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Leveraging the Power of Smartphones: Real Time Monitoring of Water Points

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ABSTRACT
In recent years, the world has become more sophisticated. Different aspects of today's life has been digitized, this include; business, education, health, communication and numerous community services. With the existing extended coverage of cellular networks, most services are constantly deployed to be accessed via mobile phones, as they are also the most pervasive pocket carried devices. Though, both regular and smartphone can be used to convey the basics of mobile based services such as mobile banking, calling and text messaging, smartphone goes extra mile. While regular phones are still the better choice for some, smartphones are tremendously taking over the cellphone market. Smartphones are powered by the vast amount of mobile apps available today which offer unprecedented features and functionalities and as well more advanced internet connectivity. To ensure reliable, sufficient and safe water supply to public, the installed water points need to be well monitored. Quality and quantity parameters of water produced from the water points are constantly tracked to determine if they are within the acceptable range. In case of acute condition, the identified parameters need to be instantly communicated to the District Water Engineer (DWE) for prompt intervention. In this paper we explore the popularity and advantages of smartphones and present a proposed prototype that exploit the power of smartphones in real time monitoring of water points.
Keywords **–** Cellular Network, Mobile app, Smartphone, WAMIS

I. INTRODUCTION

Smartphones are increasingly gain popularity and constantly become a daily necessity. The advancement of mobile technology is revolutionizing today's mobile phones such that they offer wide spectrum of features and functionalities. Smartphones are powered by the vast amount of mobile applications available, extended storage memory (internal and external), powerful processors, multiple network interfaces and more improved operating systems such as Android and Windows Phone. Unlike regular mobile phones, which are constrained by limited processing power and act as merely a conduits for passing voice or data between cellular network and end users, smartphones combine significant computing power with memory, short range wireless interfaces (such as Bluetooth), Internet connectivity and various input-output components (such as, high resolution color touch screens, digital cameras and audio/video players) [1].

Newly smartphones are delivered each day and therefore a remarkable widespread is experienced. There are already more than 2,000 different smartphone types supplied by over 100 different vendors, and over 2 million apps available for download in different application stores [2]. The witnessed improved in technology such as the growth of cellular networks from GSM networks to the present 4G networks which have significantly increased the bandwidth and as the smartphones become more affordable, both are fuelling to the increase of regular mobile phone users to switch to smartphones usage. As depicted in Table1, [3] contends that, the global smartphone audience surpassed the 1 billion mark in 2012 and will total 1.75 billion in 2014. Nearly two-fifths of all mobile phone users, close to one-quarter of the worldwide population will use a smartphone at least monthly in 2014. By the end of the forecast period, smartphone penetration among mobile phone users globally will near 50%.

Table1: Smartphone Users and Penetration Worldwide, 2012-2017

Year	2012	2013	2014	2015	2016	2017
Smartphone users (billions)	1.13	1.43	1.75	2.03	2.28	2.50
% change	68.4	27.1	22.5	15.9	12.3	9.7
% of mobile phone users	27.6	33.0	38.5	42.6	46.1	48.8
% of population	16.0	20.2	24.4	28.0	31.2	33.8

Source: eMarketer, Dec 2013.

One of the outstanding reason that make smartphones more powerful is their ability to run small computer programs so called apps. This advantage is complemented with the more advanced internet connectivity available today. Connected living has become a reality for hundreds of millions of people who cannot imagine life before the smartphone and the mobile broadband connection [4]. The normal functionalities that are normally performed by computers, like opening, reading and editing of text files, web browsing, running of application programs and data storage, can now be performed by smartphones. Seja Patel et al. [5] contend that, the range of new touch screen smartphones allows user to access the internet, use social media, get live news updates, play music and video, and much more. These features are same as the one which were previously provided by computer system architecture.

For reliable and safe water supply to public, real time monitoring of water points is vital. Currently, water points are tracked and the information are sent to the computers for DWE to access and respond accordingly. This setting demand DWE to constantly have access to computers. The ubiquitous nature of smartphones opens up a window for development of newly solutions that require larger degree of reliability and mobility. In this paper we present a proposed prototype of the system that monitors installed water points in selected districts in Tanzania central zone. The system has a pivotal role to track produced water parameters (quality and quantity) and communicate them in real time to the District Water Engineer (DWE) for appropriate intervention.

II. RELATED WORKS

A noticeable number of solutions that exploit the power of smartphones have been proposed, developed and deployed. In this section we present various solutions in different sectors such as health and education which have employed smartphones in their settings. Muhammad F et al. [6], developed android smartphone application to assist elderly people for independent living. The proposed system, Activity Tracking Application, was divided into three layers; smart home, cloud computing and application layer. Smart home employed the use of sensing technology that collects different data and sends them to the centralized server. The cloud computing layer provides processing power and storage of the sensory data. Furthermore, the application layer which is composed of Elderly Person Reminder Application and Care Giver Assistant Application is the smartphone based application. Elderly Person Reminder Application uses smartphone to remind the elderly person about incomplete activities which require their prompt attention. In addition to that, Care Giver Assistant Application uses smartphone to allow care givers of the elderly person to track what is going on at home when they are away.

Ramesh G et al. [7], deployed a Land Vehicle Tracking System which was based on Android platform. The system was developed to determine the position of land vehicle with a terminal embedded with GPS receiver and displays the position on the digital map. Vehicle information was viewed on electronic maps via internet or specialized software installed in android phone.

An offline android aptitude application developed by Nataasha R et al. [8], allows users to take their test offline. The application has a dashboard with different sections for user to select, the subsection under the selected section pops up with random set of questions for user to respond and on the same time the timer is started. At the end of the test, a score board is displayed to indicate the results along with solutions of each question. The application was developed with the intention to save as a preparation tool for job aspirants and undertaking of aptitude tests.

Automatic Traffic Accident Detection and Notification System which based on smartphones were developed by Jules W et al. [9]. The system makes use of sensors and processing capability of smartphones to overcome the challenges of detecting accidents without direct interaction with vehicle's on-board sensors. Sensors on smartphone are used to detect various parameters during accident and send them to a central server to alert the responders.

Ashrafuzzaman et al. [10], have made use of smartphone to detect heart attack. What is required is just to place an index finger on a mobile camera of which then it will detect the peak of blood. Required parameters will be recorded and compared with those stored in a database and appropriate results are given. In addition to that, other problems such as blood pressure can also be detected. The authors concluded that, anyone could take primary steps to save from heart attack with smartphone.

III. PROPOSED PROTOTYPE

In this section, a prototype that uses smartphone to deploy a solution to monitor water points in real time is discussed.

A. WAMIS Overview and Challenges

So far there is existing an information system, Water-points Management Information System (WAMIS), which enables District Water Engineers (DWEs) to track water points. WAMIS provides the very useful information to enhance decision making and ensuring sustainable and safe water supply to a public. Through WAMIS, DWEs can determine the trend and status of water produced from the water points. WAMIS keeps records of the quality and quantity parameters of water produced from each

water point installed in a village. Quantity parameters (Amount of water discharged from the water point in M^3/Hour) is useful in determining the sum of water availability in a given village. Moreover, WAMIS records the population of people and livestock in a village and as well the amount of water consumed per day by people and livestock unit is also set. WAMIS uses both (population and consumption) to compute water demand of a village. Quickly understanding of village water demand addresses the challenge of uneven distribution of water points in the district. [9] contends that, the water point mapping data showed as much as fifty percent (50%) of all water points in the 10 districts in Tanzania were not functioning, and there was a high inequality in the location/concentration of water points.

Water quality parameters are recorded and compared with the one saved in a database to check if they fall within the acceptable predefined range. In case of mismatching, a warning is triggered and promptly sent to DWE for appropriate action. This ensures constant safe water supply to public.

Currently, the centralized database server (WAMIS Database) is set to be accessed by DWE through laptop or desktop computer. WAMIS Desktop App allows DWE to record all required information (such as people and livestock population and water consumption constant value), retrieve reports and follow up warning signals. This setting causes considerable delays in delivering warning messages and details particularly when DWE is not stationed with the PC installed with WAMIS Desktop App. We can therefore conclude that, the use of computer to a certain extent limits the mobility of the solution.

B. Proposed Solution

To extend the mobility of the system, we propose the use of smartphones to supplement desktop and laptop computers installed with WAMIS Desktop App. Another version (WAMIS Mobile App) of WAMIS Desktop App to be installed in a smartphone is developed. WAMIS Mobile App is developed to run in Android Platform. WAMIS Mobile App will have nearly the same features and functionalities as those found in WAMIS Desktop App.

C. Proposed System Architecture

As depicted in Fig. 1, the system is composed of four fundamental components; Water point (WP), Centralized Database Server (CDS), WAMIS Desktop App and WAMIS Mobile App. In the system setting, GSM Network is the heart of the system with the sole responsibility to interconnect the aforementioned four components. GSM Network has extended very rapid and provides a reliable means of connectivity. Mobile phone network GSM, GPRS data connectivity provide a viable national wide and cost effective mode of connecting through the internet to any server and this is an option that need to be actively explored [10].

Figure 1: Proposed system architecture

Water Point (WP)

Water Points are among the sources of water in villages. Water from water points are mostly used for domestic and livestock. Thus ensuring the quantity and quality of water produced is vital for human survival. Safe water sources, basic sanitation, and improved hygiene practices can prevent water related diseases, other illness and death [11]. To constantly track the status of water, Water Points are installed with an electronic gadget that acts intelligently to perceive the status (quality and quantity) of water through different sort of sensors. The gadget has a number of sensors to sense the amount of water discharged and water quality parameters, all these values are communicated through an embedded microcontroller chip to the Centralized Database Server via GSM network. Each gadget is made to have a unique identification number to uniquely identify each water point and its location.

Centralized Database Server (CDS)

CDS is responsible for storage and computation of data received from the gadgets mounted on water points and WAMIS applications installed in smartphones and computers. The baseline information which are set in CDS, are used to generate other useful information and warning alerts that are finally accessed by clients (smartphones and computers). CDS communicates with the rest of the components via GSM network (GSM Modem) through SMS and Internet connectivity. SMS is used when communicating with water point's gadget and Internet is used to link CDS to the client applications in smartphones and computers. Periodically, CDS receives information from the gadgets to update its database.

WAMIS Desktop Application

The application is developed user friendly to run on desktop PCs or Laptops. The front end is developed in VB .Net and connects to the back end, CDS which runs on SQL Server 2008. The application is used by DWE to access the WAMIS database installed in CDS for data insertion and information/reports retrieval. WAMIS is composed of three key modules; Water Requirements Tracking, Water Points Records and Water Funds Records. Water Requirements Tracking module allows DWEs to record the population of people and livestock, in addition to that, DWE can view water demand and balance (surplus) of each village in a district. Water Points Records module keeps records of all installed water points, records that are kept include; Depth, Static Water Level, Draw Down and Water Strikes. These information are vital as they act as a baseline information for future drilling projects. Water Funds Records module tracks the mode of operationalization of water projects and the existing water points. Key common information tracked by this module is water fund information and the information regarding Community Owned Water Sources Organizations (COWSOs).

WAMIS Mobile App

The features and functionalities of WAMIS Mobile App are nearly the same to those of WAMIS Desktop App. The intention of employing smartphones is to extend the mobility of our solution. WAMIS Mobile App is developed in JAVA and runs on Android platform. WAMIS Mobile App uses internet connectivity to communicate with CDS via GSM network. As mobile phone is considered to be the most pervasive pocket carried device, this ensures the reliable, efficiency and remote means of monitoring water points.

IV. RESULTS AND DISCUSSION

With the extension of WAMIS to employ the use of smartphones, DWEs at their convenience can access water points' information at their fingertips. WAMIS Mobile app downloads various information/reports from CDS and displays over the smartphone screen. Charts and other details that facilitates decision making can easily be viewed. Warning alerts are promptly and directly sent to the responsible responder for further action. WAMIS Mobile App also allows DWEs to upload information to CDS. Fig. 2 depicts a chart produced by WAMIS showing total water demand for three villages; Ibihwa, Kelema and Kiteto.

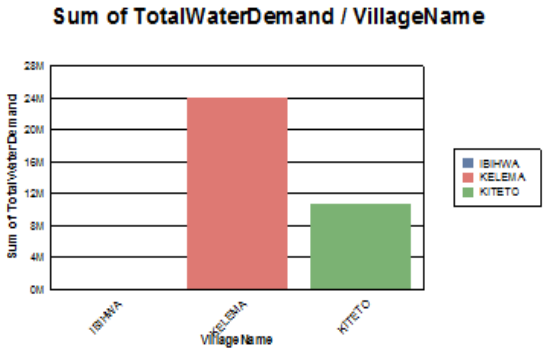

Figure 2: A chart showing Sum of Water Demand per Village

The initial setting of our solution which demanded a District Water Engineer to constantly have access to computer for monitoring what is going on in the network of water points is no longer a challenge. Smartphones have played a very important role to address this drawback through extending the accessibility of WAMIS application.

V. CONCLUSION

To escalate close monitoring of water points, smartphones have shown unprecedented opportunity.

Ubiquitous nature of smartphones and the existing extended cellular network coverage is still the best option to be exploited for the solutions that demand for higher degree of mobility. The power of today's smartphones in terms of processing, memory and running of computer programs (apps) can be efficiently used to supplement computers. Considering the sensitivity of water for safe living, more improved and innovative interventions are inevitable. The proposed prototype is anticipated to offer positive contribution to the water sector.

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