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Procedia Computer Science 110 (2017) 402–409

Procedia Computer Science

www.elsevier.com/locate/procedia

The 12th International Conference on Future Networks and Communications (FNC 2017)

Monitoring system using web of things in precision agriculture

Foughali Karim*[a],Fathalah Karim[b],Ali frihida[b]

[a] *Communication System Laboratory Sys'Com, National Engineering School Of Tunis, University Tunis El Manar, Tunisia*
[b]*Cognition and Ontology of GeoSpatial Systems,National Engineering School of Tunis, University Tunis El Manar,Tunisia*

Abstract

As water supplies become scarce because of climatically change, there is an urgent need to irrigate more efficiently in order to optimize water use. In this context, farmers' use of a decision-support system is unavoidable. Indeed, the real-time supervision of microclimatic conditions are the only way to know the water needs of a culture. Wireless sensor networks are playing an important role with the advent of the Internet of things and the generalization of the use of web in the community of the farmers. It will be judicious to make supervision possible via web services. The IOT cloud represents platforms that allow to create web services suitable for the objects integrated on the Internet. In this paper we propose an application prototype for precision farming using a wireless sensor network with an IOT cloud.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: wireless sensor networks; Web of things; monotoring; precision agriculture

1. Introduction

A wireless sensor network is a network composed of a set of nodes integrating the functions of acquiring, processing, communicating. Once deployed, the nodes cooperate with each other autonomously to collect and transmit data to a base station in order to monitor and / or control a phenomenon. Nowadays, the use of WSN knows a great boom in areas as diverse as the military, medicine, the environment and precision agriculture.

*Corresponding author. Tel.: +21696488622; fax: +0-000-000-0000 .

E-mail address: foughali.karim@gmail.com

Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.06.083

Precision agriculture can be defined as the art and science of using technology to improve crop production. This is achieved by providing information pertinent to agriculture properly related to metrological factors (temperature, humidity, sunshine, wind. In this context, implementing smart irrigation techniques that improve the efficiency of water use will help farmers to make their activities more profitable while at the same time enhancing the sustainability of agriculture in its together. Experimental results have shown that the reliability and the increase of crop growth[1,2,3].

Nowadays several IOT cloud platforms have been put on the web. These latest user interface offers friendly-uses to anyone who wants to monitor at a lower cost connected objects. Despite their use in automotive and smart city applications, the integration of these in precision agriculture applications is not very widespread. In this project we are interested in setting up and testing a system based on the network of wireless sensors and the Internet of objects and IOT cloud platforms in the context of precision agriculture. In this paper we propose to describe a prototype system based on a network of sensors and an IOT cloud that alerts the farmer when the crops need to be irrigated.

2. Related work:

IoT frameworks and platforms are still immature for agriculture, but there is a trend now to apply IOT in the agricultural sector. In [12] Duan Yan-e et al proposed an IOT application that provides agricultural information and crop information to farmers on the basis of collected wireless sensor network data. This information is used to ensure that the rate of Fertilizer application and within the recommended limit. In [13] Xiangyu HU et al. Developed an IOT application for remote monitoring and control of agricultural fields, which is based on the analysis of data collected by the wireless sensor network, which has enabled farmers to minimize the cost of hand And the efficient use of water resources. In [14] Andreas Kamilaris et al. Have proposed an application called Agri-IOT allowing the analysis and the processing of data coming from a network of sensors (WSN) while exploiting the semantic aspects. This will make it possible to associate an easy publication of data on the semantic web.

3. Background

3.1. Precision agriculture

Precision agriculture is a principle of management of agricultural parcels appeared in the United States in the 1980s. Already in 1985, researchers from the University of Minnesota vary the intake of calcium amendments on agricultural plots. We then try to modulate the insertion of certain inputs (nitrogen, phosphorus, potassium) in certain high-energy-intensive crops and inputs (maize, sugar beet for example), in the context of race to progress agricultural yields.

Mainly precision farming aims at optimizing yields and investments[4,5,6], seeking to better account for the variability of environments and improving conditions between different plots. It has influenced tillage, seeding, fertilization, irrigation and pesticide spraying. In practice The aim is to optimize the management of a plot from a triple point of view:

- Agronomic: The agronomic precision aims at improving the efficiency of inputs / yields, including the choice of strains and varieties more adapted to the edaphic or phytosanitary context
- Environmental: It also involves reducing certain risks to human health and the environment (in particular by reducing the environmental release of nitrates, phosphates and pesticides).
- Economic: Increase yields, while reducing energy consumption and chemical inputs.

3.2. WSN

Networks of autonomous wireless sensors is promising technology which is making its place to complement these existing solutions and compensate their shortcomings: Implemented in plots, they can continuously monitor different parameters. "This is a new generation of embedded systems coupled with wireless communication technologies. Thanks to these devices, it is possible to acquire, store, process and transmit data. Fig. 1.

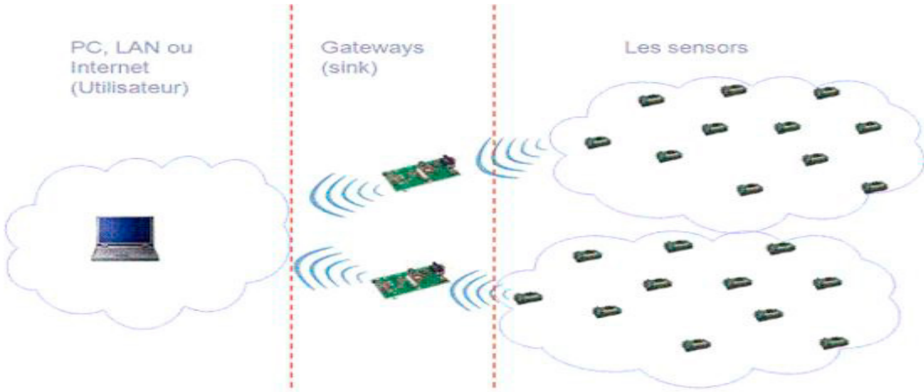

Fig. 1 WSN architecture.

3.3. IOT Cloud

IoT (Internet of Things) is a scenario in which objects, animals and people are assigned as unique identifiers, IOT makes it possible as the ability to transfer data over a network without requiring any human interaction To-human or human-to-machine. The architecture of the Internet of the objects Fig2 relies mainly on 4 processes allowing to collect, to store, to transmit and to treat data from the physical world. The role of the different processes presented in Fig 2 is described as follows:

- collect data: refers to the action of transforming an analog physical magnitude into a digital signal.
- Interconnect: allows you to interface a specialized object network with a standard IP network (e.g. WiFi) or consumer devices.
- Store: qualifies the aggregation of raw data, produced in real time, meta tagged, arriving in an unpredictable way.
- Finally, presenting indicates the ability to restore information in a way that is understandable to humans, while offering a means of acting and / or interacting.

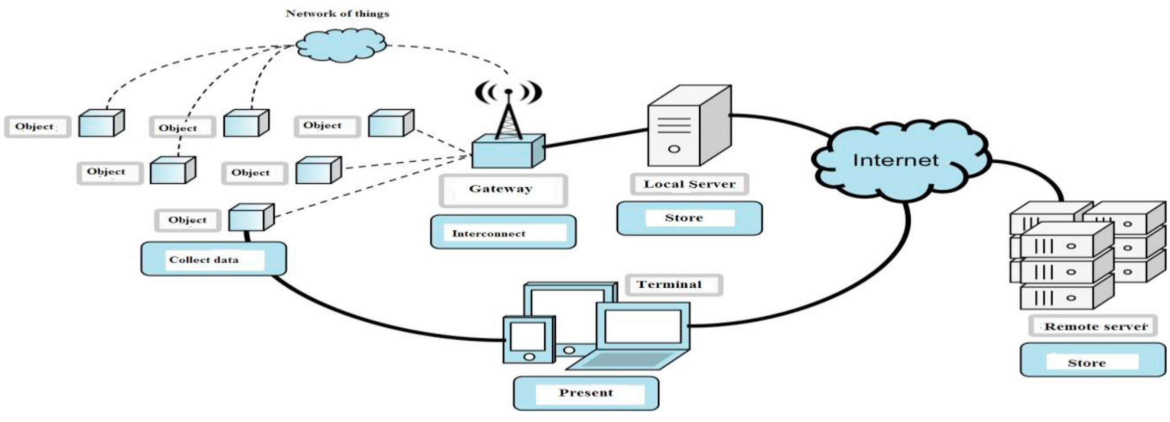

Fig. 2. IOT architecture.

4. Architecture system design

The general architecture Fig 3 of our supervisory system can be described in a three-third application. A third party connected to the sensor network deployed in the plots, a third party connected to the gateway intended to transmit the data via the Internet, and a third based on the web application of objects via the platform ubidots

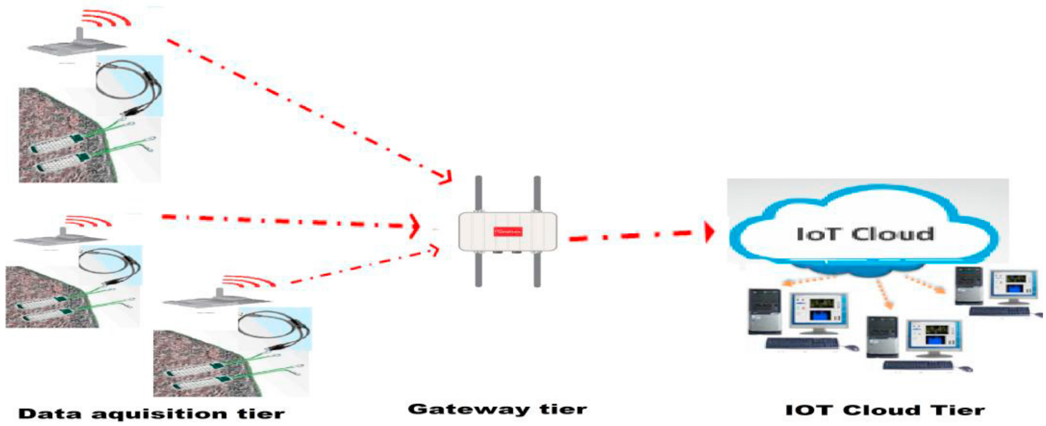

Fig. 3. Architecture system design.

4.1. Tier of sensor Network

In this part we will use sensor nodes of type waspmote 01. These are manufactured by the Libelium company based on the Arduino hardware open source technology. Each sensor node is equipped primarily with an Atmega 128 microcontroller. An IEEE 802.15.4 ZigBee Transceiver, an energy management module and a flash memory management system on an SDRAM card. The various modules of the card are connected by buses of type uart, spi and i2c. Each wasmpote node is equipped with a soil moisture sensor. The latter is equipped with two electrodes incorporated in a gain above gypsum slice. It is buried in the ground to measure the soil water pressure which reflects the moisture state of the soil. The higher the voltage, the more dry the ground.

4.2. Tier Gateway

The tier gateway allows the connection between the sensor network and the Internet network. Indeed the communications between the sensor nodes are made using the 802.15.4 protocol, the frame format of which is not directly integrable in the Internet network. This tier mainly comprises a hardware part and a software part. The hardware part corresponds to a gateway between the 802.15.4 network and the GPRS network. On the market alone the company libelium offers a gateway of this type named meshlium, this term is a derivative of the word mesh (network mesh or ad_doc) and the word "libeluim". In the remainder of this paragraph we shall describe in detail the use of Meshlium.

Meshlium is a multi-protocol router that contains 5 wireless connection interfaces: 2.4GHz Wifi, 5GHz Wifi, Blutooth, ZigBee and 3G / GPRS. This latest GPRS module is very friendly-uses for mobile applications. In addition the Meshlium is to be deployed in any environment since it made of and is also waterproofing in case it is to be placed in agricultural fields outdoors. Meshlium, multi-protocol router of Libelium , collects all data from sensor nodes and stores them in a local database or exported to an external database.

4.3. Tier IOT Cloud

This tier corresponds to the interface part of the user indeed with the development of the internet objects the need to have platforms that simplifies the task of supervising these objects is important. From the beginning of the 2010s the platforms called IOT cloud multiplied[7,8]. Their main objective is to offer plug and play to all sensor nodes however to the limit of our knowledge these applications have not been tested in precision irrigation applications. In this tier one will use ubidots in order to supervise note network sensor wasmpote in the continuation of this paragraph to describe the functionalities offered by ubidots

Ubidots offers a platform for developers that allows them to easily capture sensor data and turn it into useful information. Ubidots is used to send data to the cloud from any Internet device. In addition to this service, you can define triggers and alerts that, can automate responses to the data thresholds you have defined

5. Deployment

5.1. Field description

The chosen terrain for deployment is located in the Ras Jbel area. According to the soil classification map for irrigation[9], the top quality arable land is located in the median zone of the perimeter near the town of Ras Jebel. Occupied by vegetable crops and irrigated arboriculture. Non-arable land is located on the coastal dunes of the Mediterranean, covering 20.5% of the total area of the perimeter. These soils are reserved for dry crops.

5.2. Node programming and configuration

The application that we implemented had to meet two imperatives, Recover data from sensors and transfer them to Meshlium and Publish these data collected on the net via a cloud platform. In order to achieve this two imperatives we start to flash each transmitter motes with a program written in C language. This program can be schematized by the following flowchart fig 4.

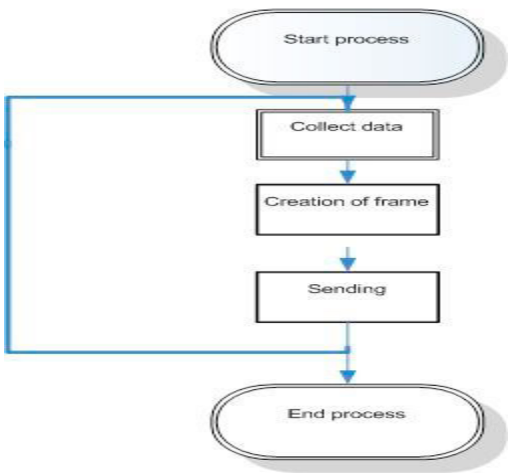

Fig. 4. Wasmpote node operation

5.3. Gateway programming and configuration

Mainly is based on a process that allows to recover the frames received on the IEE 802.15.4 module and to fragment the data then to integrate it in a Json code compatible to the format of ubidots and to transmit it via internet by the module GPRS below An overview of the Json stream format.

```
Curl –X POST -H "Content-Type:application/json"-d
'{"Parcel_one_moisture":{"value":3,"context":{"lat":37.233123,"lng":10.082181}},
"Parcel_two_moisture":{"value":11.21,"context":{"lat":37.232809,"lng":10.081591}},
"Parcel_three_moisture":{"value":156,"context":{"lat":37.233429,"lng":10.081096}},
"Parcel_four_moisture":{"value":156,"context":{"lat":37.233429,"lng":10.081096}}}'
http://things.ubidots.com/api/v1.6/datasources/585c560276254273e49eb616?token=V3gD0TEYtGfJWXvZ8j5k9dh0fXLeW7
```

5.4. Monitoring interface

The user interface is mainly composed of three parts:

The first part is an overview based on Google maps of our farm field to supervise as shown in the figure 5. It is a field composed of four plots that are managing differently. The blue dots on the map shows the actual position of the sensor nodes.

The second part represents the different soil moisture levels associated with each plot.

The third part shows the historical evolution of soil moisture on the four plots. This user-friendly interface provide a farmer with the minimum knowledge of Information and Communication Technology to understand the state of drought or saturation of Its soil in each plot fig 6.

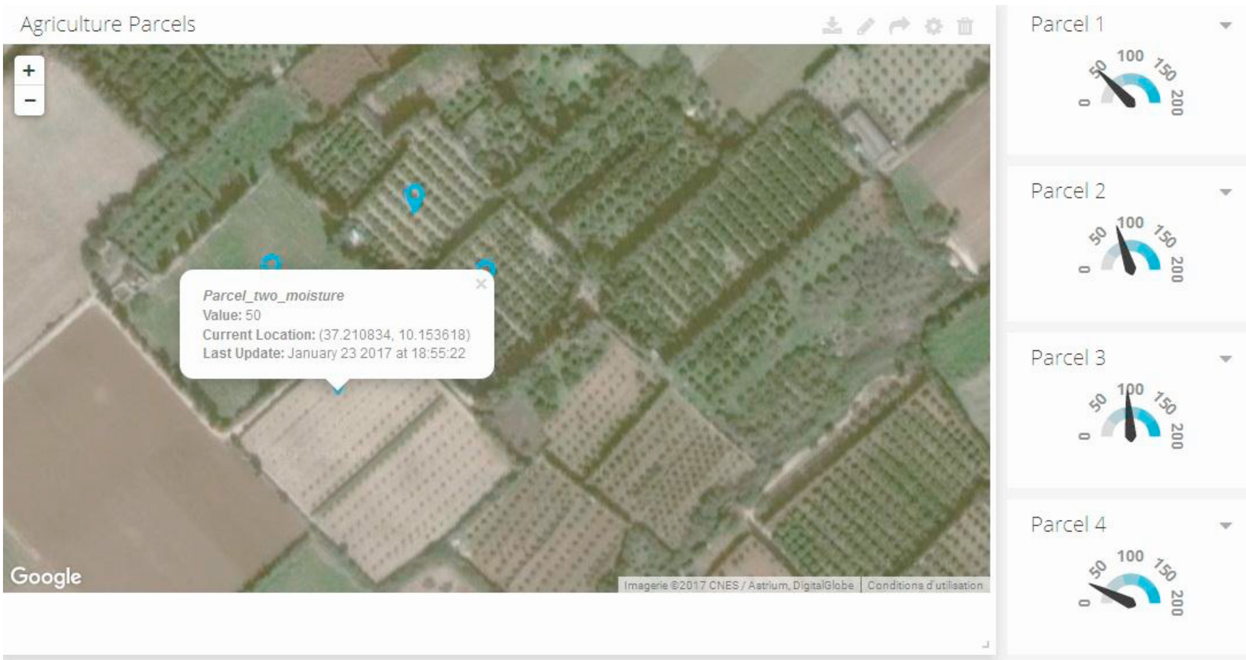

Fig. 5 Monitoring interface.

Fig. 6. Measurement of soil moisture with for nodes in flied.

Fig. 7. Alert interface

For each parcel a trigger is defined an alert will be transmitting to agriculture an SMS when the value of soil water voltage is greater than or equal to 100 cba (centibar), indicating the parcel in question in order to avoid water stress. By referring to Table 1 which represents the guide[10] for the interpretation of the values of soil moisture.

Table 1. Guide for interpreting the soil moisture

Soil water tension	indication
0-10 cba	Soil is saturated with water
10-30 cba	Soil is adequately wet
30-60 cba	Usual range for irrigation in heavy clay wet
100-200 cba	Soil becoming dangerously dry for maximum production

6. Conclusion

In this work we presented the alert system for the control of water stress of plants using IOT technology.In the first part we described the steps of the creation the decision support system intended to an agricultural community in order to be able to estimate the quantities of water required.
For irrigation management, the farmer will on the benefit from a dashboard software in the form of a graph, to monitor in real time the variations of the soil conditions and on the other hand a process of notification by sms will be transmitted Via the application when a critical level is reached to avoid water stress. This application can be improved is to make it very sophisticated one envisages the integration of the method of evapotranspiration[11] to calculate the water requirement of a plant per day in our system of decision support.

References

1. Mare Srbinovska, Cvetan Gavrovski, Vladimir Dimcev, Aleksandra Krkoleva, Vesna Borozan, “ Environmental parameters monitoring in precision agriculture using wireless sensor networks” Journal of Cleaner Production, Volume 88, 1 February 2015, Pages 297-307
2. H. Liu, Z. Meng and S. Cui, « A Wireless Sensor Network Prototype for Environmental Monitoring in Greenhouses ». Wireless Communications, Networking and Mobile Computing 2007 (WiCom 2007), In proceeding of International Conference on 21-25 Sept. 2007, Page(s) : 2344 – 2347
3. J.M. Barcelo-Ordinas, J.P. Chanet, K.M. Hou, J. García-Vidal, A survey of wireless sensor technologies applied to precision agriculture, in: Precision Agriculture'13, Wageningen Academic Publishers, 2013, pp. 801-808.
4. L. Karim, A. Anpalagan, N. Nasser, J. Almhana, Sensor-based M2M agriculture monitoring systems for developing countries: state and challenges, Netw. Protoc. Algor., (2013) 68-86.
5. E. Lichtenberg, J. Majsztrik, M. Saavoss, Grower demand for sensor-controlled irrigation, Water Resour. Res., 51 (2015).
6. Alberto Reche, Sandra Sendra, Juan R. Diaz, Jaime Lloret: A Smart M2M Deployment to Control the Agriculture Irrigation. ADHOC-NOW Workshops2014: 139-151
7. A. Alamri, W.S. Ansari, M.M. Hassan, M.S. Hossain, A. Alelaiwi, M.A. Hossain, A survey on sensor-cloud: architecture, applications, and approaches, Int. J. Distrib. Sens. Netw., 2013 (2013) 1-18.
8 Min-Sheng Liao, Shih-Fang Chen, Cheng-Ying Chou, Hsun-Yi Chen, Shih-Hao Yeh, Yu-Chi Chang, Joe-Air Jiang “On precisely relating the growth of Phalaenopsis leaves to greenhouse environmental factors by using an IoT-based monitoring system”. Computers and Electronics in Agriculture, Volume 136, 15 April 2017, Pages 125-139.
9. ZAKI M., DJELASSI M., 1979. Direction des Ressources en Eau et en Sol (D.R.E.S): Etude Pédologique de Ras Jebel N° 555.
10. Gratton, S.R. and J. Oster, 1992. Water Quality Guidlelines for trees and vines. Drought Tip 92-38, CA Dept. of Water Res., LAWR Dept.- Univ of CA, USDA Drought Response Office and USDA Soil Conservation Service.
11. Steduto, P., Todorovic, M., Caliandro, A., Rubino, P., 2003. Daily ETo estimates by the Penman-Monteith equation in Southern Italy. Constant vs. variable canopy resistance. Theor. Appl. Climatol. 74, 217–225.
12. Duan Yan-e, Design of Intelligent Agriculture Management Information System Based on IoT Fourth International Conference on Intelligent Computation Technology and Automation 2011, Volume: 1 Pages: 1045 – 1049.
13. Xiangyu Hu, S. Q. (n.d.). IOT Application System with Crop Growth Models in Facility Agriculture. IEEE
14. Andreas Kamilaris, Feng Gao, Francesc X. Prenafeta-Boldú and Muhammad Intizar Ali. Agri-IoT: A Semantic Framework for Internet of Things-enabled Smart Farming Applications. In Proc. of the IEEE World Forum on Internet of Things (WF-IoT), Reston, VA, USA, December 2016