Energy Efficiency Opportunistic Routing Using Shortest Paths (EEOR-SP).

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Abstract—Opportunistic routing (OR) is promising routing technique, which takes advantage of broadcast nature of wireless communication. The key idea behind OR is to use packets from a neighboring node, which in traditional routing technology were dropped or ignored. By utilizing these packets, OR saves the cost of retransmission and achieves energy efficiency which is one of the big problem in design of routing algorithms in wireless sensor networks. These algorithms mainly affect the performance and the lifetime of the network as transmission of data uses a significant proportion of the total energy in WSNs. The main issue which most of the time we face with them are energy consumption and the number of packet duplication. In this paper we are proposing a new routing protocol called Energy Efficiency Opportunistic Routing Using Shortest Paths (EEOR-SP) that permit to balance energy consumption and extend the lifespan of wireless sensor network as well as decrease the number of duplication packets. Extensive simulation result shows that our proposed routing strategy EEOR-SP can significantly improve the network performance on the lifetime and wireless connectivity in comparison with other existing WSN routing protocols.

Keywords__ WSN, Energy Efficiency, Opportunistic Routing, performance Analysis, EEOR, ROR, ECS-OR, EXOR.

1. INTRODUCTION

Wireless Sensor Networks (WSNs) are the area which are most of the research is done in the field of the telecommunication. This type of network is easy to deploy, low cost, very flexible and multifunctional due to advance in micro electromechanical technology. The WSN is the collection of battery power which is used to operate the sensor nodes, which can sense events in the environment share the data gathered from sensing node to the central node. Therefore design of routing protocol are necessary for these kind of network in order to control the energy cost minimization and reliable data delivery with optimal network throughput. In random deployment approach, nodes are, deployed in inaccessible terrains or disaster relief operation with no fixed topology. In deterministic approach, nodes are deploy with a fixed topology. WSNs are use in wide variety of application areas such as military, ambient monitoring, weather monitoring, security, inventory control, disaster management, health, forest fire detection. In all these applications, the sensor nodes sense the required parameters and transmit them to the sink node. Sensor nodes can communicate with each other and directly or indirectly with the base station. Transmission of data from sensor node to base station requires[1].Opportunistic routing (OR) is a routing technology for wireless networks to take advantage of such broadcast nature. Earlier works in opportunistic routing. Op have focused on improving link Reliability and overall system throughput. However,

Wireless sensor network poses special requirements, such as low power consumption and lack of storage, which differentiate them from conventional multi-hop mesh networks. Sensor nodes

Use wireless technologies to access the entire network, and there are several categories of these wireless technologies. A wireless network, not limited to wireless sensor networks, is a network based on electromagnetic wave communication (radio, ultra sound, etc.)[2]. However, WSN applications commonly requires data to be, forwarded with high reliability and energy efficiency and not high throughput. An opportunistic routing algorithm called EEOR-SP, whose objective is to deal with the problem of energy consumption in order to maximize the lifetime of the network. The remainder of this paper is organized as follows: The next section introduces briefly the network lifetime and the main problems of WSN. Section III discuss about energy recovery in OR protocol. Section IV offers details of our opportunistic routing algorithm EEOR-SP. Finally, simulation results are discussed In Section V, followed by the conclusion in Section VI.

2. THE LIFETIME OF A SENSORS NETWORK.

Sensors generally have limited, non-replaceable energy resources. Because it has the limited size it is the reason why energy is often the most valuable criterion of a network of sensors because it directly affects the lifetime of the sensors, and therefore of the whole network. The research work in the WSNs is thus oriented towards this important problem. The lifetime of a sensor network is generally defined by the time the network is capable of maintaining enough connectivity, covering the catchment area, or keeping its node loss rate below a certain level. There may be other definitions of the network lifetime associated with other network parameters. The lifetime of a sensor network is thus linked to the duration of life of the nodes. And the lifetime of a node depends mainly on the lifetime of its battery. The latter depends on the energies consumed by the various modules that make up the node, the battery technology and how to use it. Several definitions of the lifetime of a network of wireless sensors have been proposed in the literature. Among the possible definitions:

- It will continue until the first node exhausts all its energy.
- The time until all the sensor nodes exhaust their energy.
- Duration until 50% of the nodes deplete their batteries and stop working.
- The duration until the network is partitioned: the first division of the network into two or more.

Maximization of the lifetime of the network can be achieved by the different energy conservation techniques existing. The first technique aims to reduce radio activity to avoid overconsumption.

This can be implemented by setting up a scheduling of the communication time by a wake-up / awake mechanism by a TDMA (Time Division Multiple Access), etc. The second technique is oriented towards the use of routing protocols in order to route the amount of data exchanged in the WSNs. So there are a lot of algorithms which is pave the ground for a better routing schemes like LOADng exchange information between each other without the requirement for human intervention in order to increase the life time[3]. WSNs have emerged as a new powerful technology used in many applications such as military operations, agriculture, target tracking, and healthcare applications[4]. It is essential to develop cheap and energy efficient sensor nodes[5]. Since the unattended nature, replacement of those tiny batteries is impractical; hence the lifetimes of these multi-hop relaying networks directly depend on the residual energy level of its nodes[6]. EEOR-FL uses a new method in order to calculate the list of candidates. The obtained results indicate that EEOR-FL can effectively balance the energy consumption and there- fore can lengthen the network lifetime. Fault Tolerance: In special cases, the sensor node can fail, which can be caused by a lack of energy, by interference with the viewing environment or when new sensor nodes are added to the network. In particular, the network must continue to operate normally and without interruption The aforementioned architectures did not consider communication failure on virtual networks, caused by the communication failure on physical WSNs[7]. On reviewing the work, various features such as Energy, security, delay and error that pose challenges are identified[8]. Wireless sensors are independent elements, as the name implies. Therefore, they must also have a power supply autonomous. Their lifetime is limited by the lifetime of their battery. This strong constraint has a major influence on all the techniques put in place for the deployment of such networks. A major effect of this energy limitation is the maximum limitation of very expensive radio transmissions.

3. ENERGY RECOVERY IN OPPORTUNISTIC ROUTING PROTOCOLS.

Due the research work various problem raised related to the wireless sensor network. The maximization of the lifetime of a sensor network has gained particular attention. We mention that our work is closely based on the following works: formulated the problem of lifetime maximization under the assumption of aggregation of data. The positions of the sensors and that of the base station are known in advance. Since each sensor node commonly operates on batteries, it is unrealistic to equip all sensors with the infinite battery capacity. When the nodes are impossible to replenish energy via replacing batteries, network lifetime is bound to be influenced by these energy exhausted nodes[9]. We expand on this effort by building a prototype system and measuring energy consumption rates[10]. The basic idea of opportunistic routing is that each node maintains multiple relay candidates that provide positive forwarding progresses to the sink, and dynamically forwards data packet to the first candidate that wakes up[11]. Transmission power needs to be adjusted frequently, which consumes a plenty of network resource that could have been used in data packet transmission[12]. Balanced Energy Adaptive Routing (BEAR) is use to prolong the lifetime of UWSNs. The BEAR protocol operates in three phases: (i) initialization phase, (ii) tree construction phase and (iii) data transmission phase. The results demonstrated that BEAR improved the network lifetime by approximately 55%. UWSNs are particularly used for military and homeland security purposes[13]. The energy of the network by FCR protocol has preserved, the distance between the nodes has become less and more number of alive nodes has existed. Firefly algorithm is developed for maximizing the energy efficiency of network and lifetime of nodes by selecting the cluster head optimally[14]. Routing plays a major role in LLN, for minimizing the energy consumption across the network nodes. IPv6 Routing Protocol for Low Power and Lossy Networks (RPL) is a standardized routing protocol for LLN[15]. ExOR this algorithm is the primary protocol in the literature, where the routing metric used is the Expected Transmission Count (ETX). It is one of the most favored routing metrics because it has a good accuracy in determining link quality[16]. The main contribution of the COOR scheme is making full use of the remaining energy in networks to increase the transmission power of most network devices, which will provide a higher communication reliability or further transmission distance. After theoretical analysis and experimental results, it is shown that the COOR scheme can significantly improve the reliability of transmissions by 32,20%, with a delay decrease rate of 25.09%[17]. This type of protocol presents

a new type of calculation and choice of best candidates which is as follows: S is the list of S, increasingly sorted, based on the expected cost of each source node to send data to the given target node. With Fwd (u) designate the list of source nodes chosen. To find the expected cost of node u, we will first sort the list of Fwd * (u) in ascending order using their cost. Fwd(u)= v1,V2, ..., v|Fwd(u)|, i< j, Cvi < Cvj .Let α denote the probability that a packet sent per node u is not received by a node in the chosen list Fwd*(u).

$$\alpha = \prod_{i=1}^{|Fwd*(u)|} e_{uvi}. \quad (1)$$

P is the probability that a packet sent per node is received by at least one node in Fwd*(u) [14]. Then

$$P = 1 - \alpha. \quad (2)$$

$$C_u(Fwd^*) = C_u^h(Fwd^*) + C_u^f(Fwd^*) + C_u^c(Fwd^*) \quad (3)$$

With:

C_u^h represents the energy consumed by the node u to send a packet [14].

$$C_u^h(Fwd^*) = W/P \quad (4)$$

Where W is the energy consumed and C_u^f represents the total cost under U to forward the packet to the destination using the candidat set (CS) list [14].

$$C_u^f(Fwd^*) = \beta/P \quad (5)$$

β is defined by:

$$\beta = (1 - e_{uv1})C_{v1} + \sum_{i=2}^{|Fwd^*|} (\prod_{j=1}^{i-1} e_{uv_j}).(1 - e_{uv_i})C_{vi} \quad (6)$$

Where C_u^c is the cost of communication to choose thebest path. Therefore we conclude that EEOR is a protocol based on Fwd list which is a list includes minimum cost nodes calculated by equation (3). In order to minimize energy consumption and choose the best path to the destination. What monks in this type of protocol is that at the level of choice of the nodes and of calculation of costs, sometimes one chooses nodes of low energy which allows a reputation to the network. The major disadvantage of opportunistic routing protocols is the selection of several nodes to the forword list, so the solution is to work to minimize this number in order to minimize the number of possible transmissions. The minimization of the list nodes influences the total energy consumption and gives a minimal lifetime, so, the solution is to present an algorithm that minimizes the maximum number of candidate's selection.

4. OUR PROPOSED PROTOCOL EEOR-SP

The main issues in wireless sensor networks are routing protocol, energy consumed by the node, security, aggregation of data, unpredictable mobility of nodes, and so on. These sensors are sometimes deployed in hostile areas. It is therefore necessary to have an efficient strategy that takes into consideration the energy of the network to increase its lifetime by reducing the loss of energy while being reactive to changes in the environment. In this context, we propose a new routing protocol called "Energy Efficiency Opportunistic Routing using shortest paths" and denoted EEOR-SP. The objectives of our EEOR-SP protocol are as follows:

- Increase the lifetime of the sensor network.
- Minimize the number of control messages.
- Minimize the number of transmission sent.
- Minimize energy consumption.
- Presents an effective solution for WSN.

The fundamental idea of EEOR-SP protocol is to minimize the number of nodes to the list forward ie to select the best node with shortest distance at energy level, error rate, distance to destination, and the cost of sending. Our protocol is based on two phases. The first phase allows the cost calculation in the same way as the ROR protocol.

Candidate List Selection Algorithm.

Input: target node, source node, list of neighborhoods of node i N(i),
the Expected cost(d, c, e), power w.
Output: the candidat list of each node.
1/add a source node in CS list.
Repeat
2/Calculate the expected cost if
CS(u) = v1
$C = w * 1/(d + c - e)$
3/if The expected cost of $C < \sum$ cost of nodes in C then add node.

The second phase consists in the selection of the list of Candidates, this process is detailed in the following **algorithm.**

Calculating cost algorithm

Input: the candidat list of each node,target node, source node, the Expected cost(c, e, d), power w.
Output: the expected cost $Cu(CS)$ from node u to node t.
Repeat
1/Calculate the energy cost of each CS list
$C_u^h(CS^*) = W/P$
2/ Calculate the total cost under U to forward the packet to the destination using the FWD list.
$C_u^f(CS^*) = \beta/P$
3/ Calculate the communication cost reach an agreement on the choice of best path.
C_u^c until no node add a forwarder list.
4/Orders the list CS according to energy.

5. SIMULATION OF THE EEOR-SP ROUTING ALGORITHM.

In this section, we evaluate the performance of the EEOR-SP protocol by simulating under different network parameters for example, power consumption, lifetime, duplicate packets, packets loss rate using the network MATLAB Tools. We take the topology of Figure 1 as an example representing a mobile network with a 100-nodes random topology: N0 is the source and N100 is the destination. First, we give an overview of the NS2 simulator that we used and which was designed mainly for communication networks. Then we show the results of our simulations which prove the performance of this algorithm. The simulation parameters are summarized in Table 1.

Network Parameters	Values
Number of Nodes	100 to 600
Initial Node Energy	2 Joules
Tx Power	0.0762
Idle Power	0.05
Sleep power	0.000048
Rx Power	0.0831
Routing Protocols	ROR,EEOR,ExOR, ECS-OR
Propagation Model	Two Ray Ground
Antenna Model	Omni Antenna

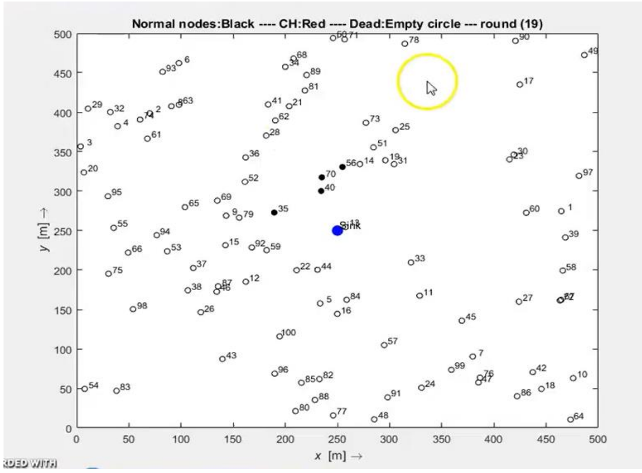

Fig. 1: The fixed network topology of our algorithm

Table 2 presents the network parameters used throughout the simulation.

The variables	Notation
V	number of neighboring nodes.
U^*	is a node list ordered by cost.
W	is the energy consumed to send a packet.
(N_i)	is the neighborhood liste of node i.
$e(N_i, N_j)$	is the probability that the packet transmission under the link (N_i, N_j) is not efficient.
c	represents the cost to send the source packet to the list FRW.
d	is the distance between the source and destination.
Y	is the probability that a received packet correctly.
$C_N i^h$	is the energy calculated that nodes Ni sending a packet to the destination.
$C_N i^f$	is the total cost expected by Ni to forward the packet to the destination using the list $FWD(N_i)$.
$C_N i^c$	is the total cost of all FWD communication nodes to reach agreement on how the node selected for packet transmission.
EI	Initial Energy of the Node(1j).
Ec	Critical Energy Level of the Node().
Er	Residual Energy of the Node().
NC	Number of nodes in the list of candidates.

A network is represented by a graph G = (U, V), with U the set of vertices (the nodes of the network), and V is the set of links. The simulated detection nodes are equipped with an application layer, opportunistic routing, random access to the medium and a physical layer.

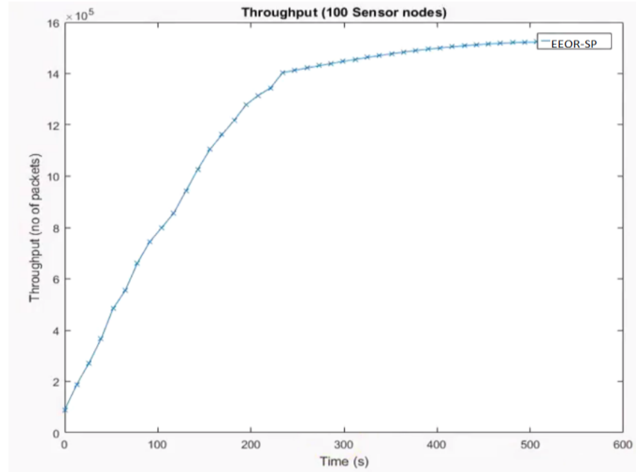

Fig 2: Throughput.

Figure 2: shows the throughput of the proposed protocol which is performing better than the other protocols like EXOR, ROR, EEOR-FL, and ECS-OR and so on. Our mentioned protocol work base of the sharing or balancing the energy consumption.

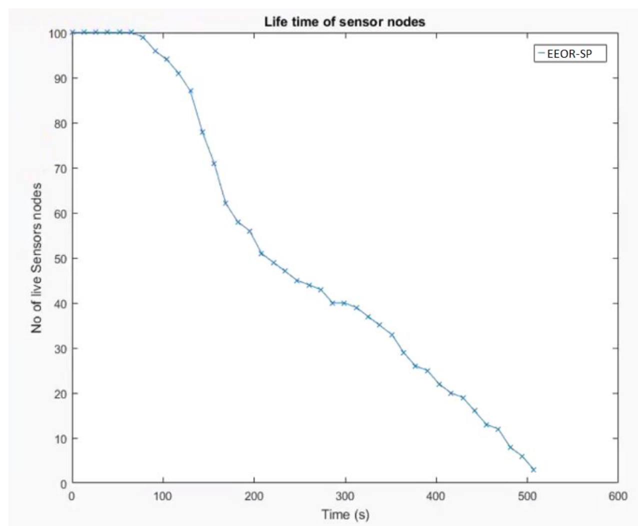

Fig 3: lifetime.

Figure 3: illustrating about the lifetime of the proposed protocol and its performing outstanding in case of lifetime because it's founding the shortest path and the number of the node which has the highest energy consumption. So our EEOR-SP protocol has the longest lifetime among of all the other routing protocols.

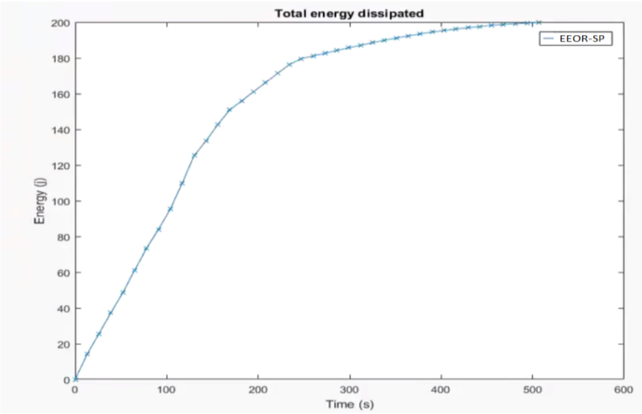

Fig 4: Energy Dissipated.

Figure 4: shows that the proposed protocol is note wasting the energy consumption and as well as increasing the network lifetime so the disappointment of the energy is very less in the EEOR-SP protocol and this Couse that the their will be node duplicate packet and number of the packet of losses is very rear.

6. Discussion

Opportunistic routing protocol in WSN is very vital field in new technology and modern development society. There are two things are important in opportunistic routing (OR) energy cost minimization and reliable data delivery with optimal network throughput. In (OR) some algorithms minimizing the energy consumption and increasing the network lifetime, some of the algorithms using more energy consumption and less network lifetime it depend the network type and the distance among the network nodes. However, our EEOR-SP Protocol is performing better than the current routing protocols like EEOR, EEOR-FL, EXOR, ROR, MERO, FCR, and ECS-OR and so on.

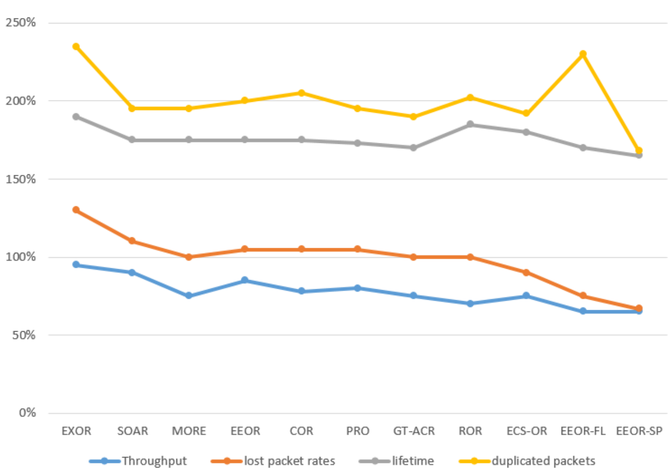

Fig 5: over all performance of the EEOR-SP.

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8. Conclusion

In this paper, we have proposed a routing protocol which is performing and transmitting the data better than all other the routing protocol that is name it EEOR-SP "Energy Efficiency Opportunistic Routing using shortest paths". Our new routing protocol permits to reduce significantly the energy consumption for each sensor node. This technique allows the minimization of number of nodes in the CS list for each source. Through extensive simulations, we disclose that the gain achieved with EEOR-SP protocol is very promising to obtain optimal energy network. From the simulation result we can say that our EEOR-SP protocol is performing better in case of throughput, lifetime, number of duplicate packet and number of losses packet and as well as the total energy dissipated from the network during the data transmission and communication of the different wireless sensor network.

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