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# Reliable Data Gathering using Multiple Sink in Wireless Sensor Networks

**Anamika* and Akwinder Kaur****

**ABSTRACT**

Energy consumption and network lifetime of WSN must be managed effectively so as to have more reliable data. Nodes nearer to sink die earlier so as to increase their lifetime it is required to develop an algorithm such that distance and reliability requirements between nodes near to sink decreases . For this multiple sinks need to be placed .Accordingly energy consumption towards nearer nodes will be decreased and will lead to extended network lifetime and reliable data gathering will be achieved.

***Keywords:*** WSN, Sink, Reliable data.

## 1. INTRODUCTION

With the expansion in technology, Wireless sensor networks (WSNs) have commensally performed a vital role in routine activities. It is due to outstandingly growing deployment, decrement in prices [1] of sensors in WSNS. Promising applications are there in WSNs like environment monitoring, vehicle tracking, and volcano monitoring, animal monitoring. WSNs effective designs, applicability, implement ability, an extensive capacity to relate virtual and physical world has developed it a trendy topic of research in current years. Information about the environment can be attained by networking many sensor nodes which were impossible to retrieve in traditional ways.

### 1.1. WSN

WSN inheres a group of light weighted, self-organizing sensor [2] nodes which are utilized to mutually observe environmental conditions. Military applications motivated research in WSN at the beginning and now many public and industries are using it. Due to sensor nodes limited bandwidth, battery, network lifetime, energy and much more protocols should be carefully designed which is because of size and cost constraints on sensors. In recent years, the focus of researchers is on improving energy efficiency which will further lead to elongation of network lifetime. For this multiple sinks are deployed so as to extend the network lifetime [3].Figure1 is an example of WSN.

### 1.2. Architecture of Traditional Wireless Sensor Network

WSN's conventional architecture mostly comply flat structure that can be also termed as single layer planar structure. Sensor nodes in huge number having similar hardware structure, processing, sensing capacity are deployed in a controlling area so as to observe and route data collected by nodes to sink node by multi-hop communication. Afterward, WSN is linked with other networks via sink node such that user can answer questioning and can control the WSN. The figure2 depicts the traditional architecture of WSN. Sink and sensor nodes are usually taken to as static in conventional WSN. [4].

* M.E Scholar, *Email: anamikagarg982@gmail.com*

** Assistant Professor, Chandigarh University, Gharuan, *Email: akwinderkaurkingra@gmail.com*

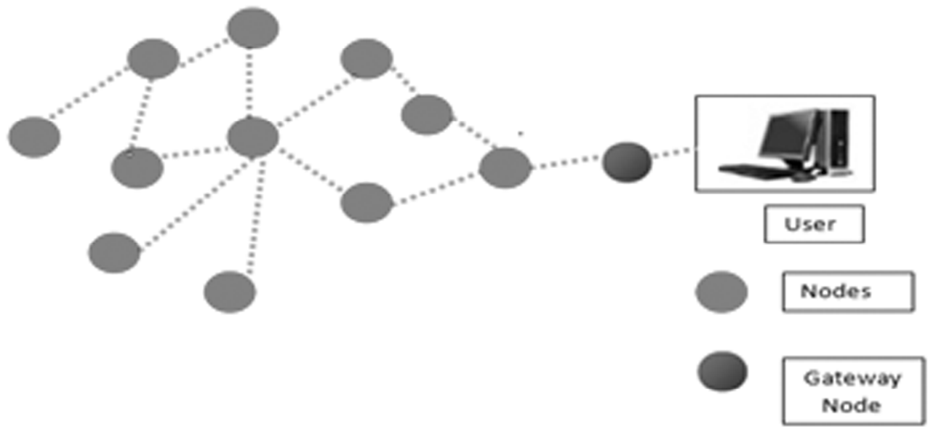


**Figure 1: Wireless Sensor Networks [3]**

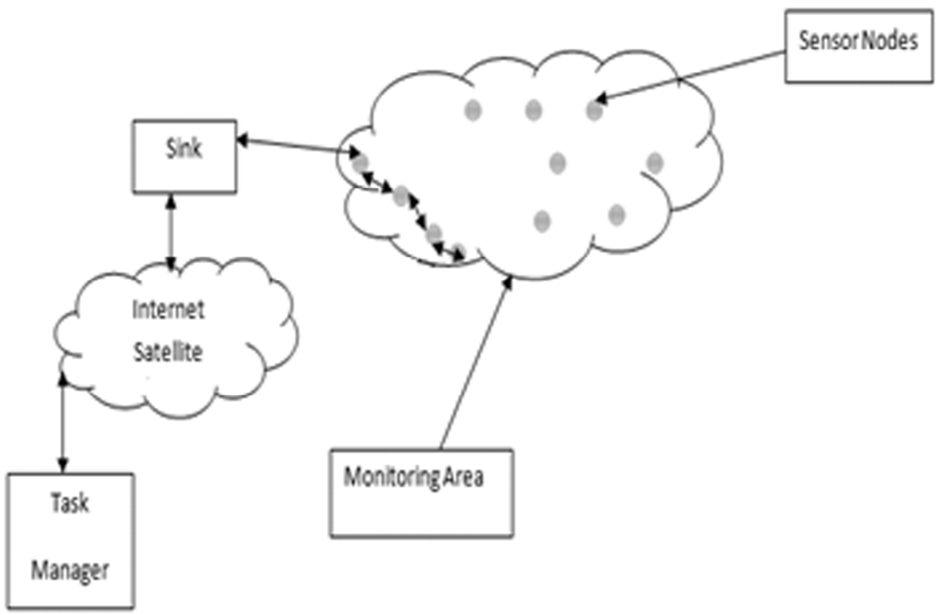


**Figure 2: Architecture of traditional WSN [4]**

### 1.3. Components of Wireless Sensor Networks

Sinks are the destination for information which gathers data directly or indirectly via nodes that are in between. Information arriving from sensors is utilized by sinks individually or makes it accessible to specific users. Data Collectors are not the sources or the destinations. They simply act as mediator nodes to collect data. Nodes are used for perceiving facts in addition to transmit messages headed for further nodes contained within the set-up [5].Nodes size varies like it can be big like the shoebox or it can be like a speck of dust. So as is the price it also differs from hundreds to dollars which merely rely on complicatedness of sensors. These constraints of sensors effect power, energy, speed for computing. Because of low battery capacity, the major challenge comes into existence which is QoS i.e. Quality of Service aware data gathering which further includes reliability, a lifetime of network, privacy, energy efficiency which are difficult to overcome[6].Deployment is also an issue as how the nodes are being placed and it also helps in maintain the battery.

### 1.4. Types of WSNs

There are various types of WSN in which they are deployed underwater, underground or on land. Sensor network deals with many constraints according to the environment they are in. Further, its five types [7] are explained as follows:

- Terrestrial Wireless sensor network.
- Underground Wireless sensor network.
- Underwater Wireless sensor network.
- Mobile Wireless sensor network.
- Multi-media Wireless sensor network

*Terrestrial WSNs* are usually made up of a number of economical sensors set upped in a provided area, via ad-hoc or preplanned manner. Reliable transmission in dense surroundings is required in terrestrial WSN. Nodes energy could be preserved via multi-hop routing, by taking transmission range short, minimizing delay etc.

*Underground WSNs* is comprised of sensor nodes which are embedded in cave or underground so as to observe the conditions. This type of WSN is more costly than the terrestrial one on the because of costlier sensor nodes, maintenance cost and deployment cost. Sensor nodes in underground WSN are contained with a scarcity of battery.

*Underwater WSNs* are comprised of sensor nodes, vehicles employed underwater. These sensor nodes are very costly and less dense. In this type, communication occurs by acoustic waves. Due to problems like fading, propagation delay etc acoustic communication is difficult to occur.

*Mobile WSNs* are having a group of sensor nodes which moves by their own and connects to an atmosphere. Mobile nodes are having the capabilities like sensing and communication just like static nodes. Key point is that the mobile nodes are having the capability to arrange its position by its own in a network. Main challenges include localization, maintenance navigation.

*Multi-media WSNs* are useful for tracking events in the mode of videos, audio clips, and figures. It comprises of low priced sensors having cameras, microphones. These are placed using the pre-planned technique so as to confirm full coverage of the environment. Content like video streaming demands more bandwidth for the content delivery [8].Higher data rates have higher energy consumption that is also a challenge needs to be resolved.

### 1.5. Routing in WSN

WSNs are destined for a supervising environment. The main goal of wireless sensor nodes is gathered data from a specified field refine that and then transmit that to sink, where it resides. By assuring direct link between sensor and sink might discharge battery instantly as for transferring messages high amount of energy is needed. So it is required that nodes must be compiled for assurance of connectivity in nodes that are at a farther distance. Hence, messages are broadcasted via other nodes in between by routing them to sink. For locating and maintaining routes routing protocols are responsible [9].

Main Issues are as Follows:

*Security*: Unauthorized users access information easily so need to care about security [10].

*Limited network lifetime*: The main point when and how much long information grasped by sensors is refined and is delivered to sink. Accordingly protocols used to gather data should establish reliable transmission, energy efficiency of data so as to increase networks lifetime.

*Node redundancy*: In cases where nodes are randomly deployed, nodes having more distance from sink will die earlier as of more power will be required for transmission mechanism while less power for transmission near a sink.

*Localization*: It is an issue as in many applications, positions are not known before deployment. Thus, no software's are there so as to locate them and can do its maintenance [11].

*QoS*: it includes energy efficiency, reliable transmission etc.

## 1.6. Reliability

It can be considered by two levels which can be either packet or event level. A number of successfully retrieved packets on the target comes [12] under packet level reliability. It can also be calculated by considering the end-to-end loss in packets. If the loss rate is less, network's reliability is greater. In Event level delivery of specified data is calculated. In this case, a receiver doesn't need to receive ejected all packets but specified percentage of packets delivered over a specified time is considered. Its requirements depend on various applications.

## 1.7. Homogeneous and Heterogeneous WSNS

*Homogeneous WSN*: Sensors, Sink are equipped with mostly common resources. In this sink acts as a base station. Data is transmitted by direct or multi-hop communications to sink via sensors.

*Heterogeneous WSN*: Uniform resources are allocated in sensors while sinks are having much more resources [13].For retrieving data, they are sparsely allocated and there is a long distance between the sensors.

## 1.8. Features of WSNs

Unattended operations, Capacity to survive through node ruptures, capability to resist insensitive environmental situations, Ease of use, The Network topology is dynamic, Ad-hoc Deployment, Very densely populated, Limited power and limited resources, Scalability, Mobility [14].

## 1.9. Applications of WSNs

Its applications are classified in two ways i.e. monitoring and tracking. Information based on events or varying facts are gathered in monitoring applications:-

*Environmental Data Collection and Monitoring*: During data collection huge amount of nodes senses and transmits information constantly to base stations which are there for storage purpose [15]. Real time example is macroscope of redwood in which monitoring, recording of redwood trees takes place in California.

*Military Surveillance*: Distant placement of sensors is required for fully planned overseeing enemy troop activities. (DARPA) Defence Advanced Research Project Agency which is the technology for sensors information gathering is real time example [16].

*Precision Agriculture*: Its goals are to develop efficient cultural processes so as to diminish environments effect. provided automatically whenever any odd event occurs.

*Detecting and monitoring traffic to avoid accidents*: Sensors are placed on roads so as to control and manage traffic. It also updates the use of new routes to follow and to be safe.

*Habitat Monitoring*: GPS embedded collars are affixed to zebras which exchange information approaching from zebras and provide access to data.

*Security Monitoring*: In this nodes are embedded at specified positions in the surroundings such that sensors can be observed on a continuous basis to notice any suspicious activity [17].

*Health Care*: Observing physiological data of patients, controlling drug applications, comes under this application. Its example can be Heart@Home which is a tracking and controlling wireless system for blood pressure [18].

## 1.10. Challenges of Wireless Sensor Networks

Mostly applications meet these challenges:

*Ad hoc deployment*: Deployment in this is done on a random basis in the area that needs that system must recognize and adjust itself with nodes connectivity.

*Unattended operation*: It is necessary to do self-configuration automatically**.**

*Physical Resource Constraints*: Limited battery power is a major issue need to overcome a lifetime of sensor network also depends on battery.

*Fault-Tolerance*: hardware failure or software failure leads to node failure. Whenever a node failure occurs protocol must handle this and should be able to maintain connectivity and extend networks lifetime [19].

*Scalability*: It is also a major issue as WSN is built up of thousands of sensors and by increasing requirements quality of observing also increases. Need to place a number of sensors can be there anytime.

### 1.11. Advantages of Wireless Sensor Networks

Implementation cost is cheaper, ideal for non-reachable places; can accommodate devices at any time, avoids wiring, flexible to go through physical partitions, can be accessed through a centralized monitor [20].

### 1.12. Deployment

During this, the creator perceives merely the numeral of nodes, sinks requisite to be embedded. Sink and nodes deployment effects majorly performance. Nodes could be deployed in a way of random or pre-planned way. [21].

### 1.13. Sink Placement

As the main consideration in WSN is the limited energy of nodes, it is necessary to place the sink at specific places which are of user's interest, so as to minimize overall energy consumption. Author's focus is on proposing approach so as to uncover the most selected location [22] meant for the sink with the aim to reduce consumption of energy to assist openly affecting life span of set of connections. One more similar difficulty is that the nodes which are nearer to the sink suffer rapidly of energy exhaustion as of more transit traffic.

### 1.14. Restrictions of Single Sink in Sensor Networks

Here single-sink networks information transmission is mostly considered by hop counts and overall total consumption of energy via source to sink. The direction-finding way is the nearer lane that may well incorporate nodes having low energy and more energy consumption for data transmission. These routing paths cannot give assurance of the utmost lifetime for the setup.

In a sensor set of connections, the distance from all sensor nodes to a sink is superior to the broadcasting range of sensors; nodes must transfer the information toward sink in a multi-hop conduct. So nodes nearer to sink dissipates energy more rapidly than nodes which are farther as of the sink as they have to transmit huge data [23].

### 1.15. Multiple Sinks in Time-sensitive WSNs

Execution issues in WSNs play a central part in countless applications. Habitually the utmost message transfer delay ought to be limited so as to permit time-sensitive applications like fire or intrusion detection systems. Thus, it is decisive to creating algorithms which decreases level of worst-case delay in WSNs. In this work, the focus of author is the trouble of planting several sinks in a way so as to lessen maximum worst-case delay and keep the energy burning up low down [24].

### 1.16. Advantages of Multiple Sink over Single Sink

Multiple sinks in a network improve unbalanced energy consumption among sensor nodes as transmission load of information is dispensed between all sinks. Multiple sinks can minimize average distance and also hop distance linking sensors and sink. Thus, it is having capability of saving energy. Multiple sink deployment avoids the problem of single sink i.e. in the case of disconnection from one specific sink; nodes can still send data towards other sinks in the network. Thus, network functions in a continuous manner. However, to have above benefits, proper sink placement is necessary [25].

## 2. RELATED WORK

There are ways to deploy nodes which are planned and random deployment. There are many multiple sink placement strategies [26] to deploy sink so as to deploy sink .GSP strategy is termed as a point of reference as compared to other strategies like Candidate location with minimum hop (CLMH), Centroid of nodes in a partition (CNP), Gossip- based WSN (GWSN) and much more [27].Optimal placement [28] of sink matters a lot as it will be further enhancing the key constraints like battery, energy efficiency [29] ,network lifetime. Network life span can be enhanced with placing sink next to proper places which are discussed in the paper [30].Energy improvisation also depends on deploying multiple sinks instead of only one sink [31].The battery is also a major constraint as nodes near the sink becomes dead easily so techniques are needed to be developed for conserving battery life [32]. To improve network lifetime schemes in WSN are discussed [33]. Reliable gathering of data is necessary so as to have better lifetime and energy [34].

## 3. PROPOSED WORK

In a homogeneous and heterogeneous network there are problems with a single sink like many times the sink is placed in a region of high node density or sometimes the distant nodes are unable to transmit their information for long and tend to die out early.

So, there is a need to use the concept of Multiple Sink placement but in every network where multiple sinks have used the need of reliability of links is a major concern because it does not matter how clever the sink placement is, if the reliability of the network is less the performance will not come to the surface.

So as to have reliable, extended network lifetime, energy efficiency a wise Data gathering algorithm with multiple sink deployment is needed.

In this existing and proposed strategies are compared.

## 4. METHODOLOGY

**Algorithm 1: Single Sink Based Strategy**

**Input:** Nodes, input values

**Output:** Positions to place sink nodes

1: for nodes = 200

2: for angle = an and radius = r // sink deployment

3: for 100 nodes distance to sink <100.

4: for left 100 nodes distance >99

5: Distance is calculated using $(x_2\text{-}x_1)^2\text{+ }(y_2\text{-}y_1)^2/0.5$

6: Let tn be transmitting node, e, f be sink location, b, c = x , y coordinates of tn node

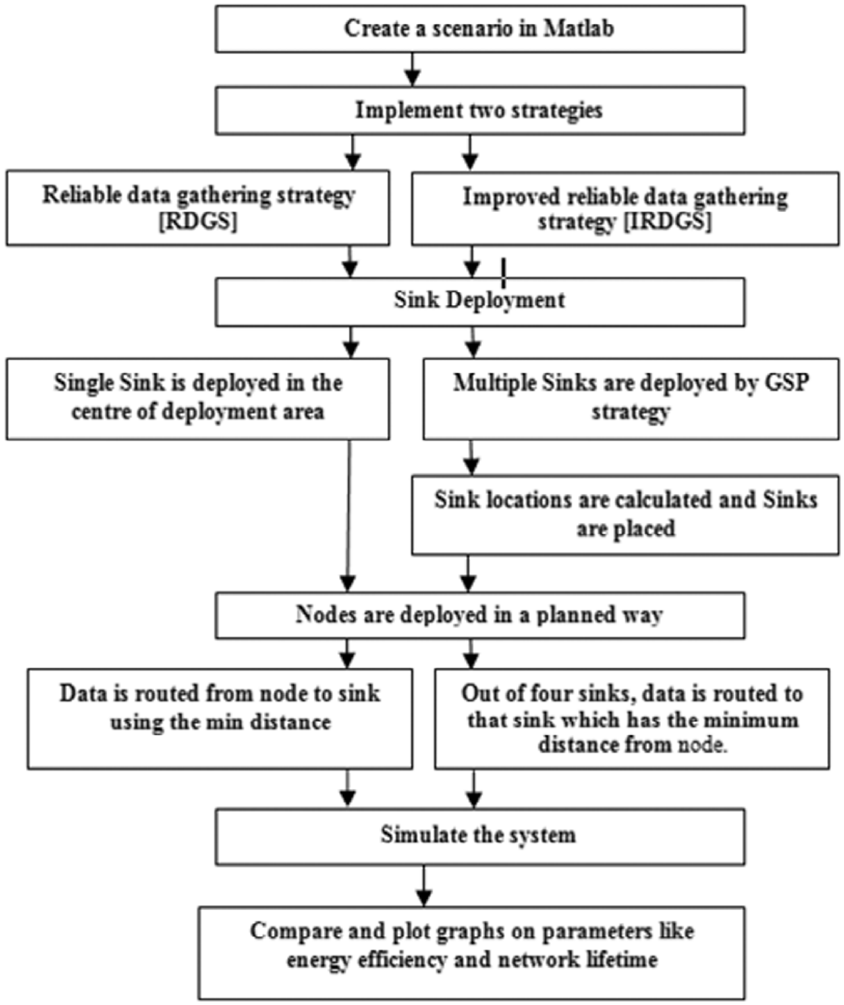


**Figure 3: Methodology of proposed strategy**

if e>b and f>c, flag =1 //for direction

else if b>e and c>f, flag = 2,

else if b<e and c>f, flag = 3

else if e<b and f<c,flag = 4

if flag == 1 then dmin is calculated. //minimum distance

7: routing occurs if sd<= dmin //sd is the shortest distance

Repeat 6, 7 for flag = 2, flag = 3, flag = 4

8: Let ‘so’ be a random node

if energy E(so)< 0, nodes become dead

energy is calculated using

$E^{REF}_{t,1} = DE_C + DK_1 \alpha_m d^{\alpha-1}_{hop} / d_{hop} + 2K_2 \beta_m (1-Cd^{hop/DN}_{b}$ ..... equn a

**Where** $D/_{dhop}$ is no. of deployed nodes N, $E_t$ is energy consumed by the transmitter, $\alpha$ is path loss exponent, $N_b$ is no. of bits per packet, $\beta_m$ type, C is minimum reliability requirement, Ec, $k_1$, $E_b$ are variable energy consumption per bit.

9: end

**Algorithm 2: Multiple Sink Based Strategy**

**Input:** Nodes, Values of data transfer, number of bits per packet.

**Output:** Sink locations, energy calculations.

1: for nodes = 200

2: Calculate Sink locations using GSP strategy.

2a: Sinks are positioned on the CGS (Center of Gravity of a sector)

b. CGS is calculated by equation 1 which computes the ratio where to put Sink at a central point of radial line at sector. $F(\alpha) = (4/3 \sin(\alpha/2))/\alpha$ ….. **Eqn…1**

Where $\alpha$ in radians, $0 \le \alpha \le \pi/2$, R is equivalent to radius,

$F(\alpha)$ = ratio where to place Sink.

c. CGS = $F(\alpha)*R$….. **Eqn…2**

d. Calculate sinks locations and repeat until sinks get placed

3: for angle = an and radius = r

Repeat 3 for 2nd, 3rd, 4th sink

4: for Node deployment

a: for 25 nodes (distance from first sink <50).

b: for deploying 25 nodes (distance >49)

c: Repeat for second, third, fourth sink

5: Distance is calculated as in previous algo.

6: let tn be the transmitting node. Distance is calculated as d1, d2, d3, d4.

If (MDS == d1), e = x1, f = y1 //minimum distance

else if (MDS == d2), e = x2, f = y2, else if (MDS == d3), e = x3, f = y3

else (MDS == d4), e = x4, f = y4

7: b, c = x, y coordinates of tn node, if e>b and f>c, flag = 1//flag is for direction,

else if b>e and c<f, flag = 2

else if b<e and c>f, flag = 3,

else e<b and f<c, flag = 4

8: if flag == 1, dmin is calculated .//minimum distance

if sd <= dmin then routing is done.

Repeat 8 and 9 for flag = 2, 3, 4

9: let 'so' a random node, if energy E(so)<0, nodes become dead

Energy is calculated using equn a

Step10: end

**Table 1**
**Some parameters of transceiver energy consumption [34]**

| *Symbol* | *Description* | *Value* |
|---|---|---|
| $\alpha$ | Path-loss exponent(>2) | 3 |
| $\beta_{amp}$ | Amplifier proportional offset(>1) | 14 |
| $N_b$ | Number of bits per packet | 2560 |
| $D_{hop}$ | Data transfer (1:12) | 1:12 |

Where $E_c$, $k_1$ are total constant and variable energy consumption.

## 5. WORK DONE

It comprises of nodes, a single sink is placed in a center. Communication from node to sink is taking place. When the nodes are running out of energy then the nodes are getting dead . The energy left after the communication of nodes and sink is calculated in the form of graphs. Time taken, by nodes; a number of nodes dead during communication are also calculated. Proposed strategy comprises of nodes, multiple sinks are placed by GSP (Geographical Sink Placement Strategy). Communication between nodes and sink is done. When the nodes are running out of energy then the nodes are getting dead. Calculations are done for energy left, Time taken, a number of nodes dead by nodes after the communication of nodes, and sink.

## 6. RESULTS AND DISCUSSIONS

Figure 4 shows the comparison between the two strategies RDGS having a single sink and Improved RDGS strategies having multiple sinks on the basis of Total Energy left of nodes and D which is data transfer. In RDGS energy left is very minimal i.e. zero in terms of proposed strategy so IRDGA is proved

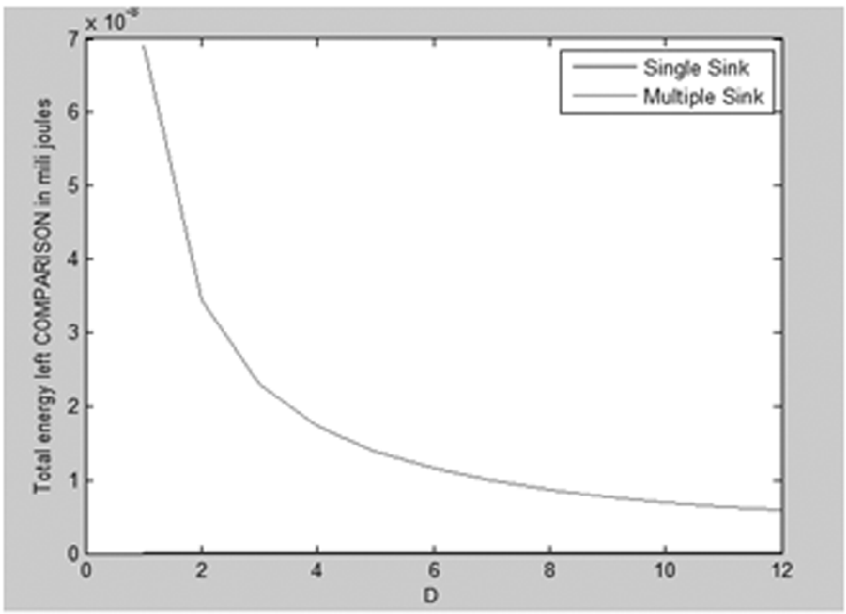


**Figure 4: Total energy left comparison**

**Table 2**
**Energy left table w.r.t. data transfer**

| *Data transfer(D)* | *Energy left in Existing Strategy* | *Energy left in Proposed Strategy* |
|---|---|---|
| D1 | $1.2040e^{-14}$ | $1.0588e^{-11}$ |
| D2 | $6.0200e^{-15}$ | $5.2939e^{-11}$ |
| D3 | $4.0133e^{-15}$ | $3.5293e^{-12}$ |
| D4 | $3.6100e^{-15}$ | $2.469e^{-12}$ |
| D5 | $2.4080e^{-15}$ | $2.1176e^{-12}$ |
| D6 | $2.0067e^{-15}$ | $1.7646e^{-12}$ |
| D7 | $1.7200e^{-15}$ | $1.5125e^{-12}$ |
| D8 | $1.5050e^{-15}$ | $1.3235e^{-12}$ |
| D9 | $1.3378e^{-15}$ | $1.1764e^{-12}$ |
| D10 | $1.2040\ e^{-15}$ | $1.0588e^{-12}$ |
| D11 | $1.0945e^{-15}$ | $9.6253e^{-13}$ |
| D12 | $1.0033e^{-15}$ | $8.8232e^{-13}$ |

better because of multiple sink placements as the distance of nodes decreased of nodes which save energy. Table 2 depicts the values for 200nodes of energy left of single sink and multiple sink.

Table 3 represents values of at different number nodes, energy left for both cases of single-sink and multi-sink.

Table 4 represents the comparison between the two RDGS and IRDGS on the basis of Time taken. In RDGS time taken by nodes is more than IRDGS. So IRDGS is proved better because of multiple sink

**Table 3**
**Energy left w.r.t. nodes**

| *Nodes no.* | *Energy left of Existing Strategy* | *Energy left Proposed Strategy* |
|---|---|---|
| 100 | $1.2*10^{-9}$ | $1.6*10^{-8}$ |
| 200 | $1.4*10^{-10}$ | $7*10^{-4}$ |
| 400 | $1.8*10^{-5}$ | $1.8*10^{-8}$ |
| 600 | $4.5*10^{-9}$ | $5*10^{-8}$ |
| 800 | $2.2*10^{-12}$ | $3.2*10^{-9}$ |
| 1000 | $1*10^{-12}$ | $1.6*10^{-9}$ |

**Table 4**
**Time taken**

| *Nodes no.* | *Time (secs) Existing Strategy* | *Time(secs) Proposed Strategy* |
|---|---|---|
| 100 | 0.0328 | 0.0110 |
| 200 | 0.0300 | 0.0091 |
| 400 | 0.0632 | 0.0098 |
| 600 | 0.0320 | 0.0092 |
| 800 | 0.0326 | 0.0120 |
| 1000 | 0.0300 | 0.0097 |

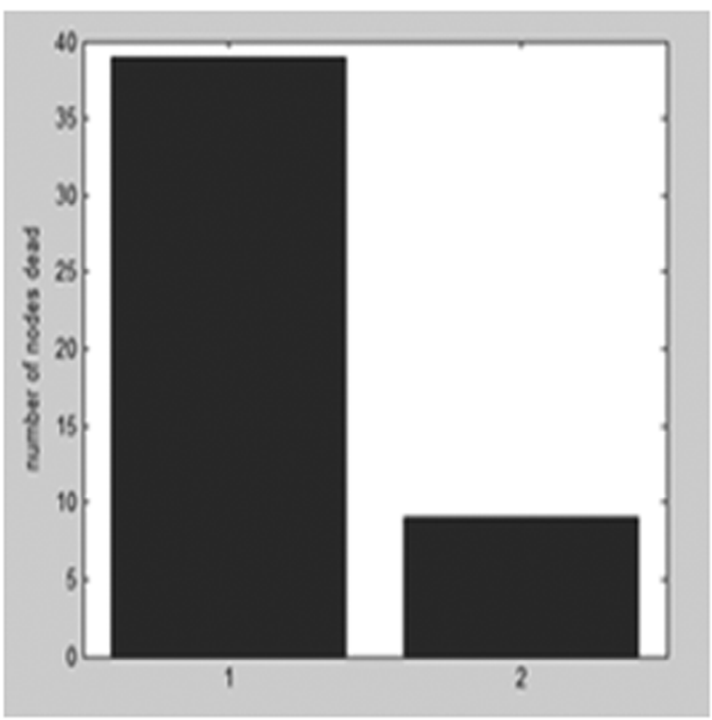


**Figure 5: Number of nodes dead Comparison**

placements as the distance of nodes decreased of nodes which save energy of nodes so fewer nodes run out of energy.

Table 4 contains values of Time taken by nodes is presented using single sink and with multiple sink.

Figure 5 shows the comparison between the two RDGS and Improved RDGS relative to a number of nodes In RDGS number of nodes, dead ate more so Improved RDGS is proved better because of multiple sink placements as a distance of nodes decreased of nodes which save energy of nodes so fewer nodes run out of energy and is more reliable in gathering data as lifetime is extended. Table 5 contains values of number of nodes getting dead when they run out of energy.

**Table 5**
**Number of nodes dead**

| *Nodes no.* | *Dead nodes in Existing Strategy* | *Dead nodes in Proposed Strategy* |
|---|---|---|
| 100 | 44 | 9 |
| 200 | 37 | 6 |
| 400 | 39 | 8 |
| 600 | 43 | 12 |
| 800 | 42 | 11 |
| 1000 | 40 | 7 |

## 7. CONCLUSION

By placing multiple sinks energy consumption is decreased, network's lifetime is increased i.e. reliable data gathering is there which is depicted in the results and tables. A comparison is there which depicts that improved reliable data gathering strategy is better for efficient results. In the future weighted approach for sink deployment according to density can be used.

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