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Smart Parking: Green IoT for Smart City

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ABSTRACT

In this paper we represent Smart parking as the part of IoT application, with the various vehicle detection techniques and smart sensors. Motivated by creating a sustainable smart world this paper also discusses the technologies and issues regarding green IoT, which henceforth reduces the energy consumption of the IoT and WSN model used in the paper. Stress is given on various compression techniques to reduce the transmission energy

Keywords: Vehicle detection, IoT Wireless Sensor Network (WSN) and Query Optimization.

1. INTRODUCTION

With the rapid development of science and technology, the world is becoming ‘‘smart’. Living in such a smart world people are automatically and collectively served by the smart devices (e.g., computer, watches, and smartphones), smart transportation (e.g., buses, cars, and trains), smart environments (e.g., homes, offices, and factories), etc. For example, using a global positioning system (GPS), a person’s location can be continuously uploaded to a server that instantly returns the best route to the person’s travel destination, keeping the person from getting stuck in traffic.Here IoT is a method under which a collections of things can be connected together via any wireless connection and can interact among themselves for the purpose of creating new services or any application.so in this way IoT allows objects to process data which can be controlled remotely across the given infrastructures of networks.

More specifically IoT can be explained in form of an equation as: Physical Object + Controller, Sensor and Actuators + Internet = Internet of Things.

One of the key issues that smart cities are facing are car parking facilities and traffic congestion.in public places like malls, hospitals drivers fins it very difficult to park vehicle it takes lot of time and also wastage of fuel. Recent advances in building low-cost, low-power embedded systems are helping developers to build new applications for Internet of Things. Followed by the developments in sensor technology, many modern cities have deployed various IoT based systems in and around the cities for the purpose of monitoring the available spaces. Smart parking system uses sensors of various types which are discussed and out of which best sensor nodes more specifically wireless sensor nodes according to current scenario is presented. Along with all the IoT and WSN deployment model few data compression techniques are used to compress data and reduce the energy consumption so as to achieve a green IoT network which is the urgent need of time where humans are facing so many environmental issues.

2. METHODS

Proposed methodology

Parking management systems includes four kinds of sensors which are wireless ,image processing based,counter type and wired type.last two types have disadvantages that they are installed at exit and entrance so cannot provide much information where as wired sensors have problem of ware and tear parts.in this paper vehicle detection algorithm along with magnetic sensors is elaborated.

3. ALGORITHMS

This part presents the acoustic and magnetic vehicle detection algorithms. Two acoustic algorithms are shown: Adaptive Threshold algorithm (ATA) and Min-max algorithm (MMA). Both methods are based on the acoustic energy temporal concentration in the measured acoustic signals. The ATA detects vehicles by searching sequences of 1’s after adaptively thresholding the energy distribution Curve while the MMA detects vehicles by searching the local maximum points of the acoustic energy distribution curve.

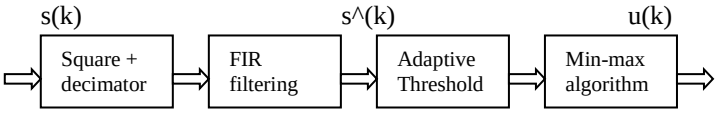

Figure 1: Block Diagram of Detection Algorithm

This adaptive threshold algorithm consists of energy distribution curve, signal filtering, state machine detector and threshold adapter. For the purpose of energy distribution curve square and decimator block is used for the smoothening of waveform FIR filter and adaptive threshold decision block models the variable u(k) which is the slope of the road so that it can be further used in modelling the algorithm as state machine. Following is the block diagram of the detection algorithm.

Min-Max Detection Algorithm: In simple words this algorithm is for the calculation of local minima and maxima. A vehicle can be tracked when the difference between the local minima and maxima is greater than the threshold value obtained by the above adaptive threshold algorithms. The functioning of this algorithm can be understood by modelling it into the state machine diagram. The state machine detects the parking lots by taking into considerations the local min/max, frequency of fluctuation which consists of 5 states: flat, flat count up, hill count up, hill count down.

Input(u):{1,0},

Output(d):{car, no car}

The sign of slope of s(k) is the input for the decision state machine defined as: u(k)=sign(s^(k)-s^(k-1))if |s^(k)-s^(k-1)|>min_deltaU

U(k)=0,otherwise.

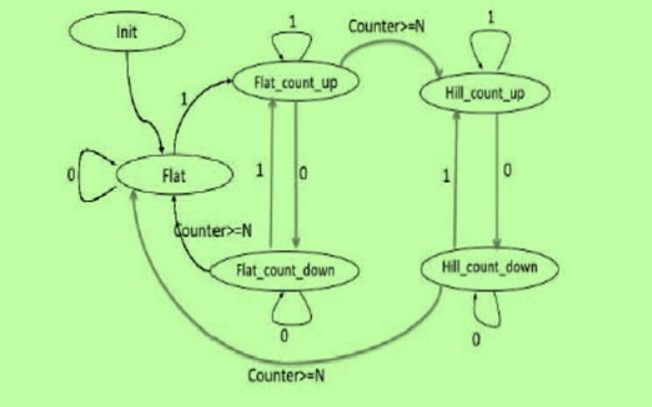

Figure 2: State Machine for Min Max Detection Algorithm

Conditions:

1) Initially machine goes to flat state

2) Flat_state = flat if u(k) =0

Flat_count_up if u (k) =1

3) Flat_count_up unchanged if u (k) =1

Flat_count_down if u (k) =0

Hill_count_up if count>=M

4) Flat_count_down unchanged if u (k) =0

Flat_count_up if u (k) =1

Flat if count>=M

5) Hill_count_up unchanged if u (k) =1

Hill_count_down u (k) =0

6) Hill_count_down unchanged if u (k) =0

Hill_count_up u (k) =1

4. HARDWARE COMPONENTS

There are three basic blocks utilized here with a wireless sensor node WSN which are:

- Wireless sensor node consisting of a processor with radio interface and battery powered components. The communication link is modelled on IEEE standard 802.15.4 using the zigbee protocols.WSN is configured with the OS which is open source tinyos.
- Sensor board components which is the data acquisition part connected with radio part.the sensor used here is the smarteye RFID sensor whose main advantages are: 1) Its can be programed remotely and updated node by node.2) gives real time notification of occupied spaces.3) adjustable stand by for longer battery life.
- Gateway: acts as the connecting link for collecting the data by all sensor nodes and transferring it into the central base station.

The IoT and WSN Deployment Model

Here a simple sample deployment model is represented where several WSN nodes acts as Iot nodes locally and then the transference of data via cloud computation is applied for storing data base.

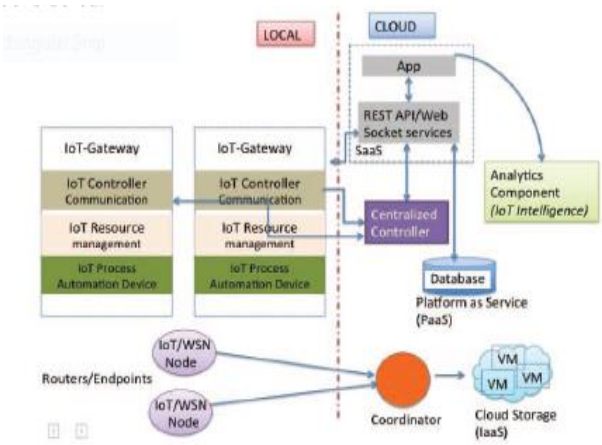

Figure 3: IoT and WSN Deployment Model

5. GREEN WSN

As seen in above model there are lots of WSN nodes used so to transmit data through these nodes to the base station or central data base energy is harnessed with the recent studies we have found if the one bit of data is transmitted from one node to other node then there is a amount of 0.4 micro joules energy used while if we compress that data the energy consumption is cutoff up to the 0.84 Nano joules which is almost 480 times the reduction in energy consumption.so referring to the current alarming rate issues of energy conservation this section of paper refers to the data compression techniques used in the WSN model as well as in the central data base so as to reduce the energy exploitation and achieve the goal of green IoT.

There are two compression methods used for serving above purpose:

1. In-network compression-The input of the sensed data which is from the sensor nodes which are referred to

as motes here are in form of the data stream. Initially these data in very first stage are in the analog form which are processed through analog to digital converters and are converted into data bit stream.so these data are taken and are tokenized i.e. converted into bit of stream and are then subjected to the various compression techniques which can be Huffman coding decoding or LZW or deflate method which ever suits best for the system is chosen from the flow chart.

2. Base station optimization-The second technique is used at the central base station for data compression here with the help of database and SQL queries these queries can be regarded as the tokens or units for the data processing in SQL language for database management system.

At the base-station, query optimization is done using query merging technique. The optimization of multiple queries at the base-station helps in significant reduction in energy consumption. As the base-station is not resource constrained, it filters out the redundant load of multiple queries into the network. If a new query arrives at a base-station where result of a query set Qs have already been calculated or obtained from the network. The new query is merged with the existing queries and a synthetic query emerges out of this merger.

Algorithm has been devised which compares energy benefits by using new query and already existing queries as it is and synthetic query. A 'Gain' metric has been developed to compare the Gain of query merging. In case, Gain is positive synthetic query is used. Slowly existing query set transforms into set of synthetic queries. Once requirement of any query is fulfilled it is removed from the query set. In addition to this as the queries injected into the network have identical expressions to a large extent these identical expressions are replaced with single characters called "Static Variables" which further compresses the data to be transmitted in the network.

Following are the flow chart of the above two technique
1) In-network compression-In the flow chart there are initial steps where the analog data is taken and converted into digital form with the help of analog to digital converter and these data are then present in form of binary numbers and now these are tokenized i.e. converted into the stream of zeros and ones then another step is to compress that generated stream of data further the data output is given to an adder from where three decision nodes arrives it decides which decision technique is suiting best for the further computation the decision can be made by keeping a decision block of certain threshold value and further depending on this value we can have the required compression technique performed on the given data. The most suited technique here is mainly Huffman's algorithm which is the lossless compression technique based on the number of times the repetition of the particular symbol occurs which is being considered. In another words we can say it's a kind of statical coding where the probability of symbol has direct bearing on its length. Another compression technique here discussed is LZW algorithm.

Lempel–Ziv–Welch (LZW) is a universal lossless data compression algorithm created by Abraham Lempel, Jacob Ziv, and Terry Welch. A particular LZW compression algorithm takes each input sequence of bits of a given length (for example, 12 bits) and creates an entry in a table (sometimes called a "dictionary" or "codebook") for that particular bit pattern, consisting of the pattern itself and a shorter code. As input is read, any pattern that has been read before results in the substitution of the shorter code, effectively compressing the total amount of input to something smaller.

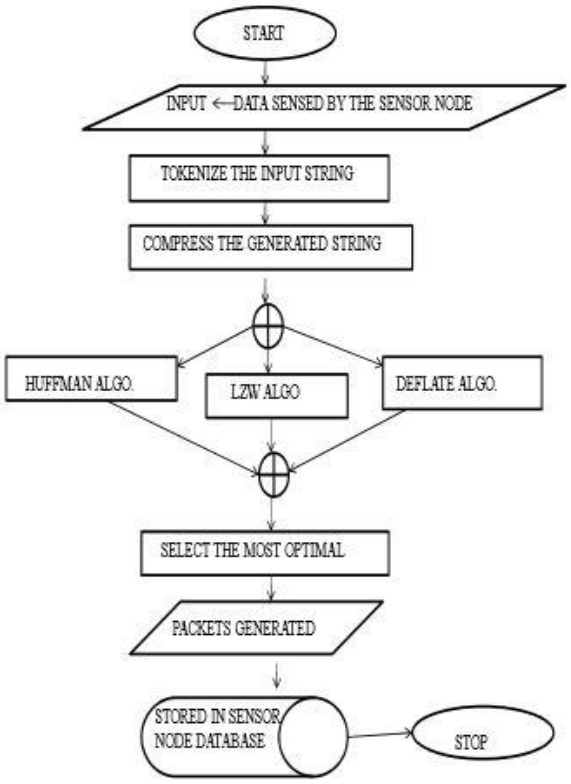

Figure 4: Flow Chart for In-Network Processing

2) The flow chart given next is about the base station optimization. In the following chart the SQL language is utilized along with some standard database queries which are nothing but the tokens or the units. Here the optimization is done at large level and both of these methods together produces the desired outcome. With the help of both of these algorithm we are able to design the green wsn model which can be installed in place of the previous deployment model only change required is the installation of the compression unit which is the compromise on the complexity part of the deployment model and here due to the increased complexity we again see a future scope or the additional useful work in the field of complexity reduction along with the above strategies involved. THE following flow chart explains the compression at base station level.

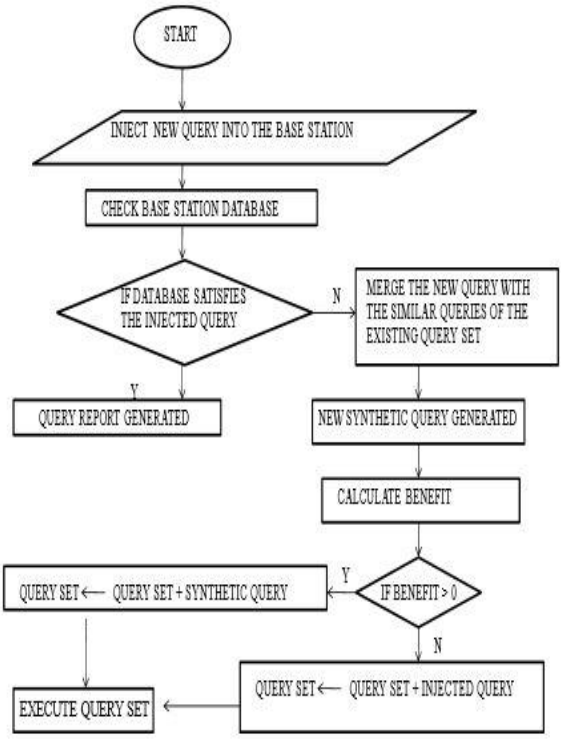

Figure 5: Flow chart of Base Station Optimization

The above two methods are utilizes and a framework of green IoT and WSN deployment model is prepared which is as efficient as the previously suggested an in addition to that it is the one with green WSN energy saver scheme.

Frame work is called as CATMOS which stands for compression at input with multi query optimization.

Performance Analysis:

The findings have been summarized in tabular form and then the graphical representations have been depicted in table in following section.

Compression table showing the original query size (in bytes) along with the Query size after compression using Huffman's/ LZW/ Deflate algorithm.

The graph depict clearly that queries transmitted after compression and the queries transmitted using static variables during program execution along with the compression prove to be a better choice as we achieve remarkable compression. The test was successfully conducted with queries when passed through three different compression algorithms i.e. Huffman compression, LZW and Deflate algorithm. There are various graphs which are studied for the three compression techniques along with the compression factor which is the percentage compression using three techniques and also the difference in amount of percentage compression using above mentioned method is calculated and finally it is inferred that the usage of the static variable in compression further improves the efficiency.

Table 1: Original data and compressed data results after Huffman compression

$Temp_{(min)}$	$Temp_{(max)}$	Epoch	Original Query size (bytes)	Query size using Huffman Algo. (bytes)	Query size using LZW Algo. (bytes)	Query size using Deflate Algo. (bytes)
10	50	5	296	152	282	360
10	40	8	296	144	282	360
10	50	5	304	152	290	368
10	35	40	304	152	290	368
15	25	50	304	152	290	368
15	30	10	304	152	290	352
5	55	120	312	160	305	376
25	50	130	312	160	291	376
30	45	60	304	152	297	368
35	50	70	312	160	298	376

THE GREEN IoT and WSN Deployment model

In this part, we have proposed use of low power consumption techniques in WSNs and query merging for optimization at base station or central database in order to decrease the energy consumption in a WSN. The application of this optimization resulted in a modest 10.29% reduction in the power consumption of the application. Energy savings in one network may seem to be miniscule but as the number of deployed WSNs is increasing day by day, these savings translate into huge amounts globally. This saving in energy will definitely reduce environmental effects and will help in achieving 'Green World'. In addition to this, WSN can be deployed in any inaccessible location to monitor impending climatic or environmental hazards which can be contained if detected timely such as movements of glaciers, forest fires etc.

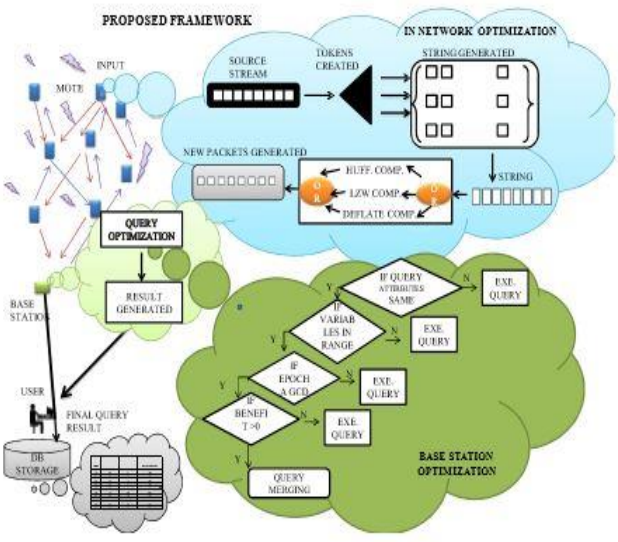

Figure 6: Green IoT and WSN Deployment Model

6. CONCLUSION AND FUTURE WORK

Over all in this paper smart parking solution is presented as IoT application in the smart city.furthur most types of sensor nodes for sensing of vehicle is used out of many sensors magnetic and smarteye RFID sensor is compared and found to be the most compatible one.

Another section of paper produced the various data compression techniques which can be employed with the WSN deployment model of IoT network to reduce the energy consumption thus taking the advancement in the technology with the environmental issues hand to hand.for future scope following directions and problems can be taken into considerations

1. Different algorithms techniques can be elaborated with the help of different more capable sensor nodes
2. The designing of the green Iot model should be handled from the overall system perspective.
3. Reduction in energy and possibility of deployment of WSN at remotely locations is a long way and vast area for achieving the environmental goals.

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