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Enhancing Functioning of WSAN for Road Surveillance

Roma Kudale, Rachana Satao

Department of Computer Engineering,
Sinhgad Technical Education Society's, Smt. Kashibai Navale college of Engineering
Pune, Maharashtra, 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. Now a days researchers have proposed to use WSAN for road surveillance which is called as road Sensor and Actor Network (RSAN). There are many algorithms and protocols designed to reduce energy consumption. But our proposed algorithm OPT is efficient than existing one. This Optimum [OPT] algorithm specifically designed for RSAN. In RSAN to choose set of working actor is one of parameter to minimize energy consumption. This is proved with simulation result.**

Keywords**: WSAN, LEACH, PEGASIS, TREEPSI, ELRS, Road Surveillance**

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 [1].

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. [2]. 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. Important among these are Flooding, PEGASIS, LEACH, TREEPSI, Gossiping, 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 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 [3].

B.PEGASIS (Power- Efficient Gathering in Sensor Information Systems)

It is chain based protocol in which each node communicates only with a close neighbour and takes turn to transmit to the sink [3].

C. 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 [4].

D. 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 [4].

E. 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.

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 [3].

F. 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) = Eactive + (Etx * h)

In SEC:

Sensor nodes:

E (t) = Eactive + (Etx * 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 [5]

Now a days researcher has proposed to use WSAN 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.

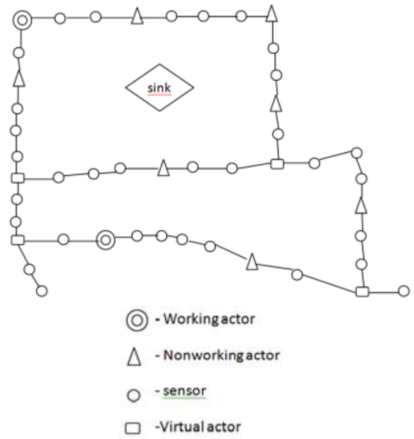

Fig. I RSAN

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. II. 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 Communication Cost
- Solutions to above Problem is by OPT algorithm using simulator.[6]

A) Find Working Actor Set(WAS)

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

S= no. of nodes/Sensors

S={1,2,3……n}

A= {a1, a2, a3….. a_m }

w_k = Working actors from 1 to k

Thus $w_k \subseteq A$

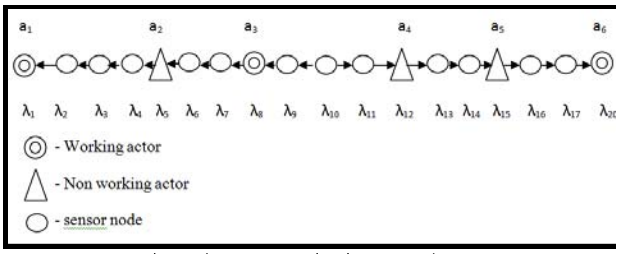

Fig. II data communication at road segment

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 [6]

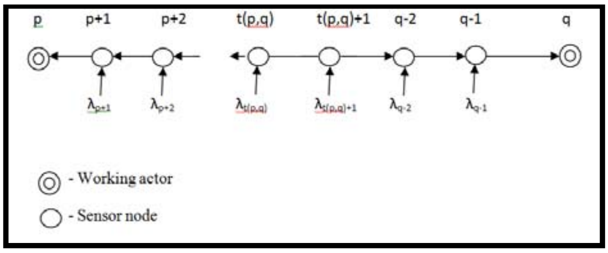

Fig. III communication between 2 working actors

C) Problem of choosing the optimal working actors to minimize total Communication Cost

In Fig. III 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…….s(p,q) are sent to actor p and data from node s(p,q)+1……q-1are sent to actor q. When $\xi_p = \xi_q$ then s(p,q) is exact midpoint of p and q.

$$\Phi(p,q) = \sum_{i=p+1}^{s(p,q)} \lambda i * (i-p)\ \xi + \sum_{j=s(p,q)+1}^{q-1} \lambda j * (q-j)\ \xi + \sum_{i=p+1}^{s(p,q)} \lambda i * \xi p + \sum_{j=s(p,q)+1}^{q-1} \lambda i * \xi q \qquad (1)$$

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 $E=2E_{elec} + \square d^{\alpha}$ where, α is the exponent of path loss □ is constant and E_{elec} is energy need to transmit or receive one bit. Communication energy parameter are set as $E_{elec=}52$nJ/bit, β=11pJ/bit/m^2 and α=3.[6]

IV. PERFORMANCE EVALUATION

In this part, we conduct simulation experiment to evaluate the performance of proposed algorithm. In this different simulation parameters set as shown in Table 1.

Table I Simulation Parameters

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

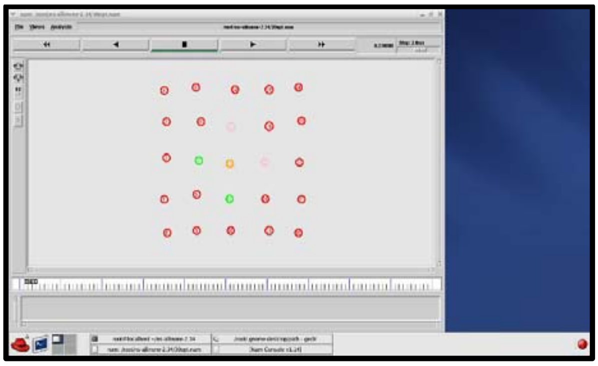

Fig. IV Finding working actors shown by green and nonworking actor by pink for 25 nodes scenario

In Figure IV there are 4 actors shown by green colour, out of which node number 13 and 17 are non-working actors shown by pink colour indicating minimum energy consumption.

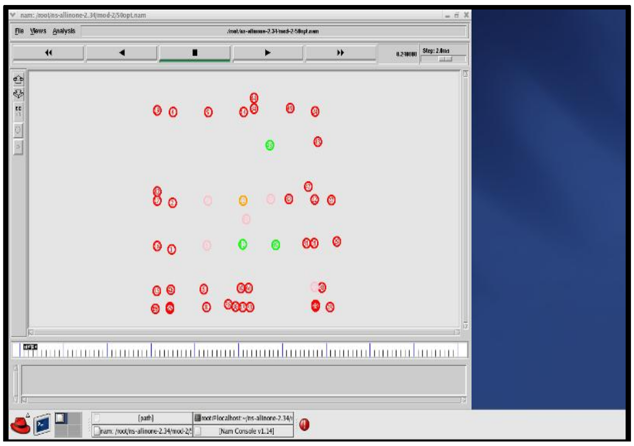

Fig. V Finding working actors shown by green and nonworking actor by pink for 50 nodes scenario

In Figure V there are 8 actors shown by green colour, out of which node number 11, 39 and 48 acts as working actors and remaining shown by pink colour indicates minimum energy consumption.

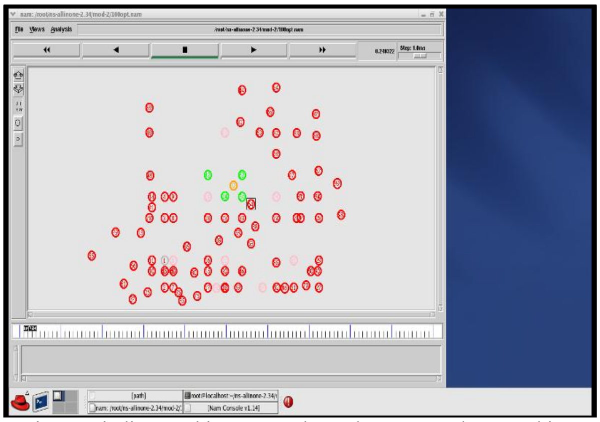

Fig. VI Finding working actors shown by green and nonworking actor by pink for 100 nodes scenario

In Figure VI there are 12 actors shown by green colour, out of which node number 24, 34, 42, 62 acts as working actors and remaining shown by pink colour indicates minimum energy consumption.

Table II Energy consumption by nodes

Sr. No.	Number of nodes	Minimized Energy Value
1	25	24.2
2	50	20.9
3	100	17.8

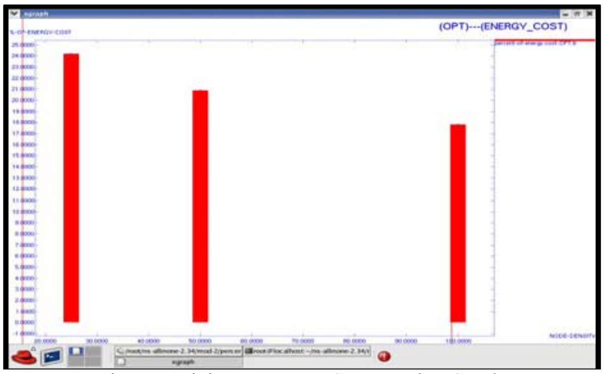

Fig. VII Minimum Energy Consumption Graph

Fig. VII shows energy consumption graph for different number of nodes which clearly indicates energy consumption get reduced.

V. CONCLUSION

The application of OPT algorithm to minimize energy consumption in Road Surveillance network (RSAN) found to be efficient in our simulation results than other studied different protocols and algorithms used to minimize energy consumption. These results will be further tested by changing deployment strategy of nodes and its implications on RSAN would be examined.

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