Abstract— In recent years, there has been a growing interest in wireless sensor networks (WSNs) due to its wide range of potential applications. They are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation and traffic control. In civilian scenarios, sensors used to monitor traffic or pollution. In terms of the most basic military applications, such networks can be used to detect, classify, and track targets in a given territory. Today wireless sensor networks (WSNs) pose a number of challenging optimization problems. One of the fundamental problems in wireless sensor network is Coverage and Lifetime. Since the sensor node have a limited battery power. Once we deploy the sensor it is very difficult to change the battery power so energy efficient deployment is very important to increase the coverage and lifetime. In some applications of wireless sensor networks, the sensing nodes is so far away from base station that relaying nodes must be employed to forward data. Some relay nodes use up their power early because they have heavier traffic load than other nodes, which affects the network lifetime. In this work, we provide an analytical framework for the deployment of sensors. We also present the formulation and solution to energy allocation of sensor node according to traffic load in every hop wireless sensor networks. The simulation results show that our deployment algorithm can significantly reduce the total number of deployed sensors and also increase the lifetime of wireless sensor network. We also present an algorithm which shows that how much initial energy is required for different sensors which are deployed in different hop WSNs.


I. INTRODUCTION

A wireless sensor network (WSN) consists of a large number of sensor nodes that are densely deployed either inside the phenomenon or very close to it. Sensor nodes monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. In the past, sensors are connected by wire lines. Today, this environment is combined with the novel ad hoc networking technology to facilitate inter-sensor communication.

Typical multi hop wireless sensor network architecture is shown in the Fig.1.

![Sensor Network Architecture](image)

Figure 1: Sensor Network Architecture

Hierarchical Architecture :- In a hierarchical architecture sensor nodes organized into clusters, where the cluster members send their data to cluster heads while the cluster heads serves as relays for transmitting the data to sink

Flat Architecture: - In a fault Architecture, each node play the same role in performing a sensing task and all sensor nodes have same transmission and communication range, each node communicate with the sink via a multi hop path and uses its point to point node as a relays.

Recently, a lot of efforts from industry and academia have been made for the purpose of effectively deploying the wireless sensor network. The power constraint of sensor devices imposes many fundamental design limitation in wireless sensor networks, such as coverage and lifetime. Thus prolonging network lifetime is an important part of the system design in wireless sensor networks. Most of the proposals use the scheduling mechanism that is to organize sensor into a number of subset such that each set completely covers an interest region. These sets can be active successively to prolong network lifetime. When one set is active to do the sensing task, the other sets are in the sleep mode. Given a network domain, different sensor deployment strategies result in dissimilar network coverage and lifetimes, which are
We first consider a homogeneous sensor node where the battery power of sensors is same. We deploy the sensor node such that traffic load is balanced in all hops sensor network. We then consider a WSNs where different wireless sensor node may have different initial energy(Eo) but sensing range(rs),and communication range(rc) of all the sensors is same. We deploy the sensor node according to the traffic like sensor which have a most energy is deploy in the first hop and sensor which have a least energy is deploy in the last hop, because traffic in first hop sensor network is maximum and the traffic in last hop sensor network is minimum. so that all sensor is die(exhaust energy) proximately at the same time so that no part of energy is wasted.

II. NETWORK MODEL

We made a few assumptions in the algorithms and techniques proposed in this paper which can be summarized as follows:

- We considered only 2-D regular terrain in which traffic load is uniform.
- We considered only for flat type architecture of wireless sensor network.
- In the proposed algorithms, we consider that energy consumption only for transmission and reception of packets (data sensed by the sensor).• In the second algorithm, we consider all sensors are homogeneous, means all the sensors are same battery power(Eo), communication range(rc) and sensing range(rs). we also assume that communication range are two times the sensing range. rc= 2rs
- In the third algorithm, we consider the battery power of sensors in different hop is different.

A. Deployment of Sensor

We consider a Wireless sensor network in 2D plane with N sensors. First we divide the given area in to different grids such that length and width of each grid is equal to the rs, where rs, is the sensing range of the sensor and rc is the communication range of sensor. If we are deploying the sensors in any area, three parameters are very important that is, coverage, connectivity and lifetime. Sensors are deployed in different hop based on energy consumption in different hop. Since the traffic load varies from hop to hop in wireless sensor network, there comes the need to deploy the sensors in such a way that the overall traffic of the network is balanced. In WSN every node behaves in a co-operative fashion with each node behaving as a relay node. So even if one intermediate node dies or fails, the entire communication link will be disrupted. Hence to efficiently use the energy of all the nodes we have to make sure that all the nodes die almost at the same time. After the division of given target area place one sensor at every alternate node as shown in the Figure 1. Now calculate the number of hops and traffic load at different hops. Once we calculate the traffic load at different hops of sensor network we get the energy consumption at different hop WSN. From obtained information about the traffic and energy consumption at every hop, we can deploy the sensors in different hop according to the traffic.

2.1 Increase the Density

If the initial energy of all the sensors is same then increase the density of sensors near to the base station because traffic load near to the base station is more. Since in the first hop, traffic is more, we have to deploy more number of sensors at the grid point of the first hop of the network. At any instant of time, of the many sensors which are deployed only one sensor is active. When this active sensor dies, any one of the remaining sensor automatically wakes up and takes up the job of its predecessor sensor.

2.2 Increase the Initial Energy

In Wireless Sensor Network once we deploy the sensor it’s very difficult to change the battery power and in some scenario we cannot change the battery power of sensors. But before the deployment of sensors we can change the battery power of sensors. Near to the base station traffic is more because sensors near to the base station relay the traffic from other sensor’s to base station. The sensors which have more battery power, we deploy them near to the base station and the sensors which have least battery power, we deploy them in the last hop WSN because in last hop energy consumption is less.

B. Energy Model

We consider a general energy model in which energy of a sensor is consumed by reception and transmission of packets through wireless channel while neglecting the consumption of other energy sources like processing and sensing. Energy cost to activate the transmitter or receiver (Eelec) 50 nj/bit. Transmitter Amplifier to communicate ( Eamp)10 pj/bit/m2. It assumes that energy consumption in transmission of packets through wireless channel square of distance.
The energy consumption to Transmit p-bit packet to distance d and the energy to receive the same packet as follows:

$$ETx(p, d) = E_{elec} \ast p + E_{amp} \ast p \ast d^2$$  \hspace{1cm} (1)

Where $K_{Rx} = E_{elec}$.

Since the communication range of each sensor is $rc$, equation (1) can be further simplified by replacing $d$ with $rc$.

$$ETx(m) = K_{Tx} \ast p$$  \hspace{1cm} (2)

Where $K_{Tx} = E_{elec} + E_{amp} \ast rc^2$

We can see that energy consumption for transmission and reception is proportional to the number of bits in the traffic.

### III. LIFETIME OF WSNs

It is a very important part of Wireless Sensor Network and its mainly Depends on following four parameter: number of sensors in different hop $N(i)$, initial energy of each sensor $E(o)$, time interval of periodic data collection $\tau$. Energy consumption for the transmission and reception of load in different hops $E(i)$.

$$LT(i) = (E_o \ast N(i) \ast \tau) / E(i)$$  \hspace{1cm} (3)

Where $LT(i)$ represents the life time of different hop WSNs and the lifetime of the network is the minimum $LT(i)$ among all hop.

The given target area is divided into different hop, which is referred to as the set $A = 1, \ldots, H$ from the inside to outside. Area of different hop wireless sensor networks is

$$Area(i) = ((2i+1)rs\sqrt{2})^2 - ((2i-1+1)rs\sqrt{2})^2$$  \hspace{1cm} (4)

For $i = 1, 2, 3, \ldots, H$.

Where $rs$ is the sensing range of the sensor In a WSN, the use of the channel is sensed by wireless radio and the traffic is relayed from the outside hops to inside hops, until it arrives at the BS. The nodes in the first hop forward all the traffic to the BS.

$$\text{Load } T(i) = \frac{\rho \ast Area(i)}{i=}$$  \hspace{1cm} (5)

$$\text{Load } T(i) = \sum_{j=i}^{H} \rho \ast Area(j)$$  \hspace{1cm} (6)

for $i = 1, 2, 3, \ldots, H-1$

Where, $\rho$ is the information rate.

Relaying traffic that is received from hop$(i)$ is equal to the traffic that is transmitted by hop $(i+1)$

$$\text{Load } R(i) = \text{Load } T(i+1); \text{for } i = 1, 2, 3, \ldots, H - 1$$  \hspace{1cm} (7)

$$\text{Load } R(i) = 0; \text{ for } i = H$$  \hspace{1cm} (8)

Total energy consumption $E(i)$ in hop i in one time interval is equal to the energy consumption for the transmission of Load $T(i)$ and the energy consumption of reception for Load $R(i)$

$$E(i) = K_{Rx} \ast \text{Load } R(i) + K_{Tx} \ast \text{Load } T(i)$$  \hspace{1cm} (9)

Where $K_{Rx}$ and $K_{Tx}$ are energy consumption per bit for reception and transmission, respectively.

### IV. ALGORITHM

**Algorithm 1:** Deployment of Sensors in Target Area

**Input:** length $(X)$ and Width $(Y)$ Of FOI

**Output:** Deployment of sensors, Energy Consumption in Different Hop WSNs

- Divide The Given Area into Grid.
  
  $x = \frac{X}{rs}$ ;

  $y = \frac{Y}{rs} ;$

- Deploy the base station at center point.

  $x = X/2 ; \ y = Y/2 ;$

- Deployment of sensor

  Deploy one Sensor at Each alter net Node

- Calculate the no. of Hops

  initialization, $i = 0 ; \ H = 2$ ;

  Do

  \[
  H = \frac{X \ast Y}{((2i+1)rs\sqrt{2})^2 - ((2i-1+1)rs\sqrt{2})^2} \\
  \]

  While($H > 1$)

  $H = i$ where $i = 1, 2, 3, \ldots, n$

- $K_{Rx} = E_{elec}$ ;

  $K_{Tx} = E_{elec} + E_{amp} \ast rc^2 ;$

- Calculate the area of different hops

  $Area(i) = ((2i+1)rs\sqrt{2})^2 - ((2i-1+1)rs\sqrt{2})^2$

  For $i = 1, 2, 3, \ldots, H$

- Transmitted traffic from diff. hops

  $\text{Load } T(i) = \rho \ast Area(i); \text{for } i = H.$

- Received traffic from diff. hops

  $\text{Load } R(i) = \text{Load } T(i+1); \text{ for } i = 1 \text{ to } H - 1$

  $\text{Load } R(i) = 0; \text{ for } i = H$

- Total energy consumption by Rx an Tx of Traffic load form diff. hop

  $E(i) = K_{Rx} \ast \text{Load } R(i) + K_{Tx} \ast \text{Load } T(i)$

In this algorithm, we divide the given target area into different grids such that, length and width of each grid is equal to the sensing range of the sensor$(rs)$. After the
division of given target area deploy the base station at the center point of the grid that is \(x = X/2, y = Y/2\), then place one sensor at every alternate grid point as shown in the Figure 3.2. After that we calculate the number of hop in a network, then calculate the area of every hop WSNs which depends on the sensing range of the sensor, then we calculate the transmitted traffic from every hop which is mainly depends on the information rate\(\rho\) and area of the particular hop, similarly calculate the received traffic from every hop which is depends on transmitted traffic from the upper hop, for example: relaying traffic that is received from hop \(H\) is equal to the transmitted traffic from hop \((H+1)\). Finally calculate the total energy consumption in every hop which is given below:

\[
E(i) = kRx*LoadR(i) + KTx*LoadT(i)
\]

Where, \(E(i), LoadR(i), LoadT(i), kRx, kTx\) are the total energy consumption in the ith hop, transmitted load from the ith hop, received load in the ith hop, energy cost to receiver one bit packet by the sensor and energy cost to transmit the one bit packet to distance \((rc)\) respectively.

Algorithm 2: Lifetime of Different Hop WSNs Based on Density of sensor

**Input:** length\((X)\) and Width\((Y)\) Of FOI

**Output:** Deployment of sensors, Energy Consumption in Different Hop WSNs

- Number of node in diff. hops \(N(i) = 8^i\);
- Lifetime of diff. hop

\[
LT(i) = \frac{Eo * N(i) * \tau}{E(i)}
\]

for \(i = 1, 2, 3 \ldots H\)

- Optimum No. of sensor in different Hops

For \(i = 1 \) to \(i = H\)

While \((LT(i) < LT(H))\)

\[
N(i) = (N(i) + 1);
LT(i) = \frac{Eo * N(i) * \tau}{E(i)}
\]

End for

- Deploy \(N(i)\) sensors in different hop WSNs.
- Lifetime of WSNs

For \(i = 1 \) to \(i = H\)

if \(LT(i) < LT(i + 1)\) then

\( \text{min} = LT(i) \)

else

\( \text{min} = LT(i + 1) \)

Lifetie of WSNs = \(\text{min}\)

In this algorithm, first we calculate the number of sensor nodes in different hop WSNs, which depends on the number of grid points. Then calculate the lifetime of every hop, which is depends on the initial energy of sensor, number of sensor in that hop, periodic data collection rate and total energy consumption rate in that hop. Then compare the lifetime of every hop with last hop sensor network and increase the number of sensors so that, life time of every hop is approximately same and all the hop die at the same time. After that get the lifetime of entire network, which is depends on the hop which has a minimum lifetime.

Algorithm 3: Lifetime of Different Hop WSNs Based on Initial Energy of Sensor

**Input:** length\((X)\) and Width\((Y)\) of FOI

**Output:** Lifetime of WSNs

- Number of node in diff. hop \(N(i) = 8^i\);
- Lifetime of diff. hop

\[
LT(i) = \frac{Eo * N(i) * \tau}{E(i)}
\]

for \(i = 1, 2, 3 \ldots H\)

- Optimum No. of energy for different hop sensors

For \(i = 1 \) to \(i = H\)

\(Eo = 1\);

While \((LT(i) < LT(H))\)

\[
Eo = \left( Eo + 0.25 \right);
LT(i) = \frac{Eo * N(i) * \tau}{E(i)}
\]

\(Eo1(i) = (Eo)\);

- Give the \(Eo1(i)\) initial energy to each sensor in different hop WSNs.
- Lifetime of WSNs

For \(i = 1 \) to \(i = H\)

if \(LT(i) < LT(i + 1)\) then

\( \text{min} = LT(i) \)

else

\( \text{min} = LT(i + 1) \)

Lifetie of WSNs = \(\text{min}\).

V. SIMULATION RESULTS

All the simulations were carried out on a Linux platform using gcc tool. C was the programming language used throughout the simulation. Simulation parameter is shown in the table 1.

<table>
<thead>
<tr>
<th>Length of area X</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of area Y</td>
<td>100</td>
</tr>
<tr>
<td>No. of sensor N</td>
<td>390</td>
</tr>
<tr>
<td>sensing range of sensor rs</td>
<td>10</td>
</tr>
<tr>
<td>Communication range of sensor rc</td>
<td>20</td>
</tr>
<tr>
<td>Periodic data collection (\tau)</td>
<td>250 s</td>
</tr>
<tr>
<td>Tx Amp. to communicate (E_{amp})</td>
<td>10 pj/bit/m²</td>
</tr>
<tr>
<td>Energy cost to activate the Tx&amp; Rx (E_{elec})</td>
<td>50 nj/bit</td>
</tr>
<tr>
<td>Information rate (\rho)</td>
<td>200 bits/s</td>
</tr>
<tr>
<td>Initial Energy (Eo)</td>
<td>1 Joule</td>
</tr>
</tbody>
</table>

5.1 Energy Consumption in Different hop Due to Traffic Load.
This graph shows that, energy consumption in different hop WSN. In Figure 5.1 we can see that in the first hop energy consumption is maximum because this hop relay the traffic from others hops to base station. In the last hop (H) energy consumption is minimum because this hop only transmit the packets (or sensed data) to Hop (H-1). It's not relay the traffic from any hop.

**5.2 Lifetime of WSN With Different No. of Hop:**
This graph shows the lifetime of different hop WSN if we deploy uniform sensor at each node. In figure 5, we can see that lifetime of last hop WSN is maximum because traffic load in last hop is minimum. As we move towards to the base station traffic increases. In the first hop traffic is maximum because this hop relay traffic from all others hop to base station that’s why lifetime of first hop WSN is minimum.

**5.3 Lifetime of Different Hops WSN:**
In the Figure 5.3 we can see that in uniform case as we move from first to last hop hop WSNs, lifetime uniformly increase because sensor deployment are uniform in all hop but in the deployment technique proposed by us, sensors are deployed according to the traffic that’s why lifetime in all hops are approximate same. In uniform deployment 1st Hop die earlier as compare to the others Hop. Once the first Hop die connectivity to the base station is broken and others hop sensors not able to sends information to the base station. So that energy is not utilized in uniform deployment. In energy efficient deployment technique maximum energy is utilize because all the sensors are die at the same time.

**5.4 Energy Required to Each Sensor in Every Hop:**

Figure 5.4 shows that, how much energy is required to each sensor in every hop WSN to balance the traffic Sensors which is deployed in the first hop from the base station require more energy as compare to the sensors which is deployed in the last hop from the base station.

**VI. CONCLUSIONS**
The main objective of our work is to develop algorithms and schemes for efficient deployment of sensor to maintain a sufficient level of coverage and lifetime for Wireless sensor networks. The design of a WSN platform must deal with challenges in energy efficiency, cost, and application requirements. It requires the optimization of both the hardware and software to make a WSN efficient. One of the fundamental problems in sensor networks is the deployment of sensors. The simulation results show that our algorithm is better than the uniform deployment. In first method, we divide the entire area in to different grids and then in place of deploying the sensors at every grid points, we deploy the sensors at every alternate grid point. By this method we optimize the number of sensors.
maintaining the same coverage area. In second method, we are increasing the number of sensors at the hop which is near to the base station. This method achieves a better lifetime compared to the uniform deployment. In the third and final method, in place of applying the same battery power to all sensors, we apply different battery power to sensors in different hop based on the traffic load. Again by this method we are achieving a better lifetime.

REFERENCES