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Design and Implementation of an IoT Assisted Real-Time LoRa Mesh WSN Based Smart water meter System for Deployment in Smart Cities.

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ABSTRACT—In this paper, we focus on the design and development of an Internet-of-Things (IoT) assisted real-time automatic meter reading (AMR) system for deployment in smart cities. At the bottom layer, the system is supported by a LoRaWAN wireless sensor network (WSN), in which smart water meters are the end user nodes. A loRaWan gateway node enables communication between the smart water meters and the utility. Code running in the electricity metering nodes enables real-time periodic reporting of water consumption data and tamper detection via the gateway node to a cloud. Access to the collected metering information, visualization, and data analytics, alert management and billing is done through a program interface that runs on the cloud.
Keywords-smart city ; water meter; loRa; wireless sensor network; automatic meter reading

I. INTRODUCTION

To improve the efficiency and accuracy of metering systems, smart water consumption meters have been widely implemented by utility companies worldwide [1]-[4]. In the most basic form, Automatic Meter Reading (AMR) systems [5]-[7] automatically collect water consumption and tampering with water meter data and transmit this information to a central database server (for billing, analysing and other operational purposes) using advanced communication technologies including long range RF wireless.

Advanced Metering Infrastructure (AMI) architecture based smart meters [17]-[20] provide two-way data communication and are capable of regularly reporting water consumption data. The benefits of AMI-based smart meters include improved accuracy and reliability, ability to monitor water consumption on daily, weekly and monthly basis and remote monitoring of any tampering with AMR Smart meter Since AMI-based smart meters provide data in real time, utilities are able to

utilize the data collected from such systems for various applications including accurate water consumption measurement, decision-making, and the detection of leakage, tampering, overload and other abnormalities.

The large streams of real time data generated by thousands of water meters have to be stored, accessed, processed and analysed dynamically whenever required. Emerging IoT and cloud technology offer the ability to take advantage of the infrastructure needed to handle this requirement without the need for significant up-front expenses on hardware and software and maintenance costs [21]. Utilities are thus increasingly implementing information and communications technologies (ICT) cloud under AMI for deployment in smart cities [22], [23].

Motivated by the above developments, in this paper we propose a smart metering system that extends the functionality of basic AMR systems, thereby providing benefits for utilities and end users using an IoT assisted cloud service for deployment in smart cities. The associated system architecture, hardware and software design and implementation are described.

I. LoRa

LoRa (from "long range") is a physical proprietary radio communication technique.[1] It is based on spread spectrum modulation techniques

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derived from chirp spread spectrum (CSS) technology.[2] It was developed by Cycleo (patent 9647718-B2), a company of Grenoble, France, later acquired by Semtech.

LoRaWAN defines the communication protocol and system architecture. LoRaWAN is an official ITU-T Y.4480 standard of the International Telecommunication Union (ITU).[5] The continued development of the LoRaWAN protocol is managed by the open, non-profit LoRa Alliance, of which SemTech is a founding member.Together, LoRa and LoRaWAN define a Low Power, Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated devices to the internet in regional, national or global networks, and targets key Internet of things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services. The low power, low bit rate, and IoT use distinguish this type of network from a wireless WAN that is designed to connect users or businesses, and carry more data, using more power. The LoRaWAN data rate ranges from 0.3 kbit/s to 50 kbit/s per channel.[6]

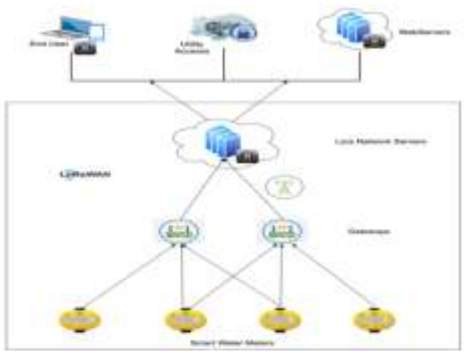

Figure 1. System architecture of the proposed system.

II. SYSTEM ARCHITECTURE

The system architecture of the proposed AMR system is shown in Fig. 1. The proposed architecture addresses a in an urban area, creating a LoRa mesh WSN in which the water meters (equipped with LoRa transceivers) are the network nodes.

The LoRa -based end node is composed of water flow sensors, a microcontroller and a LoRa communication device. The microcontroller is responsible for acquiring the sensed data,. The duty of the LoRa device is to read flow data form the microcontroller via a UART interface, and to communicate with the LoRa coordinator or a nearby LoRa router. The LoRa coordinator takes care of initiating and maintaining the LoRa devices in the LoRa network. In the proposed system, the LoRa coordinator acts as a LoRa gateway, and is responsible for Internet connection. The gateway transforms a data package (received from either an water flow node or a network extender/router node) from the LoRa protocol to the TCP/IP protocol before transmitting it to the utility cloud.

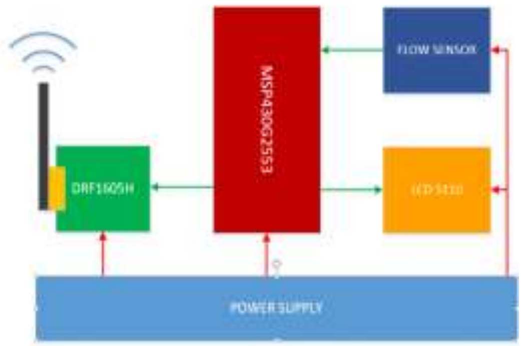

Figure 2. Functional block diagram of Smart Water meter end node.

Each LoRa based metering node is able to autonomously and independently report metering values, at regular intervals, to the nearby coordinator or the router node. The cloud enables the utility as well as the consumers to monitor the water consumption data every day. Under normal conditions, metering nodes are powered from the battery source.

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III. SYSTEM DESIGN

A. LoRa Metering Node Design

The functional block diagram of the ZigBee metering node, consisting of a microcontroller, sensing unit, communication unit and power support unit, is shown in Fig.2 The microcontroller [29] is adopted as the central processing unit responsible for calculating pulses from given input signals at its ADC terminals.An LoRa RF module is adopted as the communication module. The RF module communicates with the microcontroller through the UART port and allows for reliable and inexpensive data transfers from the microcontroller to the mesh WSN and a memory is used to store temporary data or data generated during processing. The power management unit supplies all modules with energy.Water flow sensor is used to take a note of how much water has been transferred from one area to the other. It consists of a plastic valve body, a water rotor and a hall-effect sensor.When water flows through the rotor, the rotor start rolling after feeling the pressure. Its speed changes with different rate of flow. The hall-effect sensor outputs the corresponding pulse signal. The Hall Effect is utilized in the flow meter using a small fan/propeller shaped rotor which is placed in the path of the water flowing. The water pushes against the fan of the rotor, causing it to rotate. The shaft of the rotor is connected to a Hall Effect sensor. It is an arrangement of a current flowing coil and a magnet connected to the shaft of the rotor, thus a voltage/pulse is induced as this rotor rotates. In this flow meter, for every liter of water passing through it per minute, it outputs about 4.5 pulses Calculate the flow rate in liters per hour (L/hr) using a simple conversion formula

Water flow rate is **Q=VxA**,

Where,

Q is flow rate/total flow of water through the pipe,

V is average velocity of the flow and

A is the cross-sectional area of the pipe

Pulse frequency (Hz) = 4.5Q, Q is flow rate in Liters/minute

Flow Rate (Liters/hour) = (Pulse frequency x 60 min) / 4.5Q

IV CLOUD DATA STORAGE AND MONITORING

The cloud-based service [33] provides an open source IoT application and API to store and retrieve data from "things" over the Internet using Hypertext Transfer Protocol (HTTP). is used to collect data forwarded by the application gateway, and store it for further processing and display. To use cloud the gateway was set up as a web client rather than a web server. The cloud server was also used to capture data and forgraphical display.

After creating a cloud developer's account,device channels (representing LoRa meters) were added. The customers metering data (channels) was made public for viewing with the help of special API keys. A specific feed number for each customer created. We used this feed numberwith the API key to calculate consumption data (water consumed in liter)].

While the cloud platform was used in this project to simply plot data, customers can also subscribe to events inwhich data collected through a web API is sent to a customized and secure website for data retrieval, analysis, visualization, and user interaction.

V IMPLEMENTATION AND RESULTS

The proposed system was experimentally implemented The implemented system consisted of LoRa water metering nodes,routers and a gateway. The general schema of these buildings with location of system nodes is shown in Fig. 9. Powered through standard AC-DC power adapters for power supply. Transformation and Connectivity IoT Transformation and Connectivity will provide a secure connection and provide a scalable platform for messaging between different applications. It also processes all the IoT meter information, cleans it, and makes a comparable format as per the cloud services. The core component of the cloud is the cloud application which executes the service as per the client's request. It also triggers some action as per the user requirement and logic to handle the user request. All the application control parts are coming under the Application Logic components. The end-user interfaces are coming under the visualization part. The user interacts with the end repository through the user interface shortly called UI. The UI is divided into three subcomponents called End User UI, Amin UI, and Dashboard. Through the end-user UI the normal user, like consumers can interact with the system, and through the admin UI administrator user interact with the system. The dashboard is the integration of both components and provides the platform for system settings. Analytic is the searching and presenting of the meaning full pattern of information getting from water metered data. It may help to describe and predict the water problem for the future and can analyze the requirements of water in the present scenario. The basic function of analytics is the analysis of data repository, converting the cloud as an intelligent system by learning the reason and purpose of the information for predicting the future situation, computing the data streaming, and providing a business environment using water.

Figure 3..AWS Cloud Dashboard for Visualization

We have developed Android based mobile application for water consumption reading. Application is user friendly it shows the water consumption in liters on daily, weekly and yearly basis, **is** one of the finest innovations for Mobile-based water meter reading data collection. The feature-rich water meter reading software solution is introduced. We have developed this solution using the power of Android platform and integrate user-friendly features that help users to easily fetch the meter reading record.Based on the Android platform, offers easy to use water meter reading facility, portability, and affordability to store water consumption details of endless consumers. Embedded with ultramodern features this app will help users to store and generate water consuming bills of thousands of consumers seamlessly.

VI. CONCLUSION AND FUTURE WORK

A AWS cloud assisted real time LoRa wireless mesh network based AMR system for implementation in smart cities was proposed. The hardware design and software implementation aspects of the proposed system were discussed. The system was successful in presenting metering information. The proposed system allows customers to participate demand side load management initiatives by making real-time choices about water utilization. This allows utilities to use proper water management . Utilities also benefit from the cloud based AMR systems as it improves reliability, and allows for dynamic billing and system non working and non revenue generated meter monitoring and control.

In future, we will extend this system to a larger network with two-way communication for on-off control of calibratedmetering nodes.

Figure 4. Android powered mobile app dashboaed.

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