SOFTWARE AGENT IN WSN : A REVIEW

[1]Mistry Bhavinkumar A., [2]Prof. Dhiren Bhagat
Department of Electronics and Communication
Sarvajanik College of Engineering and Technology
Surat, India
Email:[1]mistry_bhavin1991@yahoo.com, [2]dhiren.bhagat@scet.ac.in

***Abstract*—A wireless sensor network use sensors to monitor physical or environmental conditions. In today's environment deployment density increasing and size shrinking of wireless sensor nodes which implies the smaller amount of energy. That's why to compete in today's environment energy utilization must be there to increase the wireless sensor network life time One solution for enhancing the lifetime of wireless sensor network is to utilize mobile agents (software agent). In this paper an agent-based approach that performs data processing and data aggregation decisions locally i.e., at nodes rather than bringing data back to a central processor (sink). this approach increases the network lifetime by generating an optimal routing path for mobile agents to transverse the network. The approach consists of two phases. In the first phase, Dijkstra's algorithm is used to generate a complete graph to connect all source nodes in a WSN. In the second phase, a genetic algorithm is used to generate the best-approximated route for mobile agents in a radio harsh environment to route the sensory data to the base-station**

Keywords— Wireless Sensor Network, Software agent, Routing Algorithm

I. INTRODUCTION

A. Wireless Sensor Network

Wireless sensor networks (WSNs) are deployed to perform various applications such as disaster recovery, environmental monitoring, industrial control and monitoring of the battlefield. WSNs are expected to play even greater role in the next generation networks to perceive the physical world. Now a day, energy is one of the most critical resources for battery-powered WSNs.

To increase the lifetime of the network, energy potency becomes one in every of the essential views within the style of WSN protocol. To use the restricted energy offered within the most sensors nodes, most existing routing schemes plan to realize the minimum energy path to the sink to optimize energy usage at nodes. However, the question of whether or not it's spare to focus solely on energy potency is raised, whereas the look of routing protocols for WSNs, and alternative objectives like the life of the network and also the coverage should even be taken under consideration. Experiments conducted beneath the previous analysis program that nodes nearer to the sink tend to empty energy quicker than this uneven energy depletion drastically reduces the lifetime of the network. Such imbalance of energy consumption is certainly undesirable for the long health of the network. If the sensing element nodes consume their energy a lot of equally, the property between them and therefore the sink will be maintained for a extended time, therefore suspending the network partition. This lot of swish degradation of the network property will clearly offer substantial gains. Therefore, it ought to be rational and sensible to form an applicable trade-off between energy potency and balanced energy consumption

The motivation behind this paper is to solve following issue. Wireless Sensor network is a collection of nodes which have micro sensor, a CPU for perform computation, small memory to store program and data and a radio transceiver for wireless communication. The base-station is has a dedicated power supply and more resources (CPU, memory, storage, etc.) than a node. The node that can recognize the user requested i.e., attributes of interest is called source node. The source nodes transmit data to the sink either directly or by relaying it via other sensor node in WSN.

Wireless sensor network operates on batteries. Sensor deployment is usually in hard to reach remote areas like a battlefields, forest and glaciers. So sometimes it is impossible to recharging or changing their batteries. Thus, it is fundamental concerns to increasing the lifetime of WSN. The lifetime of a Wireless sensor network is defined as an operation time of WSN means till the first node die. In WSN, node Sense environment data and then send to a base station directly or by relaying other node in path of base station as in multi-hop communication.

B. *Energy Waste in WSN*

In WSN energy is lost due to many reasons. There is always competition among node for acquiring same channel. Channel contention consumes certain amount of energy. Secondly, ad hoc deployment of sensor nodes is mostly used than careful pre-planning; thus, they get self-organized to form a network. The maintenance of self organized network uses sufficient amount of energy [1]. Thirdly, broadcasting in WSN causes collision. Retransmitting a collided packet adds to the node's energy consumption. Finally, due to the high usage of nodes sensor traffic is produced in WSN. Large amount of energy is consumed while routing the traffic to the base station.

Maximum energy of WSN is consumed while routing the traffic to the base station which causes the reduction in their lifetime. The reason behind the energy loss is the transmission and receiving of data by the node. The paper [1] approach models the routing optimization problem. To transverse the WSN genetic algorithm gives the best route for Mobile Agent. In traditional travelling salesman problem the dynamic topology of sensor networks gives incomplete graph. That means source node has no direct communication with other source nodes in a WSN. To overcome a problem connection between nodes are necessity. For that Dijkstra's algorithm is used. This complete WSN graph is used by Genetic Algorithm to generate best route to send the sensory data to the sink [1].

In addition, paper [1] introduces the mobile agent that can autonomously visit the source nodes and copy data at each source node and aggregated them. MA takes a path which is generated by GA at base-station. Aggregated data is brought back to sink after every round. By using this network lifetime is increase.

II. ENERGY MANAGEMENT TECHNIQUES

There are many approaches to increase node's lifetime and to reduce redundant sensory data. For a combined approach Mobile agent is used in wireless sensor network. In mobile agent approach there are also several attempts to reduce energy consumption. Mobile agent is an intelligent, autonomous program that collects and aggregate sensory data in a target region by visiting source nodes periodically. In WSN there is one approach for data fusion named mobile agent based distributed network (MADSN) which is used to overcome problem of overwhelming data traffic. This approach is not only for data fusion, but it is also for reducing energy spending. One drawback is that this approach can only applied to cluster based topologies. Mobile agent-based directed diffusion (MADD) is also used for same kind of problem but drawback of MADD is that the sequence of node visited by mobile agent for collecting data from nodes is not best one.

Now a days, direct diffusion method is used. In this method good path is select for drain data from source node. Due to best path approach achieve considerable energy gain But still traffic of redundant sensory data is issue. Advantage of MADD is that it reduces a sensory data. By using mobile agent Data is aggregated one by one at each sensor node and bring back to sink. By using mobile agent energy of node is saved and network lifetime is increased.

To overcome all above limitation one approach is based on mobile agent is used in which Dijkstra's algorithm and genetic algorithm are used for efficient routing. The sequence order of visiting node by mobile agent is highly affects energy. As discussed above in

MADD sequence of node for agent to data aggregation is select autonomously. This sequence is not an optimal solution due to this problem here genetic algorithm is used which gives an optimal sequence.

Additionally, there are many optimizations algorithm are used. This approach may result incomplete graph of sensor network. If graph is an incomplete then there is no direct link between source node select by sink and other source node. To overcome this problem there must be a complete graph. For that Dijkstra's algorithm is used.

III. Routing Approach

A. *Overview of the routing approach*

This approach is built upon the intuition of software assisted routing research work to reduce the energy consumption of WSN. In GA assisted routing approach, how to further reduce the energy consumption of WSN successfully by providing MA an optimal path to route the data from source nodes to sink. The use of GA enables the generation of such optimal routing path. Here overview of routing approach working is discussed by use of sequence diagram shown in Figure-1

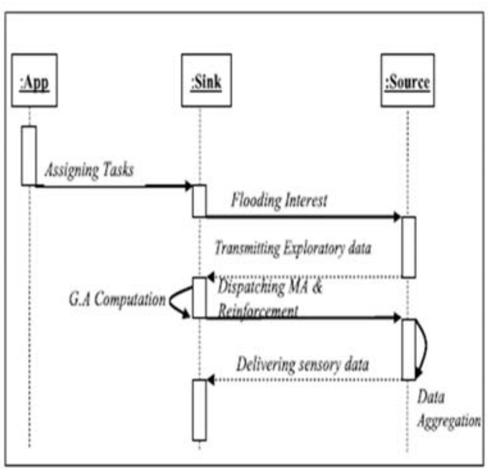

Figure 1 GA based routing approach [1]

(1) Assigning tasks: An application requiring the sensory data, assigns sink the task of collecting it from the WSN. For example, a weather station application will require the data related to temperature and humidity, an environmental monitoring application used in agriculture (i.e., vineyard monitoring) may require additional data such as pressure, light (i.e. photonics) and in cases vibration; whereas, habitat monitoring application may require data related to sound and state.

(2) Flooding interest: When sink receives a task from an application, it sends a request to each of its neighbour nodes. This request is called interest as it is normally in the form of an SQL query as shown in below The exemplary interest query in below states that after 5 min from now (the time at which query is diffused into WSN), the motes in Area_C should measure the temperature, pressure, photonic, humidity attributes per second for 120 times, and the resulting temperature should be reported within 10 min after the last sensor sampling is completed. Delay in WHILE clause is as the QoS constraint, and the SAMPLE clause specifies the temporal information. From delay and sample time, we can easily get the latest report time. The sink normally uses a flat routing protocol for flooding interest (i.e., for dissemination of interest). Our GA assisted routing approach is built upon the directed diffusion framework for the dissemination of interest in WSN.

(3) Transmitting exploratory data: Each WSN node is equipped with a stationary agent (SA).When the neighbouring nodes receive an interest, SA adds the interest to the nodes cache, and sets up gradient between the two nodes. A gradient is a direction state created between the sending and receiving nodes, from the receiver back to the sender with a specified data rate for information flow. Initially, this data rate will be low; the intention is to explore the network and set up a path to the nodes. Intuitively, these gradients are called exploratory gradients. If the neighbours are not in the region specified by the interest, they send exploratory events (i.e., an interest for a low rate event notification) to their neighbouring nodes, until source nodes are found. When a node in the specified region i.e., source node receives an interest, it schedules its local sensors to start collecting data samples. The data is named by attribute–value pairs and sent it back to base-station via relaying the data through neighbouring sensor nodes. MA on each neighbouring node uses the gradients to choose the next hop towards sink for transmitting the data.

(4) Dispatching MA: The exploratory data may reach to the sink from many neighbours. The data contains the id of every node that took part

in relaying the information from source nodes to the sink, their residual energy i.e., the remaining battery power and the message latency values. The message latency refers to the delay incurred in receiving the response on an interest from the neighbouring nodes from the time a node broadcasts the interest. Once the time mentioned in the interest query expires, the sink which has a dedicated power supply uses:

(a) Genetic algorithm on the data reported back to the sink to construct a complete and connected graph of the WSN and

(b) Dijkstra algorithm is used to assist MA for The shortest path to reach to the first source node, The shortest path to visit all the source nodes. And The shortest path to reach from the last source node to the sink.

Moreover, the energy cost is reduced. In wireless sensor network, all source nodes in target region individually transmit sensory data back to sink with a specific interval. In this approach, the mobile agent carries both the processing code as well as the source-visiting sequence generated by GA.

Once the mobile agent arrives at the first source node, it identifies the second node to be visited and continues visiting other source nodes in sequence until it reaches the last source node. This activity of the mobile agent is called round or work cycle. At the end of each cycle, aggregated data is sent back to the sink along with the path. Once the MA is back to the sink, the sink recalculates the optimal routing sequence based on the residual energy of the sensor nodes to ensure that nodes along the optimal path are aggressively used and depleted their energy quickly. The calculation of the optimal path is based on the GA fitness function. After the decision is made on the optimal path i.e. sourcevisiting sequence, the sink reinforces a path to the last source. At the same time, it dispatches again the mobile agent to the first source node. The sequence of operations demonstrating the phases and processes of our GA-based routing approach is shown in figure-2

B. *Paket structure*

The mobile agent packet structure is shown in figure 3. This packet is composed of both control segment and data segment. The control segment is divided into two parts: fixed and variable attributes.

Fixed attributes include: SinkID, MA-SeqNum, Round and LastRoundFlag. The pair of SinkID and MA-SeqNum identifies a mobile agent. When a sink dispatches a mobile agent, it will increase the value of MA-SeqNum, which initially is set to 1.

The Round attribute specifies the number of timesMAshould periodically report data to the sink while LastRoundFlag indicates that there is no more data to report back to sink after the current round of the given task. When a mobile agent with LastRoundFlag field travels to a source node, it will indicate the source node to unload the executable instructions and code required for the corresponding sensing task after the completion of the current round. The variable attributes are Visiting-Sequence and Processing code. The former describes a source-visiting sequence constructed by GA, which a mobile agent must follow within a cycle. The latter is a special program that enables any source node to perform local operations on the sensory data i.e. aggregation.

The MA distributes a copy of this special program at every source node on its first visit. A data segment of the agent contains the accumulated data. When the mobile agent arrives at the first source node, the size of aggregated data is equal to zero. The data segment is incremented whenever the agent migrates from one source node to another.

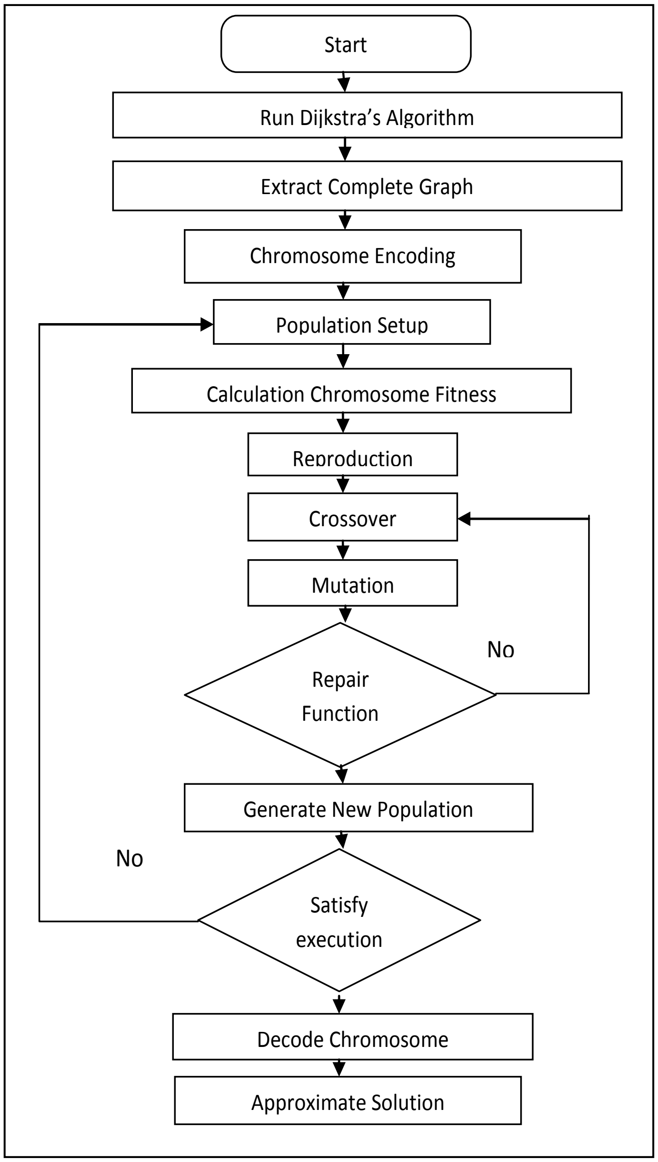

Figure 2 operation flow

Control	Fixed Attributes				Variable Attributes	
	Sink-ID	MA-SeqNum	Round	LastRoundFlag	Visiting-Seq	Processing Code
Data Segment	*Aggregated Data*					

Figure 3 Packet Structure of MA

C. Genetic Algorithm

With the increment of sensor devices in sensor network, conventional search methods (calculus-based, enumerative and random method) cannot meet required robustness. GA is different from normal optimization and search procedures in four ways:

1. GA works with a coding of the parameter set, not with the parameters themselves.
2. GA searches from a population of points, not from a single point.
3. GA uses payoff (objective function) information, not derivatives or other auxiliary knowledge.
4. GA uses probabilistic transition rule, not deterministic rules.

In a word, GA is widely used in applications where the accurate results are not very important and search space is massive. The main advantage of GA is that the process is completely automatic and avoids local minima. Therefore, utilized genetic algorithm to generate an approximate best solution rather than using the conventional search methods.

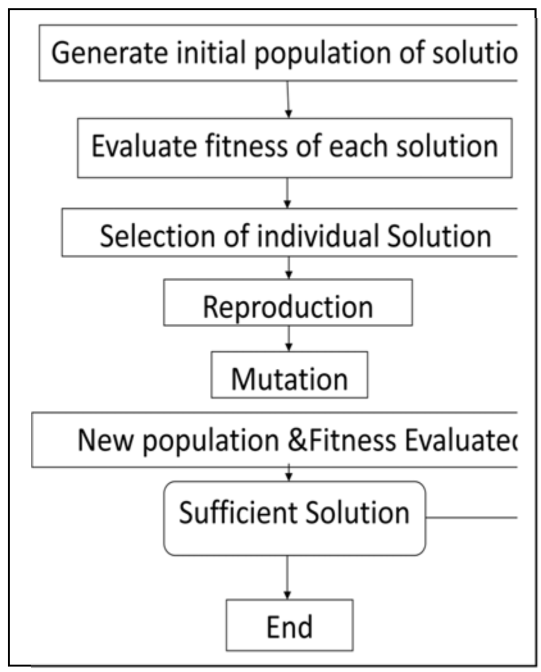

Figure 4 Flow chart of Genetic algorithm

D. Dijkstra's algorithm

Dijkstra's Algorithm is the most common single-source shortest path algorithm. It will require three inputs (G, w, s), the graph G (containing vertices and edges, the weights w, and the source vertex s. Dijkstra's Algorithm is outlined as follows:

$dijkstra\ (G,w,s)$

$[s]=0$

$for\ each\ v\in V-\{s\}$

```
        do d[v]= ∞
S=∅
Q=V
while Q≠∅
    do u=ExtractMin(Q)
    S=S∪{u}
    for each v∈adj {u}
            do if d[v]>d[u]+w(u,v)
            then d[v]=d[u]+w(u,v)
```

Dijkstra's algorithm must first initialize its three important arrays. First, the array S contains the vertices that have already been examined or relaxed. It first starts as the empty set, but as the algorithm progresses, it will fill it with each vertex until all are examined. Then, the distance array *d[x]* is defined to be an array of the shortest paths from s to x, or also denoted $(s,)$ $when\ x\in S$. Finally, Q is simply the data type used to form the list of vertices. In this case, we call it a priority queue.

Even though Dijkstra's algorithm appears to be very efficient, it must only consider non negative cost values on the edges, as having a negative value can result in an unwanted loop. However, this is not an immediate concern from our study, because in each of our networking protocols, there cannot be a negative metric value.

After the initialization portion of the algorithm is complete, we then move into the shortest path calculation. The function will have to run as long as it takes to relax each edge for each vertex. Next, we chose to use *"ExtractMin"* because we needed a method to choose a new vertex to examine. Extracting the vertex corresponding to the least shortest path so far, will guarantee choosing a new unique vertex. We must compare every edge that connects to this newly chosen vertex *u*. If the adjacent vertex *v* currently has a distance to the source that is greater than the distance to u plus the cost of the distance between *u* and *v*, then we must update the distance to *v*.5 After completion of this step, we now have an array *d[x]* that holds the value for the shortest distance for from the source to each of the vertices in the graph.

IV. SIMULATION RESULT

A. *Network Model Assumption*

The sensor network model that is used has following assumption.

1. All sensor nodes are stationary.
2. All sensor nodes have power control capabilities to vary their transmit power.
3. All sensor nodes are aware of their location information.
4. The residual energy of sensors can be calculated.
5. Sensors send their residual energy to BS in each round.

B. *Implementation of Dijkstra's Algorithm*

Dijkstra's algorithm find shortest path between nodes. It gives a complete graph of WSN. Here number of nodes is 100 and source node is 1 and destination number is 17. Result of that is shown in figure 5. Red line indicate shortest path given by dijkstra's algorithm

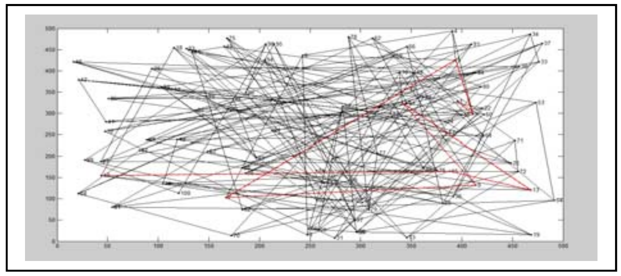

Figure 5 shortest path

C. *Implementation of Genetic Algorithm*

Genetic algorithm is used for creating a globally optimal routing path, which is based on shortest path generated by Dijkstra's algorithm. This path is used as a route for Mobile agent to collect a data from source node in WSN. Here 100 nodes are taken and then apply a genetic algorithm it gives a best solution means best route for mobile agent to travel whole WSN network. Due to best path network life time is increase.

Number of nodes: 100

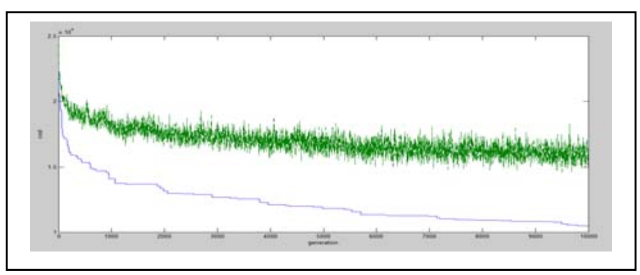

Figure 6 Generation Vs Cost Graph

Generation and cost graph is as shown in figure 6. As u can see as generation is higher cost is getting low. Now in figure 7 there are 100 nodes are shown in which genetic algorithm is applied and result for same is shown in figure 8. Genetic gives best solution for mobile agent which is shown. Nodes sequence for data collection is given by genetic. According to sequence MA visit nodes.

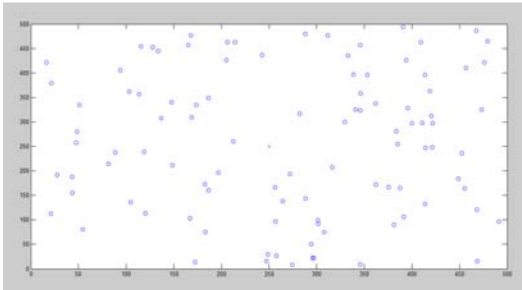

Figure 7 wireless sensor network

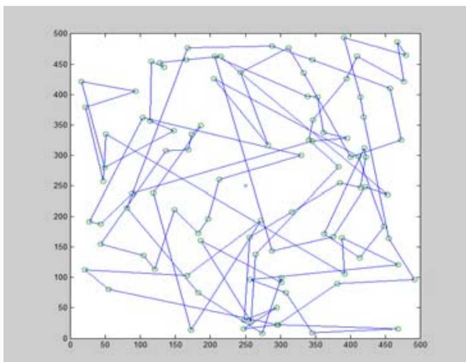

Figure 8 output of genetic algorithm

D. Radio energy model

Our energy model for the sensors is based on the first order radio model as used in [8]. In this model, the transmitter dissipates energy to run the radio electronics and the power amplifier, and the receiver dissipates energy to run the radio electronics. The radios can perform power control and hence use the minimum energy required to reach the intended recipients. Due to attenuation with distance, an energy loss model with d_{ij}^2 is used for relatively short distances and d_{ij}^4 is used for longer distances, where d_{ij} is the distance between sensor nodes i and j. Thus, in order to achieve an acceptable Signal-to-Noise-Ratio (SNR) in transmitting an l-bit message over a distance d, the energy expended by the radio is given by following equation:

$$E_{TX}(l,d) = l.E_{elec} + l.\varepsilon_{fs}d^2, if\ d < d_0 \quad (1)$$

$$E_{TX}(l,d) = l.E_{elec} + l.\varepsilon_{mp}d^4, if\ d \geq d_0 \quad (2)$$

Where E_{elec} is the energy dissipated per bit to run the transmitter or the receiver circuit, ε_{fs} and ε_{mp} depends on the transmitter amplifier model, and d_0 is the threshold transmission distance. To receive an l-bit message, the radio expends:

$$E_{RX}(l) = l.E_{elec} \quad (3)$$

The data fusion model used in our simulations assumes that the overall information collected by a n nodes, where each node collects k bits of data, can be compressed to k bits regardless of the number of nodes. In our simulations, the energy cost for data aggregation is set as EDA = 5nJ/bit

E. Experimental setup and Results

The performance measurement of the protocol is accomplished via simulation using MATLAB® version 7.8.0.347. A wireless sensor network consisting of 100 nodes that are placed randomly within an area of 500m x 500m is modeled in the simulation. Each sensor node is supplied with 1 Joules of initial energy. The base station has unlimited amount of energy. The Network Parameters and its Values are shown in Table-1.

Table 1 Network Parameters and Values

Description	Value
Simulation area	(0,0)~(500,500) m^2
Number of Node	100
Base Station position	static
Initial Energy	1J
Data Packet Size	4000bits
Electronics Energy	50 nJ/bit
Free space coefficient	10 pJ/bit/m^2
Multi path coefficient	0.0013 pJ/bit/m^4

Now, in a first case consider a Wireless sensor network as shown in Figure 7. In a first case a base station position at a location (250,250) as shown in a Figure 7.Now, after a 100 rounds Sensor Nodes away from the Base station are dead as shown in Figure 8. After 100 rounds 41 nodes are dead.

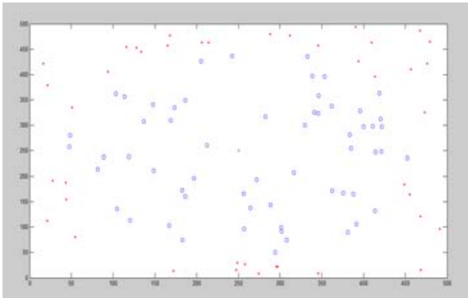

Figure 9 WSN after 100 rounds

Now in case of Mobile agent, it will take a route which is generated by a Genetic algorithm for data collection. Here consider that all 100 nodes have data of 4000bits. As shown in figure 4-6 mobile agent visits source node one by one. Visited node are shown with "*" symbol. Visiting sequence is based on output of genetic algorithm. After completion of one data collection round Mobile agent give all data to base station which is shown in figure 10

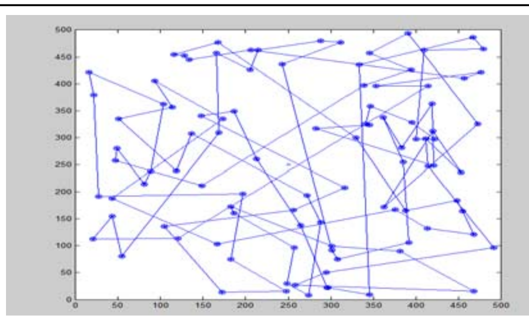

Figure 10 Mobile Agent after one Round

Table 2 Comparison of WSN With and Without Mobile agent after 100 rounds

	WSN without MA	WSN with MA
Number of nodes	100	100
Initial energy of all nodes	1 J	1 J
First node dead in a round	18	-
No. of dead nodes at 100 round	41	0

F. Data Collection by using a Mobile Agent

Number of node in this case is 20 because of easy to understand. Genetic algorithm gives best path for data collection. Mobile agent takes that path. Result of data collection is shown below. In this data is given to nodes so that data is collected by MA in sequence which is given by genetic algorithm.

Table 3 Input Data

Node Number	Data	Node Number	Data
1	43	11	27
2	51	12	93
3	34	13	86
4	37	14	91
5	30	15	59
6	17	16	97
7	03	17	11
8	75	18	05
9	48	19	10
10	01	20	02

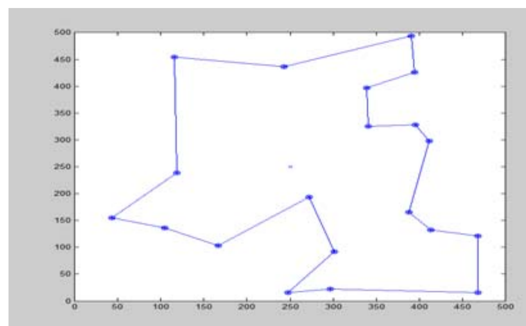

Figure 11 After one round of Data collection

Best solution given by genetic algorithm is following

05	10	11	01	03	15	09	13	19	20
08	16	02	07	14	17	12	18	06	04

As we can see data collection is done in sequence of best solution which is given by genetic algorithm. In best solution 1st is 5 so data of 5 is collected first by mobile agent which is 30 so in data 1st is 30 and then data of 10,11,1 and so on is taken by mobile agent.

Table 4 data collection table

Collection Number	Data	Collection Number	Data
1	30	11	75
2	01	12	97
3	27	13	51
4	43	14	03
5	34	15	91
6	59	16	11
7	48	17	93

8	86	18	05
9	10	19	17
10	02	20	37

V. CONCLUSION

In this paper mobile agents approach in Wireless sensor network is discussed with result shown. Two algorithms are used along with mobile agent named Dijkstra's algorithm and Genetic algorithm where the objective is to improve the energy efficiency of a network. As shown in comparison of with and without mobile agent approach we can see energy efficiency of network is improved and network lifetime is increase by using a mobile agent.

REFERENCES

[1] Elhadi M.Shakshuki, Haroon Malik, Tarek Sheltami, "WSN in cyber physical systems: Enhanced energy management routing approach using agents", *Elsevier Journal, future generation computer system* 31(2014) 93-104,Canada,2013.

[2] Pratik K. Biswas, Hairrong Qi, Yingyue Xu, "Mobile agent Collaborative sensor fusion " *Elsevier, Information Fusion* 9 (2008) 399-411, 2007.

[3] Fengyuan Ren, Jiao Zhang, Tao He, Chuang Lin and Sajal K. Das, " EBRP: Energy-Balanced Routing Protocol for data Gathering in Wireless Sensor Networks", *IEEE Transactions On Parallel and distributed system*, Vol.22, No.12, December 2011.

[4] Elhadi M.Shakshuki, Haroon Malik, Mieso K. Denko, "Software agent-based directed diffusion in Wireless sensor network", *Springer, Telecommun Syst* (2008) 38:161-174, 2008.

[5] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "*A Survey on Sensor Networks,*" IEEE Communcations Magazine, August 2002, pp102-114.

[6] Chad Hart, "Graph Theory Topics in Computer Networking", Department of Computer and Mathematical Sciences, Spring 2013.

[7] Kunal Shah, "Performance Analysis of Mobile Agents In Wireless Internet Applications Using Simulation", August 2003, Lamar University.

[8] W. R Heinzelman, A. P Chandarakasan, and H. Balakrishnan, "*Energy-efficient Communication Protocol for Wireless Microsensor Networks,*"in Procs. of the 33rd Hawaii Int'l. Conf. on System Sciences, 2000

[9] Dharma Prakash Agrawal, Qing-An Zeng, Cengage, *"Introduction to wireless and mobile system"*, Second edition, Cengage Learning, Chapter 14, pp 303-349,2010.