REAL-TIME WEB-BASED MAP APPLICATION FOR WATER DISCHARGE MONITORING

Joshua Irungu Mwaura[1*], Dr. Thomas Ngigi[2]

[1] *Department of Geomatic Engineering and Geospatial Information Systems, JKUAT, JUJA, P.o BOX 62000-00200, Nairobi*

[*] *Corresponding Author - E-mail: joshuairungu12@gmail.com*

Abstract Although water distribution systems faces many challenges, constant provision of water to customers remains the vision and mission of water providers. These challenges in the water distribution systems has also led to much appreciated advancement in the water is conveyed today through the improvement of water pipes, water valves and meters. Keeping in mind those advancements, water companies continue to face challenges such large volumes of water flowing out of the system without being remitted. The complexity behind these challenges is quit enormous since it results from non-human interference to most frequent human interference with the water distribution system.

A near real-time web GIS application for water discharge monitoring will be of important to try and reduce this challenge of non-revenue water among many water companies. Integrating the existing water distribution networks with monitoring units which transmits water discharge measurements at interval to GIS enabled web interface will help to provide indication of the locations where there is unusual water behavior unless under notification of the field operators. In case of a problem, the use of geospatial intelligence on locations and directions to the site will provides much required services to save time and thus provide quick remedy.

This paper provides a near real-time web-GIS application for water discharge monitoring which with monitoring unit installed along the water distribution network will continuously avail this information on a GIS environment for the monitoring personnel, who can make decision based on the information. In a case of multiple monitoring units sending information to a central display system an attempt to temper with the distribution systems can be detected due to unexpected changes in water discharge volumes resulting from that activity.

Keywords Global System for Mobile Communication (GSM), General Packet Radio Service (GPRS), Water Discharge Monitoring System (WDMS), Geospatial Information Systems (GIS).

1. Introduction

The traditional and advanced human societies continue to be dependent on the continuous available supply of water. In areas where the source of portable water is not available, pipe network systems have been developed and installed to convey this resource to the consumers.

Water distribution is the process of conveying water from a source to the consumers. It takes different forms from tank trunks that supply water to community's access points to piped water that delivers water directly into homes. Water distribution systems convey water drawn from a distant water source or treatment facility, to the point where it is delivered to the users. Water distribution thus involves getting water supplies to consumers, ensuring efficient use of allocated water and providing access to safe water for as many people as possible.

Currently, water supply systems are experiencing challenges which has direct impact to the end users. Public water services in many countries have been assigned to a single water authority and the abilities of governments to distribute water adequately have been negatively affected by factors such as inadequate water management and poor water resource utilization.

Thus, urban water systems are characterized by heavy losses both financially and of water itself mainly due to weak and unsustainable management systems, and poor customer confidence resulting to low revenue collection. Water distribution systems failures are universal problem where significant portion of treated water is lost in the

conveyance between the source and the consumer. This is due to breakage resulting from a variety of factors e.g. failures at the joint threads, pipe connection, mechanical damage, poorly maintained valves and fittings, inadequate corrosion protection, material defects and faulty seals. The other cause of water loss is human interference with the water network, which is termed as illegal water connection.

The purpose of this research was to development a GIS-based water monitoring systems that aims to provide information to water providers on a near real-time basis about the amount of discharge along the water network.

2. Application Design

A wireless water discharge monitoring can have varied forms of implementation and the project adopts the form of a monitoring unit, storage and visualization unit. This was inform by knowhow that water distribution networks are often underground and in the field where users are located, while the water providers supposed to monitor the distribution system are centralized at a specific location as well.

The objective of the project is to introduce an online GIS system for water discharge monitoring at pre-defined location which are determined using geospatial analysis. The online GIS system has a graphical user interface to show the location of the sensor, the location of existing water distribution network and the water discharge charts for each monitoring unit station.

The data transfer from the monitoring unit to server is via GSM/GPRS communication protocol which is an efficient data handling technique. GPRS enabled GSM allows the data transfer using data services often referred to as "packet" transfer. The monitoring units have a unique ID which is sent along with the water discharge values and time.

The figure 1 below shows the schematic diagram of the real time water discharge monitoring map application developed which consists of mainly the monitoring unit and the visualization unit where the monitoring unit components are arduino uno microcontroller, GSM/GPRS module and the water flow sensor. The visualization side requires a monitor display with internet connection to access the online GIS web interface where the information is displayed.

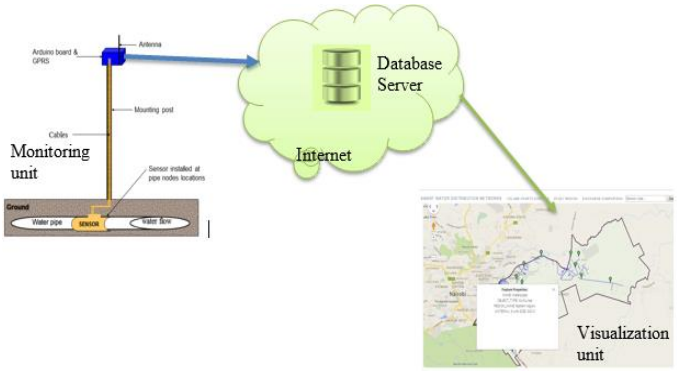

Fig. 1. Schematic Representation of the Application

As shown in figure 1 above, the monitoring unit has waterflow sensors that measures the water discharge for a second. Then, the microcontroller that connects the sensor and the GSM/GPRS module, by processing the data from the sensor and parsing it to the GSM for output via the data packet protocol to the database server. The data is continuously sent based on the programming of the control program. The system user responsibility is to check on the behavior of the flow from the charts and thus in case of a peculiar water flow behavior, appropriate actions can to taken to establish the cause of the observed behavior.

3. Application Components

a) Hardware

In this project, the SIM900 GSM module designed to be compatible with arduino uno. It's features includes software and hardware serial connection, microphone and speaker jacks, power key, power jack and power select, GSM antenna, serial port select and simcard holder. The simcard is placed on the GSM to establish communication. This GSM requires a supply voltage between "4.5V" and "5.5V" with a current of "500mA" maximum.

The water flow sensors output a series of pulses at a rate that varies proportional to the water flow being measured. The output pulse count is converted to flow rate using the sensor design scaling factor as follows.

$$Sensor\ frequency\left(\frac{pulses}{sec}\right) = 7.5 \times Q\left(\frac{liters}{min}\right) \ldots\ldots (1)$$

$$Liters = Q \times time\ elapsed(sec) \div 60\left(\frac{sec}{min}\right) \ldots\ldots\ldots\ldots\ldots (2)$$

Replacing (2) into (1):

$$Liters = \left(frequency\left(\frac{pulses}{sec}\right) \div 7.5\right) \times time\ elapsed(sec) \div 60$$

$$Liters(sec) = pulses \div (7.5 \times 60)$$

$$Milliters(sec) = liters \div 1000.0$$

The microcontroller program, acts as a simple frequency counter to determine how many pulses are received per second, and then applies that scaling factor to convert frequency into a flow-rate in liters per minute.

An arduino uno is an open source hardware programmable controller with several inputs and outputs. It connects to computer via USB and communicates using standard serial protocol, offers a variety of digital and analog inputs, SPI and serial interface and digital and PWM outputs. It comes with free authoring software.

b) Software

The software development of the project included both for the microcontroller and for the online Map application for visualization. The software for the microcontroller was written to control the water flow sensor and the GSM communication whereby as the pulses are received and converted to frequency and the water discharge measurements the GSM is called to send those values to the server. The software part for the GSM is to allow communication which involved the use of AT commands and the COMs port of the microcontroller to establish the network connection and transmission of the data.

The software for the web map application for visualization involved the use of a mapping service and database service. The software receives the data from the GSM and the stores in the database server then this data is parsed to the online GIS web interface. In addition, to the sensors data the water distribution related data such as water distribution networks, sensor station locations and zones established by the water providers are also parsed onto the web interface. The GIS component in this project provides the monitoring crew with geospatial intelligence of the location and distribution of the services facilities as well as to develop plans to mitigation based on the geospatial analysis. From this timely response to the areas where the sensors records unusual behavior can be accessed within short time possible.

4. Results and Discussion

The application interface features includes: Navigation menu to display various water distribution resources, sensor station location and zonal boundary, querying the sensor locations, Information windows with interactive near real time charts visualization at sensor locations. Pop up interactions of all the map elements with their properties, chart visualization with tooltip.

The Fig. 2 below shows an interactive near real time chart visualization showing the amount of water discharge as measured by a sensor. The chart is placed within the information window which is prompted by an on click function of the sensor markers.

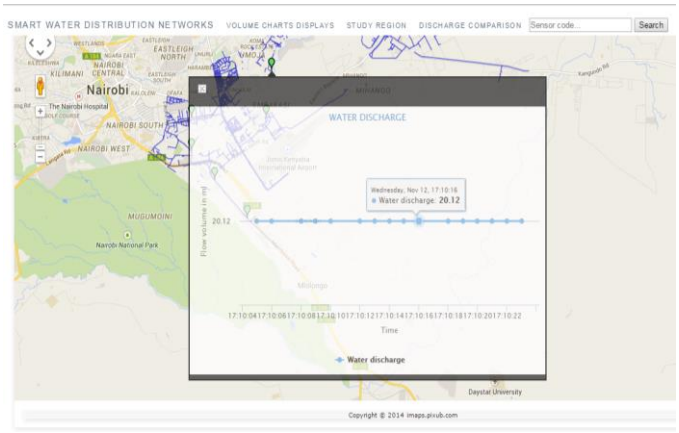

Fig. 2. Water discharge graph for sensor station

The Fig. 3 below displays a graph of 2 consecutive monitoring units to check on the water discharge variations between them. This comparison can also assist in detecting normalcy within the water distribution networks

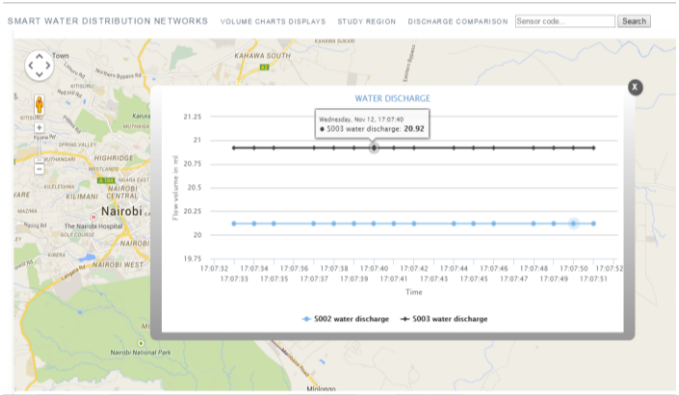

Fig. 3. A comparison of water discharge for two sensors

4. Conclusions

All water providers offer their services to large numbers of customers who are usually distributed over large geographic areas. Based on this fact and many others, identifying the exact location along the water distribution with a fault is rather time consuming and tall order without support systems, but with strategic and geospatially stationed sensors along the water distribution networks, where the faults is reported by the sensors can be easily be located and mitigation measures taken. This project presents a near real time web-based water discharge monitoring map application that is GPRS based for monitoring water distribution systems. This is achieved by the continuous transmission of measured data via internet protocol packet which gives the water providers useful information about their water distribution network

In this project, by implementing a real- time web map interface for water discharge monitoring, the discharge volume of near real-time and historic data from the sensor station location can be visualized, compared, and derive conclusion for water resources conservation

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