

Green Routing for Wireless Sensor and Actor Networks

¹Roma Kudale, ²Rachana Satao

¹ PG Student, Department of Computer Engineering, University of Pune

²Assistant Professor, Department of Computer Engineering, University of Pune
Sinhgad Technical Education Society's, Smt. Kashibai Navale college of Engineering
Pune, Maharashtra State 411041, India

Abstract- In Wireless Sensor & Actor Network (WSAN), sensors are used to sense data from environment and send this to the actor for taking appropriate action. In semi automated architecture data is forwarded to the actor and then to Sink. So the position of actor from sink is important also how many actors to be in active mode is considerable factor in minimizing energy consumption. There are many protocols and algorithm which are trying to minimize energy consumption. But our proposed algorithm OPT is efficient than existing one. Researchers have proposed to use WSAN for road surveillance which is called as Road Sensor and Actor Network (RSAN). This OPT algorithm specifically designed for RSAN. In RSAN to choose set of working actor is a one of parameter to minimize energy consumption. This is proved with simulation result.

Index Terms- wireless sensor and actor network, LEACH, PEGASIS, TREEPSI

I. INTRODUCTION

Nowadays wireless communications is becoming a measure of the fastest growing segment of the communications industry. It attracts the attention of the media and the public. Also wireless local area networks currently supplement or replace wired networks in many homes, businesses, and campuses and applications. Many new things including wireless sensor networks, automated highways and factories, smart homes and appliances, and remote telemedicine are emerging from research ideas to concrete systems [12].

The sensor network has a long history and many kind of sensor devices are used in various real life applications. Wireless sensor network has different application like collection of data of forest temperature, bioinformatics, water contamination, traffic control, telecommunication etc. Sensor network basically consist of large amount of sensor nodes which are low battery power and having less processing capability are deployed to large physical area to monitor and detect the real time environmental activities. But due to limitation of sensor node there exist new kind of network which is called as Wireless Sensor and Actor Network .As its name suggest there exists sensor node along with actor node which is more powerful in processing and long range communication. In such type of network, actor takes intelligent decision from data which has been gathered from sensor nodes. It is used in application like habitat monitoring, health monitoring, traffic, weather, pollution etc. In all such real life application sensor nodes generate large amount of data which is used for taking appropriate action by actor on this condition. [11].Rest of paper is organised as

Section II related work of existing algorithm and protocol, Section III system model, Section IV performance evaluation, Section V conclusion.

II. RELATED WORK

Depending on the application, the network should rapidly respond to critical situation in which input is coming from sensor unit and appropriate control action will be taken by the actor nodes without any delay. In order to prolong the lifetime of sensor networks, energy saving is done using sleep scheduling algorithms. There are many algorithms to minimize the energy consumption in WSN. They are Flooding, PEGASIS, LEACH, TREEPSI, TEEN, ADCP, Gossiping, Directed Diffusion, and ELRS. Though these existing methods save energy, they lead to a large increase in end-to-end latency, which affects the efficiency of the sensor-actor network which requires fast control action.

A. LEACH (Low is Energy Adaptive Cluster Head algorithm)

In LEACH there is a formation of cluster of neighbouring nodes. There is one cluster head (CH) who will collect sensed data from other nodes. Thus two CH communicates with one another and send fused information to the sink [8].

B. PEGASIS

It is chain based protocol in which each node communicates only with a close neighbour and takes turn to transmit to the sink [8].

C. Flooding

In this, as name suggest, the sink flood inquiries to each sensor node and each sensor node flood event information to the sink [7].

D. Gossiping

It is a derivation of flooding in which node don't flood but send only incoming packet to randomly selected neighbour. But Flooding and Gossiping can lead unbalanced energy consumption problem [7].

E. Directed Diffusion

In this, the sink sends interest to the nodes. Then this node stores this interest entry in cache. This entry contains timestamp field and several gradient fields. When source has data for interest it sends data along interest's gradient path then sink refresh and reinforce the interest when it receives data from the source [7].

F. ELRS (Energy Efficient Layered Routing Scheme)

In this, communication will be done in layers. In which actor can communicate with actor and sink directly and sensor can communicate sensor and actor hop by hop [7].

G. TREEPSI (Tree based Energy Efficient Protocol for Sensor Information)

In this, there is a construction of tree from root node i.e. ith node which is placed at random location in the field. Construct

hierarchical path of nodes. There are two different ways to collect information from field. with

- 1) Root will initialise data gathering by sending small control packet to child using standard tree traversal algorithm.
- 2) All leaf nodes will start to send sensed information towards parent nodes. Then this parent node fuse the received data with own and forward to parent and continues till root node receives the resultant data [8].

H. ADCP (Actor Directed Clustering Protocol)

In ADCP, the main objective is to achieve reliable and efficient communication with low energy consumption. It is based on two parameters like position of node with respect to actor and remaining energy of node [6].

I. SEC (Sleep schedule of nodes for fast and Efficient Control)

SEC protocol with a semi-automated architecture requires minimum latency. During normal operation, the sensor nodes sense the parameters periodically using a static schedule. If the value of any parameter exceeds the set point the sink calculates the error signal and the sleep schedule is changed dynamically to activate the actor nodes in the area of interest. The corresponding sensor-actor nodes are made completely active till the error signal becomes zero, i.e. till the parameters are brought within the set point. Energy management is concerned with set of nodes which should be turned on/off and when, for the purpose of energy saving and network longevity. Several MAC protocols have been proposed to reduce the energy consumption by sleep planning methods in order to increase the lifetime of sensor networks. TRAMA is a scheduling protocol that determines which node can transmit at a particular slot based on the traffic information. However, TDMA-based protocols are complex to maintain in a multi-hop network, due to their timing synchronization. When no event occurs, the nodes follow a static sleep schedule. In static schedule, Regular data collection is done using the sensor nodes periodically and the actor nodes are completely off. To control the parameters, the sensed data are compared with the reference input to find the error signal. Control action should be initiated immediately by activating the actor nodes till the error becomes zero. In dynamic schedule, When an event occurs i.e. if any parameter varies from the set point, the schedule of the sensor-actor nodes is changed dynamically based on the time of the event detection and they are kept active till the actor nodes vary the parameter by their control action i.e. till the error signal becomes zero. Sensor nodes have limited supply of power and energy savings should be done to improve the network lifetime. In addition energy consumption for SEC is based on the occurrence of an event. Energy consumption for the three protocols is calculated based on the hop length, packet transmission time, and active period of the nodes as follows: In S-MAC:

$$E(t) = E_{active} + (E_{tx} * h)$$

In SEC:

Sensor nodes:

$$E(t) = E_{active} + (E_{tx} * h)$$

Actor nodes:

When there is no event:

$$E(t) = 0$$

When there is an event:

$$E(t) = E(Terror)$$

Here, E(Terror) denotes the total energy consumption to perform an action by an actor node for Terror amount of time. In S-MAC, energy consumption is less because of its periodic sleep. In SEC, energy consumption is less because the sensor/actor nodes are made active only at the data/control packet arrival time and the event occurrence time i.e., when an error is present. Total energy consumption can be calculated based on the number of packets sent by each node and the number of nodes.

$$E = n * P(n)$$

Where E=energy consumption

n=number of nodes

P(n)= Total no. of packets sent by node [10]

Now a days researcher have proposed to use WSN for road surveillance which is called as Road Sensor and Actor network. There are many applications like vehicle tracking, driver warning, and incident detection.

III. SYSTEM MODEL

In RSAN (Road sensor and Actor Network), sensor detects an event and send their data to nearby actors. In this model assumption is actor is capable of sensing and performing long range communication. Each actor has two states: working or non-working. If actor is in working state it can sense event i.e. to collect data from sensor and pass that information to the sink. If actor is in non-working state then it acts like a normal sensor i.e. only to sense the event.

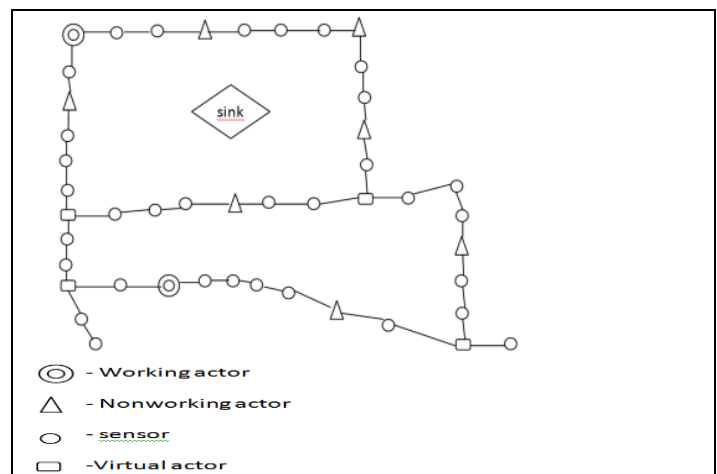


Fig. 1 RSAN

To simplify the system, we assume imaginary actors. These type of actors are deployed at intersection of the road and they are always in working condition. These are shown by double circle in the fig.1. The objective to keep imaginary actors at road intersection is that, its a section of road where traffic is more during busy hours and need careful surveillance. In the real application if such imaginary node is not deployed then this actor will redirect the workload to nearby real actor in the area. Thus imaginary actor divides road network into segment. As we have assumed the imaginary actors stay always in working state, we need to minimize only sensor-actor communication in each road segment.

Consider data communication between two imaginary actors in road segment which is shown in fig.2. Complete Work is Divided into 4 steps

- Find Working Actor Set (WAS)
- Finding and reducing Network Comm. Cost
- Problem of choosing the optimal working actors to minimize total CC
- Solutions to above Problem is by OPT algorithm

a) Find Working Actor Set (WAS)

Let A =no. of actors $1 < a_m < n$

S = no. of nodes/Sensors

$S = \{1, 2, 3, \dots, n\}$

$A = \{a_1, a_2, a_3, \dots, a_m\}$

w_k = Working actors from 1 to k

Thus $w_k \subseteq A$

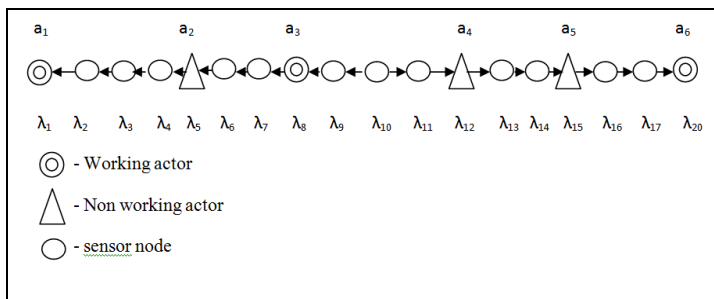


Fig. 2 data communication at road segment

b) Finding and reducing Network Communication Cost

In RSAN, there are three main components in the network. They are as follows

- 1) Sensor – sensor communication
- 2) Sensor – actor communication
- 3) Actor – sink communication

In the analysis assume that energy cost for unit data transmission in each hop of sensor-sensor and sensor-actor communication is same which is denoted as ξ .

ξ = Cost for unit data transfer in each hop of S-S or S-A

$C_{as} \propto R_s * n$

R =data generation rate

n =no. of hops between them

C_{as} =CC of Actor collection from Sensor

ξ_{ai} = energy cost for Actor to Sink

m_{ai} = energy cost for keeping actor in working state

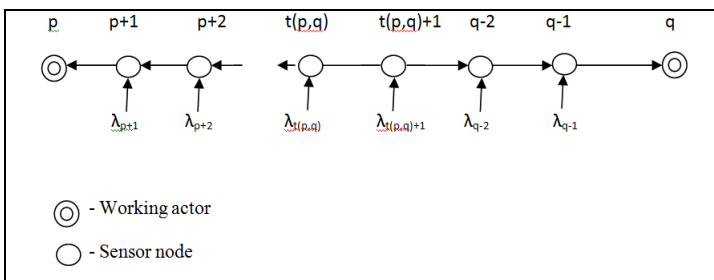


Fig. 3 communication between 2 working actors

In fig. 3 p and q are working actors and there is no working actor present between them so, sensed data will be sent to either p or q. Now consider node i ($p < i < q$) then its communication cost to p

and q is given by $|i-p| \lambda_i \xi + \lambda_i \xi_p$ and $|i-q| \lambda_i \xi + \lambda_i \xi_q$. to minimize cost, if i satisfies $|i-p| \lambda_i \xi + \lambda_i \xi_p \leq |i-q| \lambda_i \xi + \lambda_i \xi_q$ i.e. $i \leq (1/2)(p+q - (\xi_p - \xi_q / \xi))$. Data from i will be sent to p otherwise it will be sent to q. $s(p,q) = [(1/2)(p+q - (\xi_p - \xi_q / \xi))]$ where $s(p,q)$ is split point of p and q. From fig.3 we can say that data from node $p+1, \dots, s(p,q)$ are sent to actor p and data from node $s(p,q)+1, \dots, q-1$ are sent to actor q. When $\xi_p = \xi_q$ then $s(p,q)$ is exact midpoint of p and q.

$$\Phi(p,q) = \sum_{i=p+1}^{s(p,q)} \lambda_i * (i-p) \xi + \sum_{j=s(p,q)+1}^{q-1} \lambda_j * (q-j) \xi + \sum_{i=p+1}^{s(p,q)} \lambda_i * \xi_p + \sum_{j=s(p,q)+1}^{q-1} \lambda_j * \xi_q \quad (1)$$

In equation (1) first two terms gives communication cost for collection of data from sensor node by p and q and last two terms for cost sending data from actor to sink. These p and q nodes are also working as a sensors which will give actor-sink communication cost $\lambda_x \xi_x + \lambda_y \xi_y + m_x + m_y$

The energy consumption per bit is calculated as $E = 2E_{elec} + \beta d^\alpha$ where, α is the exponent of path loss β is constant and E_{elec} is energy need to transmit or receive one bit. Communication energy parameter are set as $E_{elec}=50nJ/bit$, $\beta=10pJ/bit/m^2$ and $\alpha=2$.

IV. PERFORMANCE EVALUATION

In this part, we conduct simulation experiment to evaluate the performance of proposed algorithm. In this different simulation parameters set as

Sr. No.	Parameter	Value
1	Channel type	Wireless
2	Radio propagation model	Two ray ground
3	Antenna type	Omni antenna
4	Interface queue type	DropTail/PriQueue
5	Routing protocol	AODV
6	Dimension of topography	500x500
7	Number of nodes	30,50,100
8	Initial energy level	24.3,21,20 respectively

Table 1 Simulation Parameters

Following Fig.4 shows energy consumption graph for different no. of nodes which clearly indicates energy consumption get reduced.

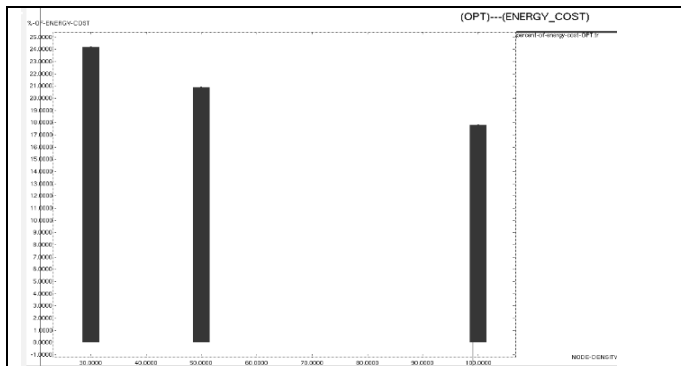


Fig. 4 Minimum Energy Consumption Graph

V. CONCLUSION

The WSN is used for real time application where instant response is major factor. One such application is road surveillance in which complete area is divided into road segment and apply OPT algorithm to minimize energy consumption. In this survey we had studied different protocols and algorithms to minimize energy consumption. In RSAN, its important to choose working actor and then forward all data to these actors which will be then send to sink for appropriate action. On these working actors, apply Dijkstra's algorithm for finding shortest route to the sink. Future work will contain to change the deployment strategy and re-check the result as deployment of nodes is one of parameter to minimize the energy.

REFERENCES

- [1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: A survey," *Comput. Netw.*, vol. 38, no. 4, pp. 393–422, Mar. 2002.
- [2] T. Melodia, D. Pompili, V. Gungor, and I. Akyildiz, "Communication and coordination in wireless sensor and actor networks," *IEEE Trans. Mobile Comput.*, vol. 6, no. 10, pp. 1116–1129, Oct. 2007.
- [3] I. F. Akyildiz and I. H. Kasimoglu, "Wireless sensor and actor networks: Research challenges," *Ad Hoc Netw.*, vol. 2, no. 4, pp. 351–367, Oct. 2004.
- [4] W. Ye, J. Heidemann, and D. Estrin, "An energy-efficient MAC protocol for wireless sensor networks," in *Proc. IEEE INFOCOM*, Jun. 2002, pp. 1567–1576.

- [5] W. Ye, J. Heidemann, and D. Estrin, "An energy-efficient MAC protocol for wireless sensor networks," in *Proc. IEEE INFOCOM*, Jun. 2002, pp. 1567–1576.
- [6] Muazzam Ali Khan+, Ghalib A. Shah++, Muhammad Ahsan, Muhammad Sher "An Efficient and Reliable Clustering Algorithm for Wireless Sensor Actor Networks (WSANs)" in the 53rd IEEE international Midwest Symposium on Circuits and Systems (MWSCAS 2010), Aug. 2010
- [7] HAN Peng, WU Huafeng, MAO Dilin, GAO Chuanshan, "ELRS: An Energy-Efficient Layered Routing Scheme for Wireless Sensor and Actor Networks" in the 20th International Conference on Advanced Information Networking and Applications, April 2006
- [8] Siddhartha Sankar Satapathy, Nityananda Sarma, "TREEPSI: TRee based Energy Efficient Protocol for Sensor Information" in the IFIP international conference on Wireless and Optical Communications Networks, 2006
- [9] Ka. Selvaradjou N. Handigol A.A. Franklin C.S.R. Murthy, "Energy-efficient directional routing between partitioned actors in wireless sensor and actor networks", in the Communications, IET, Jan. 2010
- [10] N.A Vasanthi, S. Annadurai, "Sleep Schedule for Fast and Efficient Control of Parameters in Wireless Sensor-Actor Networks", in the
- [11] Ruchi Mittal, M.P.S Bhatia, "Wireless Sensor Networks for Monitoring the Environmental Activities", in the IEEE conference, 2010
- [12] Andrea Goldsmith "WIRELESS COMMUNICATIONS"
- [13] Wenzhong Li, Edward Chan, Mounir Hamdi, Sanglu Lu, and Daoxu Chen, "Communication Cost Minimization in Wireless Sensor and Actor Networks for Road Surveillance", in the IEEE transaction on vehicular technology, Feb. 2011.

AUTHORS

First Author – Roma Kudale, PG Student, Department of Computer Engineering, University of Pune, Sinhgad Technical Education Society's, Smt. Kashibai Navale college of Engineering, Pune, Maharashtra State 411041, India
Email id - roma.kudale@gmail.com

Second Author – Rachana Satao, ssistant Professor, Department of Computer Engineering, University of Pune, Sinhgad Technical Education Society's, Smt. Kashibai Navale college of Engineering, Pune, Maharashtra State 411041, India
Email id - rachana.satao@gmail.com