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INTELLIGENT MANHOLE COVER

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Abstract - **Some systems, such as drainage system, electric power system, network system, and so on, are laid underground in modern cities. In order to manage these systems, many holes with manhole covers are made in the pavement. However, manhole cover accidents, including vehicles and people falling in the holes, frequently occur as a result of manhole cover displacement, loss, and damage, threatening lives and safety. This paper offers an intelligent manhole cover management system (IMCS) for smart cities. A unique radio frequency identification tag with tilt and vibration sensors is used for each manhole cover, and global system for mobile communication is adopted. Meanwhile, toxic gas levels are sensed using sensors and the poisonous gas build-up is reduced by venting properly.**

I. INTRODUCTION

Manhole cover accidents are primarily the result of uncovered holes, with no way to monitor their status in real time. Manholes are deadly places due to gas build-up. Many unfortunate deaths have occurred in the past due to improper safety procedures by workers who enter them without testing and venting properly. So it is really important to analyze the gas and take precaution before entering inside the manhole

The most common ways to obtain the status of manhole covers, especially their damage are periodically inspected by government officials and reports from people on the road,which depend on people. Periodic inspections by government officials consume large quantities of human resources to cover the large number of manhole covers in a city. Moreover, this does not provide real-time performance. It may take one or more days for problems to be found through such inspections, with even a month required in the suburbs. Such delays allow dangers to exist. It is difficult to solve the problem of manhole covers being lost with no method for monitoring traditional manhole covers. Moreover, a manhole cover is easy to carry.

There are mainly three types of dangerous situations which can be found in sewer manholes or "confined space" e.g. (a) explosive gas (like methane), (b) toxic gas (like hydrogen sulfide, ammonia, carbon monoxide) and (c) lack of oxygen. Methane is generated by decomposing sewer mainly hydrocarbon, which can be ignited by a small spark, causing violent explosion. All ofthese urgent problems are pushing to adoption of more intelligent technologies to manage all the manhole covers in the cities, especially in a smart city. The intelligent manhole cover management system must have the following advantages:

Self-perception. Every manhole cover has the ability to monitor whether it is tilted, damaged, or displaced, as well as the ability to locate itself. Active real-time alarm. Every manhole cover has the ability to actively alarm in real time when it has been tilted, damaged, or displaced.

Real-time response. The intelligent manhole cover management system needs a mechanism to ensure a response to the alarm from a manhole cover in real time. Moreover, repair personnel can be scheduled in real time.

Low management cost. One aim of the intelligent manhole cover management system is to reduce the costs, including those for human resources, bandwidth resources, and energy resources. Short average repair time. The most important aim is to shorten the average repair time for a tilted/damaged/displaced manhole cover to reduce the risk of falling into the hole.

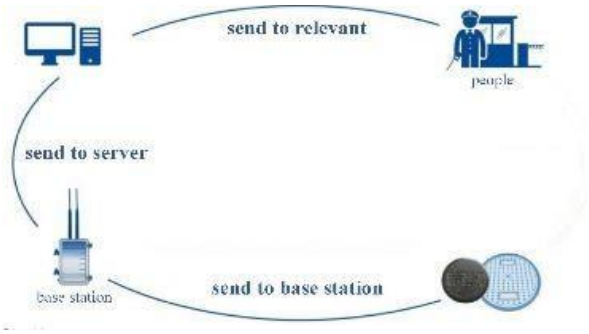
Sampling of toxic gases is a manual process which consumes a lot of time. The chemical handling is also a big problem in the field without experts. Thus the present method of collecting the gases from manholes and its analysis is very difficult and time consuming; hence the sensors are being used in this paper.

In order to meet these requirements, this paper proposes an GSM based intelligent manhole cover management system (IMCS) for smart cities using unique radio frequency identification (RFID) tag, as well as tilt and vibration sensors, additionally toxic gas detectors and ventilators are used. Therefore, it can monitor itself. The IMCS adopts GSM for communication. Thus, all the manhole covers can communicate with a server. Moreover, GSM is established to provide real-time responses. The server handles all the data for the manhole

covers, including their locations and status values, in real time. Relevant persons communicate through the server, scheduling repair jobs, noticing abnormalities, and so on. The average response time, which was defined as the time between the manhole cover alarm and servers response, was less than a minute. Moreover, the IMCS could reduce human resources by eliminating unnecessary periodic inspections. The main contributions of this paper are as follows:

Implementation of RFID based IMCS, which can efficiently manage all the manhole covers in a city with greater safety and lower cost.

Global System for Mobiles is the primary technology used globally for 3G mobile networks, with about a 73 percent market share. GSM competes primarily with Code Division Multiple Access technology, which is the technology used by five of the seven largest carriers in the United States. While GSM provides compatibility, multitasking and speed advantages over CDMA on a 3G network, most carriers around the world are switching to the Long Term Evolution standard for their 4G networks.



Sewer gas toxicity level detecting sensors, senses the minimum threshold value and ventilates automatically.

This reduces death of workers entering to clean the sewage. The remainder of this paper is organized as follows. We first analyze the related work. Next, we illustrate the IMCS architecture. Subsequently, we discuss the demonstration application of the IMCS. We finally conclude this paper.

II. RELATED WORK

RFID technology was proposed for communication between a reader and tags based on radio waves, making it possible to automatically track and locate or identify objects such as animals and people without the need for a line-of-sight method [1]. An RFID reader has two modes, fixed and static. RFID tags are intelligent barcodes, which allows them to be easily tracked. RFID tags communicate wirelessly with the reader. An RFID system can easily meet the self-perception requirement and provide a user with information about an objects type, location, and condition. An RFID system has three main components: the RFID tags, RFID readers, and antenna. RFID tags are microprocessor chips, each of which consists of an integrated circuit with a memory. A unique code for identifying the tag is stored in the memory, which is called the tags ID. There are two types of tags: passive and active tags. The circuit sizes, communication distances, and power values are the mainly differences between them.

Passive tags are smaller in size and cheaper, and the communication distance can be 8 m. However, active tags have their own power source for communication RFID technology has been identified as an attractive solution for intelligent objects [2]. RFID-based techniques have been used for monitoring displacement [3]. Therefore, in this study, we attached an RFID tag to each manhole cover to establish an intelligent management system [4]. Simultaneous Voice and Data

When you use a GSM network, you can talk on the phone and surf the Internet or sync your email at the same time. That's usually not an option if you're using a phone on a CDMA network. CDMA released an add-on option called Simultaneous Voice and Data Optimization that would enable callers to use voice and data at the same time, but the add-on would require changes to both the CDMA network and CDMA phones. Carriers in the United States have not adopted the add-on for their networks.

2.1 Speed

A GSM network is generally much faster than a CDMA network. Most GSM carriers adopted the High- Speed Packet Access extension for 3G networks that enable data transfers as fast as 42Mbps. On a 3G CDMA network, the maximum data transfer rate is 3.6Mbps.

2.2 4G LTE

Most carriers have adopted the LTE standard for their 4G networks, which enables very fast simultaneous transfers of both voice and data. However, all U.S. carriers will keep their 3G networks in place until at least 2020. Customers who live in an area without 4G coverage will need to continue to use a 3G network. iPhone users will have to upgrade to the iPhone 5 or a later version to use the popular phone on a 4G network.

III. PROPOSED IMCS ARCHITECTURE

The IMCS mainly consists of three parts, as shown in Fig. 1. 1) An RFID tag with tilt and vibration sensors is attached to each manhole cover, which facilitates intelligent and active communication. 2) Both the internet and GSM are used for efficient communication with manhole covers and the internet used for end user management. Immediately. Moreover, managers can track all the manhole covers in real-time.

3.1 RFID TAG

The RFID tag attached manhole cover has a self-perception ability, which allows it to report its own status. It has become an intelligent manhole cover.Some sensors are built into it, including tilt, vibration, and location sensors. Therefore, any movement, rotation, and vibration of the manhole cover can be immediately sensed. This is the most important part of the intelligent manhole cover.

The Gsm network is one of the most important parts for implementing the IMCS. The server needs to communicate with all the manhole covers. Managers must track all the manhole covers, and the server needs to schedule repair jobs with the relevant people. All of these operations are related to the network. However, different communication objects have different communication demands, as demonstrated The main demand for the communication between the server and manhole covers is the large number of connections. There are millions of manhole covers in a city. Therefore, the network for this communication must support a large number. Moreover, in order to reduce human resources for manhole cover management, the intelligent manhole cover must operate without human intervention for as long as possible. Thus, the communication power must be low. In addition, the network must cover as large an area as possible because manhole covers are needed in every corner of the city

Both a local area network and the internet are adopted to allow managers to track the status of all the manhole covers in real time. In the management center, the management server and management terminal are connected by a local area network, and managers can immediately track the dynamic status of every manhole cover through the local area network. In order to track the dynamic status of each manhole cover immediately outside the management center, the internet is also adopted in the IMCS.

Both the internet and GPRS are adopted to allow the server to schedule repair jobs for the relevant people. The server can send repair jobs to the relevant people through the intelligent manhole cover management. *RFID based Management System* Based on the above two parts, the manhole cover with the attached RFID tag and the network that combines GSM and internet, the server can obtain the data from manhole covers. However, it is important to respond the abnormal condition immediately when receiving an alarm information from a manhole cover.

RFID tag with the sensors in the manhole cover makes it possible for the server to obtain dynamic information about its location, even if it is moving. Moreover, the management system must respond in real time to the dynamic location information, which can be used to solve the displaced manhole cover. With a real-time response, things will become easier .Some of the necessary parts for the proposed IMCS are listed below.

Unique identification. Because of the large number of manhole covers in a city, the manhole covers need to be distinguished. Every manhole cover has a unique identification (ID). Moreover, it is very important to quickly locate an abnormal manhole cover, especially for repair. The location information (longitude, latitude) can solve this problem. Therefore, every manhole cover used has location information, (longitude, latitude).

Manhole cover state. The most normal state for a manhole cover is simply online. However, some other states may appear, such as tilted, rotated, moved, and offline, when some abnormal event occurs to the manhole cover.

Intimating relevant people using GSM. After the server receives an abnormal state, it will notify relevant people . The text that is sent will contain the following information: 1) the unique ID of the abnormal manhole cover, 2) its location (longitude, latitude), and 3) possible faults, which are used to accelerate the repair.

Vibration Sensor Ventilation of toxic gases the primary purpose for having an Ventilator fan is to remove the moisture out of the sewer. These fans help to control and gradually reduce the sewer odors and toxicity levels. Additionally, they add to the safety of the manhole

workers and it's residents by reducing fumes from cleaning agents that could potentially cause health related issues. The threshold levels of toxic gases are listed below.

Sensor name	Detection range
Methane sensor	300-10000 ppm
Carbon monoxide sensor	10-10000 ppm
Carbon dioxide sensor	0-100% (Volume)
Ammonia sensor	5-500 ppm
Hydrogen sulfide sensor	1-200 ppm

IV. EVALUATION OF RESULTS

In this section, we present the results of a case study where some abnormal states for the intelligent manhole covers were set to evaluate the effectiveness of the IMCS. We established a server for the system in the management center. It lists the configuration specifications. For each manhole cover, we only stored dynamic information about its location (longitude, latitude) and state. Therefore, the amount of data was not very large, and a large storage system was not needed. *Response Time Analysis* The greatest advantage of IMCS is its quick response to abnormal status of the manhole covers to reduce risk. In order to analyze the response time of the IMCS, we recorded the time between the tilt/move/rotate actions for a manhole and the reception of a repair notice. First, the manhole cover sends abnormal information to the base station through the GSM According to the abnormal action. The sent information consists of the unique ID, location (longitude, latitude), and state. Second, after receiving the information from the manhole cover with the attached RFID tag, the base station sends the information to the sever through the internet. Third, the server sends the information to the relevant people to schedule a repair. Finally, the people go to the location of the abnormal manhole cover to make the repair. The received information consists of the location and state. Because the time that passes before the maintenance personnel go to make the repair after receiving the scheduled job is not easy to evaluate, in this paper, we only use the first three parts to analyze the response time. The manhole cover sends abnormal information to the base station; the base station sends this abnormal information to the server; and the server sends the abnormal information to the relevant people. The tilted, rotated, and moved states are actively alarmed by the manhole cover itself, whereas the offline state is checked periodically by the running thread.

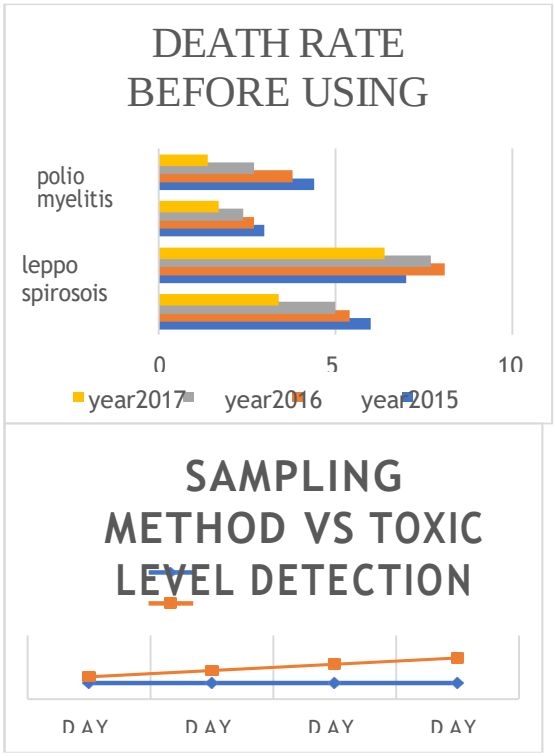
4.1 RFID (Reader & Tag)

Death before using sensors

4.2 Extended Applications

There are some extended applications that can be merged into our proposed edge computing-based IMCS. Intelligent distribution. Multiple repair people are located in every corner of a city. When the server receives abnormal information from manhole covers, it is better for the intelligent management system to distribute the repair jobs based on the locations of

both the repair people and the abnormal manhole covers. This can reduce the time and traffic burden. Optimal scheduling during floods. The manhole cover can be equipped with additional sensors such as for water level monitoring. In this way, during a flood, the system can be used for real-time evacuation mapping Map. Every road in the city has numerous manhole covers. Therefore, more accurate traffic data could be collected using the manhole covers with attached sensors.



V. CONCLUSION

In order to cater to smart cities, this paper proposed an IMCS. A unique RFID tag with tilt and vibration sensors was attached to each manhole cover to make it more intelligent and allow it to monitor itself. The IMCS adopts a GSM for communication because of its high efficiency and also sewer toxicity is reduced to minimal levels by venting automatically using sensors.

Thus, all the manhole covers can communicate with the server. Relevant persons can be notified by the server to distribute repair jobs. The average response time, which denoted the time between the manhole cover alarm and server response, was less than a minute Moreover, the IMCS could reduce human resources by eliminating unnecessary periodic inspections.

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