ANT COLONY OPTIMIZATION ON CLSTERED WSN FOR INDUSTRIAL MONITORING

1. Rajalakshmi.R
PG scholar,
Department of ECE
Prathyusha Engineering College
lakshmi.raghu91@gmail.com

2. Premalatha G
Associate Professor,
Department of ECE
Prathyusha Engineering College
hod.ece@prathyusha.edu.in

3. Malathi S
Associate Professor,
Department of ECE
Prathyusha Engineering College
malathisharavanan.ece@prathyusha.edu.in

4. Iniyan E U
Assistant Professor,
Department of ECE
Prathyusha Engineering College
iniyan.ece@prathyusha.edu.in

***Abstract*— Wireless sensor network, efficient technology to build the monitoring system which consists of nodes with limited power deployed in several area. Minimizing the deployment cost is one of the major criteria in wireless sensor network design, as the positions of sensors have to be carefully determined. In this work, two important facts are being focused and that includes an energy efficient transmission and a prolonged network lifetime. A Power-Aware Scheduling and Clustering algorithm based on Ant Colony Optimization (PASC-ACO) with energy efficient transmission using compressive sensing is deployed for large scale wireless sensor with multi hop data delivery. The proposed algorithm improves the energy of each sensor node in the clustered network.**

Keywords: Compressive sensing, IOT Platform, Application Program Interface.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) enable the observation of the world with an unprecedented resolution. These networks are composed of many tiny low-cost low-power on-chip sensors. Typically, a sensor node includes four main components: a sensing unit for data acquisition, a microcontroller for local data processing, a communication unit to allow the transmission/reception of data to/from other connected devices and finally a small battery. Short communication ranges and limited bandwidth of sensor nodes lead to multi-hop communications and low data rates. Hence, the individual devices sense the surrounding environment and send their data, directly or via multiple hops, to a central device, namely the sink for processing.

In electrical power plants, radiation measurements can be delivered by sensors without compromising the life of people working in these plants. Besides, in an accident caused by an earthquake or tsunami, wired sensors networks may be damaged. However, wireless sensors can be easily deployed after plant's accident.

Thus, they can provide an accurate damage assessment. Moreover, the typical communication pattern in the industrial application is many-to one communication. Every node plays the role of data source and/or router node through a routing tree to deliver packets to the sink. This data collection is called raw data converge cast. In this context, nodes that are near the sink should forward more packets than sensors far away. Hence, the scheduling of transmissions should be traffic-aware

A Wireless sensor network consists of low size and low complex devices known as nodes that may sense the environment and gather the data from the monitoring field and communicate through wireless links. The information collected is forwarded through multiple hops to a sink. In WSN, the sensor nodes are deployed randomly in a sensing area. Each sensor in WSN monitors its environment and delivers some global data or an inference about the environment to a base station which could be located randomly in a network. So, it collects the local information, process them and send it to a remote base station. Using GPS technology, the information about the environment are collected and given to the application Web server for data communication. In the proposed system, two important facts are taken into account for energy efficient transmission and to have a prolonged network lifetime. In this work, a Power- aware scheduling and clustering algorithm based on Ant Colony Optimization (PASC-ACO) with energy efficient transmission using compressive sensing is deployed for large scale WSN multi hop data delivery. It improves the energy of each sensor node in the clustered network as well as enhances the lifetime of the real sensor network.

II. EXISTING SYSTEM

Conventional measuring stations are equipped with multiple lab quality sensors. The majority of deployment approaches uses a simple detection model assuming the detection range of the sensors. Most research work is based on atmospheric dispersion modelling which calculates the threshold using ILP formulation for WSN coverage. Some of the work is based on geographical analysis to identify the flow of effect over the region and the network is switched based on the result generated by the geographical conditions of the area.

III. PROPOSED SYSTEM

We focus on raw data converge cast in multichannel WSNs. We tackle the problem of finding a schedule that minimizes the delay needed to collect a large amount of data from sensors to the sink. The aim of this work is to provide a set of conflict free schedules for converge cast that orchestrate nodes activities through a shared wireless medium. These solutions should be well suited for the inherent characteristics of WSNs such as energy efficiency, delay constraints, adaptively to environment and scalability.

Energy efficiency is a critical feature of wireless sensor network because sensor nodes run on batteries that are generally difficult to recharge once deployed. To improve the performance of nodes in network and prolong the network lifetime, schedule the nodes in network by TDMA scheduling and cluster the nodes for finding shortest path to communicate and sense the data in network

A. Advantage of proposed system

It provides efficient way of communication in the network.
ECS based Compressive sensing provides energy efficient data transmission between the nodes. The process is performed within the WSN nodes so not need of any processor system. Minimize the energy wasted while transferring the redundant data. Enhance the network lifetime by selecting optimal path. Information's collected are updated periodically and useful for further manipulation.
Easy to maintain with low cost.

B. *Objectives*

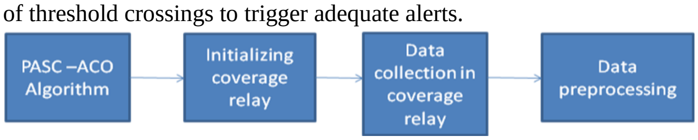
To improve the performance of nodes in network and prolong the network lifetime. To balance the energy load among all the nodes.
To minimize the energy wasted in a densely deployed network.
To implement user friendly prototype model. To get the accurate values within a prescribed period.

C. *Methodology*

Improve the performance of nodes in network and prolong the network lifetime, balance the energy load among all the nodes, minimize the energy wasted in a densely deployed network, implement user friendly prototype model, get the accurate values within a prescribed period.

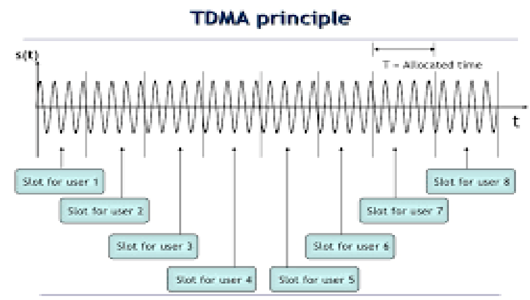
IV. ALGORITHM FOR MONITORING SYSTEM

The block diagram illustrates the flow of behavior of the proposed system. The main objective of this work is to monitor the various parameters in the industry using wireless sensor networks by effective deployment of sensor nodes. Industrial monitoring may target two objectives: i) the periodic sampling and ii) the detection of threshold crossings to trigger adequate alerts.



Sensors are deployed to monitor the parameters. In the proposed work, power aware scheduling and clustering algorithm is used to deploy the sensors to improve the network lifetime and also to minimize the wastage of energy while transferring the redundant data. Ant colony optimization is implemented for finding shortest path which maintains the routing table for avoiding link failure. This methodology further improves the efficient transmission of data packets in the optimal path. Temperature sensors and multi gas sensors are used to sense the pollutant gas under any weather condition.

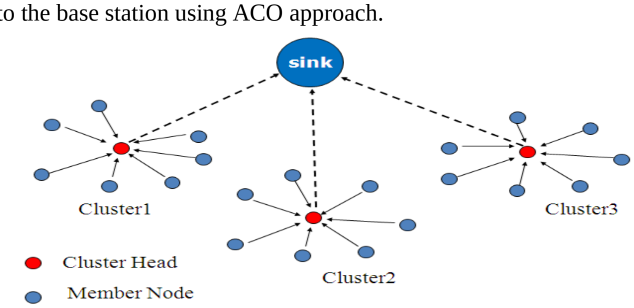
Using TDMA scheduling, equal number of slots are assign to the nodes member of the same cluster which balance the power



consumption of nodes within the same cluster and also avoid collision among the nodes. For the data communication phase, an Ant Colony Optimization (ACO) algorithm is implemented to find the optimal path to the sink or base station. The information from the base station is given to the data base using GPS technology. From there, the collected information is being updated in the application server or web server. Here the concentration of pollutant sources is being recorded periodically.

A.NETWORK MODEL

A wireless sensor network consists of large number of low cost nodes which is randomly deployed to monitor the environment. Sensors are communicate with each other using multi hop approach and the flow of data ends at the special node called base station (sink).A base station links the sensor network to another network as a gateway to disseminate the data sensed for further processing. They have sufficient memory, storage and computational power. Basically, nodes are placed closely for effective sensing. Therefore they are organized as a group called clusters in which the communication is passed through the cluster head to transmit information. Multiple cluster heads are used to carry the data packets to the base station using ACO approach.



B. PASC-ACO TECHNIQUES

PASC-ACO is an efficient algorithm for balancing the energy load among the nodes. Air quality monitoring is divided into three phases. (i) Setup phase or clustering technique (ii) finding optimal path (iii) ECS based transmission approach.

Setup phase or clustering technique:

Nodes can be geographically located according to the two - dimensional location information to form the clusters. This information is being tracked out using (GPS) globally positioning systems. The network lifetime is divided into rounds. Each round initiates the selection of cluster head among the nodes in the network. Usually, all the nodes are in active state and the nodes which possess maximum energy will be elected as cluster head.

All the data transmitted from each node is collected by cluster head and forward it to the base station. Each CH set up a TDMA schedule among the cluster member for broadcasting the data. This is achieved based on the residual energy of nodes in the clusters. This is achieved by TDMA scheduling by assigning equal number of slots to the nodes member of the same cluster. The main task in designing a TDMA schedule is to allocate time slots depending on the topology and the node packet generation rates. A good schedule not only avoids collisions by silencing the interferers of every receiver node in each time slot but also minimizes the number of time slots hence the latency:
phase is completed.

Ant colony optimization in WSN

Ant colony optimization approach is implemented to find the shortest path between the cluster head to base station for maximizing the lifetime of the network and to minimize the wastage of energy among the nodes. The basic idea of the ant colony optimization (ACO) is taken from the food searching behavior of real ants. Ant agents can be divided into two sections:

FANT (Forward Ants)

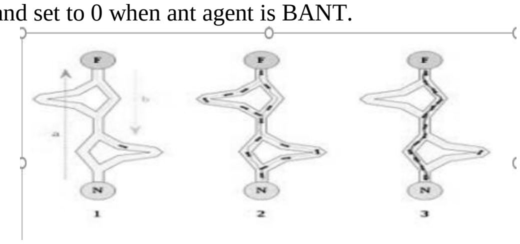
BANT (Backward Ants)

The various steps how these agents are passing routing information to each other are as follows:
Each network node launches FANT to all destinations at regular time intervals.Ants find a path to destination randomly based on current routing tables.
The FANT creates a stack, pushing in trip times for every node as that node has reached. When destination is reached, the BANT inherit the stack.
The BANT pop the stack entries and follows the path in reverse.
The routing table of each visited node is updated based on trip times.

Source address (4 bytes)	Sequence Number (2 bytes)	Destination Address (4 bytes)	Stack	Stack pointer (2 bytes)	Fwd (value =0 or 1)

Frame format

These fields are defined as:
Source Address: The 4 bytes field, which contains address of source node discovered by route discovery phase.
Sequence Number: The 2 bytes field or local counter maintained by each node and incremented each time when FANT generated by source.
Destination Address: The 4 bytes field, which contains address of node where to send the information from source.
Stack: The memory area in which data gathered by FANTs is stored.
Stack Pointer: It is 2 bytes field, which keep track of number of visited nodes. 6. Fwd: The 1bit field set to 1 when ant agent is FANT and set to 0 when ant agent is BANT.



Routing in wsn using ant-like agents

- Using AntNet, nodes in the network frequently send ant agents to randomly selected destinations in the network.
- After reaching the destination, the ant agent traverses the same path going back to the original source node.
- On the way back to the Source node, the ant agents update the routing table of the nodes.
- Launching ant-agents continuously increases the control overhead a dynamic network such as WSNs, by the time, the ant agent reaches the source node; the routing information may have changed.

The Three Phases of Ant Based Algorithm

- Route discovery phase
- Route maintenance phase
- Route failure handling

Route discovery phase:

Route discovery phase uses control packet to discover route from source to destination. Route discovery uses two ant agents called Forward Ant (FA) and Backward Ant (BA).A FA is an agent, which establishes the pheromone track to the source node, and BA establishes pheromone track to the destination. A forward ant is broadcast by the sender and relayed by the intermediate nodes till it reaches the destination. A node receiving a FA for the first time creates a record in its routing table. The record includes destination address, next hop and pheromone value. The node interprets the source address of the FA as the destination address, the address of the previous node as the next hop and computes the pheromone value depending on the number of hops the FA needed to reach the node. Then the node forwards the FA to its neighbors. FA packets have unique sequence number. Duplicate FA is detected through sequence number. Once the duplicate ants are detected, the nodes drop them. When the FA reaches the destination, its information is extracted, and it is destroyed. BA is created with same sequence number and sent towards the source. BA reserves the resources at along the nodes towards source. BA establishes path to destination node.

Route maintenance phase:

Route Maintenance plays a very important role in WSN's as the network keeps dynamically changing and routes found good during discovery may turn to be bad due to congestion, signal strength, etc. Destination node receives a packet, it probabilistically sends a Congestion Update message to the source which informs the source of the REM value for that route. This Congestion Update message also serves an ACK to the source.

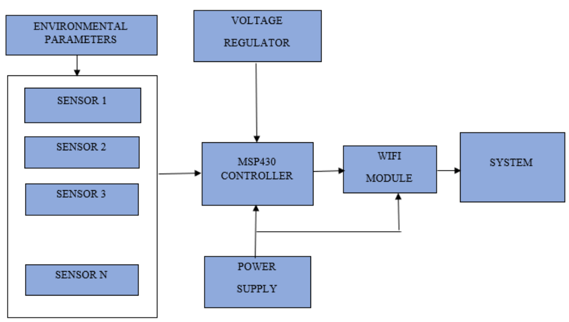
Route failure handling phase:

This phase is responsible for generating alternative routes in case the existing route fails. Every packet is associated with acknowledgement; hence if a node does not receive an acknowledgement, it indicates that the link is failed. On detecting a link failure, the node sends a route error message to the previous node and deactivates this path by setting the pheromone value to zero. The previous node then tries to find an alternate path to the destination. If the alternate path exists, the packet is forwarded on to that path else the node informs its neighbors to relay the packet towards source. This continues till the source is reached. On reaching the source, the source initiates a new route discovery phase. Hence ant algorithm does not break down on failure of optimal path. This helps in load balancing. That is, if the optimal path is heavily loaded, the data packets can follow the next best paths.

V. DESIGN AND IMPLEMENTATION

A. Hardware description of the proposed model

A simple block diagram of the proposed model is described in Figure for industrial pollution monitoring. The hardware components used in the proposed model are given below:



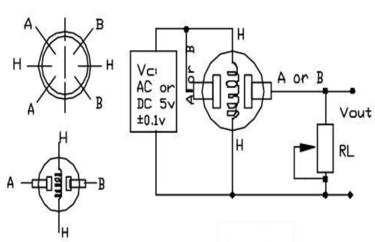
Block Diagram of Hardware Description

B. Sensor Module

In the proposed work, the sensor module consists of gas sensor and temperature sensor that are used in the field for gathering data.

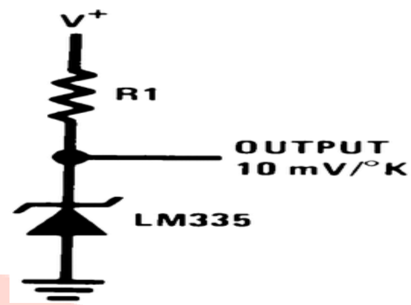
MQ6 Sensor

MQ6 sensor composed of micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless-steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-6 have 6 pin ,4 of them are used to fetch signals, and other 2 are used for providing heating current



LM335

LM335 series are precision, easily-calibrated, integrated circuit temperature sensors which are operating as a 2-terminal Zener diode which is shown in Figure 4.4. The LM335 has a breakdown voltage that is directly proportional to absolute temperature at 10 mV/°K. With less than 1 Ω dynamic impedance, the device operates over a current range of 400 µA to 5 mA with virtually no change in performance. When calibrated at 25°C, the LM335 has typically less than 1°C error over a 100°C temperature range. Unlike other sensors, the LM335 has a linear output. Applications for the LM335 include almost any type of temperature sensing over a –40°C to 100°C temperature range. The low impedance and linear output make interfacing to readout or control circuitry are especially easy.



Schematic Diagram of LM335

Special Features of LM335

Directly calibrated to the Kelvin temperature scale, 1°C initial accuracy available, Operates from 400 µA to 5 mA

MSP430F5529 Launchpad

The MSP430F552x is one of several USB-equipped MSP430 MCU families. The MSP430 is a family of 16-bit RISC microcontrollers produced by Texas Instruments. The most important feature of the MSP430 is its low power consumption.

Figure shows the LaunchPad development kit, with its important features and configuration controls.

Hardware Features of MSP430F5529:

1.8-V to 3.6-V operation, Up to 25-MHz system clock

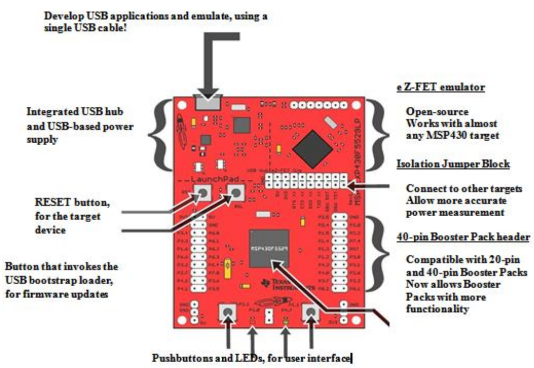
128KB flash memory,

8KB RAM (in addition to 2KB shared RAM with the USB module)

Ultra-low-power operation

Full-speed USB with 14 endpoints – enough for almost any USB application

Five timers, up to four serial interfaces (SPI, UART, or I2C), 12-bit analog-to-digital converter, analog comparator, hardwaremultiplier,
DMA.



ESP 8266 WIFI Module

ESP8266EX implements TCP/IP, the full 802.11 b/g/n WLAN MAC protocol and Wi-Fi direct specification. It supports not only basic service set (BSS) operations under the distributed control function (DCF) but also P2P group operation compliant with the latest Wi-Fi P2P protocol. Low level protocol functions are handled automatically by ESP8266EX.

Parameters:

- RTS/CTS
- Acknowledgement
- Fragmentation and defragmentation
- Aggregation
- frame encapsulation (802.11h/RFC 1042)
- Automatic beacon monitoring / scanning, and
- P2P Wi-Fi direct
-

Voltage Regulator

7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output.

Power Supply

The power supply used in this model is 12v, 500mA step down transformer which transforms 220v AC to 12v that provides a maximum of 500mA current. It is easy and flexible to be used as a regulated power supply

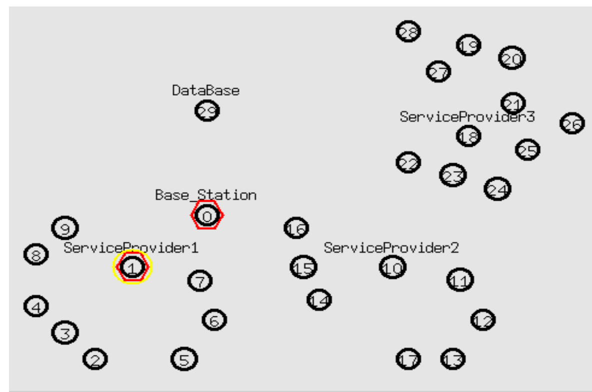
VI. SIMULATION AND HARDWARE RESULTS

A. SIMULATION RESULT

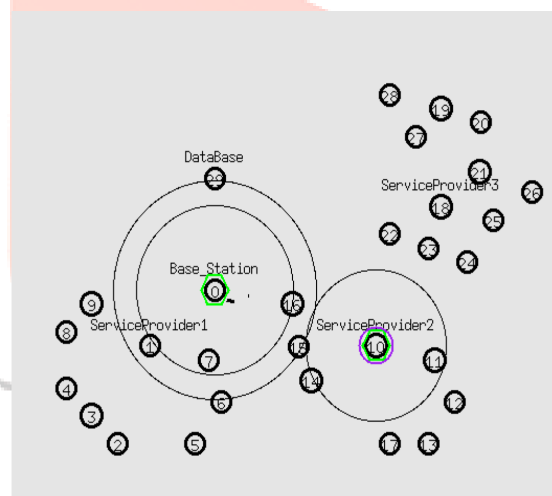
The simulations were carried out in network simulator (NS2) to evaluate the performance of proposed method.

Table : Simulation Parameters

Parameter	Value
Simulation tool	NS2
Simulation time	16 sec
Maximum nodes in the network	50
Area of deployment	1000*1000 m²
Initial energy for each node	2J
Transmission energy	0.015J
Receiving energy	0.015J



Cluster node formation



Formation of PASC algorithm

B. HARDWARE RESULT

Energia IDE

Energia is an open source & community-driven integrated development environment (IDE) & software framework. Energia is supported in Windows, Mac & Linux. The Energia IDE also supports in-line C, assembly & Driver Library based code. Energia IDE and ESP 8266 module using the C/C++ script and uses the **MSPGCC** compiler.

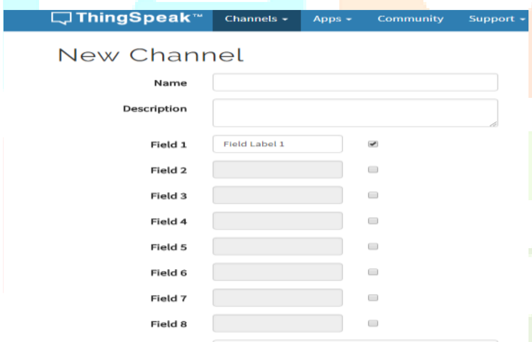
Data monitoring in IOT Platform

Thing speak.com is an open source "Internet of Things" API to store and retrieve data from things using HTTP over the internet or via a local area network with think speak. It can able to create sensor logging application, location tracking application and a social network of things with status updates.

Procedure: Step 1 Using Gmail account, sign into the thing speak.com as a new user and fill all the relevant details related to the hardware environment

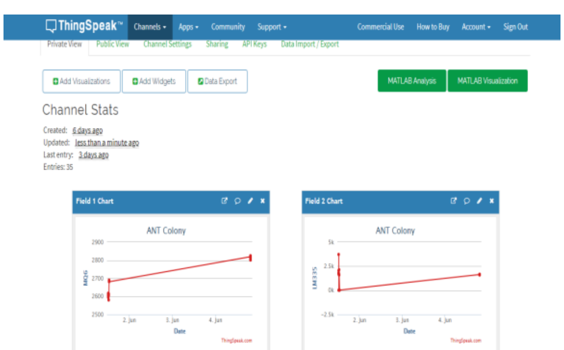
Creating new Account in ThingSpeak

STEP 2 A new channel is being created with the required fields andthe specifications for the field chosen.



Creating New Channels with the Relevant Fields

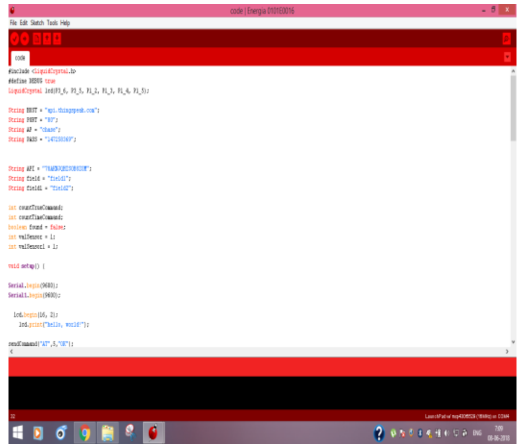
STEP 3 Through the Wi-Fi it's started to get the updated information from the hardware resources in the kit.



Information from Hardware Kit

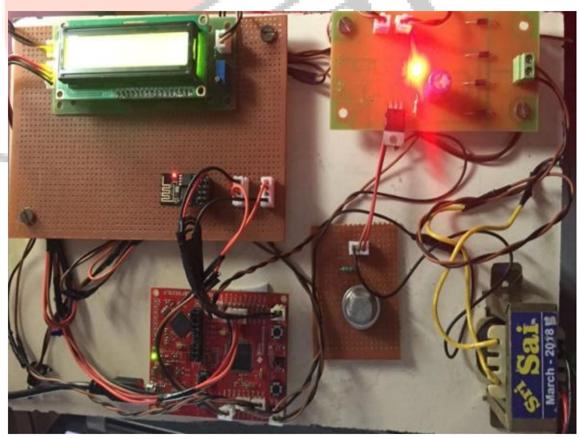
C. OUTPUT FROM HARDWARE

The network connection is being established among the sensor module, MSP430, WIFI module and API is displayed in PC.



Network Establishment

After the connections are established between the MSP430 and ESP 8266 wifi module, it is connected to the PC for setting up the network establishment. The circuit diagram shown below in Figure 5.12 details the whole hardware setup.



Processing of Hardware Setup

The hardware setup starts to collect data from the environment through the MQ6 sensor which is used to collect the information about the dust particles around the atmosphere. LM 335 is the temperature sensor checks the average temperature at the environment.

VII. CONCLUSION

In the proposed approach, Wireless sensor network are used for industrial monitoring and in particular the deployment of sensors using scheduling and clustering algorithm. Energy Efficiency is the major criteria of WSN as the sensor nodes are running on the battery power which is difficult to recharge once it is deployed. Therefore, in order to maximize the lifetime of the network and also to minimize the wastage of energy consumed by the redundant data, we use Power Aware Scheduling and clustering algorithm based on ACO and energy efficient compressive sensing. PASC-ACO is to find the optimal path for data transmission and TDMA scheduling is slotted to each node for balancing the load among all the nodes. ECS is used to recover the signal for efficient transmission of data packets. From this work, the overall network lifetime is maximized, and power consumption is minimized.

The prototype model is being designed, implemented and verified through the above results and output is evolved with the accurate reading by comparing the threshold values of the toxic gases present in the environment. In proposed work, design and implementation of hardware components are discussed with appropriate specification and sensed environmental data are collected and updated periodically through IOT technique and with the help of cloud-based tool. These data are stored and can be retrieved by the researchers and civil society people in future to take necessary steps to control the pollution occurrence in the environment through indoor and outdoor appliances.

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