ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

Energy Saving by Opportunistic Routing in Wireless Sensor Networks

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ABSTRACT*:* Energy optimization is major concern in designing routing algorithms and protocols for wireless sensor networks (WSN), due to the fact that many wireless sensor nodes are remotely deployed. It becomes extremely difficult to replace drained batteries. We propose an algorithm named ENSOR (Energy Saving via Opportunistic Routing) based on the opportunistic Routing Strategy, to improve reliable data packet transmission with less energy consumption and improve network lifetime. This algorithm considers the residual energy of nodes during data transmission. NS2Simulator is used to run the proposed work; it can improve the network lifetime with minimum energy consumed. In this Paper, minimizing vitality utilization and boosting system lifetime has been engaged. As indicated by the standard of shrewd steering hypothesis, multi-bounce transfer choice to enhance the system vitality productivity is made in view of the distinctions among sensor hubs, as far as both their separation to sink and the leftover vitality of each other.

KEYWORDS*:* WSN, ENSOR, total transmission energy, traffic management authority.

I. INTRODUCTION

Wireless sensor network (WSN) offers a huge range of applications in areas such as traffic monitoring, medical care, inhospitable terrain, robotic exploration, and agriculture surveillance. The advent of efficient wireless communications and advancement in electronics has enabled the development of low-power, low-cost, and multifunctional wireless sensor nodes that are characterized by miniaturization and integration.

In order to cooperatively monitor physical or environmental circumstances, the maintask of sensornodesis to collect and transmit data. It is well known that transmitting data consumes much more energy than collecting data [2].Sensor hubs will send the gathered information to transfer sensor hubs, and afterward the hand-off sensor hubs forward movement data along the vitality productive way to the sink hub that is one or more bounces away. At long last, far reaching activity data will be built up by the sink hub and sent to the Traffic Management Authority.In the meantime, Traffic Management Authority will choose proper data and offer it to thecustomers through the system. This savvy movement data securing arrangement can be utilized to develop the lifetime of system in the need of vitality sparing in WSN-based Information Technology (IT) foundation.

The primary requirement behind vitality productive calculation is to augment the system lifetime. Vitality proficient calculations can be founded on the two measurements: i) Minimizing complete transmission vitality ii) augmenting system lifetime. The primary metric spotlights on the aggregate transmission vitality used to send the bundles from source to destination by selecting the extensive number of bounces criteria. Second metric spotlights on the leftover player vitality level of whole system or individual battery vitality of a hub [1].

II.SYSTEM ARCHITECTURE

In this paper, we propose an energy-efficient routing algorithm for above 1-D queue network, namely, Energy Saving via Opportunistic Routing (ENS_OR). ENS_OR adopts a new concept called energy equivalent node (EEN), which selecting relay nodes based on opportunistic routing theory, to virtually derive the optimal transmission distance for energy saving and maximizing the lifetime of whole network. Since sensor nodes areusuallystatic,eachsensor'suniqueinformation,suchasthedistance of the sensor node to the sink and the residual energy of each node, are crucial to determine the optimal transmission distance, thus, it is necessary to consider these factors together for opportunistic routing decision. ENS_OR selects a forwarder set and prioritizes nodes in it, according to their virtualoptimal transmission distance and residual energy level. Nodes in this forwarder set that are closer to EENs and have more residual energy than the sender can be selected as forwarder candidates. Ours chemeistargetedforrelativelydense1-Dqueuenetworks, and can improve the energy efficiency and prolong the lifetime of the network.

The main contributions of this paper include the following.

1) We calculate the optimal transmission distance under the ideal scenarios and further modify the value based on the real conditions.
2) We define the concept of EEN to conduct energy optimal strategy at the position based on the optimal transmission distance.
3) We introduce the forwarder list based on the distances to EEN and the residual energy of each node into EEN for the selection of relay nodes.

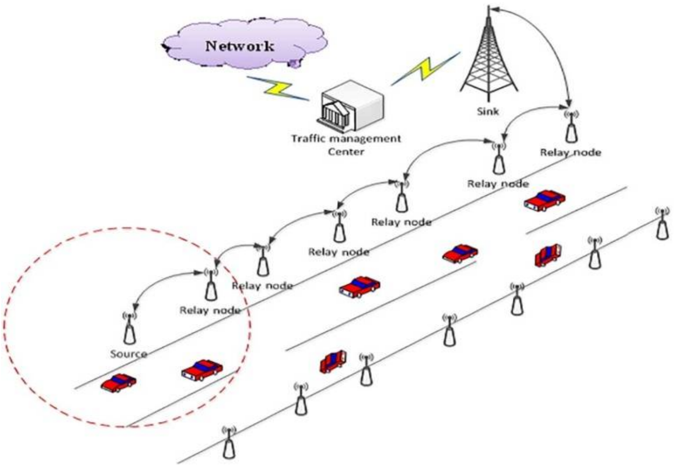


Fig. 1.Smart traffic information acquisition system.

4) We propose ENS_OR algorithm to maximize the energy efficiency and increase the network Lifetime.

The remainder of this paper is organized as follows. Section III describes the related work. Section III introduces 1-D queue network and an energy models. Section IV pro- poses the concept of EEN and initiates theoretical analysis of the optimal transmission distance. To address the problem of unbalanced distribution of residual energy, a new opportunistic routing mechanism based on optimal energy strategy is devised in SectionV. Section V evaluates the integrated performance of ENS_OR algorithm compared with existing routing protocols. Finally, the conclusion and future directions are drawn in Section VI.

IV. RELATED WORK

Previous works [8] and [9] studied the connectivity probability of two certain nodes versus the entire network. Other work in [10], [11] investigated on uniformly and independently distribution under the assumption that the transmission range is fixed among sensor nodes. Some energy-efficient approaches have been explored in the literature [12]–[14]. As transmitting data consumes much more energy than other tasks of sensor nodes, energy savings optimization is realized by finding the minimum energy path between the source and sink in WSNs. In [12], the theoretical analysis about the optimal power control and optimal forwarding distance of each single hop was discussed. There is a tradeoff between using high power and long hop lengths and using low power and shorter hop lengths. With this in mind, minimum energy consumption can be achieved when each sensor node locates with the optimal transmission distance away from others in dense multi-hop wireless network. The most forward within range (MFR) [13] routing approach has also been considered in 1-D queue networks, which chooses the farthest away neighboring node as the next forwarder, and eventually results in less multi-hop delay, less power consumption.

Another approach proposed in [14] reduces the total consumed energy based on two optimization objectives, i.e., path selection and bit allocation. Packets with the optimum size are relayed to thefusion node from sensor nodes in the best intermediate hops. Surprisingly, the benefit of optimal bit allocation among the sensor node has not been investigated in 1-D queue networks. The unreliable wireless links makes routing in wireless networks a challenging problem. In order to overcome this problem, the concept of opportunistic routing was proposed in [15]. Compared with traditional best path routing, opportunistic routings, such as extremely opportunistic routing (ExOR) [16], geographic random forwarding (GeRaF) [17], and efficient QoS-aware geographic opportunistic routing (EQGOR) [18], take advantage of the broadcast nature of the wireless medium, and allow multiple neighbors that can overhear the transmission to participate in forwarding packets.

Opportunistic routing (OR) [21] is a recent routing technique for wireless multi-hop networks. It exploits the broadcast nature of wireless medium which is not utilized by traditional routing. The important features of OR is selection of forwarding nodes and co-ordination among the nodes to deliver the packets to their destination. Therefore, OR works well in wireless multi-hop networks with higher node density such as mesh or sensor networks. OR enables multiple paths and dynamic relay selection, thus it obtains higher link reliability and larger transmission range.

IV. PROPOSED ALGORITHM

A. *Design Considerations:*

- Deployment of nodes using traffic scenario
- Selecting Vehicular nodes
- Deployment of Traffic Management Authority
- Key Generation by the TMA for all the nodes for security purpose.
- Initial battery energy (IBE) is 50Jules for each node.
- Nodes are able to calculate its residual battery energy (RBE).
- Relay Node Selection based on Optimal Path
- Considered all possible paths at beginning.
- Receiving energy is not considered.
- The time when no path is available to transmit the packet is considered as the network lifetime.

B. **ENS_OR** Algorithm

Event: Node *h* has a data packet to send to the sink n

```
/ □ Steps □ /
start a retransmission timer
select the forwarder set $F(h)$ from neighboring nodes $N(h)$;
for each node $i \in N(h)$ do
    if $((d(i, dop) < d(h, dop)) \cup (E_i > \zeta))$ then
        add $i$ to $F(h)$;
    end if
end for
```

```
8: prioritize the forwarder set using Optimal Energy Strategy;
9: for each node $i \in F(h)$ do
10:   $P(i) = (di - dh)\,|di - dop| + (Ei - \zeta)$
11: end for
12: broadcast the data packet;
13: for each node $i \in F(h)$ do
14:   receive the data packet;
15:   checks the sender ID and start a timer and $time(i) = \alpha P(i)$ ;
16: end for
17: if node $n$ which has the highest-priority receives the data packet successfully then
18:   reply an ACK to notify the sender;
19:   for each node $i \in F(h)$ except $n$ do
20:     discard the data packet and close timer;
21:   end for
22: else
23:   if the priority timer expire then
24:     set $n = n\_$, node $n\_$ has the lower-priority;
25:     goto 17;
26:   end if
27: end if
28: if no forwarding candidate has successfully received the packet then
29:   if the retransmission timer expire then
30:     drop the data packet;
31:   else
32:     goto 2;
33:   end if
34: end if
35: return
```

C. *Description of the Proposed Algorithm:*

Aim of the proposed algorithm is to maximize the network life by minimizing the total transmission energy using energy efficient relay nodes to transmit the data. The proposed algorithm is consists of four main steps.

Step 1: Calculating Transmission Energy:

The transmission energy (TE_{node})of each node relative to its distance with another node is calculated by using eq.(1)[8].

$$TE_{node} \alpha d^n$$

$$TE_{node} = k\, d^n \quad \text{eq. (1)}$$

where k is constant and n is path loss factor which is generally between (2-4) [8].

Step 2: Secret Key Generation:After the energy is calculated of individual nodes, the traffic management authority is going to generate the secret key for all the deployed nodes. The key is used for verifying whether the nodes are registered with the TMA or not, which is mainly used for the finding the intrusions in the network.

Step 3: Relay Node Selection Criteria:

Relay Node should have more residual battery energy (RBE) than the required transmission energy (TE_{node}) to transmit the data to the next node in the route. All the nodes in the route will be checked with this condition even if one node of a route is not satisfying this condition then that route will not be considered as a feasible solution. All the other routes having all the nodes with sufficient amount of energy are considered as the feasible solution. And those nodes having equal RBE than (TE_{node}) are made to go into sleep mode. This selecting criterion helped to prolong the network life by avoiding the link breakage. We tried to avoid the repeated use of the path. But at one stage we have to compromise with energy efficiency when we have a route with less energy consumption but it is already being used and a rout with maximum consumption of energy which is not used. So till this point we avoided repeated use of the paths and tried to increase the network life. Transmission energy of a node to node in a rout is calculated according to the distance and the total transmission energy (TTE_R) for that rout is calculated using eq. (2).

$$TTE_R=\sum_{i=1}^{m} TE \text{eq. } (2)$$

where m is the number of hops in the route, TE = TE_{node} is the transmission energy between the nodes. The route having minimum total transmission energy i.e. min (TTE_R)will be selected as energy efficient route.

Step 4: Finding the Optimum Path:

Once the relay node is selected we are going to select the optimum path for reaching the traffic management authority for transferring the data

D. *Pseudo code*

```
    Step 1: Deploy the nodes
    Step 2:  Calculate the $TE_{node}$ for each node of each route using eq. (1).
    Step 3:  Calculate the secret key for all the nodes for identifying the nodes.
    Step 4:  Check the below condition for each route till no route is available to transmit the packet.
    if ($RBE <= TE_{node}$)
                        Make the node into sleep mode.
    else
                    Select all the routes which have active nodes
    end
    Step 4:  Calculate the total transmission energy for all the selected routes using eq. (2).
    Step 5: Select the relay nodes for transferring of data to TMA.
Step 6:  Calculate the RBE for each node of the selected routeusing eq.  (3).
    Step 7: go to step 3.
    Step 8: Data will be transferred to the TMA
    Step 9: Check for the key of the node sending the data.
    Step 10: if( key is matching)Accept the data packet

    Else
                        Drop the packets and notify it as attacker or malicious node
    Step 8: End.
```

E. *Key Generation Algorithm:*

Key generation is an important part where we have to generate both public key and private key. The sender will be encrypting the message with receiver's public key and the receiver will decrypt its private key.Now, we have to select a random number **'n'** within the range of **'r'**.

Using the following equation we can generate the public key:

$$Q = n * P$$

n = The random number that we have selected within the range of (**1 to r-1**). **P**is the point on the curve.

'Q' is the public key and**'n' is the private key.**

Encryption

Let 'm' be the message that we are sending. This has in-depth implementation details.Randomly select 'k' from [1 – (n-1)].

Two cipher texts will be generated let it be **CP1** and **CP2**.

$$CP1 = k*P$$

$$CP2 = M + k*Q$$

CP1 and CP2 will be send.

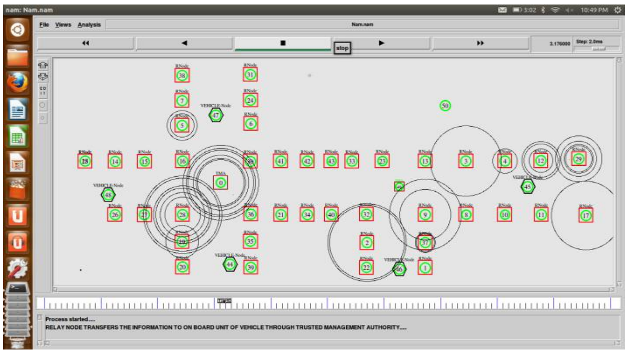
Decryption

We have to get back the message 'm' that was send to us,

M = CP2 – n * CP1
M is the original message that we have send.

V. SIMULATION RESULTS

The simulation studies involve the deterministic traffic network topology with 50 nodes as shown in Fig.1. The proposed energy efficient algorithm is implemented with ns2. We transmitted same size of data packets through source node 1 to destination node 50. Proposed algorithm is compared between two metrics Total Transmission Energyand Maximum Number of Hops on the basis of total number of packets transmitted, network lifetime and energy consumed by each node. We considered the simulation time as a network lifetime and it is a time when no route is available to transmit the packet. Simulation time is calculated through the CPUTIME function of ns2. Our resultsshows that the throughput, delay time taken for transmission and key generation time taken analysis through the network.



Process started....
RELAY NODE TRANSFERS THE INFORMATION TO ON BOARD UNIT OF VEHICLE THROUGH TRUSTED MANAGEMENT AUTHORITY....

Fig.2. Ad Hoc Network of 50 Nodes Deployment

The network topology is showed in Fig.2 which shows the traffic management scenario.Here the nodes are deployed with relay nodes monitoring the traffic. It senses the vehicular movement and transmits the information to the TMA.

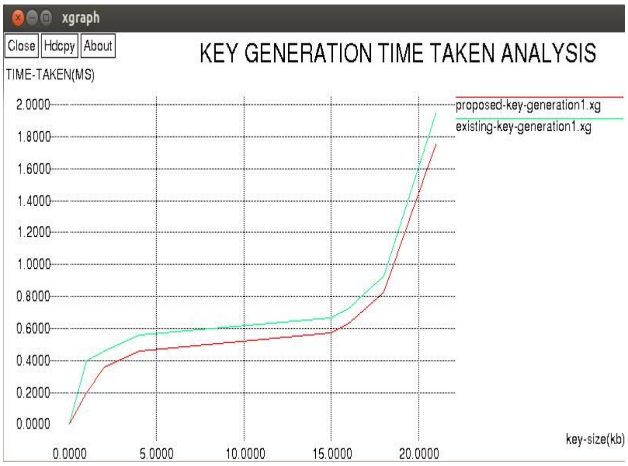


Fig. 3.Key Generation Time Taken for each Node

Fig. 3 shows the Key Generation Time Taken for each Node. In the graph the existing system consumes more time to generate the key for detecting unauthorized nodes whereas the proposed takes considerably less time.

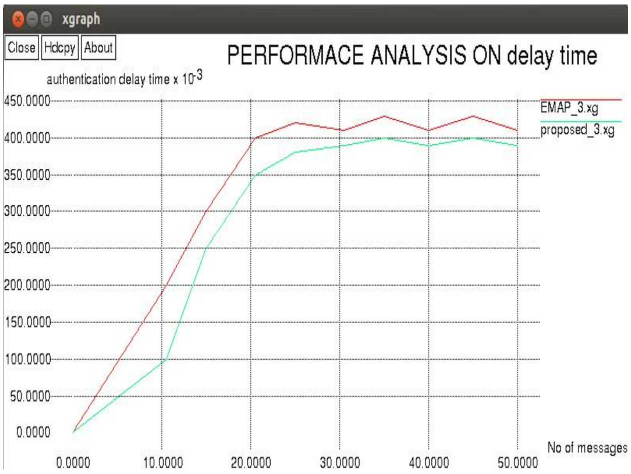


Fig. 4 Performance Analysis on delay time

Fig. 4 shows the performance analysis of the system in terms of delay time taken for the data transmission. Initially the delay increases gradually for less number of messages and further remains stable at significant point of time with increase in the message count.

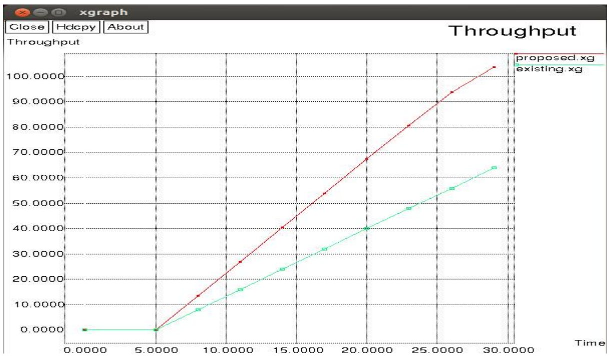


Fig 5. Throughput of the system

Fig. 5 shows the throughput of the system. Our results show that the proposed system is better than the existing systems considering the suitable analysis for delivering the packets successfully.

IV. CONCLUSION AND FUTURE WORK

In this project, we focus on minimizing energy consumption and maximizing network lifetime of 1-D queue network where sensors locations are predetermined and unchangeable. For this matter, we borrow the knowledge from opportunistic routing theory to optimize the network energy efficiency by considering the differences among sensor nodes in terms of both their distance to sink and residual energy of each other. We implement opportunistic routing theory to virtually realize the relay node when actual relay nodes are predetermined which cannot be moved to the place according to the optimal transmission distance. Hence, our objective is to design an energy-efficient opportunistic routing strategy that ensures minimum power is cost and protects the nodes with relatively low residual energy. Numerous simulation results show that the proposed solution makes significant improvements in energy saving and network partition as compared with other existing routing algorithms thereby this will prolong the lifetime of the network.

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