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Designing Albaha Internet of Farming Architecture

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Abstract. Up to now, most farmers in Albaha, Saudi Arabia are still practicing traditional way, which is not optimized in term of water usage, quality of product, etc. At the same time, nowadays ICT becomes a key driver for Innovation in Farming. In this project, we propose a smart Internet of farming system to assist farmers in Albaha to optimize their farm productivity by providing accurate information to the farmers the right time prediction to harvest, to fertilize, to watering and other activities related to the farming/agriculture technology. The proposed system utilizes wireless sensor cloud to capture remotely important data such as temperature, humidity, soil condition (moisture, water level), etc., and then they are sent to a storage servers at Albaha University cloud. An adaptive knowledge engine will process the captured data into knowledge and the farmers can retrieve the knowledge using their smartphones via the Internet.

1. Introduction

Al-Baha region is a tourist destination in Saudi Arabia rich with natural resources and is known for its cool weather and natural diversity. Its seasonal crops are pomegranates, almonds, bananas, and kadi patta. Most farmers in Albaha are still practicing traditional way, which is not optimized in terms of water usage, quality of product, etc., whilst modern agriculture provides farmers with new innovations, research and scientific advancements to produce safe, sustainable and affordable food. Intensive scientific research and robust investment in modern agriculture during the past 50 years has helped farmers double food production while essentially freezing the footprint of total cultivated farmland.

In the context of our work, we have specified a farm management system that takes advantage of the new characteristics that ''Future Internet'' offers, we propose a smart Internet of farming system to assist farmers in Albaha to optimize their farm productivity by providing accurate information on the right time to harvest, to fertilize, to watering and other activities related to the farming/agriculture technology. The proposed system utilizes wireless sensor cloud to capture remotely important data such as temperature, humidity, soil condition (moisture, water level), etc., and then they are sent to a storage server. An adaptive knowledge engine will process the captured data into knowledge and the farmers can retrieve the knowledge through their smartphone via the Internet.

2. Related Works

To enhancing crop production, we need to monitor the crops constantly using sensors. Wireless Sensor Network in agriculture is showing progress [1-3]]. Jiou, et al. [4] has designed a farm environmental monitoring system based on the Internet of Things (IoT) and to realize the automate management of agriculture and the implementation of precision production. The system is made up of three layers which are sensor layer, transmission layer and application layer, respectively. Kaloxylos, et al., discussed in [5] the implementation of an innovative cloud based Farm Management System, It provides a framework that allows the interconnection among services developed by different service providers. Furthermore, the work utilized domain independent software modules called generic enablers, developed within the FI-WARE project.

Research works have been done on WSN implementation in agriculture/farming. Malik et al. [6] implemented energy aware WSN to monitor soil of palm-oil farm using PEGASUS routing protocol introduced by Lindsey and Raghavendra [7]. Perera and Collins [8] introduced ZigBee wireless soil moisture sensor design for vineyard management system. Mohanan et al. [9-10], proposed a holistic network selection algorithm to provide personalized always best connection (ABC) in 4G communication. The proposed algorithms consider dynamic parameters in achieving the ABC to the nodes in the network.

3. Proposed Design

The architecture of the whole system is exhibited in Figure 1. The system consists of 4 main components as follows.

1. Albaha University (ABU) Cloud
2. Adaptive Knowledge Engine
3. Mobile Applications/Services
4. Wireless Sensor Cloud

The ultimate goal of the system is to create a knowledge of the farming domain from data that collected via sensors deployed in the farm. The farmers need to procure the data acquisition components which will be deployed in their farms and then via Internet they can monitor the situation in their farm remotely using their smart phones.

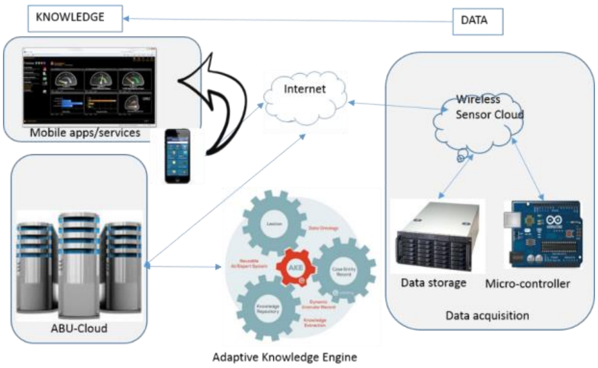


Figure 1. Overall design of the proposed design.

3.1. Albaha Univesity (ABU) Cloud

Albaha University (ABU) Cloud is a simple enterprise cloud designed and developed by the researcher in the College of CSIT. It consists of two application servers and two data storage servers, cloud communication servers, including: cloud controller, cluster controller, data storage (Walrus) controller, and node controller. ABU Cloud uses UEC (Ubuntu Enterprise Cloud), a free Linux-based cloud computing with Eucalyptus middleware and Windows server 2013 as for storage and application servers. Figure 2 illustrated the ABU cloud.

3.2. Adaptive Knowledge Engine (AKE)

Machine learning methods will be elaborated in this project with the intention of producing new Algorithms for AKE. To create knowledge on farming from the sensed data needs adaptive capability of the AKE due to the nature of farming and weather data that changing from time to time. Besides, accuracy is also needed to provide accurate prediction as well as suitable recommendation to the farmers.

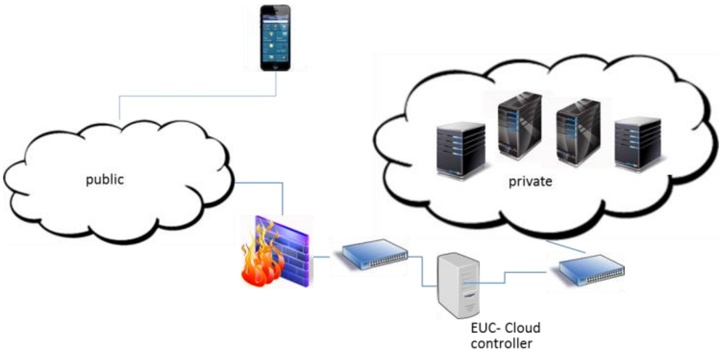


Figure 2. ABU Cloud

3.3. Mobile Applications

Overall architechture design of the mobile Baha farming cloud is illustrated in Figure 3, whereas its backend architecture is shown in Figure 4.

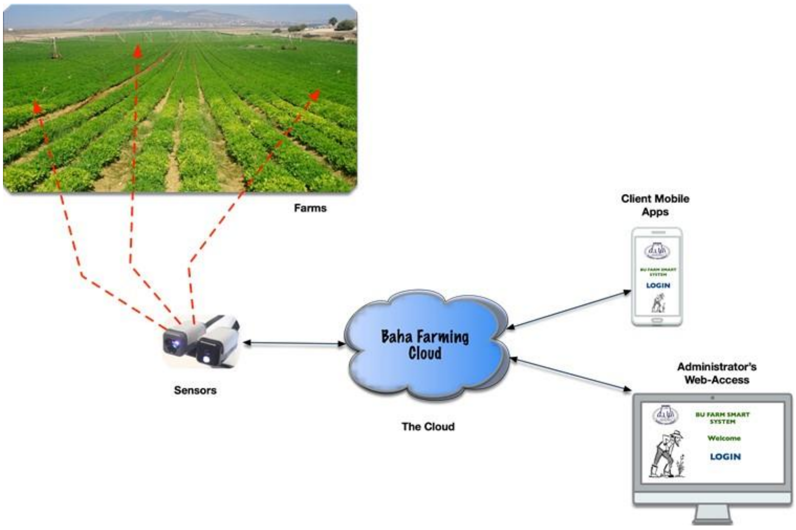


Figure 3. Mobile Albaha farming overall system architecture

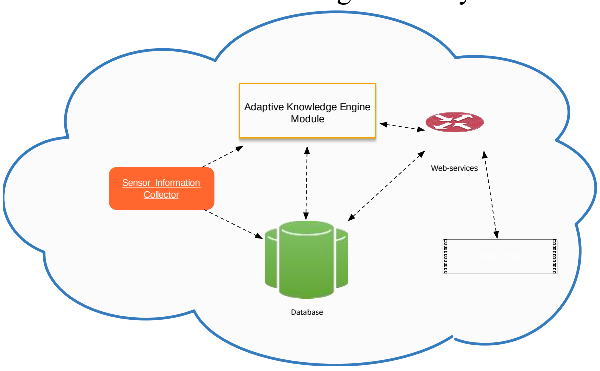


Figure 4. The backend engine architecture

The sensed and collected data/information are stored in a database, the AKE module will process some of the data/information to produce a useful knowledge to the farmers. Web application run at background and web service is employed to support interoperable machine-to-machine interaction over a network.

The farmers, using their smart phones will be able to access services with a graphical user interface (GUI) (see Figure 5). The services include the following:

- Real time farm monitoring system; Remotely or locally
- Recommender system; assist the farmer in emergency, extreme weather situation, etc.
- Storage cloud services; storing the farming data resulting from sensing the farm
- Farming management systems; to optimize the farm production
- Forum; sharing knowledge, experience, and other activities

Weather prediction system; short term and long term prediction.

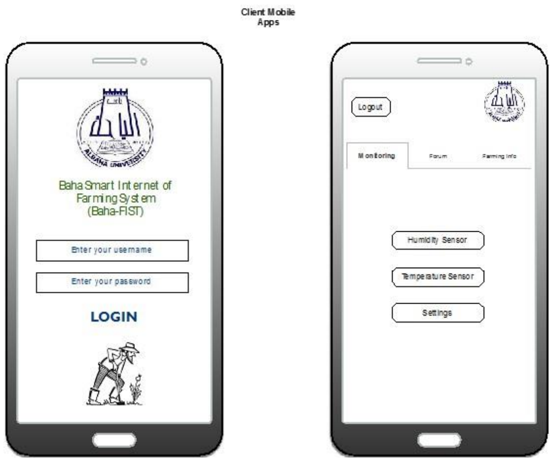


Figure 5. The GUI dashboard design.

3.4. The wireless sensor cloud

The wireless sensor cloud (WSC) for data sensing is designed according to the requirements of specific farm. Geographically, Albaha region is a hilly area. In addition, some area in Albaha have extreem wheather.

3.4.1. The wireless sensor network (WSN) design. A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices that use sensors to monitor physical or environmental conditions. These autonomous devices, known as routers and end nodes, combine with a gateway to create a typical WSN system. The distributed measurement nodes communicate wirelessly to a central gateway, which acts as the network coordinator in charge of node authentication, message buffering, and bridging from the IEEE 802.15.4 wireless network to the wired or mobile Ethernet network.

The design uses three layers: network layer is responsible for communication with the data sink/server; Reliable distributed storage layer is responsible to collect the data using coordinator node (sn); Sensor node layer is responsible to sense the data. The sensor nodes (sn) can be deployed in two different ways using grid topology or random topology as shown in Figure 6.

3.4.2. The Always Best Connection (ABC) network. The proposed WSN system is built on an IEEE 802.15.4 wireless mesh network. The 802.15.4 radio in each WSN device provides for lowpower communication of measurement data across a large network of devices. A software built on top of that to provide reliable communication from the host PC or Programmable Automation Controller (PAC) to the node devices.

The access network selection mechanism must also be flexible in adapting to fast changing environment. Current access network selection mechanism use single or limited criteria to identify the context on which the selection occurs and this will not scale up to the more challenging 4G environment. Current access network selection methods tend to allot static weights to the criteria.

Predetermined weights that are fixed will not correctly represent a scenario that has changed. A new algorithm to select the best connection is proposed by considering a dynamic weight to each available connectivities based on the most active applications that are using the connections.

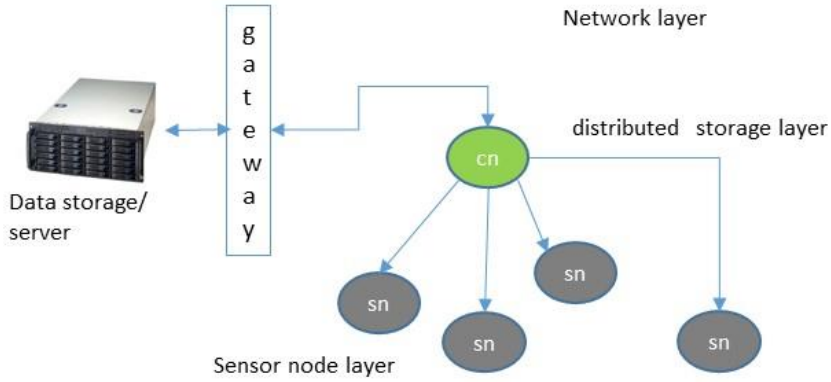


Figure 6.The sensoring components

3.4.3. The sensor design. Providing an always best connection (ABC) using wireless technologies in a region such Albaha is a big challange. Thus, we attempt to design a wireless sensor with the capability to provide ABC feature through a multiple communication protocols running in a sensor unit. Besides, in order to come up with a low cost sensor design we put multiple sensors in one microcontroller. The challange here is to deal with an efficient battery power usage. Overall block diagram of the sensor design is shown in Figure 7.

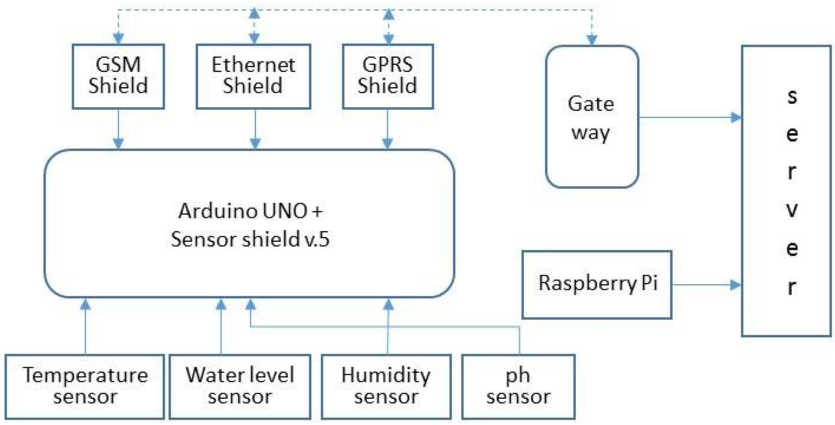
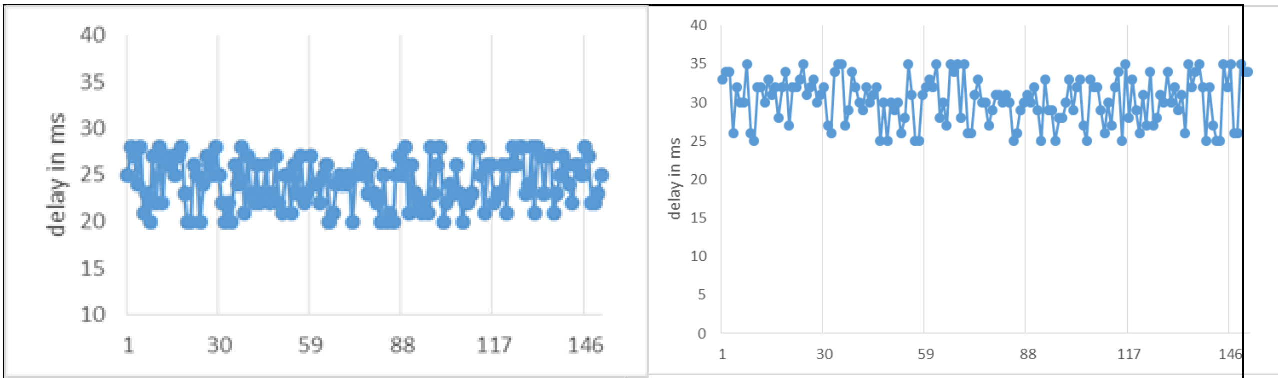


Figure 7. Block diagram of the sensor

3.4.4. Initial experiment and the results. For the initial experiment purpose, the WSN hardware is designed using 3 units of microcontroller Arduino Uno Rev5 with additional Raspberry Pi unit. Four sensors are attached (soil temperature, soil water level, soil pH, humidity soil humidity). Only GSM communication protocol is used in this simple experiment. The data sensing capability and end-to-end delay are measured during the *experiment*. Figure 8 (a) and Figure 8 (b) exhibit the end-to-end delay for WSN with 2 nodes and 3 nodes, respectively. Delay average for 3-nodes WSN is 30.31 ms., while delay average for the 2-nodes WSN is 24.19 ms. It is shown that WSN nodes, able to transmit sensed data to the server through its gateway with a reasonable delay. We do not apply any WSN routing protocols in this simple experiment.



(a) WSN with two nodes	(b) WSN with three nodes

Figure 8. End-to-end delay of the WSN

4. Conclusion
In this paper, the author shared an experience on the development of Internet of Farming system for rural area in Albaha province, Saudi Arabia. The project is at the early stage. The next stage is to detail the design and to implement the four components at laboratory scale. Having done some experiments and measurements, the pilot project will begin to deploy the real system in 10-15 farms as a pilot project.

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