Power Saving Scheduling For Iot Based Garbage Monitoring System

V. Mallikharjuna Rao, M. Satya Sai Ram, M N Giriprasad

Abstract— ***Now a days to protect our self from the environment pollution is very important because the environment was polluted by the different things in different ways. One of the common biggest challenges is garbage which was produced by the human things negligence or by external factors. To minimize this problem many authors proposed their own solutions which are useful to garbage collectors during the garbage collection process. These proposed solutions are so efficient but they are not giving maximum performance due to their internal designing problems, like software hanging, reliability, battery backup etc. One of the biggest problem is battery backup; due to lack of battery backup these garbage collection systems are not sending the garbage information to the garbage collectors, so these collectors are not collecting the garbage in time. To solve this problem the current research is proposing the concept about energy management for the garbage collection system.***

Keywords: Energy efficiency, Garbage, Garbage collectors, Scheduling, Environment, Pollution,

I. INTRODUCTION

With the demonstration of new generation technology in the world, i.e. IOT (internet of things) [1] has Upcoming evaluated as well defined structure of universal dispensation [2]. IOT is Innovating Technology handled by the intelligent way. It is integrated by every single "event" through a system. The appearance of every event included by technology. The technology like sensing devices, actuators, some apparatus, and intellectual programming. The Advantages of IOT used by so many fields like medicinal services, electrical and electronic industries, transport services and home machinery. The main purpose of IOT is integrated intellectual technology in the world communicating through hardware and collected information without human interface, accumulated into those objects. The IOT devices mainly consist of CPU, Sensors, driver circuits which can operate the actuaries. All devices are power up by the single battery, comparing with software the hardware always consumes maximum power which was explained below.

CPU:

The heart of the IOT based device is CPU. The CPU always collects the data from the sensors and it will process the data based on the application, like to send the data to the cloud, to receive the data from the cloud etc. In the current digital life there are very sophisticated 8, 16, 32-bit Microcontrollers available in the market. All are working at the less power. Based on the application execution speed it is choice of the designer to select the, 16, 32-bit Microcontrollers.

Sensors:

Many IOT devices contain different types of sensors, like temperature sensors, gas sensors, heartbeat sensors, IR sensors, Ultrasonic sensors, industrial sensors etc. Whatever the sensor may be, each sensor consumes some amount of current based on the internal designing mechanism. The sensors are always useful to sense the physical parameters like temperature, pressure, smoke, pulses etc, depending upon application it is mandatory to select the sensors. Once the sensor senses the data it converts the physical data into electrical data. Here the sensor is poor device it can't take any decision even the sensing data is exceeding the threshold value. Hence the data is given as an input to microcontroller, which can control all devices.

Wireless devices:

In the IOT technology many communication devices are wireless, which are useful to exchange the data between cloud and CPU. There are many wireless technologies available in the market like WIFI, Bluetooth, GPRS, 6LoWPAN etc. Each technology has its own advantages and disadvantages with respect to power consumption and range of operation.

Actuators:

Actuators are useful to control the devices. These are also poor devices they can't take own decisions, they can be always controlled by the controlling system like microcontroller or microprocessors.

As per above discussion all devices which involve in the construction of IOT device, consume the current. When the numbers of devices are increased the Battery backup time also decreases. So it is better choice to select the appropriate device for the IOT application, which consumes the minimum power. Different types of sensors and their power consumption has given in the **Table. 1** , and same thing was depicted in the **Figure .1.**

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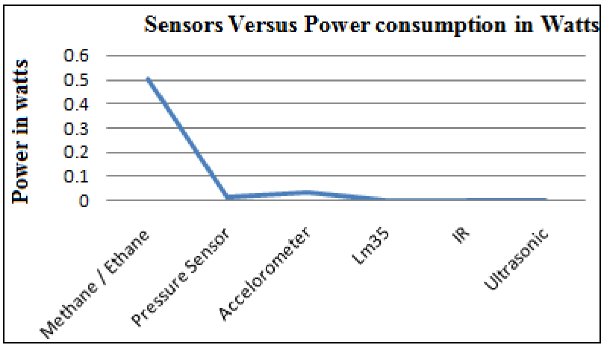

Figure .1 Sensors Versus power consumption [3].

Table. 1. Sensors and their power consumption [3].

S.no	Sensor	Power(in watts)
1	Methane / Ethane	0.5 to 0.8
2	Pressure Sensor	0.01 to 0.015
3	Accelerometer	0.03
4	Lm35	0.0005 to 0.005
5	IR	0.0001 to 0.0025
6	Ultrasonic	0.0005 to 0.006

II. ABOUT INTERNET OF THINGS

Internet of things is a technique which is useful to monitor and control the devices by using cloud. It is day by day vastly increasing technology. Because the device which was communicating through internet can easily monitor the different house hold devices, patient conditions and different types of daily usage applications like bus tickets .train tickets and movie tickets etc.

Business peoples are constantly worried about increasing their operational expenses and related costs. In this way, organizations are continually hunting down arrangements that improve their frameworks' dependability, adaptation to non-critical failure, adaptability, and cost effectiveness. By receiving such arrangements, the multifaceted nature and intuitiveness of interchanges inside the mechanical frameworks expected to grow. One such answer for satisfy the present needs of modern frameworks is the idea of IoT, which includes distributed computing. The web of things (IoT) is a system of appropriated (sensor) hubs, (cloud) servers, and programming. With the quick improvement of Internet of Things (IoT), there are assortments of IoT applications, which add to our regular daily existence. They spread from customary gear to general family protests, which help make person's life better. It is of incredible potential [4]. The Internet of Things (IoT) alludes to a consistently developing system including the articles, which are customary PCs or cell phones; however the physical substances like watches, wearable gadgets, and other brilliant items [5]. It can consider as a system or interconnection of sensors and actuators having one of kind structure for data sharing. The IoT doesn't adhere to a particular convention however available to any best in class convention is accessible now and upgrades the range to the greatest [6]. Further, the administration of information and system can mechanize and the effectiveness can be expanded utilizing the M2M interactions when every one of the gadgets becomes shrewd. Indeed, even the client sources of information can be computerized with sensors and the arrangements will be imparted straightforwardly to the things where it should happen [7].

The possibility of a huge measure of touchy data transmitted between sensor hubs is appealing to noxious outsiders, which makes the IoT framework an essential focus of digital assaults. Research has appeared in a plenty of gadgets, including vehicles [8], child screens, restorative gadgets, and even lights. Since IoT hubs generally utilize remote correspondence innovation to trade data, they are powerless against listening in and man in the center assaults. There is additionally the danger of altering since, as a rule, IoT hubs left unattended. Moreover, traditional cryptography strategies, for example, open key cryptography are excessively exorbitant, between times of vitality and data transfer capacity, to execute on IoT situations [9]. Albeit lightweight cryptography arrangements are being looked into, they are insufficient to shield the system from inside assailants. There are many more challenges and issues exist in the IOT application implementation, hence it is mandatory thing to address such type of issues and challenges while implementation of an IOT application. The idea of IOT application possess many problems like reliability, data security, power source backup, reliability etc. Many engineers and application developers proposed their own algorithms to overcome above problems, but the problems are not overcome by this decade. The IOT applications are expecting that they were play the major role in the human lives by this second half of this decade and the first half of the next decade. Various standard industries' forecasts about the usage of IOT devices worldwide have shown in the **Table.2** and it was depicted in the **Figure.2.** As per **Table.2** an average around 30 Billion will play major role in the world and around 10.5 Billion devices will play the major role in the business applications.

Table.2.Forecast about worldwide usage of IOT devices.

Source	Year Forecast	Forecast of IOT devices In Billion	year	Source
Ericsson	2010	~49B	2020	[10]
Cisco	2011	~49B	2020	[11]
BSRIA	2015	~49-199B	2020	[12]
IBM	2012	~99B	2015	[13]
HIS Markit	2016	~31B	2020	[14]

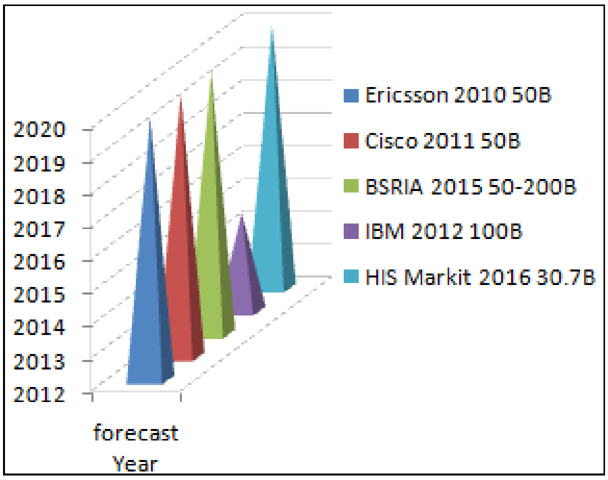

Figure.2 Forecast about worldwide usages of IOT devices in Billion.

III. BACKGROUND AND MOTIVATION

Now a days many electronics devices like mobile phones, electronic home needs, hand held devices, IOT based wearable devices etc are working using the battery based power sources, However the time is passing or the devices are in working state ,they consumes much more power. Hence often some time their batteries were get discharged. The users who are using such devices they expect the maximum battery backup time, to get the uninterrupted services from these devices [15]. Current days there are many sophisticated technologies available in the cyber world. Which are useful to improve the battery backup time and which can estimate about the battery backup time. For example many smart phones and handheld devices applications are designed and developed based on the O.S (Operating System).Whenever a device is OS based , there should be some advantages and disadvantages has to face. One of the disadvantages is battery backup time. The OS based machine always consumes maximum power which decreases battery backup time, because in each millisecond the machine is executing thousands of applications. Like WIFI, Bluetooth, display, keypad, audio, video applications etc. Some devices are executing unwanted applications also .It is always good and suggestible that to keep the such type of unwanted applications into sleep mode, where they require less power and which can improve the life time of power source(Battery).

IV. RELATED WORK

Gubbi et al were provided a clear picture about the power source backup time for the IOT based applications [1], they listed different types of challenges and issues which occur in the IOT based applications, and also they introduced "cloud-centric architecture" which was suitable for the industrial based IOT , home and medical based IOT applications. Later many engineers and scholars were worked in this way and they applied such type of techniques for the design and manufacturing environment [16], for the architectures which works based on the time [17] applications, environment monitoring [18]. The importance of IOT in the application has been explained by the Xu et al. in [19] which was vastly used in the industrial applications. To get the maximum battery (power source) backup time is the one of the biggest challenge for the IOT based applications. Hence the authors in [20] were introduced an IOT architecture which was called Self-Organized Things" which can reduce the power consumption to increase the battery backup time. An "Energy-efficient index tree" was introduced by the authors Zhou et al. in the [21] which was useful to save the power for the sensor node. The main aim of this architecture is to serve the device node which was located in the different locations based on the priority. Their architecture doesn't collect the data from the low priority node, simply they will keep in the sleep mode to save the power. In [22] Damjanovic et al was proposed "clustering index tree" where the IOT area was separated into small cells and they were approved in the right of way manner, in this architecture the only high priority node will come into the execution conditions means remaining nodes will keep in the sleep modes to reduce the power consumption.

In 2014, D'Oro et al. [23] future technique that abuses the way that many "objects" move together when they are passed by a vehicle or a person. Henceforth, the creators utilized gathering creation and spatial relationship for diminishing the power decrease in an IoT framework. In 2013, Liang et al. [24] additionally anticipated technique to spare intensity of the client instruments. The strategy permitted the client device to change to rest mode amid their no activity period and wake up when important. The creators examined way to deal with broaden the rest time of the detecting gadgets for better power productivity. In 2013, Qiu et al. [25] wanted for an improved GEAR organize convention, which not just decreased the loss of motion rate of the system yet in addition improved the power utilization of the framework. The storytellers are utilized a multipath way to deal with organize the hubs in a power-productive and mistake seeing way. In including, the creators in [26] offered vitality productive systems in various methods for IoT applications. In [27] It is seen that every one of the power-sparing procedures proposed in the majority of the previously mentioned research papers is substantial just in one of the IoT situations and that none of them ready to make the whole IoT framework control ingenious.

Reams et al. [28] offered a power-mindful scheduler that plans strings so that they won't past their normal power decrease rate. Applicable to Nemesis, the power-mindful scheduler gauges the power utilization of strings dependent on execution counters in processors. In the event that a string expends more power than is permitted, the scheduler will plan end cycles rather than that string. This methodology is somewhat utilized by the existed plan in this paper to control the power utilization rate of each capacity.

Backholm et al. [29] built up a save compartment that sees a method as an asset key and precisely represents control decrease for an express development worried out by an application. Past ways to deal with confirmation battery life length required variety of utilizations to give low-control modes in which applications spare power to the detriment of administration dedication. In a few examinations [30], the unit for battery life length ensure was the entire framework, and not an individual application. To ensure battery lifetime for individual applications, existing applications must be redo to unequivocally control their vitality use by means of submitted programming interfaces, [31]. Not the same as the past strategies, this paper proposes a plan that ensures battery life length increment for individual applications with no alteration of existing applications. Also, the proposed plan in this paper does not expect clients to know about the power decrease rate or asset use of the objective applications. Rather, clients just need to realize to what extent the objective applications ought to be last.

V. RESULTS & DISCUSSIONS

When the system is executing different tasks it consumes more power because it is executing unnecessary tasks which was called “Normal mode”. “The sleep mode” can be defined as, where the system is consuming minimum current which is not executing code. The Normal mode flow chart has shown in the **Figure.3.** The observation from the **Figure.3** it is very clear that the system is executing all tasks without any sleep modes so each task will consume maximum power that criteria decrease the battery (source) backup time. Let us say the system is executing ‘n’ tasks with same code density or may not, and each task is executing different peripherals of the microcontroller or microcontrollers, Here all peripherals doesn’t consume same power i.e. some peripherals will consume more power and some peripherals consume less power.

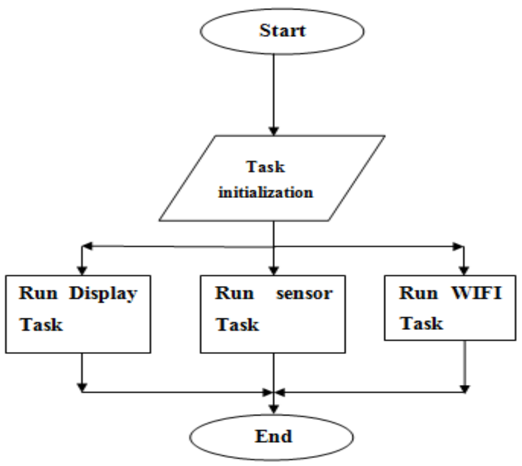

Figure.3 Task Execution in Normal mode.

Now

Task$_1$ power consumption in one hour is T_{1p}.

Task$_2$ power consumption in one hour is T_{2p}.

Task$_3$ power consumption in one hour is T_{3p}.

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Task $_n$ power consumption one hour is T_{np}.

The Total power consumption of the system

T_P in one hour = $T_{1P} + T_{2P} + T_{3P} ....T_{nP}$ **Eq. (1)**

Here the total power (T_p) can decide the power backup time (T_{backup}) of the power source, so it is necessary to decrease this power consumption to increase the backup time of the power source, and it is always inversely proportional to the T_p.

Source Backup time $T_{backup} \infty \frac{1}{T_p}$. **Eq. (2)**

At any point of time it is not necessary to power on some peripherals when the system is executing another task where the other peripherals have been accessed, in this condition it is wise decision to keep the particular peripheral in the sleep mode to decrease the T_p.

5.1 Source power calculation:

As per above discussion the power source backup time can be increased by the processor or microcontroller sleep modes which has been discussed below.

Let us say

C is the capacity of battery in mAh (milliamp hour).

I_{sleep} Is the current consumption when device is in sleep mode (in milliamps).

I_{Awake} Is the current consumption when device is awake (in milliamps).

N_{wph} Is the how many wakeups in one hour

D_w is the single wakeup duration (milliseconds).

Now,

Wake up time per hour (in milliseconds)

$W_{tph} = N_{wph} * D_w$ **Eq.(3)**

Sleep time in one hour (S_{tph}) = (milliseconds per hour) - W_{tph}. **Eq.(4)**

Total current consumption in one hour

$$mAmph = \frac{(I_{Awake})(N_{wph}) + (I_{sleep})(S_{tph})}{3600000}$$ **Eq. (5).**

From equation (3) and (4) it is very clear that (W_{tph}) value increases the (S_{tph}) value decreases, it means the power consumption increase which was represented by the equation (6).

$$T_p \infty \frac{(I_{Awake})(N_{wph}) + (I_{sleep})(S_{tph})}{3600000}$$ **Eq. (6)**

By using equations (3), (4), (5) we can calculate the T_p which is inversely proposal to the (T_{backup}).

From equation (6) it is very clear that when the system or task is in sleep mode automatically the power consumption also decreases.

5.2 Methodology

Based on above equation (6) and (1) the proposed work was implemented, which can increases the power source life time. The block diagram of the proposed work has been given in **Figure.4.** Here the proposed system was existing with different peripherals which are given below.

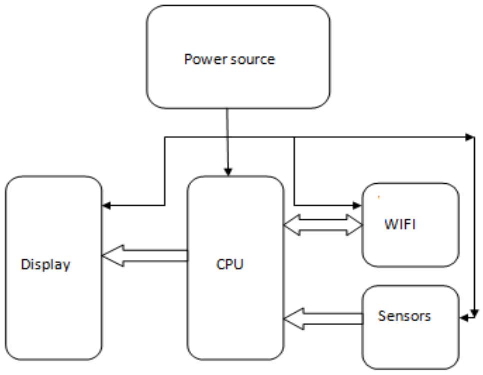

Figure.4: Block diagram of sensor node

1). Display.
2). Sensor.
3).WIFI.

The proposed work exists with 3 peripherals one is display which was useful to display the garbage status, Sensors which are useful to sense the level of the garbage and WIFI which is useful to send the information to the cloud.

Let us say,

The display task current consumption is I_D,

Sensor task current consumption is I_S,

And the WIFI task current consumption is I_{WIFI}

Now Total system current consumption is

$$I = I_D + I_S + I_{WIFI}$$

Here one of the important thing is when one task is executing no need to wake up the remaining tasks, just keep them in the sleep mode to decrease the power consumption, automatically the system power source life time will increase.

For the understanding purpose say each task is consuming the same power, and power source backup time is T_{backup}.

$$I_D = I_S = I_{WIFI}$$

$$I = 3I_D = 3I_S = 3I_{WIFI}$$

$$I_D = I_S = I_{WIFI} = \frac{I}{3}$$

When the three tasks are running in normal mode the T_{backup} time was minimum, when one task is running based on the requirement automatically the T_{backup} increases in sleep mode.

Hence when the display task is executing the current consumption is I_D and remaining tasks consumptions are 0.

And total current consumption is

$$I = I_D + I_S + I_{WIFI} = I_D + 0 + 0$$

$$I = I_D = \frac{I}{3}$$

it means the Display task will consume one third of actual current like sensor and WIFI task.

By using above currents it is very easy to calculate the power consumption of the system.

Total power consumption of the system

(T_p) = (current) * (voltage)

From equation (2)

$$T_{backup} \infty \frac{1}{T_p}$$

$$T_{backup} \infty \frac{1}{(Current)(Voltage)}$$

$$T_{backup} \infty \frac{1}{((Current * Voltage)/3)} \quad \textbf{Eq. (7).}$$

From the above equation it is very clear that when one task is in wakeup mode then the system is taking very less current (one third current) which increases the T_{backup}.

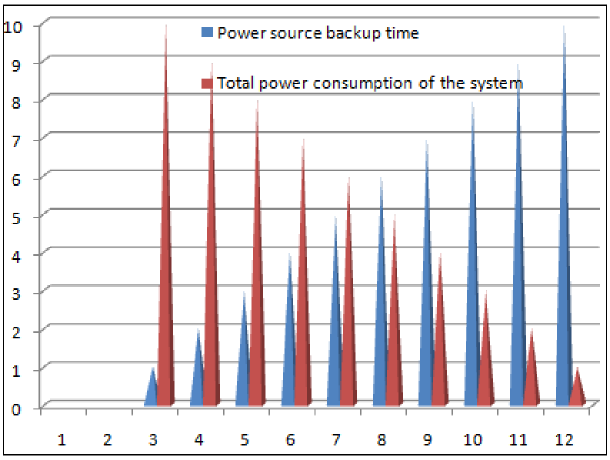

Figure.5 Task power consumption Versus source backup time.

Using above equation the above graph was depicted between Source Backup time T_{backup} and *Total* power consumption of the system (T_p) which are always inversely proportional to each other. The relation was depicted in the **Figure.5** the observation from the **Figure.5** here the light blue color indicates the source backup time and red one indicates the task consumed power which is always inversely proportional to each other.

VI. RESULTS AND DISCUSSION

The research result was examined by the ARM cortex family which works at the low power, and the application was developed by using RTOS which can provide the multi tasking environment. The notable things from the **Table .3** are that when the frequency is increased automatically the CPU current consumption also increases; the same thing was depicted in the **Figure.6**. At 1 MHz the CPU is consuming minimum current where as it is maximum at 32 MHz. It was elegant and suggestible that, to select the minimum crystal frequency always provides low power consumption which provides maximum source (Battery) backup time.

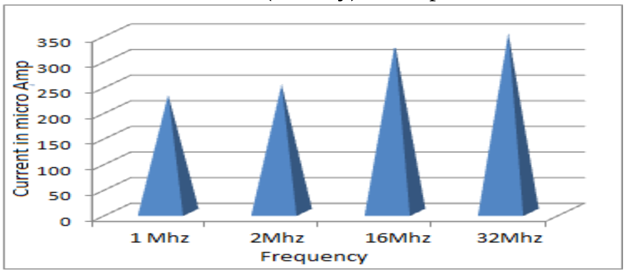

Figure.6 Frequency Versus CPU Current consumption.

Table.3 Frequency Versus Current consumption.

Frequency (MHZ)	Current (µAmp)
1	230
4	250
16	330
32	350

Finally the sleep modes are activated which can reduce the power consumption of the system for the proposed work and taken analysis between normal mode and sleep mode and the values are given in **Table.4**. From this analysis it is very clear that when the power saving modes are activated the system is consuming less power than the normal mode whose backup time is much more good than the normal mode which satisfy the **Eq** (7) the same thing was depicted in the **Figure.7.** The graph is drawn with two lines one is red line and another one is green line. The red line indicates the normal mode backup time and green one indicates the sleep mode backup time which was showing better performance than the normal mode.

Number of batteries(6v 7 ah)	Normal mode(Backup time in hours)	Sleep mode(Backup time in hours)
1	1	3
2	2	6
3	3	9
4	4	12
5	5	15
6	6	18
7	7	21
8	8	24
9	9	27
10	10	30

Table.4.Battery backup time in normal mode and scheduling mode (sleep mode).

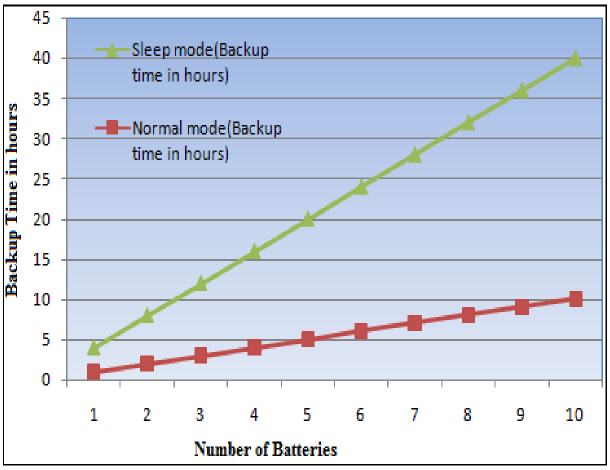

Figure.7 Battery backup time in normal mode versus sleep mode.

7. CONCLUSION

The proposed system was tested in different conditions and achieved maximum performance in case of energy management of each garbage collecting node in contrast of others. When the proposed algorithm was not applied to the node the node quickly discharge due to unwanted code execution, when the algorithm was applied the node power back up was rapidly increased due to restriction of unwanted code execution. The experiment was done by the 6V,7ah batteries ,when the number of batteries are increased the backup time also increases in the sleep mode which was obviously much greater than the normal mode.

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