WasteMiner: An Efficient Waste Collection System for Smart Cities Leveraging IoT and Data Mining Technique

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***Abstract*—An efficient and automated waste collection system can facilitate the overall waste management of any smart city. Many IoT-based techniques are developed to make waste collection system optimized and autonomous. However, none of them considers any situation when IoT-based technique could fail to transfer data due to any unforeseen reasons (e.g, natural calamity, poor maintenance, device failure, connection outage, etc.). In this work, we propose an IoT-based technique named *WasteMiner* for collecting waste in an efficient way where we also calculate the shortest distances between the waste bins for making the system fuel and time efficient. Moreover, we collect data of waste levels of the bins and apply data mining technique to the collected data for extracting important information. This information help us collecting waste in an efficient way in the case of any system failure in the IoT-based network of WasteMiner. Our experimental results show that WasteMiner is effective and efficient when, i) IoT-based system functions properly, ii) any system failure or communication problem occurs, and iii) if scaled up properly, can be applicable to real-world systems by integrating WasteMiner as one of the key smart city components.**

***Index Terms*—IOT, Data Mining, Waste collection, Shortest Distance, Frequent Itemsets.**

I. Introduction

Waste management is challenging in urban areas due to its high density of population, diverse culture, food habits, and different lifestyles. Today, nearly 56% of the world's population lives in the cities [1]. According to statistical trend, almost 70% of the population will move to the cities by 2050 [2]. Thus, the cities will produce more unwanted materials from homes, public areas, educational institutions, religious institutions, health sectors, etc. Therefore, smart sustainable infrastructure is required to manage waste in the cities. Although many developed countries manage their waste quite efficiently, waste management situation in developing countries like India, one of the most populated countries in which one-sixth population of the world resides is still facing multiple challenges for managing their everyday waste. With dense population, some other factors like social taboos, citizen attitudes, poor assessment, the unorganized informal sector of waste, and poor implementation of government policies make the entire waste management system inefficient [3].

For ensuring proper waste management, a key part is to collect waste from waste bins in a timely manner. Otherwise, waste can be disposed in an unauthorized area which can raise concerns regarding public health and safety, property values, community pride, and overall quality of life [4]. In this paper, we propose a smart waste collection system that monitors waste bins and provides real-time status updates. To perform this, we use the Internet of Things (IoT) based technique [5]. We also collect data regarding wastes levels of bins and leverage data mining technique [6] on that for extracting useful information that can facilitate future waste collection.

There are many existing works [5], [7]–[13] where researchers used IoT-based techniques to implement smart waste bins. In all of these works, researchers developed a waste collection system where they monitor all the waste bins of the defined area and reported the percentage of the waste level in the bins. Thus, they send notifications about which bins need to be emptied in any cycle of collection of waste. We also develop a similar kind of prototype where after receiving the notification, we calculated the shortest path among the bins, so that the garbage collection can be done more efficiently. However, in real-time, this kind of automated system sometimes may get down due to a malfunctioning of hardware, natural calamity, or any kind of system failure. Especially, in developing counties, the outage of Internet for some period is quite common. When we design our proposed technique, we keep the limitations of IoT in our mind. Therefore, in our proposed technique, we not only perform real-time monitoring but also collect waste level data. We use this data to do offline data analysis so that we can collect waste efficiently in case of any hardware failure in the waste bins. Although some existing techniques [10], [12] collected data from the waste bins, these techniques did not leverage any data mining technique to extract interesting patterns which can help facilitate offline waste collection in case of any emergency. To the best of our knowledge, WasteMiner is the first technique that not only performs real-time monitoring of waste bins but also supports the waste collection system in the case of any system failure by analyzing collected data.

In WasteMiner, LED light is used to display the status of the level of waste in the bins. A web-based monitoring tool, on the other hand, is designed to show the status to the user who is monitoring it. The web tool gives a graphical view of

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the waste bins and highlights the garbage collected in color to show the level of garbage collected. The color of the LED indicates the status of the garbage level. The system changes the color of the LED when the level of garbage collected crosses the set limit. We calculated the shortest route from the locations using the MapQuest [14] free directions API and we get the location sequence and the distance, In this method, we use Arduino UNO R3 [15], an ultrasonic sensor which is considered a node. Each node has attributes which are ID, Location, Latitude, Longitude, and Waste Level. These nodes are placed at different locations across the city and are unique for a particular place. For this work, we stored data in MySQL database in the local host (laptop). Each node calculates the capacity of the bin at a particular place and sends the data to the database for each day. We then apply a data mining algorithm named Apriori frequent pattern mining [16] on the collected data to extract necessary interesting information. By leveraging the data mining technique, WasteMiner can report the list of waste bins that have a high chance to fill up on the same day of the week. It also can provide information on the bins that have a high chance to fill up on same days of the week. By using this information, we can efficiently collect waste in case of any system failures or emergencies. We used SPMF [17], a free data mining library to apply the Apriori algorithm.

We conducted an experimental evaluation of our technique. We developed the prototype for simulation and used six google map locations in India. Our prototype can effectively and efficiently show the garbage level. It is also effective and efficient in calculating the shortest path among the bins. We also evaluated our technique for the offline scenario by applying our extracted patterns collected by leveraging the data mining technique. The experimental results show that our technique is effective and efficient in waste collection in both real-time and offline scenarios.

In summary following are our contributions:

- We design an IoT-based waste collection system for collecting waste efficiently and for gathering real-time data about waste levels in different bins.
- We propose a data mining based technique to collect waste in an efficient way when real-time notifications do not function properly.
- We implement a prototype of WasteMiner using software simulation and conducted an experimental evaluation to demonstrate its effectiveness and efficiency.

II. Motivation & Background

In this section, we first discuss the motivation of our work, and then we briefly discuss some background terms related to our work.

A. Motivation

In the Indian subcontinent, it is a common scenario to see a lot of bins that are filled and stinky. This scenario is not very rare in some parts of the developed countries too. However, this scenario is not good for our physical and mental health, as well as for the environment. This waste has to be treated within a certain amount of time to prevent it from becoming hazardous. According to WHO, parasitic infections, lung infections, skin infections, HIV and hepatitis B and C viruses, candida, meningitis, and bacterial infections are all caused by untreated waste [18]. With modern technologies, there are many ways to treat waste that will be eco-friendly such as recycling, composting, etc. Leaving this waste untreated for long period reduces the chance of recycling the waste, which will turn poisonous and will be harmful to nature by releasing greenhouse gases. Therefore, it is very important to collect waste in a timely manner. Moreover, if the wastebasket is full, then citizens may dump waste in unauthorized areas such as roads, rivers, public places, etc. Hence we are motivated in developing a real-time waste bin monitoring system that can ensure an effective and efficient waste collection system.

In some real-world scenarios, where the hardware can be ruined, the internet can go down. It may cause by any natural calamity or, lack of maintenance. In such situations, it may happen that we are not being able to get real-time notifications for a specific period of time. However, in this scenario, we should keep collecting the waste. If we know some interesting factors about the waste bins, then we can develop a smart waste collection system in offline mode also. Some information like, how fast the bins are filling in a particular location, and which bins usually filled up together is very useful to develop a waste collection system where real-time monitoring does not work.

To overcome these real-time challenges we are motivated to develop a technique where we collect the waste not only by monitoring real-time levels of waste in the bins but also develop a technique that can work when real-time notification gets non-functional for any reason. Our proposed technique, WasteMiner is a solution to solve these real-time problems in waste collection.

B. Background

In this paper, to design and develop WasteMiner, we have used some techniques and terms. In this section, we present them briefly.

Internet of Things (IoT). The online mode of WasteMiner is developed on an IoT-based technique. IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that has unique identifiers (UIDs) and the ability to transfer data over a network without any human interference [19]. In WasteMiner, we used an Ultrasonic Sensor [20], Arduino UNO [15] and Bluetooth device to create unique identifiers of waste bins. Each unique waste bin with the installed devices is considered a child node. These child nodes are connected via the internet with a parent node and transfer data to the parent node. The details approach of this step is described in section III-A.

Apriori Frequent Itemset Mining Algorithm: Apriori algorithm is a very well-known and influential algorithm in Data Mining [21]. It was the first algorithm to mine frequent itemset. An itemset is a set of items. Frequent itemset mining

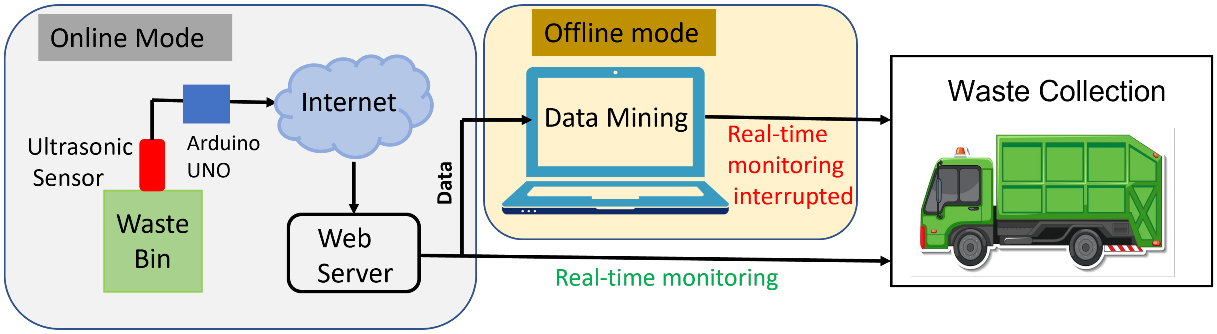

Fig. 1. The Overview of WasteMiner Framework

is a data mining technique that identifies the items that often occur together [21]. In this algorithm, we set up a minimum support threshold. If an item or itemset appears more than or equal to the minimum support threshold in the transactions of the database, then it is considered a frequent item/itemset.

III. Approach

Figure 1 shows the overall overview of WasteMiner which works mainly in two modes: online mode and offline mode. In online mode, WasteMiner monitors the waste level of waste bins by using a set of hardware and then transmits the notification to the web server. WasteMiner calculates the shortest paths among the bins and collects waste in an optimized way. During this time, WasteMiner also collects data about the waste level of the bins and stores them. If WasteMiner's real-time monitoring is interrupted for any undesired reason it uses the data collected in the online mode and performs offline data analysis by leveraging data mining Apriori frequent pattern mining algorithm for calculating an optimized way to collect waste. In the following two subsections, we describe WasteMiner's details work process.

A. Online Mode

The grey color part of figure 1 represents the online mode of WasteMiner. In this work, we use Arduino UNO R3 [15], ultrasonic sensor [20] and a Wi-Fi module for setting up the hardware for sending real-time notifications of the waste level in the waste bins. This hardware is altogether considered a node. Different nodes are placed at different locations across the city and each node is unique for a particular place. Each node has attributes which are ID, Location, Latitude, Longitude, and Waste Level. Table I represents the data for four different bins. This data can be used in the future if there is any system failure in the online mode. In section III-B we discussed in detail how we can use these data for making the waste collection system more efficient.

The ultrasonic sensor is connected to the Arduino UNO that receives data and transmits data to the Wi-Fi module. WasteMiner has two standalone devices one attached to the dustbin (child) and the other at the node point (parent). Many children can be connected to the parent node. The tools used for this child node are Arduino UNO (ATMega328P), Bluetooth (HC 05), and an ultrasonic sensor. The tools used for the parent node are NodeMCU (ESP8266), Bluetooth (HC 05), and Switches for location change. The child measures the bin capacity at the location and sends data to the parent via Bluetooth.

TABLE I
Sample dataset saved in MySQL

Bin	*Location*	*Latitude*	*Longtitude*	*W.Level*
1	Kukatpally,Hyderabad	17.49	78.40	70%
2	Jubiliee Hills,Hyderabad	17.41	78.41	91%
3	Tarnaka,Hyderaba	17.40	78.54	75%
4	Dilsuknagar,Hyderaba	17.38	78.53	40%

Each node calculates the waste level of a bin at a particular place and sends the data to the database. We used Arduino IDE for building our code using inbuilt libraries. This device also indicates the trash can's garbage level using LED lights, as follows: if the trash level exceeds 90%, the RED LED blinks; if the trash level exceeds 60%, the YELLOW LED blinks; and if the trash level exceeds 30%, the GREEN LED blinks.

If the garbage level of any waste bin is more than 75%, then by using the bin's location information and MapQuest [14] direction API, we calculated the optimized route and distance. We use already-defined data from google maps. With this extracted data we will be finding the shortest distances among a set of waste bins according to the quantity of dirt present in the bin. Our goal is to find the minimum optimized route for the locations where the bins are almost full and collect waste according to that.

WasteMiner works perfectly when all the hardware and Internet connection work expectedly. However, in real world, we may face scenarios, when some part of the hardware could be non-functional. The Internet connection may experience inconsistent jitters. These may cause some child nodes' real-time notifications be interrupted. In the worst case, the connection among the child nodes and the parent node can be stopped for some days. It may happen due to poor maintenance, natural calamity, or any other unavoidable circumstances. However, WasteMiner considers these situations and calculates the optimized way to collect waste. In the next section, we describe how WasteMiner works in offline mode.

TABLE II
ONE SAMPLE EXAMPLE OF TRANSACTION DATABASE AND FREQUENT ITEMSSETS

Day	*T.ID*	*Items*	*Freq. Itemsets*
Saturday	1.	$bin1_{red}$, $bin2_{green}$, $bin3_{red}$, $bin4_{yellow}$	$\{bin2_{red}\}$
	2.	$bin1_{red}$, $bin2_{red}$, $bin3_{red}$, $bin4_{green}$	$\{bin1_{yellow}\}$
	3.	$bin1_{yellow}$, $bin2_{yellow}$, $bin3_{yellow}$, $bin4_{green}$	$\{bin3_{yellow}\}$
	4.	$bin1_{yellow}$, $bin2_{red}$, $bin3_{yellow}$, $bin4_{red}$	$\{bin1_{yellow}$, $bin3_{yellow}\}$
	5.	$bin1_{yellow}$, $bin2_{red}$, $bin3_{yellow}$, $bin4_{yellow}$	

Interesting Frequent Patterns Identifying Algorithm

```
Inputs: TransactionDatabase(T)
Outputs: Seq_a
begin
  Seq_l ← AprioriFrequentItemsetMining (T)
  for each seq_i ∈ Seq_l
    if CheckWasteLevel (seq_i) is true
      Seq_a.add (seq_i)
    if CheckTwoBinsLevelSame (seq_i) is true
      Seq_a.add (seq_i)
  endfor
Seq_a
```

Fig. 2. Identifying Interesting Frequent Patterns

B. Offline Mode

When WasteMiner is in offline mode, it uses data that it collected in the online mode. In this mode, WasteMiner collects waste based on some important information that can be extracted from the previously saved data. Figure 2 shows the algorithm which is used to identify interesting information which can facilitate waste collection. A transaction database *(T)* is used as input in this algorithm. This algorithm outputs a list of waste bins *(Seq_a)* . We mainly extracted two kinds of information from the saved data by applying a data mining technique. The information are:

- Identify the bins for that waste level is high quite often on any particular day of the week.
- Identify the set of bins that contain same level of waste on any specific day of the week frequently.

To extract this information WasteMiner uses the Apriori Frequent Itemset Mining algorithm [16]. The intuition behind applying this algorithm is, WasteMiner aims to extract the frequent behavior of the waste bins by analyzing the real-time data collected in the online mode. As we assume that the online monitoring system is not working for any unwanted reason, we analyze the data saved in recent times and extract the frequent behavior of that data. Thus, we keep providing the waste collection service efficiently without any real-time monitoring at a specific time. Apriori Frequent Itemset Mining algorithm discovers itemsets (group of items) that occur frequently in a transaction database [17]. Therefore, we use this algorithm to find out the frequent waste level behavior of the waste bins.

To apply the algorithm to our collected data, we need to pre-process and reorganize the data first. The first three columns of Table II represent the transaction database which is created by pre-processing data from Table I. Table II gathered data for 5 weeks on every Saturday. Each transaction ID (T.ID) represents each week. The 3rd column (*Items*) contains the data of each bin (bin1, bin2, etc.) waste level by color (red, yellow, and green) on that day. In this table, we show examples for only Saturday. However, we collect and similarly organize the data for all seven days of a week. The fourth column of Table II shows the frequent itemsets which we obtain by applying the Apriori algorithm on the transaction database (columns 1 and 2 of Table II).

We set the minimum support threshold to 60% and obtain 4 frequent itemset by applying the Apriori algorithm on this dataset. From these frequent itemset, we can infer two pieces of information.

- The waste bin2 is often filled up on Saturday. Thus, if our system can not send real-time notifications for any undesirable cause, we can collect the waste from bin2 every Saturday.
- The waste bin1 and waste bin3 have similar waste levels often. Thus, if we collect waste from waste bin1, on the same day we can also collect waste from bin3. As there is a high chance that these two bins would be filled up together on the same day.

We applied pattern mining algorithm to data from the recent month. The intuition behind this is, more than one month older data may represent some behavior which might have changed recently over time. Our experimental results show that one month-long data provides us with the most recent and accurate patterns for collecting waste in an optimized manner.

IV. EXPERIMENTAL EVALUATION

We use *Tinkercad* [22], a software where real-time hardware parts (UNO (ATMega328P), Bluetooth (HC 05), and Ultrasonic sensor) are available for software simulation. We use Arduino IDE [15] to write the code logic so that Arduino UNO works according to our logic. We create a link that has access to google maps. We use Jupyterlab [23] software to write the code for calculating the shortest distance. We use SPMF [17], an open-source data mining library to apply Apriori frequent itemset mining algorithm [21].

In order to evaluate WasteMiner, we consider three research questions:

RQ1: How effective is WasteMiner in showing real-time notification in online mode?

RQ2: How effective and efficient is WasteMiner in calculating shortest path to collect waste?

TABLE III
WASTEMINER PERFORMANCE IN ONLINE MODE

NoB	*Dis.(mi)*	*WDis.(mi)*	*T.(min)*	*WT.(min)*
6	55.302	51.574	134	118
5	45.982	42.875	161	127
4	41.632	39.146	163	139
3	30.447	27.340	62	52

RQ3: How effective and efficient is WasteMiner in collecting waste in offline mode?

A. Benchmarks

In this work, we use six real locations in India. We use locations from India because we have access to google map there. For applying the data mining technique, we collect data for the recent month and extract interesting information from that data.

B. Evaluation Metrics

Online Mode: To evaluate WasteMiner in online mode, we count how many times it shows the exact LED light according to the waste level. We also evaluate the shortest path calculation by WasteMiner. To do that, we calculate the differences among the distances after applying the shortest path algorithm and without applying it. We also calculate the difference between the total time to travel.

Offline Mode: After generating the list of waste bins that are filled up frequently on the same day and filled up often together (i.e same level of waste), we calculate the precision of the itemsets of this rule. Precision represents the percentage of the waste bins which are filled up on the same day together in real-time from the frequent itemsets generated by our technique.

For calculating the precision we use the following formula [24]:

Precision = (true_positive) / (true_positive + false_positive)

To determine whether a rule is a false positive, we manually examine the real-time data collected for one week by our simulation model. If the item/itemset do not have the same waste level on a specific day, it is marked as a false positive.

C. Result and Analysis

In this section, we will present the results which help us find the answers to the research questions. Table III and Table IV show the performance of WasteMiner in online and offline mode respectively.

RQ1: Effectiveness of WasteMiner in showing real-time notification in online mode: We run our simulation model to check if WasteMiner can send the LED notifications perfectly when the waste level changes. We change the waste level randomly 30 times (assume 30 different days). And we found that WasteMiner shows the real-time LED light notifications perfectly for all of these 30 days. Figure 3 represents the waste levels of six different bins in six different locations for thirty days. In every case, WasteMiner shows the correct waste

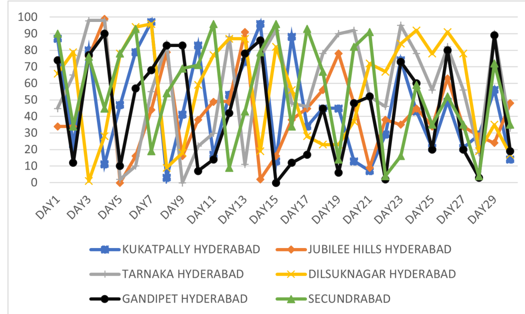

Fig. 3. Waste Level of Six Different Waste Bins on 30 Different Days

level in the simulation software. This finding proves that the simulation model for WasteMiner is 100% effective in the case of sending real-time notifications in online mode.

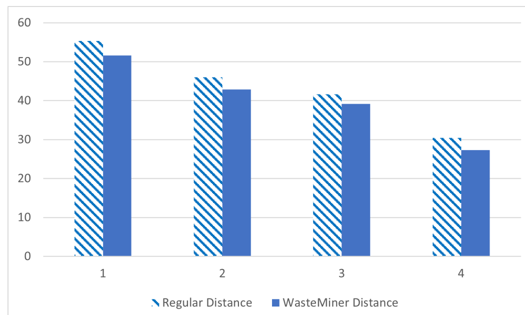

Fig. 4. Distance Traveled without Applying Shortest Path Algorithm Vs. Distance Traveled by WasteMiner to Collect Waste

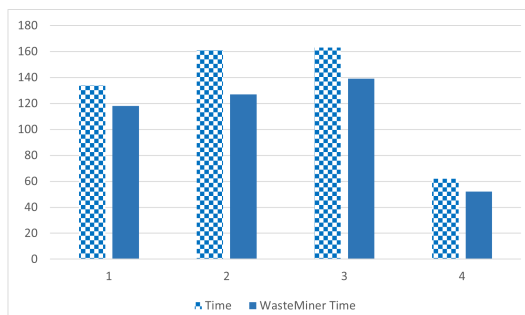

Fig. 5. Time Need to Collect Waste without Applying the Shortest Path Algorithm Vs. Time need to Travel by WasteMiner

RQ2: Effectiveness and efficiency of WasteMiner in calculating shortest path to collect waste: Column 1 of Table III shows the number of waste filled bins. Columns 2 and 3 represent the distances needed to travel for collecting waste randomly and the distances needed to travel for collecting waste after calculating the shortest paths by WasteMiner respectively. Columns 4 and 5 record the total time needed to travel the distance for collecting waste before and after applying the shortest path algorithm. Figure 4 shows that in every four cases WasteMiner needs to travel less distance due to applying the shortest path algorithm. In summary, WasteMiner needs to travel 8% less distance if the shortest path algorithm is applied. Figure 5 represents the comparison

TABLE IV
WASTEMINER PERFORMANCE IN OFFLINE MODE

Day	*NoFB*	*NoSB*	*T.(ms)*	*Prec.*	WT.(min)
Saturday	4	2	1.2	75%	139
Sunday	5	2	1	80%	127
Monday	1	0	0.6	100%	12
Tuesday	1	0	0.6	100%	25
Wednesday	5	2	1	100%	142
Thursday	0	0	0.7	100%	0
Friday	2	1	1	100%	52

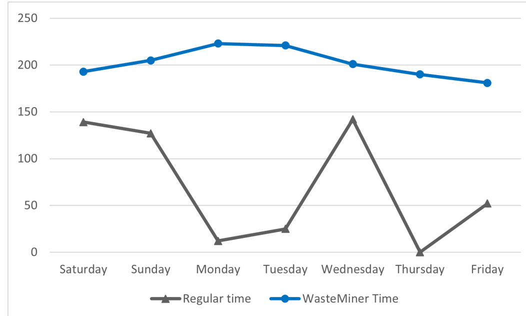

Fig. 6. Time needed by WasteMiner after conducting Data analysis Vs. without any data analysis for collecting data in offline mode

plot of total time WasteMiner needs to travel with and without applying the shortest path algorithm. This plot shows that in every four cases, WasteMiner requires less time if we apply the shortest path algorithm. In summary, WasteMiner takes 16% less time for collecting waste when the shortest path algorithm is applied. In practical scenario, when the number of bins would be large, and the traffic congestion, road construction, and other situations could cause more time to collect waste, WasteMiner can play a significant role in collecting waste efficiently.

RQ3: Effectiveness and efficiency of WasteMiner in collecting waste in offline mode: Table IV represents the performance of WasteMiner in offline mode. The first column of table IV shows the 7 days of a week. The second column (NoFB) represents the number of waste bins that are filled up and shows red color in LED for that specific day identified by our data mining technique. The third column (NoSB) shows the number of itemset that contains the waste bins that have the same waste level on a specific day. The fourth column (T.(ms)) contains the time that our algorithm took to analyze the data in offline mode. After collecting these results, we evaluate the effectiveness and efficiency of our technique. The right side columns which are separated by the double line in table IV represent the results that we evaluate over 7 days of data collected by WasteMiner. The precision column shows the percentage of the itemset identified by the data mining algorithm in the real-time data for 7 different days. This result shows that WasteMiner is effective in identifying waste bins that are filled up on the same days without getting real-time notifications. The average precision of this technique is 93.5%.

Figure 6 shows a comparison between the waste collection time by WasteMiner in offline mode and the time needs to collect waste from six different bins without any data analysis. We assume, if there is no data analysis performed or real-time notification is turned on, any regular system needs to collect waste every day. Figure 6 represents that WasteMiner needs less time to collect waste in offline mode. Thus WasteMiner is both effective and efficient in collecting waste in offline mode.

V. RELATED WORK

Researchers have conducted many research [5], [7], [9], [12], [25] to collect waste smartly. Raaju et al. proposed an automated waste monitoring and collection process [5] with lower cost. They use ZigBee to reduce the cost of data collection. This embedded system detects the level of garbage in the bin and sends the acquired data over the Internet using Wi-Fi. In this project, researchers use renewable energy in the nodes, with the use of solar panels. They developed a pilot project in which real-time information about garbage bins can be seen on mobile phones to evaluate the effectiveness and efficiency of their proposed technique. In this project, the researchers mentioned that the collected data can be used for data analysis in the future. However, they did not provide any solution about how they are going to analyze them and how those data can be useful in case of waste collection. Our proposed technique WasteMiner provides a solution about how we can use our stored data to make the waste collection system more efficient. Although we did not develop any pilot project, we evaluated our technique by doing software simulation and showed its effectiveness and efficiency.

Pawar et al. proposed an IoT-based technique [9] where the microcontroller AVR Atmega16 is the heart of the system. In this model, the AVR Atmega16 microcontroller receives the information from the IR sensor system and processes the signal. An alert signal is sent before the dustbin gets overflowed. It sends the text message via the GSM module and will update the status on the web server. In this technique, the researchers did not do any data analysis to support the waste collection when the real-time notification system could stop working. Our proposed technique WasteMiner uses a different set of hardware to develop the IoT-based waste collection system. Moreover, WasteMiner also generates an optimized solution to collect waste in case of hardware failure.

Yusof et al. developed a smart garbage monitoring system [25] which used much similar hardware to our system. However, we calculated the shortest path between the bins to collect waste efficiently and we also proposed a data analysis technique to make the waste collection efficient in offline mode.

Haque et al. proposed a prototype [12] where they not only developed a real-time waste level monitor but also calculated an optimized way for collecting waste from bins. However, they did not consider a situation where the IoT system can be failed due to any unforeseen situation. Therefore, they did not use any data analysis technique.

Another Arduino-based Smart Garbage Monitoring System developed by Muyunda et al. [7] has many similarities with

WasteMiner. The major difference between WasteMiner and this work is that WasteMiner uses data mining techniques to analyze data saved in the online mode. Although, WasteMiner's online monitoring part has many similarities with the existing prototypes, the offline data analysis part is a unique one. Applying data mining to collect and manage waste is a novel contribution to our work.

VI. Conclusion

We have presented WasteMiner, the first waste collection tool that works both in online and offline mode. WasteMiner monitors real-time waste levels and calculates shortest paths for collecting waste efficiently. WasteMiner performs analysis on the real-time waste level data. Thus, WasteMiner provides efficient solution in offline mode too. Applying data mining technique is a unique and novel feature of WasteMiner which provides a new future direction for analyzing data in this field. We have evaluated WasteMiner and the result demonstrated that WasteMiner is effective and efficient in collecting waste. For making this prototype applicable in the real-world, we plan to scale up this project in future and integrate this as a component of smart city. Hence, this project requires extensive financial support from both public and private parties as well as cooperation from civil society.

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