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Smart Underground Drainage Water Management System - A Review

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Abstract-- Underground drainage water management system and the manholes in cities of our country India is one of the major issues, due to its poor maintenance. The drainage water that contains sewage and other domestic and industrial waste water is overflowed on the roads causing water logging and sometimes gets mixed up in the drinking water which causes health hazards to common people. To overcome this issue a model called Wireless sensor network based smart underground drainage water and safe multiple manholes management system is proposed. This proposed system will monitor various parameters related to various fluids in the underground drainage system such as the water level and gas level in the drainage system, manholes conditions, locating the underground blockage and removing the same in the drainage system and the measured values will be stored in the cloud storage. Then the stored data will be analysed and conditions of underground drainage water system and manholes will be sent to nearby corporation office as short message using IoT module.
Keywords— Iot(Internet of Things), WSN(Wireless sensory network), GSM(Global System for mobile Communication), CPU(Central processing Unit), Zigbee, Wi-Fi(Wireless Fidelity), GPRS(General Packet Radio Service), UDS(Underground Drainage System), RTC(Real Time Control)

I. INTRODUCTION

In India most of the cities has underground drainage system are maintained by Municipal Corporation to make clean healthy surroundings and hence environment. Often due to poor maintenance of the underground drainage system, the water in the drainage system gets mixed up with the pure water and consumption of this polluted water leads to water borne diseases. Due to sudden changes in the atmosphere and variations in the climate during different seasons the drainage gets blocked or water logged, making environment unhealthy and disturbs the healthy routine of common people. To overcome all these issues in the underground drainage system and inform the municipal corporation about the condition of the underground drainage system by sending short messages through internet , so that the officials can take the necessary action to repair the drainage system and the manholes. Also various gases are formed inside the drainage system due to domestic and industrial waste will also be detected using the different gas sensor so that we can avoid explosion due to pressure inside the drainage system. If the drainage system manhole lid is opened for long hours then by using tilt angle sensor modules we can detect the opening of the lid over the manholes and inform the municipal corporation officials to take proper action on it. Thus, main aim is to monitor the underground drainage fluids and manholes. If there is any kind of issue in the drainage system and it gets blocked or water overflows or if the drainage lid is opened, it is monitored using the different wireless sensors and the sensed information are sent to the nearby municipal corporation official via short messages using the internet and the sensed information are stored in the cloud storage for the later analysis purpose.

A. Overview of Internet of Things

Internet of Things (IoT) [1] is a sprawling set of technologies and use cases that has no clear, single definition. One workable view frames IoT as the use of network-connected devices, embedded in the physical environment, to improve some existing process or to enable a new scenario not previously possible.
These devices, or things, connect to the network to provide information they gather from the environment through sensors, or to allow other systems to reach out and act on the world through actuators. They could be connected versions of common objects that might already be familiar with, or new and purpose-built devices for functions not yet realized. They could be devices that you own personally and carry with you or keep in your home, or they could be embedded in factory equipment, or part of the fabric of the city you live in. Each of them is able to convert valuable information from the real world into digital data that provides increased visibility into how your users interact with your products, services, or applications.

B. Overview of WSN

Typically, a WSN [2, 3] can be defined as a network of nodes that work in a cooperative way to sense and control the environment surrounding them. These nodes are linked via wireless media. Nodes use this connection to communicate among each other. The architecture of a typical WSN consists of following 3 components: sensor nodes, gateway and observer (user). Sensor nodes and gateways constitute the sensor field. Gateways and observers are interconnected via special networks or more commonly via internet as shown in figure 1.1. Sensing Unit is necessary to monitor surrounding environment and its conditions such as humidity, pressure and vibration. After completing monitoring and sensing processes, necessary computations are accomplished in CPU. Lastly, computed environmental data are transferred by Radio Unit through the wireless communication channels among the nodes. Finally, these data are sent towards the Gateway. WSNs are collection of nodes and these nodes are individual small computers. These tiny devices work cooperatively to form centralized network systems. There are some requirements for nodes to be used in these networks such as efficiency, multi-functionality and being wireless.

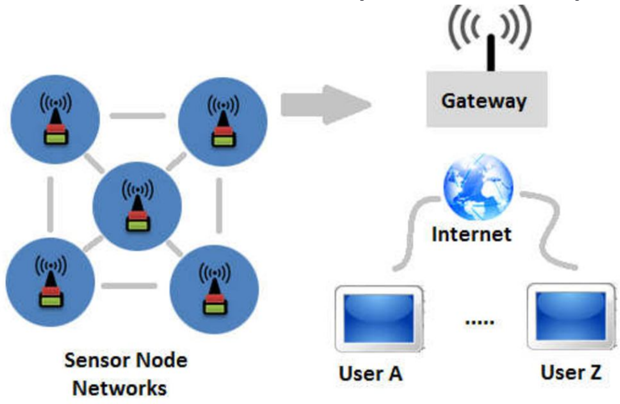

Figure 1.1 Wireless Sensor Network (WSN)

Moreover, each node in any network has a predefined goal. For example, if it is aimed to collect information about microclimates across all sections of any forest, these nodes are placed in different trees in the forest to form a network. In this network, they should have a centralized and synchronized structure for communicating and data sharing. The sensor nodes are placed in a connected network according to a certain topology such as linear, star and mesh. Nodes of the network in any topology have a limited broadcast range which is generally 30 meters.

In WSNs, data collection and data transfer are accomplished in 4 steps: collecting the data, processing the data, packaging the data and transferring the data as shown in figure 1.2. A WSN is composed of several numbers of sensors and a gateway to provide connection to the Internet.

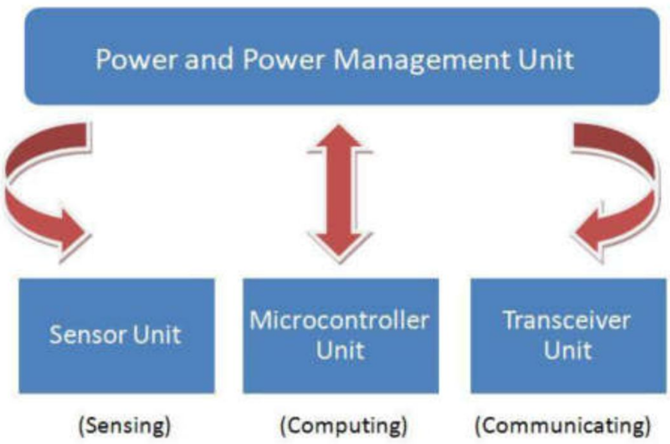

Figure 1.2. Data collection and data transfer

II. LITERATURE SURVEY

Hans Arisz, Brian C. Burrell [4] presented details on the effects of urbanization on storm-water management and design of drainage infrastructure with the effects of climate change. Hence they suggested various approaches in infrastructure planning and design. The first approach to accommodate the effects of climate change is to design using historic design flows and accept a gradual decrease in the level of service provided by the drainage infrastructure. In situations where periodic flooding and the incurrence of minor damage associated with flooding are acceptable. A second approach that can be taken to accommodate the effects of climate change is to design and construct structures with sufficient flow capacity to handle future, rather than current, flow conditions. A third approach is to design and build infrastructure for shorter design lives, and then retrofit or replace the infrastructure in the future when conditions necessitate. The implications of climate change for drainage infrastructure can be managed through long-term planning that accounts for future increases in flows. The ability to adjust the hydraulic capacity in these instances is facilitated by the fact that large drainage infrastructure (such as bridges and large culverts) generally is "standalone" and can be isolated for refurbishment or replacement. Urban drainage infrastructure, in particular the storm sewer system, is however integrated and "intermixed" with a large number of other infrastructure (water supply system, sanitary sewer system, gas lines, buried power utilities, communication systems, and transportation systems), and is surrounded by real estate that generally over time becomes more valuable and more densely developed. A fourth approach to the planning and design of urban drainage infrastructure consists of using historic design flows and the acceptance of a gradually decreasing level of service for the minor system, while accommodating the expected future effects of climate change during the planning and design of the major system. During the design of new drainage infrastructure, the interaction between the minor and major system should be carefully assessed, and the hydraulic performance of the combined minor/major system should be designed in an integrated manner. Drainage design criteria should ideally be reviewed and revised based on a cost benefit analysis and risk assessment considering the threat of climate change.

Chan H. See, Kirill V. Horoshenkov, Raed A. Abd-Alhameed, Yim Fun Hu, Simon J. Tait [5] presents the development and validation of the deployment of sensors at pilot scale within a residential urban area. They demonstrated that water level data collected at gully pots (the most basic entry to the sewer network at a residential property level) can be used to reduce residential flooding incidents.

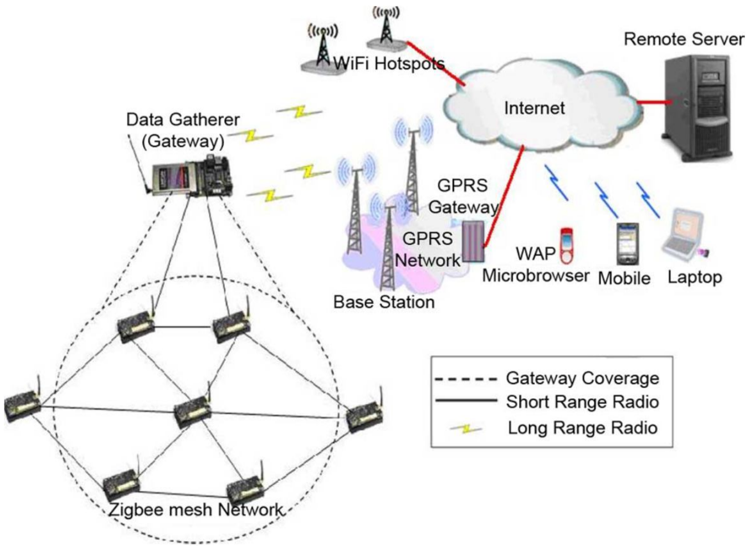

Figure 2.1. Wireless sensor network system architecture.

Figure 2.1 describes the architecture of the low power mesh network wireless sensor system. This system is designed to monitor the water level in gully pots connected to the sewer network. Zigbee [6,7] based short ranged WSN was selected for this application because of its low cost, low data rate, low power consumption, simple communication infrastructure, low latency and capability to support one master and up to 65000 slave control Units. The system consists of sensor nodes, a data gatherer and a remote user terminal. Each sensor node comprises of a radio transceiver, data acquisition board and acoustic sensor probe. Communication between the sensor nodes and the data gatherer is via the Zigbee protocol. The data gatherer communicates with the remote user terminal via either the Ethernet connection or WiFi/GPRS access, depending on the type of user terminal being used. Apart from providing the interface between the sensor nodes and the user terminal, the data gatherer also acts as a web-server. Once the sensor nodes received the digital sensor signal via the interface circuit board, by implementing a mesh network communication configuration, this WSN allows for continuous connections and reconfigurations around blocked paths. This results in hopping from sensor node to node until a connection can be established with the data gatherer. It should be noted that the mesh networks possess the self-healing capability that will operate even when a node breaks down or a connection fails. As a result, it forms a very reliable network. As soon as the data arrived at data gatherer, it is stored in the web-server database. The data is then retrieved by the user terminal and a graphical output of the water level and the battery level are displayed through an application interface.

The results of field trial give sufficient information to the collaborating water company to evaluate the success of the system based on cost-benefit criterion so that planning for future large scale sensor deployment could be made.

Muragesh S K and Santhosha Rao [8] proposed a system for avoiding blockages in the drainage systems during rainy season. Thus it will solve problem for routine life such as traffic may get jammed, the environment becomes dirty, and totally it upsets the public. The system has a remote monitoring system to monitor the internal states of the manhole. Figure 2.2.1 shows the transmitter block diagram in which sensors senses all the parameters and converts it into electrical quantity. To overcome the problem of open drainage system, most of the cities were adopted the underground drainage system to keep the city clean, safety and healthy. This is a design of monitoring manholes through internet.

This design provides three way alert systems, which include Route map, LCD display and Speakers. Figure 2.2. 2 shows the block diagram of receiver which collects the serial data from the serial port and displayed it on the monitor using terminal emulator program. This proposed model includes the overall view of the city which shows the manhole locations and different areas of the city. All the problems occurred in manhole are detected by sensors and sends this information to remote monitoring station.

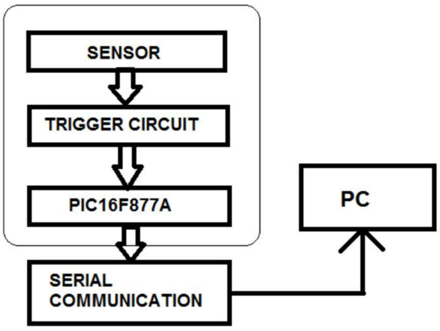

Figure 2.2.1: Transmitter

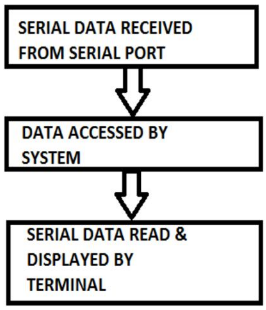

Figure 2.2. 2: Receiver.

Sensor unit senses all the physical parameters like temperature, water overflow, manhole lid open or closed, explosions due to release of chemical and electrical energy inside the manhole and convert these inputs into electrical output, this electrical output received as a input to PIC 16F877A and programmed in such a way that to display all the alert information into readable text messages and displayed on the monitor.

R. Girisrinivaas, V. Parthipan , [9] proposed a network system where in figure 2.3 shows the system architecture of the proposed WSN, the network consists of GSM [10] sensors nodes, network coordinator, and Cloud storage.

Figure 2.3 Proposed System Architecture

In order to examine the information and analysis results, a remote graphical user interface is developed further. Based on the proposed system architecture, sensor nodes response to sample the physical parameter to measurable voltage level through corresponding sensors; then GSM module digitalizes and codes the voltage level to network information; sent these acquired data to the organizer through the established wireless links. Coordinator is focusing to constellation maintenance, collect data and transfer the reassemble information to the cloud storage using the GSM transceiver through mobile internet. Open WSN Cloud data storage platform Xively [11] custom-made in this work. The Xively platform offers versatile data assortment and visual image; therefore ease the support of enormous number of sensor data streams and processing.

S. Ravichandran,[12] proposed architecture that exploit RFID communication to reduce costs, and support scaling at urban level. The system enables cleaning operators to better plan their cleaning schedules and routes. There is a module present under each manhole which is having a microcontroller interfaced with gas sensors, level indicator, zigbee protocol and RFID. All the data or any crisis in regards to the blockage will be sent by the microcontroller to the user. The manholes present in the drainage are identified with numbers such as 1, 2, and 3 by using the RFID. The RFID tags are attached to every manhole each of which is having an RFID reader to give detailed information of the manholes on the map. Whenever there are any issues regarding the blockage or gas leakage, the RFID will display the exact location of the manhole followed by the level indicator and gas sensor data respectively.

The level indicator can identify the blockage between two manholes and it will be helpful for the user to identify the blockage and take necessary action. As the level indicator to indicate the level of drainage underneath the manhole that is calibrated to two different levels of drainage. The first level is marked under the manhole at h/3 (where 'h' indicates the height of the drainage) which serves as a warning zone indicating the rise of the level. The main control hub room will be notified in case there is an increase in this level. The second level is marked under the manhole at a height of 2h/3 (where 'h' indicates the height of the drainage) to indicate the personnel that further rise in the level indicating the blockage; an alarm will be triggered in case any such situation regarding the emergency/blockage is detected. Whenever there is blockage in the drainage, the level indicator will send information to the main server with the help of communication module, ZigBee. If the gas sensor detects the leakage of any hazardous gas then it will be highlighted in the map along with the manhole number on the map. After getting the information regarding the blockage or any gas leakage, the user can clear the blockage with the help of water jetter or electrical reel.

Joaquim Leitão, Alberto Cardoso, José Alfeu Marques, Nuno Simões[13] proposed a rule-based control system to monitor a underground drainage system(UDS), determining when and how to operate a set of barriers to attenuate as much as possible the effects of intense rainfall events. The developed control system monitors a given UDS remotely, by using rainfall, flow and water level sensors and actuator networks to collect information in strategic locations, process it, identify critical regions in the UDS where it must actuate, and compute control actions to be executed with the goal of avoiding overload scenarios. The proposed method plays a significant role in the accommodation of increasingly intensive rainfall and flood events due to natural calamities.

L. García, et al.[14] presented a review paper where some relevant RTC(Real Time Control) strategies applied to UDS, which can be divided into optimization based and heuristic-based algorithms. Moreover, some relevant modelling approaches commonly used for UDS are also reviewed, proposing a taxonomy of UDS models (simulation-oriented and control oriented), and discussing the run-time and complexity of the considered UDS models. The most relevant software tools used to simulate and to control UDS are also presented.

Numerous studies have led to actualize the idea of IoT[15] and cloud computing[16,17] to make the urban areas, more intelligent with the usage of sensors which creates vast measure of information.

III. CONCLUSION

The proposed systems provides a smart drainage management system that monitors various parameters under the multiple manholes , removes blockage based on the indication received and can utilizing solar power[18,19]for their operation.

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