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OGC SWE Sensor Web Enabled Irrigation System Based on Wireless Sensor Network

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Abstract--In the view of increased scarcity of water resources and the need of sustainable green landscape setups like recreational parks, golf courses, the overall efficiency of irrigation water usage needs to be raised. In this regard a wireless sensor network based precision irrigation systems relying OGC SWE standards has been developed to improve the overall efficiency of irrigation water usage. This paper focuses on the Open Geospatial Consortium's (OGC) Sensor Observation Service (SOS) which is capable of directly access the sensor data and helps the client to visualize the sensor observations over the internet. The prototype developed leverages on Sensor Web architecture for data acquisition, evaluation and interpretation, the sensor data is accessed using SOS web service which defines standards how to interchange sensor data between a client and SOS server. The client uses standard XML-HTTP methods mapped to SOAP interface to interact with the SOS server to retrieve the sensor observation that is structured on Observation and Measurement (O&M) data encoding model.

Keywords— Wireless sensor network (WSN), Open Geo-Spatial Consortium (OGC), Sensor Web Enablement (SWE), Sensor Observation Service (SOS), Service Oriented Architecture (SOA).

I. INTRODUCTION

Properly designed, installed, maintained and managed landscape irrigation systems greatly reduce the volume of irrigation water that is wasted every year. Well designed irrigation system can reduce the volume of water used, but in addition to the necessary capital investment, a commitment of time to manage and monitor the system is required to obtain its full benefit. Keeping these things in consideration we developed wireless sensor network architecture a promising tool; implementing multi criterion rule based decision support system for providing the efficient and cost-effective management system for irrigation and control in landscapes. Our aim is to optimize current irrigation systems by measuring and calculating the correct water requirements in real time using information gathered by sensors deployed along the field. The sensors used for monitoring are soil moisture sensor, temperature sensor, humidity sensor, wind speed sensor and water flow sensor. Based on the information gathered from these sensors various rules are applied, to interpret when and how long the landscape needs to be irrigated and moreover if the leakage from sprinkle heads are detected the alert will be send to the registered users via Email or SMS to take proper action. The prototype aims at the development of monitoring and control system for irrigating the landscape using wireless sensor networks and spatial data infrastructure technologies for interoperable data according to OGC (Open Geospatial Consortium) guidelines for real-time monitoring. The proposed architecture collects phenomenal observations from sensors, transmitting it to web service enabled user application, collects these observations in comma separated values (CSV) file and stores in SOS server. The client uses standard HTTP methods to interact with the SOS server to retrieve the sensor observation that is structured on Observation and Measurements (O&M).

II. RELATED WORK

A various WSN's applications with varied topologies have been developed and investigated by different researchers in the past decade. The first reported greenhouse WSN was a Bluetooth monitoring and control system developed by Liu & Ying (2003)[1]. Since then the number applications have been developed mostly on Zigbee technology like Gonda and Cugnasca presented a proposal of a distributed greenhouse control and monitoring system using ZigBee [2], Yoo et al. (2007) describes the deployment of a wireless environmental monitoring and control system in greenhouses [3]; Wang et al. (2008) also developed a specialized wireless sensor node to monitor temperature, relative humidity and light inside greenhouses. Lea-Cox et al. developed a WSN in a greenhouse, that integrates a variety of sensors which can measure substrate water, temperature, electrical conductivity, daily photosynthetic radiation and leaf wetness in real-time. Benefits came from an improved plant growth, more efficient water and fertilizer applications, together with a reduction in disease problems related to over-watering [4].

III. FACTORS DETERMINING THE NEED OF IRRIGATION

To ensure the complete and proper design of an irrigation system, we have followed below procedures.

1. Obtaining site information:- A site plan is a scaled drawing of the areas that are impacted by the irrigation system. Complete and accurate field information is essential for designing an efficient underground sprinkler system. Without an accurate site plan of the field conditions, there is little hope for an accurate irrigation plan.
2. Determining the irrigation requirement: explains how much water has to be applied to the plant and how often and how long the system need to run does. The local climate is one of the main factors that influence how much water is needed to maintain good plant growth. The plant water requirement includes the water lost by evaporation into the atmosphere from the soil and soil surface, and by transpiration, which is the amount of water used by the plant. The combination of these is evapotranspiration (ET).
3. Soil moisture:-Soil moisture sensor observes the moisture in soil it is the ratio of the volume of water in the soil to the volume of void space between the soil particles and is presented as percentage value, based on information from the sensors, mapping and monitoring methods are developed for precision irrigation scheduling, to determine how long and how much water is required to irrigate the landscape
4. Water Pressure: - The first step is, the designer needs to establish two points of critical information concerning the water supply. The first is the flow in gallons per minute (meters cubed per hour or liters per second) available for the irrigation system. The second is the working pressure in pounds per square inch (bars), at the previously determined flow, at the point-of-connection (POC) for the system.
5. Temperature:-Another factor that affects the use of water is the temperature; the hotter the temperature the more water is required for irrigation. The temperature sensor monitors the temperature of the observed environment and if temperature goes above the threshold the irrigation is required for the filed.
6. Humidity:-If the air is humid, evaporation will be lower as compared to a climate with the same average temperature but drier air.
7. Wind Speed Sensor: - Wind speed affects evaporation by speeding it up. Wind speed sensor monitors the wind speed and determines how frequently the irrigation should be done.
Climate Environmental Parameters

TABLE I

Climate	Inches (millimeters) Daily
Cool Humid	.10 to .15 in (3 to 4 mm)
Cool Dry	.15 to .20 in (4 to 5 mm)
Warm Humid	.15 to .20 in (4 to 5 mm)
Warm Dry	.20 to .25 in (5 to 6 mm)
Hot Humid	.25 to .30 in (6 to 8 mm)
Hot Dry	.30 to .45 in (8 to 11 mm) "worst case"

Cool = under 70° F (21˚ C) as an average midsummer high
Warm = between 70° and 90° F (21˚ and 32˚ C) as midsummer highs
Hot = over 90° F (32˚C)
Humid = over 50% as average midsummer relative humidity [dry = under 50%]

IV. THE SYSTEM STRUCTURE OF WIRELESS SENSOR NETWORK

In order to achieve environmentally conscious water management system, WSN mainly focuses on Data acquisition, effective transmission and automatic irrigation control. One of the major requirements for irrigation monitoring and control system is the efficient delivery of data in near real-time. The proposed network consists of number of sensor nodes; each node is having its own transmission and receiving unit, micro-controller, internal memory and power supply. Sensor nodes are deployed at different locations in the field observing the phenomenon of interest and are responsible for collecting real-time information of the landscape. Wireless sensor nodes, observes the environment, samples and collects the heterogeneous data from the interested field and then transmits the data packets to the sensor gateway which is the fundamental gateway for controlling entire system. The data received by sensor gateway is transmitted in real time to the GPRS terminal via Zigbee radio, which is responsible to transmit it to the user through web service interface.

Each node of the WSN is composed of four fundamental units: a sensing unit, a processing unit, a communication unit and a power unit. Sensing unit of the node consists of two subunits: sensors and analog-to-digital converters (ADCs). Sensors are responsible for receiving the data which can analog or digital. In case of analog data perceived by the sensors, the data is fed to the ADC which efficiently converts the analog signals into the equivalent digital signals for further processing. The processing unit of the node is implemented with microcontrollers which preprocess the data captured by the sensors and looks after the control and coordination of sending and receiving the data to other nodes and/or to base station. The communication module of the sensor nodes is employed with the radio transceiver capable of communicating with the neighbouring nodes. Finally the power unit of the node is responsible to provide the required power for both sensing, processing as well as communication units. Each node has group of sensors attached to it, sensing different environmental parameters. The various sensors attached to node are: Soil moisture Sensor, Water flow sensor, Humidity Sensor, Temperature Sensor, Wind Speed Sensor.

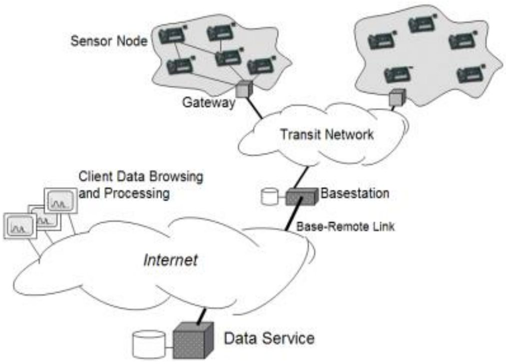

Fig. 1 General Architecture

Taking above scenario in consideration an automatic irrigation system leveraging on Service Oriented Architecture is designed. The physical parameters like temperature, humidity, and wind are the key factors for design to determine when and how long the water will be supplied to the compound. However the flow of the water is another important factor to determine how much flow is required to irrigate the field. The sensor nodes deployed in the field observe the environment and sends data to sensor gateway. SOAP API is designed to provide the data gathered by the Sensor Gateway to Web applications where the processing and the evaluation of the data are done. If the overall evaluation of the data indicates the observed factors are crossing the threshold, the system will start irrigating the area. Meanwhile if the water flow sensor observation crosses the maximum pressure threshold the excessive water leakage will be perceived and alert will be generated to indicate pipeline or sprinkle head leakages. Notification service will act as OGC SWE's Web Notification service to send the alert to the registered users of the system (Typically by displaying the alert on web client or Text SMS and emails in our prototype).

Fig. 2 Sensor Gateway Hardware

V. EMBEDDED DEVICE HARDWARE

The transmission of real time data and processing of monitoring information requires embedded hardware called node. The node structure comprises of array of sensors, wireless transceiver unit (Zigbee 2mW Wire Antenna-Series 2), MCU control unit (Atmega 328-PU), SM5100B-D GPRS module and GTPA010 GPS module to track the present location and time awareness. The real time observed data is gathered from temperature sensor, humidity sensor, wind speed sensor, water flow sensor and soil moisture. The sensors used are G3/4-water flow sensor, 10HS soil moisture sensor, 014A-Lwind speed, HSM-20G Bridge Humidity sensor and LM-35 temperature sensor. The micro-controller board connected to group of sensors and transceiver unit communicates through Zigbee radio to sensor gateway which is connected to GPRS terminal. The web connectivity between the GPRS terminal and the central computer is achieved through SM5100B-D GPRS so that all real time data is available on web.

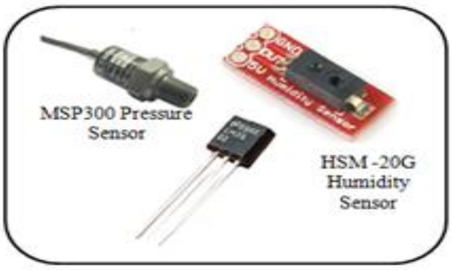

Fig. 3 Sensors Connected to Microcontroller Board

VI. SERVICE ORIENTED ARCHITECTURE

In our prototype the three layer Service Oriented Architecture (SOA) architecture is implemented as, sensor gateway, Sensor Observation Service (SOS) and distributed application client. The distributed application acts as service requester querying data from sensor gateway. Sensor gateway acts as service provider. They provide the service descriptions of the whole sensor network, and they offer access to such services. SOS act as service directory, keeping a repository with services descriptions of each sensor type existing in the sensor network.

A. Sensor Observation Service (SOS)

The SOS specification provide access to observations from sensors and sensor systems in a standard way that is consistent for all sensor systems including remote, in situ, fixed and mobile sensors[5]. The SOS has two standard data models, Observations & Measurements (O&M) and Sensor Model Language (SensorML) for exchanging the information between the SOS clients and servers. The observation are gathered from the interested environment and grouped in observation offering, in order to access the observation data and related information SOS implementation defines three basic operation profiles: core profile, transactional profile and enhanced profile. The core profile operation is mandatory and contains three operations: GetCapabilities, DescribeSensor, and GetObservation. These are the basic operation to access the stored observations from SOS server. The other two profiles are optional. The transactional profile provides the client with DescribeSensor and RegisterSensor operations for requesting information about the sensor itself encoded using SensorML and for connecting new sensors with the SOS respectively while as enhanced profile offers operations; GetFeatureOfInterest, GetFeatureOfInterestTime, DescribeFeatureOfInterest, DescribeObservationType to provide enhanced interface to interact with server.

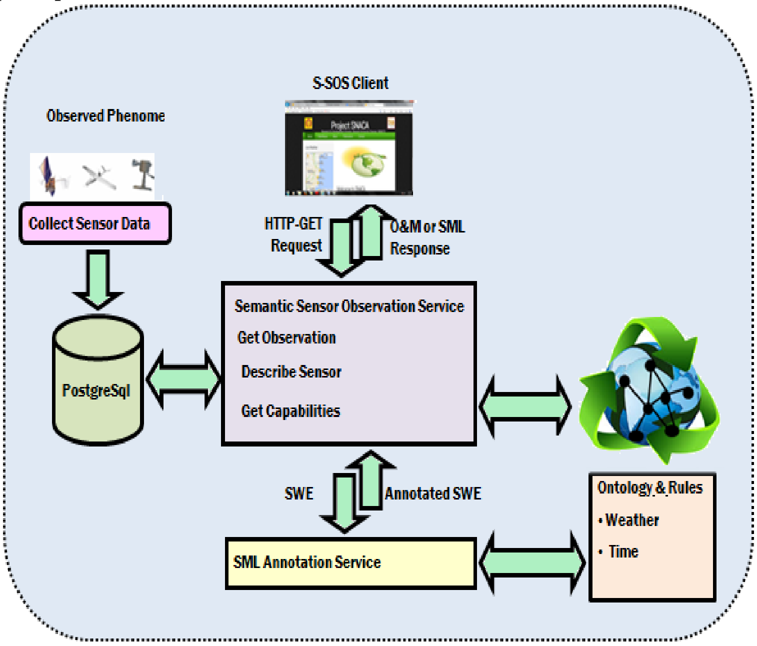

Fig 4 SOS Architecture

B. SOS Import Tool

To publish sensor data, SOS import tool is used which is capable of being importing data sets available in the form of comma-separated values (CSV) files to the SOS Server. The import tool has ability to read existing data archives, helping users to specify how the data is encoded in these files and then converting the data sets into the according SWE data formats (i.e. Observations and Measurements, Sensor Model Language) and to store them into SOS instances through the transactional operations of the SOS interface and subsequently it is accessed by the geographically distributed application clients through standard XML-HTTP requests. The advantage of using SOS importer interface is its interoperability: Any data provider using proper query syntax is able to register with the SOS server and supply it with data sets without previous knowledge

C. Distributed Application Client

The Sensor Web Enablement (SWE) distributed client based on Google technology allows to access sensor data which provides interface to select the interested operations allowed by the server and visualize values of the request which has been communicated. This application implements the OGC Sensor Observation Service (SOS) specification to access services and visualizing sensor observations. The information received from the SOS server is displayed on the client application. The client locates the sensor using web mapping service along with observed parameters and time interval. SOS client provides access to sensor data along with time series in form of diagrams or tables and the data is exported using Excel, PDF or CSV files while as SAS Client defining and submitting alert conditions and notification information. These clients facilitate the visualization of sensor data on the web by executing standard XML-HTTP requests (e.g. GetCapabilities, GetFeatureofInterest, etc.) on SOS database.

VII. SYSTEM REQUIREMENTS

The following software needs to be preinstalled for the proposed prototype; Windows 2000 or higher, Linux/Unix, JRE/JDK 6 [1.6.x], Apache Tomcat [7.0.x, 6.0.24],PostgreSQL Version [9.0.x], PostGIS Version [2.0.x], SVN client, Apache Maven [3.0.3]

VIII. SOFTWARE IMPLEMENTATION

The software implementation is a Java-based web service package, requiring the components Java Runtime Environment (JRE) and Java Development Kit (JDK) Version 1.6.0 , Glass Fish Version 3.1.1.and backend consists of Postgre SQL database server version 8.4 and to support geographic objects, with PostGIS extension version-1.5 spatial database plug-in / template has been used. All the Web services have been developed with Java web technologies using Simple Object Access Protocol (SOAP) architecture. The motivation of using the technology was due to the fact that SOAP is a standard web service middleware protocol. The Integrated Development Environment (IDE) Eclipse release-Helios has been used with Google Web Toolkit plug-in (GWT, 2011) to convert source Java code into web-based JavaScript code. This toolkit provides a set of Java-based libraries that abstract most of the functionality of the web design and the client/server communications, making the programming and deployment of web applications easy to build-up and to maintain. Apache Tomcat, open source servlet container has been used. It implements the Java Servlet and the JavaServer Pages (JSP) and provides a "pure Java" HTTP web server environment for testing and deploying the distributed web application client.

IX. CONCLUSION

This paper presents interoperable data model of irrigation monitoring and control, based on open standards of OGC SWE, implemented using SOA approach. The system focuses on an easy accessibility of real time data using two standard data models: Sensor Model Language (SensorML) and Observation and Measurement (O&M) for exchanging the data between the SOS client and the server. The standard HTTP methods are used to invoke the operations to interact with the SOS server which enables clients to retrieve observation of interest for landscape irrigation. The retrieved observations are structured on Observation and Measurement (O&M) standard which achieves the feature of interoperability and enables to access data over internet. Because of the interoperable data model, open standards and modularized architecture the system has flexibility to be transferred to other application domains and scenarios.

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REFERENCES

[1] Liu G, Ying Y. Application of Bluetooth Technology in Greenhouse Environment, Monitor and Control. J Zhejiang Univ Agric Life Sci. 2003;29:329–334

[2] Gonda L, Cugnasca CE. A Proposal of Greenhouse Control Using Wireless Sensor Networks. Proceedings of Computers in Agriculture and Natural Resources, 4th World Congress Conference; Orlando, FL, USA. 24–26 July 2006.

[3] Yoo S, Kim J, Kim T, Ahn S, Sung J, Kim D. A2S: Automated Agriculture System Based on WSN. Proceedings of ISCE 2007. IEEE International Symposium on Consumer Electronics; Irving, TX, USA. 20–23 June 2007.

[4] Lea-Cox JD, Kantor G, Anhalt J, Ristvey A, Ross DS. A Wireless Sensor Network for the Nursery and Greenhouse Industry. Proceedings of Southern Nursery Association Research Conference; Atlanta, GA, USA. 8–9 August 2007;

[5] Botts, M. (2007): OGC White Paper – OGC Sensor Web Enablement: Overview and High Level Architecture. – Version 3. – URL: http://www.opengeospatial.org/pressroom/ papers. OGC 07-165.

[6] Simonis, I. (2007): Sensor Alert Service Implementation Specification – Version: 0.9.0. – URL: http://www.opengeospatial.org/standards/ requests/44. OGC 06-028r5

[7] Zhou YM, Yang XL, Guo XS, Zhou MG, Wang LR. A Design of Greenhouse Monitoring & Control System Based on ZigBee Wireless Sensor Network. Proceedings of 2007 International Conference on Wireless Communications, Networking and Mobile Computing (WiCom 2007); Shangai, China. 21–25 September 2007.

[8] Morais R, Fernandes MA, Matos SG, Serodio C, Ferreira P, Reis M. A ZigBee Multipowered Wireless Acquisition Device for Remote Sensing Applications in Precision Viticulture. Comput Electron Agric. 2008;62:94–106.

[9] Secchi, S., Gassman, P.W., Jha, M., Kurkalova, L., Feng, H.H., Campbell, T. & King. C.L. 2007. The Cost of Cleaner Water: Assessing Agricultural Pollution Reduction at The Watershed Scale. J. Soil Water Conservation 62:10–22.

[10] Aijaz Reshi, Shabana Shafi, Dr. M. Sridhar, Dr. M. Rajani. Developing Online Weather Monitoring System Using OGC SWE. International Journal of Scientific & Engineering Research, Volume 3, Issue 4, April-2012 _ISSN 2229-5518

[11] Shabana Shafi, Aijaz Ahmad Reshi, Dr. M Sridhar, Dr. Rajani S.M. Real Time Sensor Web Enabled Water Quality Monitoring System Using Service Oriented Architecture (SOA). International Journal of Scientific & Engineering Research, Volume 3, Issue 5, May-2012 1 ISSN 2229-5518

[12] Web Enablement White Paper Mike Botts, PhD, University of Alabama in Huntsville
[13] OGC White Paper OGC® Sensor Web Enablement: Overview And High Level Architecture. Reference number: OGC 07-165 Version: 3
[14] Simon Jirka *, Arne Bröring and Christoph Stasch , Discovery Mechanisms for the Sensor Web
[15] Amit Sheth, Cory Henson, and Satya S. Sahoo Kno.e.sis Center, Wright State University,Semantic Sensor Web
[16] N. Bennis, J. Duplaix, G. Enéa, M. Haloua, and H. Youlal. Greenhouse climate modelling and robust control. Computers and electronics in agriculture, 61(2):96–107, 2008.
[17] Shabana Shafi , Aijaz Ahmad Reshi and A. Kumaravel , "Wireless Sensor Network Based Web Enabled Application framework for Fire Monitoring", Middle-East Journal of Scientific Research 19 (8): 1056-1061, 2014
[18] Shabana Shafi , Aijaz Ahmad Reshi and A. Kumaravel, "Wireless Sensor Network based Early Warning and Alert System for Radioactive Radiation Leakage", Middle-East Journal of Scientific Research 19 (12): 1602-1608, 2014
[19] Reshi, Aijaz Ahmad , Shafi, Shabana ; Kumaravel, A., "VehNode: Wireless Sensor Network platform for automobile pollution control," IEEE Explore, vol., no., pp.963,966, 11-12 April 2013
[20] Aijaz Ahmad Reshi, Shabana Shafi and A. Kumaravel, "Developing Web of things application for Wireless Sensor Network based vehicular pollution monitoring" Middle-East Journal of Scientific Research 19 (11): 1449-1454, 2014
[21] Shabana Shafi , Aijaz Ahmad Reshi, Dr. A. Kumaravel, "SOAAM: Service Oriented Architecture for Wireless Sensor Network in Avalanche Monitoring" Proc. of IEEE, 2013 International Conference on Human Computer Interactions (ICHCI)
[22] Shabana Shafi , Aijaz Ahmad Reshi, Dr. A. Kumaravel, "Wireless Sensor and Actuator Network based WoT Interface for smart fire detection and control in Real- estate infrastructures" , Proc. of IEEE, 2013 International Conf. on Human Computer Interactions (ICHCI)
[23] Shabana Shafi , Aijaz Ahmad Reshi, "Multi-Criterion Rule Based Irrigation System Based on Wireless Sensor Network and OGC SWE Standards", Proc. of IEEE, 2013 International Conf. on Computing, Cybernetics and Intelligent Information Systems (CCIIS).
[24] Aijaz Ahmad Reshi, Shabana Shafi, Dr. A. Kumaravel, " MineSense: Web of Things approach for Wireless Sensor Networks in Coalmine Environment Surveillance and Alert Systems", Proc. of IEEE, 2013 International Conf. on Computing, Cybernetics and Intelligent Information Systems (CCIIS)

