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REVIEW ARTICLE

IoT Based Smart Bins for Smart Cities: A Review

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ABSTRACT

In this Paper, IoT based Smart bins for smart Cities using Arduino and Raspberry Pi is discussed and reviewed. Population growth and rapid urbanization lead to huge increase in waste Generation. Traditional method of waste collection has become inefficient and costly. The most efficient way to collect the waste is Smart Bin Management System. Smart Bin Management System is effectively done using IOT, the Result is Tremendous and it is very useful for all cities and even for overall world. Both Hardware and Software embedded to Produce Good output .Many research already existed by using Arduino and Raspberry Pi. The Internet of Things (IoT) is currently considered as a basic communication infrastructure for Smart Cities, Where machine Communicates automatically between each other. The main objective of this paper is to ensure the protection of the environment through effective Waste Management. Ensure Separation at Source in all metropolitans and local Municipalities. Preventing Pollution and Ecological degradation. To protect the health and well-being of people by providing an affordable waste Collection Service. Arduino and Raspberry pi are open Source Hardware Platform. This Paper mainly focused on comparing their Performance, how effectively it will separate dry waste and wet Waste, Cost and User Friendly by using Arduino and Rasperry pi as which is more reliable and efficient.

Keywords: IoT, Arduino, Raspberry pi, Smart Bin, Environment,Pollution, Ecological Degaradation.

INTRODUCTION

Waste Management is the term given to a waste Collection System, Which may include in Transportation, disposal and recycling. Waste management is all about the collection of waste from domestic, Corporate, Commercial and an industrial entity after it has served its purpose and is deemed not useful. This can lead to disorder of diseases that are spread by insects. Waste Management also acts on various economic, administrative and social issues that required be handling and solving at high Levels. Every year, an estimated 11.2 billion tonnes of solid waste is collected and decay of the organic proportion of solid waste is contributing about 5 percent of global Greenhouse Gas Emissions of all the waste streams, waste from electrical and electronic equipment containing new and complex hazardous substance presents the fastest growing challenge in both developed and developing Countries[14]. Poor Waste Management of ineffective disposal causes air pollution, water and Soil Contamination of drinking water and which can cause infection and transmit diseases. The solution is the minimization of waste firstly. Where waste cannot be avoided, recovery of materials and energy from waste as well as remanufacturing and recycling waste into usable products should be the Second Option[14]

The UNEP International Environmental Technology centre (IETC) in Japan Supports the implementation of integrated Solid Waste Mangement System. Its Works also focuses on the Proper Treatment of Special Waste(Electronics, Agriculture, Biomass, Plastics)in developing Countries And Cities. Waste Management nowadays is not the Same in Every Country region or Even Vary Among different Sectors Such as Industrial and Residential Sector. Six Elements of waste management are Refuse, Reduce, Reuse or Repair, ROT, Recycle, Repurpose. Waste Generation involves all the activities that identifying if materials are no longer Usable and if they can be used for Systematic Disposal. After Waste Generation there are activities to facilitate easier Collection of the waste .Detection, Monitoring and management of waste are one of the Primary Problems of Present days. Usual way of monitoring the waste is a tedious Process and utilizes human effort, Time and Cost which can easily be avoided with our Present. Currently there are increasing initatives by Government and Public authorities in relation to waste management to efficiently improve the collection and intelligent disposal of waste generated by a city. Urbanization is a current Society and its rapid growth demands Smarter for Waste Management in Cities. A Probable Solution to this problem is adoption of IOT based Smart Waste Management System.

IoT works on Four Components Devices/ Sensors, Connectivity, Data Processing and User Interface as shown in the Figure 1. Sensor is a device that measure physical input from its environment and converts it into data that can be interpreted by Computer. Sensing, Temperature, Pressure, Light, moisture, sound etc. Sensor is typically integrated with microprocessor Based embedded systems which can collate the data and connect to internet. Several Communication Protocols and Technology used in IoT. Depending upon Power and Cost. All the collected data is send Via Internet to Cloud infrastructure. Processing Stage Computer transform the raw data into information. Information is Carried out by different Manipulation Techinques. Data Aggregation is the Aggregating from Multiple devices like AC, Light. Data Extraction is Extracting Car number plates from Video Feed of Speeding Cars. Data Classification is Classifying Data .Data Analysis is analyzing data and identify Patterns.

MATERIALS AND METHODS

Arduino: The Arduino is an open Source microcontroller board based on the MicrochipnATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits [17]. The board has 14 digital I/O Pins,6 analog I/O Pins and is programmable with the Arduino IDE(Integrated Development Environment)via a type B USB Cable. It can be Powered by a USB cable or barrel connector that accepts voltage between 7 and 20 volts,such as 9 volt battery[15].

Raspberry pi: Raspberry Pi is a series of small Single board Computers (SBCs) developed in the United Kingdom by the Raspberry pi Foundation in association with Broadcom. Raspberry pi is a very cheap computer that runs Linux,but it also provides a set of GPIO(General Purpose Input / Output)pins, allowing to control electronic Components for physical computing and explore the Internet of Things (IoT).Its main operating System Pi OS is Open Source and runs a suite of open source Software. It is a low cost, credit card sized Computer that plugs into a computer monitor or TV and uses a standard Keyboard and Mouse. It is a capabale little device that enables People of all ages to explore Computing and to learn how to program in Languages like Scratch and Phyton. Debian with Raspberry pi is operating system for PC and MAC. It can run Multiple operating Systems, Through RP2040 Micro Controllerchip. With an extensive range of accessories and add ons, the Raspberry pi range can be expanded to utilize computer networks and Visual multimedia Processing, Sensors and emulation while connected to the internet or Local networks [16].

In this Study Several Parametes must be considered to establish if a technology has Reached its Maturity phase or is still in the growth phase. These Cover Various Technical Specifications, Economic Perspectives, Competitors, Population Opinions, etc. Multicriteria Analysis is usually the best approach to accommodate these different areas [12].

MCA is a hirerarchy technique that quantities each object's Performance Considering a set of Criteria. For our study in this paper the boards that we are comparing were Arduino UNO and Raspberry pipico. The criteria that we are used to rank were Hardware Setups,cost,Power assumption and number of Projects based on two boards. The Performance matrix for the chosen criteria is calculated to perform MCA [13]. Each domain has a specific weight and each objects receives a score for each Criteria. The Element with highest score receives the entire criteria , while others get Proportional scores.

The Point allocation method is Proposed in this review in the table 1 as it is easy to allocate the Points and it states that "The total of all criterion weights must sum up to 100" and it is applied for scoring and is shown in Table 1. Here Hardware Setups like Memory and digital Pins have given weights as 35 and 15.Cost have given 10 weights, Power assumption given 25 and Papers have given weightage of 15.so total all together 100.The Weighting is adopted based on the Mean Weight Method a straight forward weighting approach that considers all attributes equally important. since there are five criteria in total, an equal weight of 10% is attributed to each component.Hardware Specifications for Arduino UNO and Raspberry Pi Pico were obtained based on the manufacture Table and are summarized in the Table 2.

The Economic concepts conceptsconsiderd the initial investment cost that is the price for the two boards and the Power consumption[18,19]. Power Consumption is relevant for IoT applications because they require constant measurements for extended periods,leading to increased operating costs. Power consumption and cost have been got from the internet and it is tabulated in the Table 3. In this study we considered in a broader sense, like analayzed 10 papers in many research journals and Proceedings realated to Smart waste management and the focus of the paper, most commonly used approach, components like Sensors used ,different technologies, IoT platforms, Microcontoller boards used ,Output components to display the result were reviewed [13]. The most commonly used approach is to prevent the waste container or bin to be overloaded. Level detection implemented in many Paper using ultrasonic sensorand IR Sensor. Distance from one bins to other bins are also measured using many Ultrasonic sensor in some of the paper. Weight of the trash in the bin is measured using weight sensor i.e.Load cell .Wet and dyr waste is separated in some of the papers by using soil moisture and humidity sensor. However in Many Research papers Researchers have used different technologies like GSM, GPS, RFID and WIFI Module to share the information over internet. Microcontroller boards like arduino UNO and Raspberry pi were used .

Out of 10 papers reviewed only in 2 Papers Raspberry pi is used. But it is also understood that Arduino UNO and Raspberry pi combined to produce a fabulous result and more modules can be implemented. Arduino UNO does not have External port like Ethernet port and HDMI port. whereas Raspberry pi will have External communication

technology as well as WIFI(802.11n) and Bluetooth 5.1 which allows to retrieve and transmit data through internet connection[18,19]. And also IOT platforms like Thingspeak is used for communication.The Output will be displayed through LCD's and RGB's LED and even servo motor is also used to display the output in a paper[1-10]. And the result with paper name along with Microcontroller used is displayed in the Table 4.

RESULTS AND DISCUSSION

MCA Performance matrix was constructed and scored 10 point for each Criteria and the best result is found. Result is given in the Table 5. After Summing all the scores obtained by each board the total value represents the ranking criteria for the developed MCA.As can be seen, the Arduino UNO scored the lowest value with 17.08 from 100 [13].It is Clearly indicated that Arduino UNO has reached its Maturity phase and also fulfilled the developed phase now in the decline phase. Raspberry pi pico scored almost twice as much as Arduino UNO and is placed in the other end of the scale being best board according to Proposed MCA. Also Pico board obtained top marks for three criteria Memory, Digital Pins and Cost. The two things that Pico board scored worse was the Power Consumption and also Research Papers were Raspberry pi was very less Compared to Arduino.10 Papers were Reviewed in that 8 Papers used Arduino UNO and only 2 Papers Used Raspberry Pi[9,10]. Raspberry pi understood the lesson that made Arduino UNO a intimidating board i.e the communication interface and adapted these specification to IoT environment by doubling the number of mean for Communication

CONCLUSION

The Paper Reviews the Arduino UNO Boards evolution in the IoT Context. Hardware Setup,Economic,Feasability and researching the Papers were Considered. MCA Criteria to evaluate its role in the future of IoT. After gathering all the data and constructing Performance Matrix, One can conclude that Arduino UNO will no longer be Part of IoT future but will Viable Solution for an IoT. Raspberry Pi Picois the Best Suited board for IoT application as which has excellent Communication Protocols, Balanced Economy and Good Hardware Setups.

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Table 1. Boards Criteria Weight Using Point Allocation Method

S.NO	Criteria	Weights
1	Memory	35
2	Digital Pins	15
3	Power consumption	25
4	Cost	10
5	Papers	15
	Total	100

Table 2 .Hardware Specification

Specification		Arduino Uno	Raspberry Pi Pico
Memory	SRAM(kB)	2	264
	Flash(kB)	32	2000
Digital Pins		14	23

Table 3. Power Consumption and Cost

		Arduino UNO	Raspberry Pi Pico
Power consumption	5.21V	290mA	600mA
	12 Neo pixel LEDS	1.5 W	3.1 W
Cost (Rupees)		1500	350

Table 4.Paper Review of Boards for the iot based smart bins for smart cities: a review

Paper id	Paper Name	Boards Used
P1	Smart Work Management system Using IoT	Arduino UNO
P2	IoT based Framework for smart waste monitoring and control systems :A case Study for Smart Cities	Arduino UNO
P3	IoT based Smart Garbage Monitoring System	Arduino UNO
P4	Smart Dust bin for Efficient waste Management	Arduino UNO
P5	Smart Dustbin Monitoring System Using LAN Server and Arduino	Arduino UNO

P6	Smart Dustbin	Arduino UNO
P7	Smart Waste Management using IoT	Arduino UNO
P8	Smart Waste Management Using Arduino	Arduino UNO
P9	Smart City Implementation of Smart bin using Raspberry pi	Raspberry pi & Arduino UNO
P10	Accurate and High Speed Garbage detection and Collection Technique Using Neural network and Machine Learning	Arduino UNO

Table 5. Performance Matrix

Specification	Arduino UNO	Raspberry Pi Pico
Memory	0.08	7.5
Digital Pins	6	10
Power Consumption (mA & watts)	6	3
Cost	2	10
Papers with Microcontroller board	3	0.5
Total	17.08	31.0

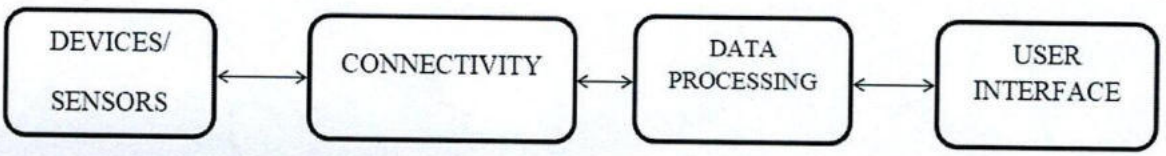
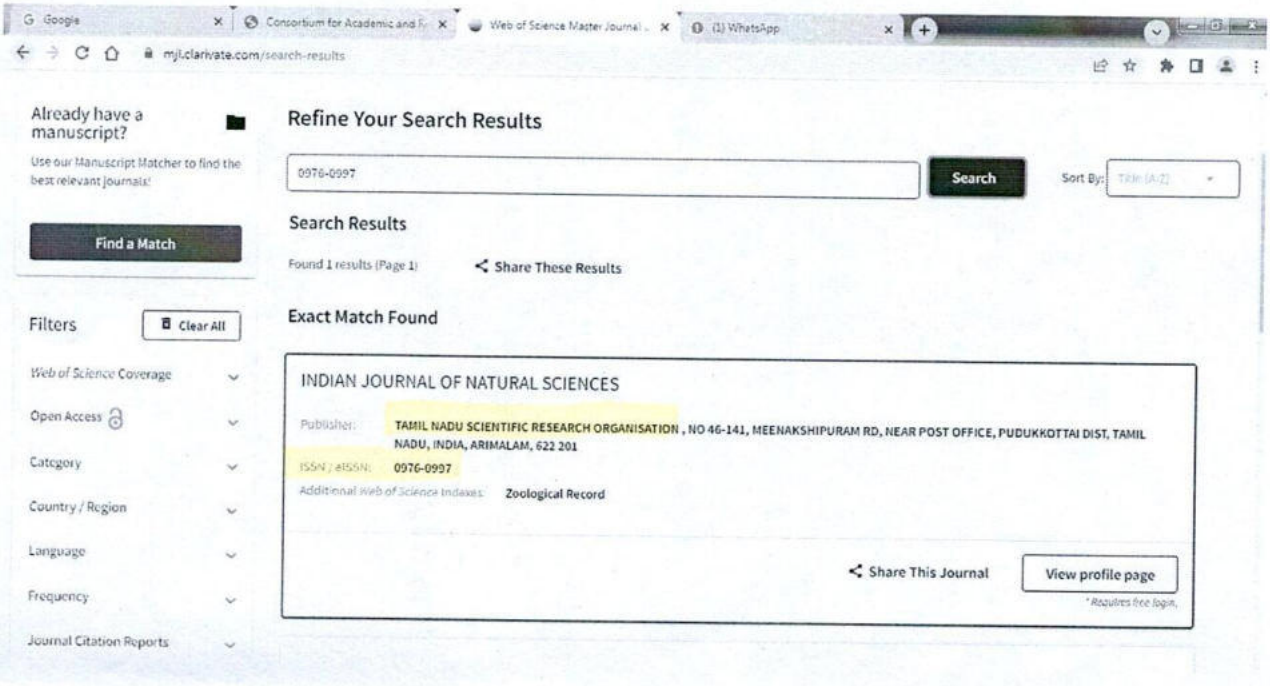


Figure 1. Components of IoT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