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Proposal of a LoRaWAN-based IoT System for Food Waste Management

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ABSTRACT

Waste management is one of the main concerns with our environment which impacts the health of our society. A significant amount of waste disposed by people are organic material. Kitchen wastes like food scraps disposed by families and restaurants, are becoming in large amounts and the natural capacity of the environment cannot assimilate them. Therefore, construction of waste management systems is needed. Internet of Things (IoT) and technological development can be used for different solutions in waste management. In this paper, we have proposed a low cost food waste management system, capable to convert food wastes to compost. To make the management system, safe, efficient, and less time consuming, we propose to use a LoRaWAN-based IoT approach.

Keywords: LoRaWAN; IoT; Waste Management System; Compost; Sensor.

1. INTRODUCTION

Food wastes generated from kitchen refers to a big percentage of the total waste disposal and are considered as biodegradable pollutants. Food wastes and scraps are produced from the food industry, restaurants and homes. Biodegradable pollutants can be neutralized and converted into harmless compounds. However, they can become serious pollutants if released in large amounts in small areas, thus exceeding the natural capacity of the environment to assimilate them. Therefore, construction of the composting management systems is needed to save the resources and minimize the wastes.

The waste management industry is beginning to develop and implement Internet of Things (IoT)-related solutions to these problems. With Radio-Frequency Identification (RFID) and sensor technology [1-4], composting, recycling and waste management systems can be further optimized to increase productivity and save costs while moving to a more sustainable smart cities and improving the quality of life.

In [5], authors propose an IoT-based smart garbage system for efficient food waste management by only monitoring the wastes. In our previous work [6], we designed and implemented a waste management robot where a laptop is used to control the state of compost. The system will do aerobic composting and the compost will be created for a short time, if temperature, moisture, and air flow are properly maintained. This system can control, monitor the state of the compost and notify the user about the condition of the compost and when the process is finished and compost is ready to be used.

The rest of the paper is organized as follows. Section 2 describes the motivation and background. The proposed food waste management system is presented in Section 3. Finally, conclusions and future work are presented in Section 4.

2. MOTIVATION AND BACKGROUND

The waste management system currently used in many cities is not efficient. For the waste collection, trucks travel long distances to the landfills and cause traffic jams and gas emitting. Organic materials in large amounts in landfills release methane and it effects in climate change. Food waste is an organic material that can be easily decomposed into high quality compost. The usage of the composting will reduce landfills volume and also the need for chemical fertilizers [7]. One way to reduce the amount of food waste going into landfills is to compost it at home.

Composting is an aerobic degradation of organic wastes. During this process, the temperature is increased due to the heat released by oxygen-consuming microbial metabolism. The temperature increase will increase the consumption of oxygen and the production of carbon dioxide. Users should open the container many times in order to enter fresh air.

It is thus important to understand and control the environmental factors that affect microbial life in composts. The most important parameters for the microorganisms are temperature, oxygen, moisture, pH and substrate composition [8].

This work is motivated by the need for a low cost food waste management system that will reduce the amount of wastes in landfills and also eliminate the cost for storing and transport to landfills. For this reason, in this paper we propose an integration of sensors with different communication technologies for a low cost management system that will shorten city management costs and contributes to a better environment. The natural process of composting usually needs time. The usage of IoT technologies can shorten the time that the composting process will need.

We propose the usage of Low Powered Wide Area Networks (LPWANs) [9] for our system because these communication technologies can establish communication with low bit rates and low energy consumption for long distances. LoRaWAN [6] is a media access control layer protocol that can be used to enable the communication between LPWANs. LoRaWAN is a good solution because it allows to make very scalable and low cost networks. LoRaWAN network can be deployed free of charge for license or data transfer. The free, open source The Thing Network (TTN) [11], can be used as a collaborative platform.

3. PROPOSED LoRaWAN-BASED IoT WASTE MANAGEMENT SYSTEM

The proposed LoRaWAN-based food waste management system architecture is presented in Figure 1. The main purpose of the proposed system is to create compost at home. Compost can be used as fertilizer in gardens to improve the plants growth and health. Three are the main processes that effects the composting process: heating, humidifying and mixing:

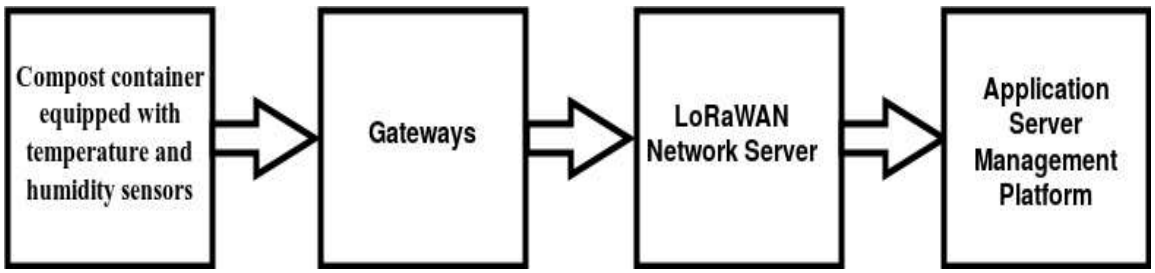

Figure 1. The proposed LoRaWAN-based food waste management system architecture.

This system requires a temperature sensor, and a moisture sensor that will be placed inside the container to measure temperature and the level of humidity. These sensors will use wireless technology to communicate with GWs. GWs will receive the packets from the sensors and forward these data towards LoRaWAN Network Server that in these case can be used The Things Network. Application servers after receiving the data from the sensors will analyze them and give real time information about the state of the compost and notify the user on what actions to take in order to speed the process of composting.

The human interaction with the composting container will be needed for cases when:

- The compost is dry and the user should add water to increase the humidity or when it is wet and to add materials to low the humidity.
- The temperature is high and the container should be opened or when temperature is low and a compost activator is needed.
- To mix the material inside the container because it will help the composting process.

In order to implement the proposed system in a smart city application for Tirana city, we will first evaluate number of GWs we will need for the full network coverage.

3.1 Evaluation of the network coverage

We used Radio Mobile software [12] to evaluate LoRaWAN coverage in Tirana city. From the simulation results, the best scenario is considered to use two gateways that will offer the full coverage. One GW is located in city center at the top of a high building and the other GW located on the top of mount "Dajti" from where the antenna can see all the city as shown in Figure 2. The parameter settings are presented in Table 1. The usage of only two GWs helps in the low cost deployment of this system.

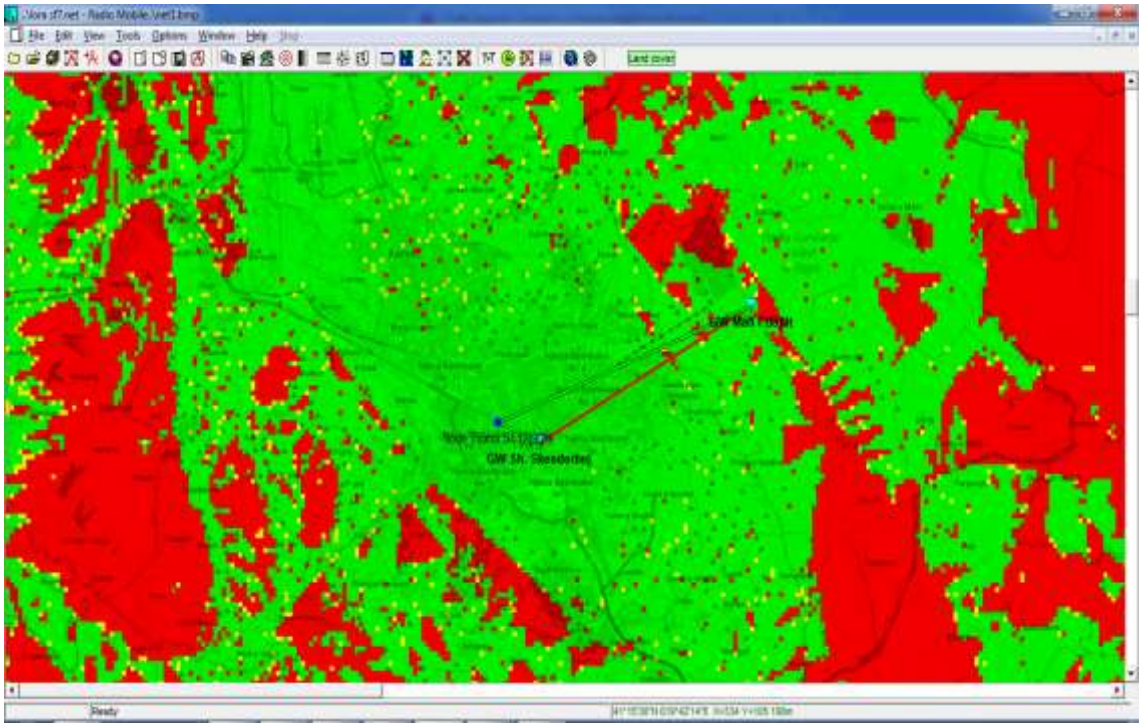

Figure 2. The best coverage of Tirana city area using two GWs.

Table 1. GWs Parameter setting

Unit	Elevation	Antenna height	SF	Transmit Power	Receive Sensitivity
GW located at Main square in City Centre	100m	70m	SF7	+12dBm	-117dBm
GW located at the top of Mount "Dajti"	1500m	45m	SF12	+12dBm	-130dBm

The colours in Figure 2 represents:

- The green area: an area with very good coverage where the signal strength is +3dBm
- The yellow area: an area with bad coverage where the signal strength is -3dBM - +3dBm
- The red area: an area without coverage where the signal strength is < -3dBm

The main square at the city centre elevation is 100m. The GW can be placed in a high building located there and the total height will be around 170m. Positioning the GW at this location enable all the sensors located near the city centre to transmit with SF7. In this way we will assure energy efficiency, longer battery life for the sensors and fast communication.

The main purpose of the usage of another GW placed on the top of mount "Dajti" is to offer the coverage to suburban areas that cannot be covered by the GW positioned at the city center. Most of the sensors located in Tirana city can communicate with the GW positioned at the city center with minimal energy consumption. The GWs will receive the data from the sensors and sent to the Application Server. Dashboards and mobile apps can be used to access the data collected by the sensors and also to notify the user when some actions need to be taken [13, 14].

4. CONCLUSION

In this work, we proposed a low cost LoRaWAN-based IoT food waste management system [15]. This system includes information network, and sensor technology. Our system will monitor the state of the compost inside the containers and will guide the user to convert the food wastes into compost. In order to implement the proposed system for Tirana city, we also evaluated by simulations the network coverage. The simulation results showed that two GWs can offer the full coverage of Tirana city.
The proposed system:

- Will reduce the amount of wastes that need to be transported and managed at landfills and will shorten the city management cost.
- Will reduce the need to buy chemical fertilizers.
- Can be implemented with only two GWs for Tirana city.
- Will contribute in a better environment.

In the future, we would like to implement and evaluate the performance of our proposed system by different experiments.

CONFLICT OF INTERESTS

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

REFERENCES

[1] Saha, S. Automated Traffic Law Enforcement System: A Feasibility Study for the Congested Cities of Developing Countries. *International Journal of Innovative Technology and Interdisciplinary Sciences*, 2020; 3(1); 346-363.

[2] Valeri A. and Musalimov, V. MATLAB-based Graphic User Interface for Monitoring and Control of Wireless Sensor Networks. *International Journal of Innovative Technology and Interdisciplinary Sciences*, 2019; 2(2); 181-191.

[3] Minh V. T. and Khanna R. Application of Artificial Intelligence in Smart Kitchen. *International Journal of Innovative Technology and Interdisciplinary Sciences*, 2018; 1(1); 1-8.

[4] Tamre M., Hudjakov R., Shvarts D., Polder A., Hiiemaa M. and Juurma, M. Implementation of Integrated Wireless Network and MATLAB System to Control Autonomous Mobile Robot. *International Journal of Innovative Technology and Interdisciplinary Sciences*, 2018; 1(1); 18-25.

[5] Hong I., Park S., Lee B., Lee. J., Jeong D. and Park. S. IoT-Based Smart Garbage System for Efficient Food Waste Management. *The Scientific World Journal*, 2014; 2014; 01-13.

[6] Matsuo K., Umezaki K., Spaho E., Barolli L., Iwashige J., Takizawa M., Experimental Evaluation of a Waste Management Robot System, *in Sixth International Conference on Complex, Intelligent, and Software Intensive Systems* , Palermo 2012, p. 28-33.

[7] Composting at home, EPA United States Environmental Protection Agency, Link: https://www.epa.gov/recycle/composting-home Accessed on July 2020.

[8] Miller F. C. Composting as a process based on the control of ecologically selective factors. *In: Soil microbial ecology. Metting, F. B. J. (Eds). Marcel Dekker*. p. 515-544, 1993.

[9] Raza U., Kulkarni P. and Sooriyabandara M. Low Power Wide Area Networks: An Overview. *IEEE Communications Surveys & Tutorials*, 2017; 19(2); 855-873.

[10] Bertolaud A., Delclef J., Delport V., Duffy P., Dyduch F., Eirich T., Ferreira L., Gharout S., Hersent O., Kasttet A. LoRaWAN 1.1 Specification; *Technical Report 1.1; LoRa Alliance*: San Antonio, TX, USA, 2017.

[11] The Things Network – Getting Started, [online] Link: https://www.thethingsnetwork.org/getting-started, Accessed on July 2020.

[12] Radio Mobile Freeware, Available online: http://www.ve2dbe.com/english1.html

Accessed on July 2020.

[13] Spaho E., Sula A., Matsue K., Barolli L., Xhafa F., Iwashige J., An Integrated System of Robot, SmartBox and RFID as an Approach for Internet of Things, *in 8th International Conference on Broadband and Wireless Computing, Communication and Applications*, Compegnie 2013, p. 589-594.

[14] Elmazi D., Spaho E., Matsue K., Oda T., Ikeda M., Barolli L. F3N: An Intelligent Fuzzy-Based Cluster Head Selection System for WSNs and Its Performance Evaluation. *International Journal of Distributed Systems and Technologies*, 2015; 6(2); 28-44.

[15] Cuka M., Elmazi D., Bylykbashi K., Spaho E., Ikeda M., Barolli L. Effect of node centrality for IoT device selection in opportunistic networks: A comparison study. *Concurr. Comput. Pract. Exp.*, 2018; 30(21); 01-13.