# PERFORMANCE EVALUATION OF AN EFFICIENT POWER MANAGEMENT PROTOCOL FOR WIRELESS SENSOR NETWORKS

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**ABSTRACT**

**Aggregating the data from several sensor nodes allows us to monitor an area accurately. While aggregating the data bandwidth and battery power are the major constraints in a sensor network. The main aim of this paper is to introduce a new protocol that reduces the power consumption and supports mobile nodes in a sensor network. The protocol presented here is EPMPAC (Efficient Power Management Protocol with Adaptive Clustering), clustered and hierarchical protocol where each cluster is maintained by a cluster head and an organizer node. Energy efficiency and Mobility management are salient features of this protocol.**

**Keywords: Wireless sensor networks, Data aggregation, Data fusion, Adaptive clustering.**

## I. INTRODUCTION

Sensors are small light weight wireless nodes deployed to monitor a large area. Each sensor node contains — sensor subsystem (senses the environment), processing subsystem (performs computations on sensed data) and communication subsystem (exchange of information with neighbouring nodes). Sensor network is fault tolerant because several nodes are sensing the same event. The nodes sense the changes and report them to other nodes over flexible network architecture.

Sensors are typically disposable and expected to last for a short period until their energy drains. Therefore, energy is a very scarce resource for such sensor systems and has to be managed wisely in order to extend the lifetime of the network.

Also the data sensed by the sensor nodes is highly correlated. This fact encourages to use some kind of grouping of nodes so that data from sensor nodes of a group can be combined or compressed together in an intelligent way and transmit only compact data. This reduces traffic and hence contention in a wireless sensor network. This process of grouping the sensor nodes is called as clustering. The intelligent way to compress and combine the data belonging to a single cluster is known as data aggregation.

In this paper, we introduced the EPMPAC (Effective Power Management Protocol with Adaptive Clustering), which is a clustered based protocol that manages the energy effectively and also supports the mobility of nodes. EPMPAC is a modified version of the LEACH protocol.

The LEACH protocol fuses the data to reduce the amount of data packets transmitted between sensor nodes and the base station. LEACH is a cluster based protocol in which nodes organizes themselves into small clusters and each cluster is maintained by a cluster-head. It is hierarchical as the data collected by the sensor nodes is aggregated at the cluster-head and the information is transmitted to the base station after removing the correlated data. LEACH rotates the cluster heads in a random fashion before the cluster head dies.

The main difference between EPMPAC and LEACH are described below :

- EPMPAC has an extra organizer node along with the cluster-head
- Cluster-heads are selected based on energy level of sensor nodes
- It allows existence of mobile sensor nodes in the network

EPMPAC splits the network into non-over lapping clusters and assigns an organizer and a cluster head for each cluster. The organizers are chosen in a random rotation fashion. These features enable EPMPAC to outperform LEACH and other classical clustering algorithms.

The organization of the paper is as follows. Section II describes the protocol. Section III presents the simulation results, and section IV concludes the paper.

## II. EPMPAC PROTOCOL

The main application of a wireless sensor network is to monitor a remote area. Data of individual nodes are usually not critical. Since the data of sensor nodes are correlated with their neighbor nodes, data aggregation can increase reliability of the measured parameter and decrease the amount of traffic to the base station. EPMPAC uses this observation to increase efficiency of the network.

To develop EPMPAC some assumptions are made about sensor nodes and the network model. For sensor nodes, it is assumed that —

- all nodes are able to transmit with enough power to reach the BS, and
- each node can support different Medium Access Control (MAC) protocols and perform signal processing functions.

EPMPAC has two phases of operation — setup phase, where organizer is selected, clusters are formed and cluster-heads are selected, and Steady-state phase where data transmission takes place. The detailed description of EPMPAC protocol is given in the following sections.

### *A. Organizer Node Selection Algorithm*

Organizers are selected randomly and each node becomes an organizer only once in ‘p’ rounds. This algorithm is same as the one used for cluster-head selection in LEACH. Each node is allowed to select a number x between 0 and 1. If the selected number x is less than the threshold T(n), then, the node becomes an organizer for the current round. The threshold T(n) is set as follows.

$$T(n) = \begin{bmatrix} \dfrac{P}{1 - P * \left(r \bmod (1/P)\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{bmatrix}$$

Here, n is the given node, P is the probability of the node to become an organize, r is the current round and G is the set of nodes that were not organizers in the last 1/p rounds.

The algorithm is designed in such a way that each node has a chance to become an organizer only once in p rounds. Here, the energy of the organizer is not very important than cluster-head because all the power consumption tasks are done by cluster-head only. So, organizer need not be the highest energy node.

### *B. Cluster Formation Algorithm*

After the organizers are selected, they broadcast invitation packets to their neighbours to form into clusters. Each non-organizer nodes reply to the organizers by sending a join-REQ along with their own power levels and register with the corresponding organizer. If a node receives invitation from more than one organizer, it selects its organizer based on the maximum received signal strength of the invitation message. At the end each node belongs to a cluster.

### *C. Cluster-Head Selection*

Now, each organizer has the list of nodeIDs and their power levels. The organizer selects the highest energy level node as the cluster-head for the current round.

The mobile nodes can never be selected as organizer or cluster-head.

### *D. Steady-State Phase*

The steady-state phase is divided into frames. The organizer assigns TDMA schedule for its cluster members, where nodes send their data to the cluster head during allocated time slots.

They can switch-off their transmitters till their next chance to save energy. The cluster-head aggregates the data and sends it to the BS. The organizer always monitors the operation of cluster-head. If cluster-head fails to work for any reason, organizer changes clusterhead on the basis of the power of current nodes in the cluster. Cluster-head also monitors the organizer. If the organizer itself fails to function properly, the clusterhead itself will play the role of organizer for the current round.

Organizer places some empty time slots at the end of the TDMA frame for mobile nodes. It broadcasts ADV packets for mobile nodes in those empty slots. If any mobile node hears this ADV packets, responds to the organizer by sending the join-REQ along with its power level.

The above discussion describes communication within a cluster, where the MAC and routing protocols are designed to ensure low energy dissipation in the nodes and no collision of data messages within a cluster. However, radio is inherently a broadcast medium. Thus, transmission in one cluster will affect communication in a nearby cluster. To reduce inter cluster interference, each cluster communicates using direct sequence spread spectrum (DSSS). Each cluster communicates using a unique spreading code and all the nodes in the cluster transmit their data to the cluster head using this spreading code. The data from the cluster head nodes to the BS is sent using a fixed spreading code and CSMA. When a cluster head has data to send (at the end of its frame), it senses the channel if anyone else is transmitting using the BS spreading code. Cluster-head sends the data only if the channel is found free. Otherwise the cluster head waits to transmit the data.

## III. SIMULATION RESULTS

To evaluate the performance of the LEACH and EPMPAC protocols simulations have been carried out using the NS 2 simulator. In this paper simulation results are shown by varying number of nodes, number of connections and speed of nodes. The simulation scenario are shown in table 3.l.

TABLE 3.1 Simulation Scenario

| Simulation Parameter | Value |
|---|---|
| Simulator | NS (v2.34) |
| Topology Size | 1000m*1000m |
| Number of Nodes | 10,20,30,40,50 |
| Traffic Type | CBR |
| Packet Size | 512 Bytes |
| Speed (m/s) | 5,10,15,20,25 |
| Routing Protocol | EPMPAC, LEACH |
| No. of connections | 4,8,12,16,20 |
| Simulation Time | 100 sec |

*A. Simulation results obtained by varying number of nodes :*

Simulation is done for 100 sec by keeping the number of connections and speed of nodes constant i.e. 4 connections and 10 m/s respectively. The number of nodes are varied from 10 to 50.

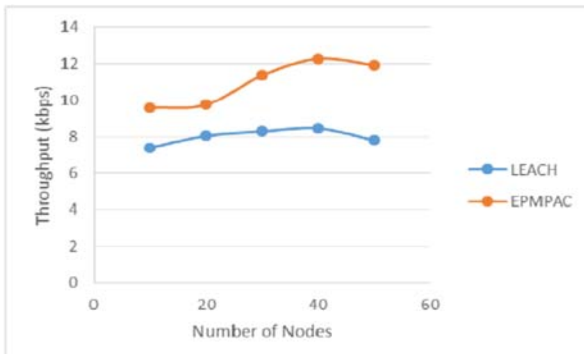


Figure 1. Throughput Vs No. of nodes

The figure 1 shows the throughput for LEACH and EPMPAC protocols by varying nodes. Simulation results show that the EPMPAC has higher throughput than LEACH.

The figure 2 shows that Average End-to-End Delay in case of LEACH and EPMPAC protocols at 10, 20, 30, 40, and 50 nodes.

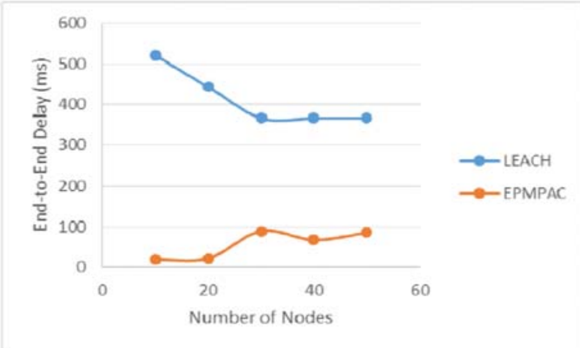


Figure 2. End-to-end delay Vs No. of nodes

Results show that the EPMPAC is having less delay compared to LEACH.

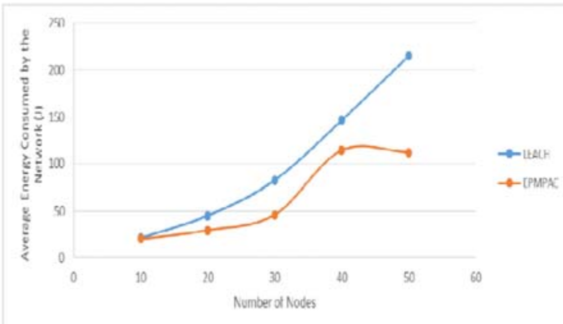


Figure 3. Energy Consumed Vs No. of nodes

The figure 3 shows the average energy consumed by LEACH and EPMPAC protocols by varying number of nodes. Results show that the EPMPAC is consuming low energy so we can say EPMPAC is more energy efficient than LEACH.

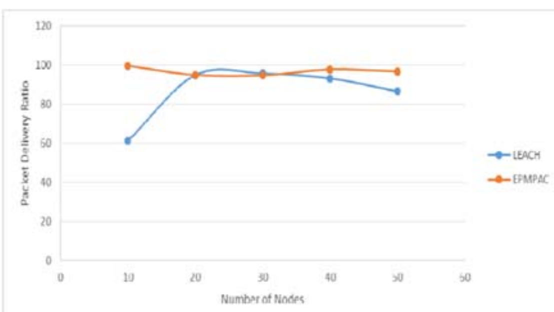


Figure 4.Packet delivery ratio Vs No of nodes

The figure 4 shows the Packet Delivery Fraction obtained in case of LEACH and EPMPAC protocols by varying number of nodes. The EPMPAC is having high packet delivery fraction compared to LEACH.

*B. Simulation results obtained by varying number of connections :*

Simulation is done for 100 sec by keeping the number of nodes and speed of nodes constant i.e. 50 nodes and 10 m/s respectively. The number of connection is varied by changing the traffic from 4 to 20.

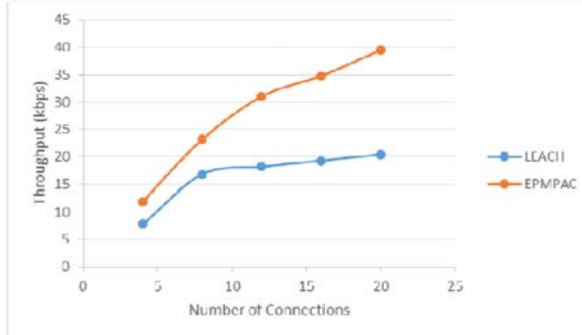


Figure 5. Throughput Vs No. of connections

The figure 5 shows the throughput for LEACH and EPMPAC protocols by varying connections. Simulation results show that the EPMPAC has higher throughput than LEACH.

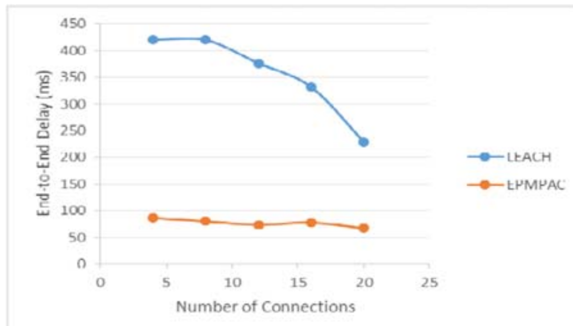


Figure 6. End-to-end delay Vs Connections

The figure 6 shows that Average End-to-End Delay in case of LEACH and EPMPAC protocols at 4, 8, 12, 16, and 20 connections. Results show that the EPMPAC is having less delay compared to LEACH.

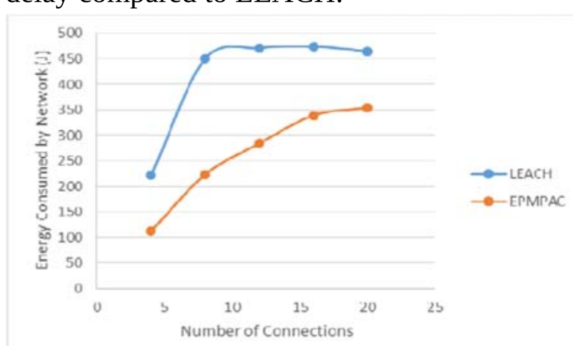


Figure 7. Energy Consumed Vs Connections

The figure 7 shows the average energy consumed by LEACH and EPMPAC protocols by varying number of connections. Results show that the EPMPAC is consuming low energy so we can say EPMPAC is more energy efficient than LEACH.

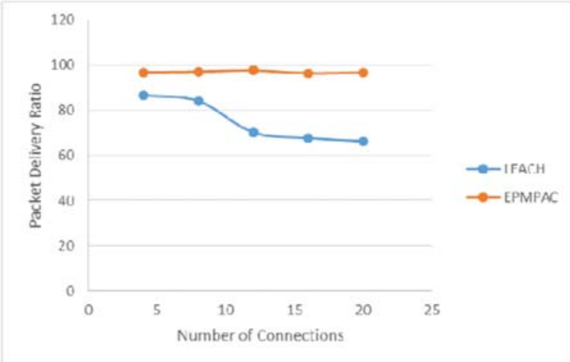


Figure8. Packet delivery ratio Vs Connections

The figure 8 shows the Packet Delivery Fraction obtained in case of LEACH and EPMPAC protocols by varying number of connections. The EPMPAC is having high packet delivery fraction compared to LEACH.

*C. Simulation results obtained by varying speed of nodes :*

Simulation is done for 100 sec by keeping the number of nodes and traffic constant i.e. 50 nodes and 4 connections respectively. The speed of nodes is varied as 5, 10, 15, 20 and 25 m/sec.

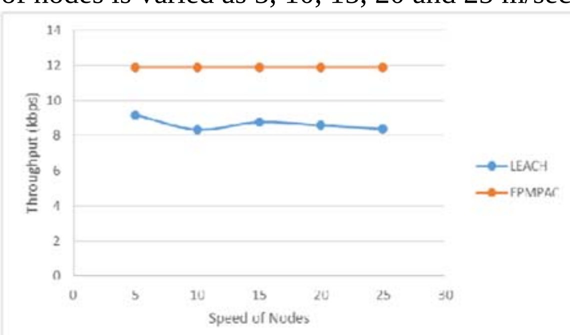


Figure 9. Throughput Vs speed of nodes

The figure 9 shows the throughput for LEACH and EPMPAC protocols by varying nodes. Simulation results show that the EPMPAC has higher throughput than LEACH.

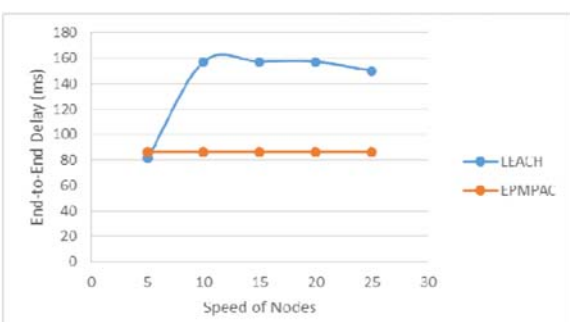


Figure10.End-to-end delay Vs speed of nodes

The figure 10 shows that Average End-to-End Delay in case of LEACH and EPMPAC protocols. Results show that the EPMPAC is having less delay compared to LEACH.

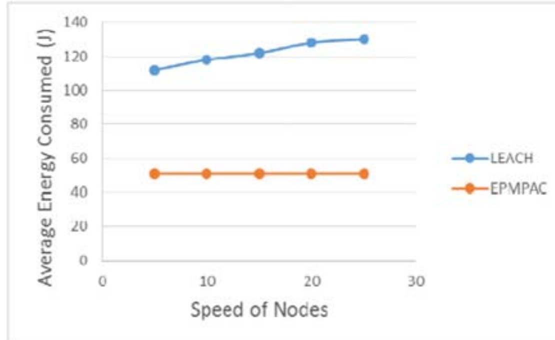


Figure 11. Energy Consumed Vs speed of nodes

The figure 11 shows the average energy consumed by LEACH and EPMPAC protocols by varying speed of nodes. Results show that the EPMPAC is consuming low energy so we can say EPMPAC is more energy efficient than LEACH.

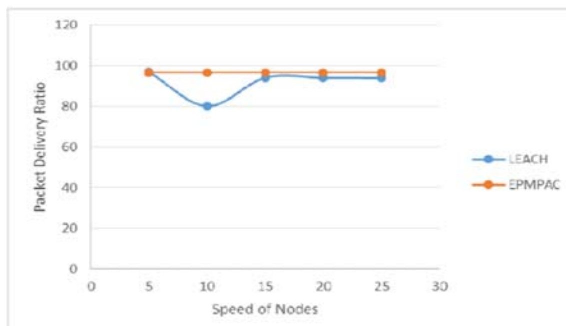


Figure12. Packet delivery ratio Vs speed of nodes

The figure 12 shows the Packet Delivery Fraction obtained in case of LEACH and EPMPAC protocols by varying speed of nodes. The EPMPAC is having high packet delivery fraction compared to LEACH.

## IV. CONCLUTION

In this paper simulation of Low Energy Adaptive Clustering Hierarchy (LEACH) and Efficient Power Management Protocol with Adaptive Clustering (EPMPAC) is carried out using NS2 simulator.

Performance analysis and simulation results show that EPMPAC protocol is more efficient in terms of Throughput, Energy Consumed, End-to-end delay and Packet Delivery Ratio as compared to LEACH. This indicates the lifetime of the network is extended a little with respect to EPMPAC that also support mobility of the nodes. The ease of deployment, energy conservation, mobility management, and extension of network lifetime make EPMPAC a remarkable and robust protocol for wireless sensor networks. Simulation results show EPMPAC outperforms LEACH.

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