Research on Application of IOT in Domestic Waste Treatment and Disposal*

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Abstract - There have been a number of deficiencies in domestic waste source regulation, dynamic monitoring, etc., caused by geographical conditions, technology and other factors for a long time which brought low efficiency and illegal behaviors to refuse treatment. As a new network technology, IOT has significant advantages for its traceability, dynamic characteristics in solving the problems above. This paper established a brief introduction of IOT, summarizing its application in domestic waste treatment and disposal. In case of a certain place, the current situation and existing problems were presented. Furthermore, the promotion of Information management efficiency were expounded and prospected with the combination of the Internet of Things technology.

Index Terms - Internet of Things (IOT), Radio Frequency Identification (RFID), Geographical Information System (GIS), Global Position System (GPS), Sensor Network.

I. INTRODUCTION

With the improvement of people's living standard, domestic waste is increasing rapidly in our country. China has become the world's biggest trash producer, whose domestic waste accounts for about 26% of the world’s total and is increasing 8%-10% each year. In 2011, domestic waste output was about 2.77 tons, among which 1.64 tons was collected, the percentage of domestic waste treatment was 91.9% and the percentage of domestic waste treatment/disposal harmlessly treatment reached 67%. Percentage of landfill, incineration and compost proportion accounted for 61.4%, 15.9% and 2.6%, the remaining 20.1% was stacked or simple land filled.

Currently, there are still many problems existing in the process of domestic waste treatment and disposal of our country, such as low resource utilization rate, serious secondary pollution, waste violating treatment and so on, which have seriously restricted the sustainable development of society. The main reasons for these problems are that existing supervision means are difficult to master information such as waste sources, transport vehicles and waste disposal site. IOT has advantages of traceability, dynamism, real-time etc. which can completely solve problems above.

This paper introduced application of internet of things technology in domestic waste treatment and disposal, and then summarized the current situation and existing problems, finally, we looked forward to the future of IOT potential in promoting the efficiency of information management.

II. INTERNET OF THINGS TECHNOLOGY

Internet of Things (IOT) is a kind of network technology, which is based on information sensing equipments such as RFID, infrared sensors, GPS, laser scanners, gas sensors and so on, can make anything join the Internet to exchange information according to protocol, in order to realize intelligent identification, location, tracking, monitoring and management. In short, IOT can realize active information exchanging among things and achieve a variety of information services and applications. IOT has played a key role in areas such as industry, agriculture, medical care, transportation, environmental, protection, logistics, etc. depending on its technical advantages.

Domestic waste treatment and disposal, for example, IOT has significant advantages on waste traceability, dynamic trajectory tracking, online parameter monitoring, etc.:

1) Radio Frequency Identification (RFID) is an important node in IOT, combining a variety of cutting-edge technology, such as computer technology, network technology, RF technology and so on. It achieves automatic identification of objects by using the transmission characteristics of radio frequency signals or spatial coupling (inductive or electromagnetic coupling). With its advantages such as unique identifying, information diversity, unattended operation, strong anti-jamming, etc. combining with the Internet and communication technology, it can realize traceability and supervision of domestic waste.

2) Geographical Information System (GIS) is a spatial information technology system, whose role is to collect, store, manage, calculate, analyze, display and describe the data on geographical distribution in the whole or part of the earth's surface (including the atmosphere) space. Because GIS is based on the geographic spatial database, it can provide many kinds of spatial and dynamic geographic information.

Global Position System (GPS) is mainly to provide real-time weather and global navigation services such as three-dimensional position, velocity, system time and so on for sea, land and air.
With the combination of GIS and GPS, the dynamic trajectory tracking of domestic waste can be realized.

3) Sensor Network integrates sensor technology, embedding computer technology, modern network, wireless communication technology, distributed information processing technology, etc... First of all, It monitors, senses and gathers various kinds of environment or supervised objects information through the cooperation of micro sensors, and then processes the information take advantage of the embedded system, finally, it sends the sensed information to the terminal user as the multi-hop relay mode.

III. APPLICATION STATUS OF IOT IN DOMESTIC WASTE TREATMENT AND DISPOSAL

In recent years, more and more researchers applied IOT into monitoring of domestic waste sorting, transport, etc., and acquired some fruits, which have laid the foundation for the comprehensive use of IOT in the process of domestic waste treatment and disposal.

Since the mid-1990s, when RFID technology was first applied to the recognition of domestic waste and dustbin, Germany has led RFID technology into the management of MSW collection and transportation: German Federal Waste Management Association collates the relevant data that collected by RFID, and collects fee according to it\[^{18}\]. The Korean government invested 2.3 billion won to install dustbins with RFID technology in seven demonstration areas in 2013, in order to Monitor the source information and be charged by weight. Aiming at the problem that California's hazardous waste regulation ability is weak, John E. Estes\[^{19}\] introduced GIS into the monitoring and management system, which improved efficiency greatly. In view of the increasingly serious solid waste management issues in Malaysia, Maher et al\[^{20, 21}\] introduced RFID + GPS technology into the detection system, and realized the real-time tracking and supervising of solid waste.

IOT in domestic waste treatment and disposal is increasingly attractive at home: the management platform of Wuhan renewable resource information by Li Xiang\[^{22}\] the electronic waste recycling system by Shanghai Gold-bridge Renewable resources market management Co. Ltd., the platform of Shanghai domestic waste logistics information\[^{23}\] and so on, which were all based on the integration of RFID, GIS, GPS, and sensor network technology, have achieved expected effect.

IV. APPLICATION EXAMPLE OF IOT IN DOMESTIC WASTE TREATMENT AND DISPOSAL

Treatment and disposal of domestic waste contains three links including treatment, transportation and disposal. Treatment contains sorting, physical treatment (compaction, crushing, solidification), incineration, biological treatment and so on; disposal consists of marine disposal (ocean dumping) and land disposal (landfill, land farming, deep well injection).

In accordance with the treatment/disposal methods and procedure, we established the flow chart of domestic waste treatment and disposal (Fig. 1).

There are still problems in above process: 1) Due to the high dispersion and low traceability of waste sources, the collection and statistical information such as waste output, waste composition, waste sorting rate, etc., were not timely and accurate, which greatly reduced the rationality of domestic waste treatment and disposal and seriously affected the efficiency of domestic waste utilization; 2) Due to the lack of dynamic trajectory tracking methods, the information of waste transportation can't be real-time mastered, which lead to the phenomenon of violation occurred frequently; 3) Because of the lack of complete sensor network, the important parameters such as equipments status, environmental index and so on were missing, which led to the problems of inefficiency and secondary pollution.

Aiming at the above problems, since 2012 we began developing the real-time monitoring and management system of domestic waste treatment and disposal basing on IOT typical technologies and database technology (Fig. 2).

According to IOT architecture, the monitoring and management system is divided into 3 layers\[^{6}\]: perceptual layer, transport layer and intelligent application layer (Fig. 3):
Fig. 3 Technology architecture of domestic waste treatment and disposal real-time monitoring and management system.

1) Perceptual Layer
Perceptual layer is mainly to realize information collection, capture and recognition, whose key technologies including sensors, RFID, GPS, short distance wireless communication, etc.[6]

According to the characteristics of each link in the process of domestic waste treatment and disposal, we configured different technologies into each link of the system, which made them an organic whole through interaction, interrelated and coordination, accordingly realize the maximum of technical advantages (TABLE I).

| Station                        | Technologies                  |
|-------------------------------|-------------------------------|
| Waste Sorting                 | RFID - Wired Sensors          |
| Resource Treatment/Disposal   | RFID - Wireless/Wired Sensors |
| Recycling Treatment/Disposal   | RFID - Wired Sensors          |
| Landfill/Ocean Dumping        | RFID - Wireless/Wired Sensors |
| Transportation                | RFID - GPS                    |

TABLE I
TECHNOLOGIES OF EACH STATION IN PERCEPTUAL LAYER

2) Transport Layer
Transport layer is mainly to transmit information, which is the basic bearing network of IOT. It is classified as access network and core network: access network provides internet access, mobility management and so on, containing all kinds of wired access and wireless access; core network is a uniform, high performance and scalable network which is based on IP, supporting heterogeneous access and terminal mobility[6].

TABLE II
TECHNOLOGIES OF EACH STATION IN TRANSPORT LAYER

| Station                        | Access Network | Core Network |
|-------------------------------|----------------|--------------|
| Waste Sorting                 | Wireless Sensor Network | GPRS-VPN |
| Resource Treatment/Disposal   | Field Bus Wireless Sensor Network | Internet |
| Recycling Treatment/Disposal   | Field Bus Wireless Sensor Network | |
| Landfill/Ocean Dumping        | Field Bus Wireless Sensor Network | |
| Transportation                | Wireless Sensor Network | SATCOM |

Differences among links of perceptual layer leads to the heterogeneity of access networks, which is mainly manifested in the following aspects: 1) The diversity of wireless sensors leads to the heterogeneity of spectrum; 2) The diversity of technologies of perceptual layer leads to the difference and incompatibility of interface and relevant protocols; 3) According to the diversity, redundancy and randomness of transmission data, we choose internet, GPRS-VPN and SATCOM as the wired and wireless core network to realize common fusion and feature collaboration, so as to accomplish the ubiquity, high speed and convenient of data transmission (Table II).

3) Intelligent Application Layer
Intelligent application layer is divided into supporting sub-layer and application sub-layer:

Supporting sub-layer is based on database, intelligent information processing, cloud computing, middleware, GIS, expert system, service support platform, information discovery and so on (Chart 3). It realizes the functions of information storing, data mining, application deciding, etc. through the selection, fusion and optimization of data from transport layer, so as to form the real-time dynamic data repository meeting the supervision needs.

Considering the basis, and the help of the real-time monitoring and management platform (Fig. 4), application sub-layer can realize the monitoring and management of domestic waste treatment and disposal as following, and then can solve the major problems of waste treatment and disposal effectively.

1) Realizing the traceability of waste sources; 2) Realizing dynamic trajectory tracking; 3) Realizing the online monitoring of important parameters such as equipments status, environmental index.

In addition, the platform also provides functions of data statistical and analysis, report printing, intelligent query and so on, which improves the efficiency and accuracy of supervision work greatly.
The popularity and application of IOT in the supervision of waste treatment and disposal will become the
tendency of development because of the potential, significant
technology advantages and application requirements. Although
we have made some achievements, there are still many technical problems, such as low power consumption, low cost,
miniaturization of wireless sensors, the coordination of technical standards, etc. IOT still has plenty of potential, with
the deep study on it, IOT will be more huge promotion.

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