for precision agriculture," in 2015 2nd National Foundation for Science and Technology Development Conference on Information and Computer Science (NICS), Sept 2015, pp. 294–299.

[4] T. H. F. Khan and D. S. Kumar, "Mobile collector aided energy reduced (mcer) data collection in agricultural wireless sensor networks," in 2016 IEEE 6th International Conference on Advanced Computing (IACC), Feb 2016, pp. 629–633.

[5] T. Suzuki, H. Tanaka, S. Minami, H. Yamada, and T. Miyata, "Wearable wireless vital monitoring technology for smart health care," in 2013 7th International Symposium on Medical Information and Communication Technology (ISMICT), 2013, pp. 1–4.

[6] X. Mao, K. Li, Z. Zhang, and J. Liang, "Design and implementation of a new smart home control system based on internet of things," in 2017 International Smart Cities Conference (ISC2), 2017, pp. 1–5.

[7] R. N. Rao and B. Sridhar, "Iot based smart crop-field monitoring and automation irrigation system," in 2018 2nd International Conference on Inventive Systems and Control (ICISC), 2018, pp. 478–483.

[8] J. Gutierrez,´ J. F. Villa-Medina, A. Nieto-Garibay, and M. A. Porta-Gandara,´ "Automated irrigation system using a wireless sensor network and gprs module," IEEE transactions on instrumentation and measure-ment, vol. 63, no. 1, pp. 166–176, 2014.

[9] Y. Shaobo, C. Zhenjianng, S. Xuesong, M. Qingjia, L. Jiejing, L. Tingjiao, and W. Kezheng, "The appliacation of bluetooth module on the agriculture expert system," in 2010 2nd International Conference on Industrial and Information Systems, vol. 1, 2010, pp. 109–112.

[10] L. Xiaoman and L. Xia, "Design of a zigbee wireless sensor network node for aquaculture monitoring," in 2016 2nd IEEE International Conference on Computer and Communications (ICCC), 2016, pp. 2179– 2182.

[11] S. S. Shivaji and A. B. Patil, "Energy efficient intrusion detection scheme based on bayesian energy prediction in wsn," in 2015 Fifth International Conference on Advances in Computing and Communications (ICACC), 2015, pp. 114–117.

[12] X. Li and N. Xie, "Multi-model fusion harvested energy prediction method for energy harvesting wsn node," in 2018 IEEE International Conference on Electron Devices and Solid State Circuits (EDSSC), 2018, pp. 1–2.

[13] H. Horie, M. Asahara, H. Yamada, and K. Kono, "Minimizing wan communications in inter-datacenter key-value stores," in 2014 IEEE 7th International Conference on Cloud Computing, 2014, pp. 490–497.
[14] T. Phatak and S. D. Sawarkar, "Enhancing qos of wireless sensor network by detection of faulty sensor node," in 2016 International Conference on Computing, Analytics and Security Trends (CAST), 2016, pp. 100–105.