EFFICIENT WIRELESS SENSOR NETWORK WITH ENHANCED-OMRA ROUTING ALGORITHM WITH LOW OFDM PAPR

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ABSTRACT
In modern scenario, government and other agencies are using Wireless Sensor Networks (WSN) in different sectors like defense, society, roads, forest, railway etc. Due to existing node failure, energy consumption problems in WSN, it’s very complicated to deploy denser node network which is the current age requirement. Sensor nodes usually work on battery-powered source with manual intervention and it is a very tedious and time consuming task in forest and defense areas. Hence, it becomes a necessity to reduce energy consumption of sensor, it will also increase energy lifetime. Many algorithms like Radio Aware (RA), Distance Source Routing (DSR) and directed Diffusion (DD) could not solve problems like network connectivity & asymmetric links. To overcome this problem Optimized Mobile Radio Aware (OMRA) technique is demonstrated in this paper. OFDM (Orthogonal Frequency Division Multiplexing) is wireless communication system which is used for node to node communication in WSN. Hybrid system is proposed here by adding PAPR reduction algorithm for improving BER efficiency.

Key words: Wireless Sensor Networks, OMRA.


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1. INTRODUCTION

Wireless sensor networks have wide applications in society, industries, military areas, roads, forests etc. A WSN network is nothing but huge number of small sensor nodes (e.g. heat/humidity sensor) which has different capabilities like sensing capacity, data processing and communication. These capabilities are necessary for some applications like military applications, monitoring and fire detection. One of the problems is to replace/recharge sensor node batteries. Because of this minimizing energy consumption is very important [13] [15].

Node failure, asymmetric communication & energy conservation are existing problems in WSN. Different routing algorithms can be used to solve some existing problems of WSN [13]. In proposed OMRA algorithm, network disconnection may occur after removing failed node [1][2]. Due to limited transmission range of WSN nodes, there will not be direct communication between nodes even after detecting common event. In this paper, enhanced optimized mobile radio aware (OMRA) routing algorithm is proposed. RA routing problem has been handled by OMRA algorithm. By using this algorithm, nodes can be moved to new location which in turn helps in energy saving and also, keeps nodes within communication range.

![Figure 1 Typical Wireless Sensor Network](Image)

In this algorithm, intermediate nodes are choosing by considering multiple factors such as node failure, sink node to current node distance, communication radius and airtime cost for each available path. Proposed OMRA algorithm always choose best route amongst source and sink. A nonlinear programming model is used to enhance the flow rate to sink node and reduce the consumption of energy [12].

The OFDM signal, which has many subcarriers, would have high amplitude when these signals are in phase and thus generate large amplitude which leads to large PAPR. This large PAPR adds noise in communication which downgrades the BER in WSN.

2. RELATED WORK

Direct Diffusion (DD) is used in distributed network as it is data centric protocol. To overcome the disadvantages of DD protocol, two totally different routing ways are developed. Main technique focuses on increasing the network period of time by utilizing sensing element node energy properly. In [4-6], the authors planned the ideas of clustering to cut back the energy consumption and increasing the network’s period of time. In [7], the minimum remaining energy and gradient depth were used to choose successive hop. In [8], the authors realized that time-sensitive information traffic and load-balanced routing theme was not supported by DD. This motivated them to design a Real Time (RT) filter that provided reduced end to end delay and a Best Effort filter (BE) that gives higher energy potency.
Previous work attempted to solve the problems of Directed Diffusion (DD) protocol and increase the network lifetime. They addressed different kinds of issues e.g. energy conservation and load balancing etc. But, in case of lossy WSNs reliable data transmission was not guaranteed in previous work as they considered network as a stable network [14]. Also, previous work didn't think of asymmetric communication link problems in WSN.

The RA routing algorithmic rule was proposed to deal with the issues of lossy WSNs [9] by providing QoS, responsiveness and reduction of overheads in unstable WSNs. It also provides a reliable information transmission for even a lossy WSNs. Steps of RA algorithm:

- Get radio information
- Select the node
- Fast reroute scheme.

RA algorithm has one disadvantage that is network disconnection occurs while removing failing node.

In [10], the optimum device displacement drawback in WSNs that deals with the mobile sensors nodes is introduced. The nonlinear programming model proposed in this paper uses totally different situation that permits to adaptively reconfigure the network and repair itself underneath the unpredictable runtime circumstances. In [11], a technique was developed to schedule flows at intervals that maximize the network lifespan. In [12], two general flows-based square measure involving information extraction for relentless energy and less total energy usage was proposed.

3. ALGORITHM DESIGN

Fig 2 shows the flowchart explaining the working of OMRA algorithm. The various steps in the algorithm is given below

- Define a system:
- Let O be OMRA protocol, O = {}
- Identifying the input:

Let, O1 = {N, Pkr, Pks, t, Rt, Oi}

O = {O1, ....}

N = {Nj | j = 1, 2, ...} where N is nodes
Pkr = Packets received
Pks = Packet sent
Rt = Data transfer rate from node to sink O1
Nj = {Imn, Pmn, Fm, Ri, LE, Rc},
where,
Imn = Node m to node n information flow rate
Pmn = Link m to n transmission power
Fm = Node m's fairness index
Ri = Max source rate for given node
LE = All node's limited energy
Rc = Max communication radius
- Identify the Weights:

\[ W_{mn} = F_{mn} + P_{mn} \quad (1) \]

- \( P_{mn} \) is Tx power
- \( F_{mn} \) is normalized min valu of flow rate

\[ F_{mn} = f_{max} - \text{Imn} \quad (2) \]

where, \( f_{max} = \text{Max information extracted from WSN.} \)

In terms of functions,

1) Weight Function:

\[ W_{mn} = F_{mn} + P_{mn} \quad (3) \]

- \( P_{mn} \) in Tx power

2) Least weight function:

- Node\_PH = min (W_{mn}), path from source to sink

3) Fast re-route function:

   if Node\_PH = TRUE then select Node\_PH else find next least weight Node\_PH

The GNP model is used in OMRA algorithm to calculate WSNs flow rate. Advantage of GNP model is that it can balance out the min energy consumption and max flow rates. The GNP model hybridizes two nonlinear optimization models. The energy required for each sensor node is addition of transmission energy and reception energy. Equation 4 shows the reception energy and equation 5 takes care that the outflow rate is at least as large as in-flow rate for sensor nodes except the aggregators. For aggregator, equation 6 is used and \( \sigma \) denotes the data reduction ratio.

\[
\text{max} \sum_{k=1}^{n} \cdot \sum_{k=1}^{n+1} P_{ik} + C(1 - \alpha \gamma)(\sum_{k=1}^{n} F_{ik}) + q \sum_{k=1}^{n} f_{ik}
\]

(4)

Such that

\[
\sum_{k=1}^{n} f_{ik} \leq \sum_{k=1}^{n+1} f_{ik}
\]

(5)

\[
(\sum_{k=1}^{n} f_{ik})(1 - \alpha \gamma) \leq \sum_{k=1}^{n+1} f_{ik}
\]

(6)
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3.1. Dynamic Programming and Serialization
The enhanced OMRA algorithm makes use of the following functions to improve the performance of WSN and its data flow architecture is shown in figure 3.

**Figure 2** Proposed algorithm: OMRA

**Figure 3** Data flow architecture
Fast Reroute Function: Fast reroute function algorithm checks the availability of the selected path. Algorithm for fast reroute function is as follows:

Data: Data Tx-RX path
1. If sensor node N has a data
2. Then N sends RTS signal to node which is intermediate and has highest priority
3. Else wait for incoming data
4. End If loop
5. If N reaches to sink node then return
6. Else if N receives CTS signal before timeout occurs then
7. N sends out the data to node which is intermediate and becomes N
8. Else follows the priority and send it a signal RTS
9. End all if loops.

2. WEIGHT FUNCTION: Weight function algorithm is given below, is used for finding the weights of all links.

3. LEAST WEIGHT FUNCTION: Least weight selection function that choose the path with least weight from node to sink.

4. OPTIMAL PLACEMENT FUNCTION: Optimal placement function that is used in case of node failure. Enhanced OMRA finds all flows from source to sink and calls corresponding functions to find the optimum route.

3.2. OFDM PAPR Reduction
This method of OFDM PAPR reduction divides the data subcarriers in OFDM into different groups called as bands. Then PAPR calculation will be done per band. Then band having maximum PAPR value will be selected for switching data-null subcarriers. By switching operation, PAPR will be reduced with low computational overhead.

The flowchart of this method is shown in Fig. 4. The method is explained in detail here. First divide the total number of data subcarriers into certain number of bands. As per 802.11a standard, there are 48 data subcarriers. If we divide it into 4 sub-bands then each band will have only 12 subcarriers. Then perform oversampling by certain factor to match with your IFFT size. Now, Perform IFFT operation for each sub-band and find PAPR value of each sub-band. The main idea here is to find the sub-band having maximum PAPR value. Once this sub-band is found, then perform switching of null subcarriers with data subcarriers of only that sub-band.
4. RESULTS AND DISCUSSIONS

Tools Used
- Linux OS
- NS-2 (Network Simulator) tool
- GCC compiler
- tcl-devel tool
- libX11 and Xt devel tool

Results of Experiments
The proposed algorithm is implemented in NS-2 and the results are given below.
1. Simulation Environment: Proposed OMRA is simulated in NS2. To check efficiency, proposed algorithm is compared with routing protocols such as Radio Aware (RA) and dynamic source. Simulation parameters are given below.

<table>
<thead>
<tr>
<th>SIMULATION VARIABLES</th>
<th>500 x 500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of WSN</td>
<td>500 x 500</td>
</tr>
<tr>
<td>Total nodes in WSN</td>
<td>110</td>
</tr>
<tr>
<td>Initial Energy</td>
<td>10Jl</td>
</tr>
<tr>
<td>Noise level</td>
<td>0.0001</td>
</tr>
<tr>
<td>Cost per bit (CPB)</td>
<td>0.00005</td>
</tr>
<tr>
<td>Data Reduction Ratio (Delta)</td>
<td>0.48</td>
</tr>
<tr>
<td>Aggregation cost in WSN</td>
<td>1</td>
</tr>
<tr>
<td>Receiving Power of nodes</td>
<td>0.01</td>
</tr>
<tr>
<td>Transmission Power of nodes</td>
<td>0.02</td>
</tr>
<tr>
<td>Total simulation Time</td>
<td>200</td>
</tr>
</tbody>
</table>

2. Simulation Results: Parameters which are considered for testing proposed OMRA protocol are shown in Table II
Table II SIMULATION RESULTS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Proposed Algorithm</th>
<th>Existing Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of packets sent in WSN</td>
<td>620</td>
<td>620</td>
</tr>
<tr>
<td>Number of packets received in WSN</td>
<td>587</td>
<td>552</td>
</tr>
<tr>
<td>Packets delivery ratio in WSN</td>
<td>95</td>
<td>89</td>
</tr>
<tr>
<td>WSN Control overhead</td>
<td>9584</td>
<td>9587</td>
</tr>
<tr>
<td>WSN Normalized overheads: routing</td>
<td>16.274</td>
<td>18.34</td>
</tr>
<tr>
<td>Total delay</td>
<td>0.044023</td>
<td>0.3454</td>
</tr>
<tr>
<td>Total throughput</td>
<td>14641.2</td>
<td>11233.2</td>
</tr>
<tr>
<td>WSN: Jitter</td>
<td>0.262275</td>
<td>0.2843</td>
</tr>
<tr>
<td>Number of dropped packets</td>
<td>29</td>
<td>68</td>
</tr>
<tr>
<td>Dropping ratio in WSN</td>
<td>5.01</td>
<td>11</td>
</tr>
<tr>
<td>Total Energy Consumption of WSN</td>
<td>4.92498</td>
<td>5.3433</td>
</tr>
<tr>
<td>Average Energy Consumption per node</td>
<td>0.0497473</td>
<td>0.053433</td>
</tr>
<tr>
<td>Overall Energy in WSN: Residual</td>
<td>955.072</td>
<td>966.072</td>
</tr>
<tr>
<td>Average Energy in WSN: Residual</td>
<td>9.65025</td>
<td>9.75941</td>
</tr>
</tbody>
</table>

As mentioned in tabular format of the obtained result, it is observed that the implemented system is more superior to techniques currently in vogue. The problems of data links failure are reduced to a large extent; energy conservation is improved a lot average energy per node is only 0.0497473 which is 10%-20% improved if compared to traditional methods. There are only 29 number of packets have been dropped, which is about five percent of total packets send which can be ignored considering simulation environment. Packets are dropped due to energy allocated to each node and the way traffic is handled in network. Speed of communication also seen a marginal improvement over traditional technique. Fig.5 and Fig.6. Two graphs fairness index vs. dropping ratio and average energy which also shows, implemented system is far better than the traditional technique used now a day.

Figure 5 Fairness Index vs. Dropping Ratio
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PAPR

![Figure 6 Average Energy vs. Fairness Index](image1.png)

Fig. 6 Average Energy vs. Fairness Index

Fig. 7 shows the comparative cumulative distribution function (CCDF) of PAPR for OFDM with no PAPR reduction, the original method (PTS) and proposed method. From this figure, it can be seen that switching method reduces the PAPR to further level compared to original method (PTS) but with very low computational overhead. From this figure, it can be shown that proposed scheme has low PAPR compared to existing algorithm.

![Figure 7 PAPR reduction of switching method.](image2.png)

CONCLUSION

The proposed algorithm considers the fact that network can be stable or unstable. Also, links across the nodes can be asymmetric or symmetric. Due to this approach, proposed algorithm solves instability and asymmetric link problems in WSN. For many existing algorithms, it’s not possible to maintain network connection during network instability which is solved by proposed algorithm. The proposed enhanced OMRA optimizes the RA routing algorithm and has low communication complexity. By adding PAPR reduction scheme to enhanced OMRA algorithm, hybrid algorithm is proposed. This hybrid algorithm is proved to be efficient in terms of BER.
REFERENCES


