ABSTRACT
Water Audit in most water service providers in Kenya continues to be a challenge due to the designs being used to monitor and audit water loss. This necessitates the need to design a long range prototype th Stephen Kipkoro at enables audits to be executed remotely, affordable and is an adaptable and efficient model specifically designed to manage data and provide solutions to long-lived water loss. The main objective of this study is to design a long range WPAN or Wireless Sensor Network (WSN) model based on IEEE 802.15.4g LoRa standard for the purpose of water loss detection. The specific objective of the study is to design and evaluate a scalable long-range model to detect water loss in real time, remotely and accurately. Research design will include an actual experiment, expert interviews and literature review to develop a scalable, iterative and flexible model. The methodology and design to be used in this study will be PPDIOO network design lifestyle approach. The study will design a network simulator - NS2 so as to rapidly design and develop the model and use it to evaluate and validate the prototype. LoRa is a wireless technology that offers a better solution over other technologies like WiFi, Bluetooth, 2G/3G/4G, RFID and ZigBee to provide the best applicable model for water loss detection and management.

Keywords: Water loss, Long Range, Wireless Sensor Network Model, PPDIOO

I. INTRODUCTION
Water service providers have contributed to poor performance due to unattended loss in the distribution network designs and at the customer’s premises (Hirvi & Whitfield, 2015) [1]. Piped water connections to premises still the most affordable and safe system of water provision (Heymans C., 2014)[2] there is need to strengthen service providers to ensure water loss are controlled for affordable and quality water provision. Arising from these scenarios there is need for effective design technological strategies in water telemetry, most appropriately through a wireless radio system for data transmission within area of jurisdiction to detect, measure, reduce or minimize leaks consistently for the growth of water service companies (S., 2015) [3].

The current water supply network strategies are costly, inaccurate, time-consuming way of detecting loss (Huang et al. 2010). Wireless Sensor Networks provide the technology for cities to more accurately monitor their water pipe systems and identify their greatest water loss. Cities that are addressing water leakages with sensor technology are generating high savings from their investment. Tokyo, for example, has calculated they save USD170 million each year by detecting water leakage problems early.Hydrosense is a low–cost approach which provide information on water flow using pressure waves propagated to sensors when valves are open or closed using Bluetooth technology (Froehlich, 2009) [4].

LoRa (Long Range), technology is a digital wireless data communication IoT technology developed by Cycleo of Grenoble, France which enable a very-long-range transmissions (more than 10 km in rural areas) with low power consumption (Semtech, 2012). LoRa RF1276 provides pure loRa p2p (peer to peer) a low cost, ultra-low power, high performance transparent technology for water loss detection. LoRaWAN network architecture can be deployed using star- topology unlike mesh topology in Zibgee technology. It has IP based -network stations at physical layer to relay data between the sensor nodes and the network server. There are a number of wireless technologies which include WiFi, Bluetooth, 2G/3G/4G, RFID, ZigBee and many others that allow IoT network deployment. This depends on the Network coverage, energy consumption of devices and transmission bandwidth (Khutoane O., Isong B., Abu-Mahfouz A.M., 2017).

While there are a wide range of technologies in remote telemetry; the design to be used can improve water balance and water loss control (Lauridsen M., 2017) [6] The LoRa architecture has gateways and nodes which connect thousands of devices with sensors to detect loss for longer distance. The need to have a common smart meter for standard information-sharing remotely using LoRa technology is the best pet despite of many other competing technologies .The possibility to connect such devices remotely will increase high proceeds and opportunities to most water service providers (Rezgui, 2015) [7].

L1 PROBLEM STATEMENT
The current approach designs employed by water companies in Kenya to detect water loss, whereby field officers physically check for leaking pipes or illegal siphoning is slow,
unreliable, inefficient and inaccurate thus compromises water accountability. There is need to design a technological solution that is scalable and cost-effective to solve this problem. LoRa technology model will be designed to track water distribution from the source 5-10 km in real-time. Being a long-range low power battery, the power source using a secure and standardized smart metering technology, can last for more than 10yrs. This LoRa will be designed to have a Wireless Personal Area Networks and the simulation and prototype will be evaluated for performance analysis.

III. RESEARCH QUESTION

How will a scalable long-range model be designed to detect water loss?

IV. RESEARCH OBJECTIVE

The main objective of this study is to design a scalable long-range star WPAN model for the purpose of detecting water loss.

V. LITERATURE REVIEW

The design for LoRaWAN networks are of standard IEEE 802.15.4-g thus speeds up IoT applications which can be deployed anywhere. The LoRa model consists of Network and application layers where both complete communication protocol in a Wireless Sensor Network (Yusuf, 2014). Asset tracking remotely forwards information through nodes and gateways to network server. The Network server then forwards the same information to application server. The LoRa Technology enables GPS best for detection of water loss with high capacity of connectivity at low cost. The use of this technology helps to save operation cost as well as minimal battery replacement (Agapiou.A., 2016) [8].

The Gateways connected to power source (not on the battery) receive data from LoRa sensors, and sends over IP to the server. The LoRa embedded sensors transmit data to the LoRa gateways which are connected to the internet via the standard IP protocol i.e. server, a network or cloud. LoRaWAN network is more secure as it encrypts data twice i.e. data sensors encrypted by the nodes and IP before being sent to gateways as normal IP network to the server network. The following keys ensures security; Unique Network key (EUI64) based on network level while Unique Application key (EUI64) ensure end to end security on application level and finally the (EUI128) is the Device specific key. The Network layer has unique encryptions feature of 128-bit Network Session Key shared between the end-device and network server. Network server solution that can be hosted on the Cloud e.g. The LoRa-IOT Cloud or The Things Network (TTN) (Lauridsen M. V. B., 2017).

The WPAN LoRa technology is more secure and standard hydro sense smart meter for tracking water from water points to the clients registered with the company (Brown, 2015) [9]. LoRa technology can be able to detect upto 30 miles apart within area of jurisdiction where it measures and evaluates water amount relationship and the resulting pressure (Morison, 2015) [10]. The easy to install LoRa technology is more powerful when connected to existing or new networks (Ibrahim, 2015) [11].

Smart meters using LoRa technology sensors stand the best bet for water loss detection (Almazyad, et al., 2014) [12]. The LoRa technology meter sensors network can be operated by the 3rd party water companies’ i.e between the clients and water utilities. The company intermediary can provide this smart meter, collect consumption data and metering infrastructure sold as service (Sanchez-Iborra R., 2018) [13].

I. METHODOLOGY

The design of the LoRa sensor WPAN network is to be addressed using IANA licensed uncast global addresses of 2340: AEBF: 3040: /48 networks. The design will be done after prepare and plan stages of PPDIOO life-cycle. The network topology diagrams, addressing plan, transmission media using Sensors are put in place to meet current business and technical requirements of water companies for loss detection.

The methodology defines the continuous life-cycle of services required for a network (Cisco, 2010) Figure 1 below. This methodology is ideal as it helps to lower ownership total cost of network, improves business agility, enhance network availability, speeds up applications access and services.

Figure 1: Prepare Plan, Design, Implement, Operate, and Optimize Network Design and Implementation methodology (Source: Cisco)
The design stage follows initial requirements derived from the planning phase to drive the activities of the network design specialists. The network design specification is a comprehensive detailed design that will meet current business and technical requirements of water companies. It will be incorporated to support availability, reliability; security, scalability and performance specifications for implementation activities. The stage will guide and propose scalable solution architecture of a higher level according to the financial assessment on whether it can meet the budgeted cost. The design phase includes network topology diagrams, addressing plan, transmission media, Sensors and both end and intermediary devices involved in the set-up.

II. CONCEPTUAL FRAMEWORK

The LoRa based remote model will consist of the following modules;

i. Water Device calibration module to identify physical addressing of each water meter.
ii. ModBus conversion of analogue water flow to digital reading
iii. LoRa radio frequency module to aid joining, connection and collection of protocol and user data within the WPAN.

The meter with LoRa Wireless Sensor Network sends and receives data from Network layer or Network Coordinators (NC) (Yu, Wu, Han, & Zhang, 2012)[14] The smart meter LoRa module is connected to the network server remotely sends data to water companies. The water company Central Offices (WCCO) receives data from Network servers and forwards to a software system which will analyze and detect any water loss. The software system has the following modules.

i. Data collection module which will interface with networks
ii. Data analysis module will generate reports from smart LoRa meter sensors on water loss.

The water service providers receive the analyzed information and provide mitigation on the water loss. These remote communications enables analysis, monitoring, loss detection and effective provision water to clients.

The technical model will have the following components;

1. The LoRa WPAN made up of smart water meters and;
2. A gateway router to forward data to the cloud.
3. The WPAN-to-WAN that will relay data for to be used by the water service providers Central Office (CO).

VI. CONCLUSION

To achieve a conclusive comparison study, a scalable sensor LoRa technology connected to a network in real time. There is also need to further investigate security mechanisms for better confidentiality, authentication and availability of the LoRa system for detecting water loss.

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REFERENCES


