Sensor Data Aggregation using a Cross Layer Protocol for IoT in Smart Cities

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ABSTRACT
Smart cities are developed with the help of many Internet of Things applications. WSN is made of few to hundreds and thousands of nodes and a node is connected to one or many sensors. Sensor nodes communicate with each other through wireless network and generates a vast amount of data. To transmit the sensed data, more energy is required. There is a need of a proper framework for the IoT applications to search and use the data efficiently. The purpose of this project is to design a cross layer framework for data aggregation to extract the sensor data from different applications. The first application refers to garbage management which abstain from spreading some dangerous infections, by observing the status of the dustbin. The second application is weather management to evaluate the environmental conditions. A middleware is designed to store the data extracted from the sensors, and applications will access directly to the middle ware. The cross-layer protocol analyzed in this project is based on cross layer designs of the application layer and network layer.

Keywords
Smart Cities, IoT, Wireless Sensor, Data aggregation, EEPROM, Cross Layer.

1. INTRODUCTION
With the emergence of Radio-frequency identification, the concept of IoT has started and has grown rapidly with the support of Wireless Sensor Networks. WSN has an important role to play in the growth of IoT as the hardware becomes low-priced, hefty and boost the battery life [1]. Sensor network provides a bridge between real and virtual world. However, the sensor nodes in wireless sensor network have limited battery and are resource constrained with respect to energy, computation and memory. A sensor node generates data and transmit sensed data packet to the sink through intermediate sensor nodes. Since more energy is required to transmit data over long distances, so to save energy and resources and to reduce the traffic, the data must be aggregated. Aggregator nodes collect data from multiple sensor nodes, uses some aggregation function to aggregate the data and sends the aggregated data to the sink node. Data aggregation reduces the energy consumption and get rid of unwanted data transmission. Smart cities are based on a lot of IOT applications [2] which requires a billion of sensors which generates a vast amount of data. To make use of these data efficiently, the applications should analyse the data properly. For this, there should be a proper framework to search the required sensor. The distributed cross-layer commit protocol is implemented to reduce the consumption of sensor energy by introducing query based data aggregations. It uses the cross-layer communication between the network layer and application layer.

The rest of the paper is organized as follows, Section 2 discuss the related work, Section 3 discuss the proposed block diagram, Section 4 discuss the implementation details, Section 5 discuss the results and the paper is concluded in Section 6.

2. LITERATURE SURVEY
In this section, the existing methods and protocols in data aggregation and cross layer designs are briefly explained. Data aggregation approaches has been extensively studied before [3]. Sensor networks are dispersed occasion based frameworks that vary from conventional networks in several ways: sensor systems have extreme vitality requirements, repetitive low-rate information, and many-to-one streams. The delay trade-offs and energy reductions involved in data aggregation and the factors affecting them, such as network topology, number of sensors are studied. Data-centric approach is modelled and its performance is compared with traditional end-to end routing schemes.

The approach proposed is not efficient for query-based search data aggregation approaches that are used by most of the ETL systems for IoT applications.

In the existing cross layer protocol called CLCP uses general agreement among all the contributors to reach a transaction decision and uses acknowledgement messages to send back the information [4]. It utilizes both layer three & application layer to exhibit low energy consumption due to implementing cross layers. Since acknowledgements are used to send back information, it ensures correct delivery of messages as well as makes the protocol competitive with respect to energy. Many transactions are permitted to commit in CLCP than the other protocols and is aborted when most of the contributors communicates together for an extensive time.

The approach proposed is not suitable for data aggregation which makes use of query search but only makes use of the cross-layer communication to handle the network failure.

In [5], a query layer which takes requests in a declarative language is modelled for wsn. To decrease requirement of resource, the queries are rearranged to create effective query implementation plans. A database layer for sensor networks is evaluated; where the element situated on each sensor is called as the query proxy. It gives higher level services and is situated between the application and network layer.

The approach assumes bidirectional links, which is usually not true in practice and to obstruct the network packets, filters are used for data aggregation which brings up about the efficient implementation of filters.

To shield the sensors from disintegration and to expand their lifetime we need to utilize energy conservation techniques. In [6] the authors proposed an approach which depends on a blend between a few existing methods of energy saving to take care of the issue of constraint of the system with respect to energy resources. Smart sensors are used to obtain intelligent cities by the overview of ordered group which depends on different layers crossing, to get protocol proposed.

Numerous Internet of Things applications like brilliant stopping, squander administration, and movement blockage administration, are being produced for keen urban areas. These applications make utilization of billions of sensors which thus creates a huge measure of information that goes under the classification of Big Data. For IoT/Smart-city applications to make utilization of this information effectively there should be an appropriate system through which the required sensor could be effortlessly looked and made use of. The current Extract-Transformation Loading (ETL) apparatuses and other scan systems for sensors accept there exist registries where the sensors can be looked for the coveted criteria through ontologies or other appropriate procedures. Be that as it may, there has not been sufficient commitment to proficiently recover the sensor information and to make it accessible in the required arrangement for the registries to look for. In [7] a distributed protocol (CLCP) is analyzed for information accumulations and its support for inquiry based search for IoT application.

3. PROPOSED BLOCK DIAGRAM

The architecture of IoT is designed with four layers: application layer, middleware, network layer, sensing layer.

The applications will operate in the application layer from where it can communicate directly with the middleware. The applications operating in the application layer can get their data from the sensing layer by sending a query request via the middleware. Data from the sensors in the sensing layer are transferred to the data store present in the middleware via the network layer. Network layer is responsible to interconnect the sensors through wireless mode, thus forming a wireless sensor network.

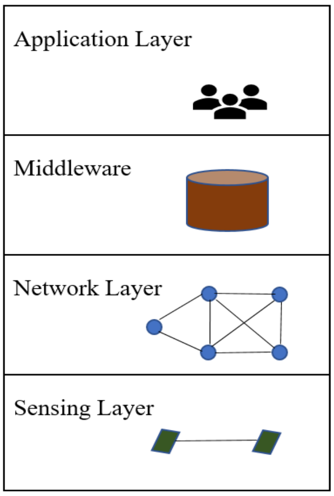

Figure 1: IOT architecture

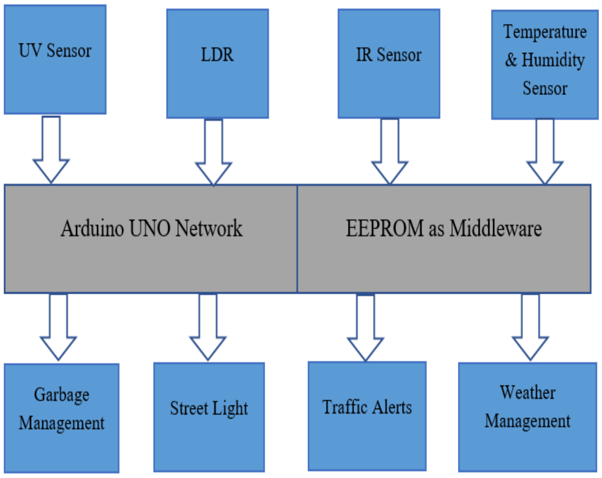

Figure 2: Block Diagram

4. IMPLEMENTATION

The entire system will be used to monitor the following applications:

Garbage Management:
There is a fast development in populace which prompts more waste transfer. So, an appropriate waste administration framework is important to abstain from spreading some dangerous infections, by observing the status of it and in like manner taking the choice.

Smart dust bins are used here which should be connected to the internet for the real-time information. Microcontrollers are integrated into the dustbins which contains Infrared Sensor and RF Transreceiver. The dust level is detected by the sensor and the data is sent to the microcontroller. The signal is encoded by the RF transmitter and decoded by RF receiver. The data received by the cloud via the internet is examined and processed and the status is being displayed in the graphical user interface of the website.

Weather Management:
Current technological innovations for the most part concentrate on controlling and checking of various activities. These are progressively rising to achieve the human needs. Much of this innovation is centered around productive observing and controlling diverse activities. To screen and evaluate the conditions if there is a rise in the occurrence of surpassing the endorsed level of parameters, an efficient environmental monitoring system is required. Smart environment is achieved at the point when the items like condition furnished with sensor gadgets, microcontroller and different programming applications turns into a self-securing and self-checking condition.

Board Hardware Resources Features:
Arduino Uno:
The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

Ultrasonic Sensor:
It is used to detect any moving or stationary objects within the specified range which is pre-decided. The HCSR04 ultrasonic sensor uses sonar rays reflection and reception mechanism to calculate the distance from the object.

Temperature and Humidity Sensor:
AM2302 output calibrated digital signal. It applies exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements are connected to 8-bit single-chip computer.

Cross Layer Commit Protocol for Data Aggregation:
The cross-layer commit protocol implements data aggregation using both the network and application layer. The application layer initiates the query request and goes to the network layer. Whichever nodes will reply to the query will be considered as the members of the cluster. In this protocol, two parameters are considered to determine the cluster head: residual energy and average distance between cluster members. The nodes having higher value for both the parameters is selected as the cluster head.

There are two stages involved in this approach:

1. To find the cluster head:
   - Sensor nodes should take the routing decisions.
   - The data registry generates a query which is forwarded to the sink node.
   - The sink node then forwards the query to the sensor network.
   - The nodes which will be responsible to provide data for that particular query should reply to the root node by sending an acknowledgement message.
   - All the nodes which will the send the acknowledgement will form a cluster.
   - Based on the highest residual energy and the average distance of the cluster members, the cluster head will be selected.
2. To collect the data:
   - After receiving the acknowledgement, the sink nodes will a send a signal to the cluster members to send the data.
   - The cluster members will now send the data to the sink node via the cluster head.
   - Cluster head is responsible for data aggregation in the network layer.
   - As the query period expires, the cluster and cluster head identified will be removed and new cluster will be formed for new queries.

5. RESULTS AND DISCUSSION
The system is developed using Arduino UNO as the core and Arduino IDE as the programming tool. Sensors are initiated by Arduino and gross the data and passes it to middleware. Application layer consists of many designed applications like garbage management, street light, weather management and traffic alerts. Application layer takes the data from Middleware and performs the data aggregation.

Figure 3 is the entire model developed. The entire system will continuously monitor the temperature, humidity, CO2 and garbage level. The aggregated values of the temperature, humidity and CO2 will be continuously displayed in the LCD, since the values keeps on changing. When the sensor in the dustbin detects that the bin is full, the information will be updated in the data store and will be displayed in the LCD.

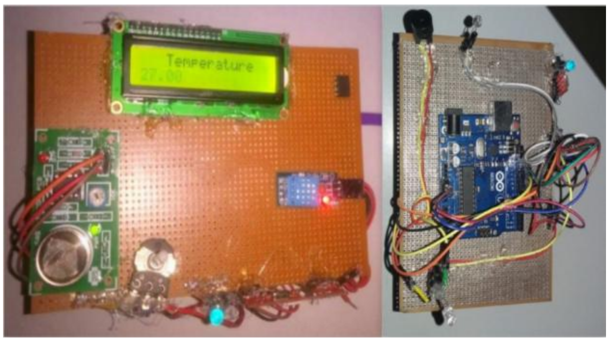

Figure 3: Prototype module

The garbage management system is an extraordinary imaginative framework to make the cities clean. This system is used to monitor the garbage bins. For this, ultrasonic sensors are being used which are placed on the cover of garbage bins to detect the level of garbage. The model makes utilization of Arduino microcontroller, LCD screen and 433 MHz RF module for sending information and a signal. A buzzer is used to indicate the end user when the garbage in the dustbin crosses the predefined limit. The LCD screen is utilized to show the status of the garbage bins.

The Weather management system allows to directly and constantly check the weather statistics like temperature, humidity and CO2 level. The system constantly monitors the temperature and humidity through DHT sensor and CO2 level through the Gas sensor. The data is continuously transmitted to the Arduino controller where the data is aggregated and is stored in the EEPROM. Also, LCD display is used to display the values of temperature, humidity and CO2.

Figure 4: Monitored LCD Value

Serial monitor window in arduino is used to display the outcomes in a window. It is used to debug the code and the computer can send different commands via this serial monitor. It sends serial information and acts as consecutive terminal.

The output of the temperature, humidity and CO2 sensors can be observed in serial monitor of arduino software

6. CONCLUSION AND FUTURE SCOPE
The proposed model is a realistic approach adopted to show the data aggregation using cross layer protocol using smart city applications. The two applications used are to monitor the

smart dustbin and environment in order to make the city smart. The protocol used, perform better than other protocols to reduce the energy consumption of the entire network. The realistic operation of the protocol for aggregation of the data generated by the sensors used for the applications is shown. The sensors are continuously monitored and the data are aggregated and stored in the data store. The aggregated data is directly displayed in the LCD. Middleware is designed so that multiple applications of smart city can be implemented.

The system directly displays the aggregated data but all the data generated by the sensors can be shown using online cloud. The system can be improved by using caching mechanism to store the aggregated values for a long time which is not possible in the current system. Smart meter dataset can be used to display all the aggregated values in real time.

7. REFERENCES

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