International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

# CROSS LAYER OPTIMIZATION IN WIRELESS SENSOR NETWORKS

**ADITYA G NAYAK[1], BARAH[2], BASAVAKIRAN[3], HALESH S H[4], LOKESH S[5], KIRAN BN[6]**

[1,2,3,4] *Student, Dept. of Computer Science and Engineering, The National Institute of Engineering, Mysuru, India.*
[5]*Associate Professor, Dept. of Computer Science and Engineering, The National Institute of Engineering, Mysuru, India.*
[6]*Assistant Professor, Dept. of Information Science and Engineering, The National Institute of Engineering, Mysuru, India.*

---

**Abstract -** *Nowadays, the minimization of energy consumption in terms of cost and lifetime is the main preoccupation in the recent research studies. This paper deals with the proposition of a Power Consumption Protocol-Physical, Mac and Network (PCP-PMN) based on cross-layer for wireless sensor networks which uses three layers (Physical, Mac and Network). Our PCP-PMN algorithm presents the minimum transmission power between nodes at the physical layer. It uses this minimum transmission power as a metric at the network layer for the proposed routing based on LEACH protocol and performs scheduling at the mac layer for the proposed hybrid spread spectrum. The evaluation results mark that the implementation of our proposed approach preserves more energy and leads to a better performance system.*

***Key Words*: Cross layer, Energy management, Wireless Sensor Networks, LEACH, PCP-PMN.**

## 1. INTRODUCTION

Wireless sensor networks (WSNs) are one of the most important elements in the internet of things (IoT) paradigm, as they are a sensor nodes battery powered devices. Accordingly, energy efficiency is one of the determining factor for lifetime and a major research topic of WSNs. The limitation of energy in the sensor nodes which demanded every functionality of WSNs to be energy efficient. In fact, we must face concern how to reduce the energy consumption to extended the network lifetime. So, optimization of energy consumption in Wireless Sensor Network nodes has become a critical challenges to researchers. In this context, an increasing number of research works has been conducted in order to propose a wide solutions to the energy-saving problem. Thus, all layers of protocol architecture influence the energy consumption. Thus, using interaction between these layers by a cross layer design will result in an efficient energy and improve the overall network performance. Indeed, recent papers on WSN reported in (1), (2) based on cross layer result progress in term of energy preservation. This paper makes the following key contributions. First, at the level of physical layer, the minimum transmission power between nodes is obtained and gives this node where it is obtained a higher priority. Second, at the network layer, we used the parameter obtained previously as a metric to make elect cluster-head and make improvement of proposed routing algorithm based on LEACH protocol. Third, at the level of Mac Layer, PCPPMN treats the scheduling by using proposed hybrid spread spectrum. To evaluate the performance of our approach, we simulated our WSN on NS-3 Simulator. PCP-PMN economizes energy and prolongs the life cycle of the entire network.

## 2. BACKGROUND AND RELATED WORKS

In this section, we will present a brief description of some basic concepts used in literature and some related works in relation to our work to help understanding the contributions of the paper. All layers of WSN protocol stack influence the power consumption since WSN nodes have stiff energy constraint because they are powered by batteries. Therefore, using interaction between these layers by a cross layer design will result in an efficient energy. In this paper, we propose power consumption protocol based on cross-layer for Wireless Sensor Networks.

### 2.1 Background Description

Firstly, we present the layered architecture to understand the cross-layer approach.

#### 2.1.1 Layered Architecture:

The protocol stack in wireless sensor network is an hybrid model between OSI and TCP/IP model as shown in Figure1.

We are interested to present the layers that will be used in our work. The physical layer is responsible for frequency generation, modulation, and data encryption. The two sub layers of Data link layer are DLC (Data Link Control) which is responsible of multiplexing and error control, and MAC (Medium Access Control) which is responsible for Channel access and scheduling. The primary function of network layer is routing. More detailed description can be found in (6).

#### 2.1.2 Cross Layer Design Overview:

In layered architecture each layer has its own functionality and can use only the services provided by the layer below it. So, the communication is permitted only between adjacent layers. On the other side, in the cross layer approach, each layer can use services provided by any other layer. The interactions between all layers of the network protocol stack improve performance of WSN.

Different cross-layer designs have been classified into six approaches in terms of possible interactions between physical (PHY), medium access control (MAC), Routing (NET), and application layers (APP).

### 2.1.3 LEACH Protocol Overview:

*LEACH - Low Energy Adaptive Clustering Hierarchy:* As shown in Figure 1, LEACH Protocol is an hierarchical clustering-based routing protocol. It is self-organizing and adaptive clustering. LEACH utilizes randomized rotation of local cluster base stations (cluster-heads) to evenly distribute the energy load among the sensors in the network, operations are broken into rounds, each round is made on two phases: Setup Phase and Steady Phase.

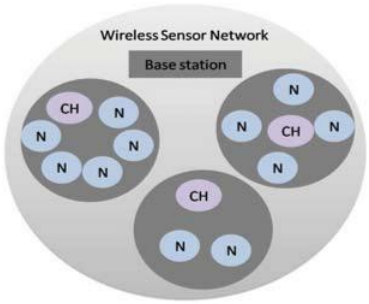


**Fig -1**: Energy Adaptive Clustering Hierarchy Protocol

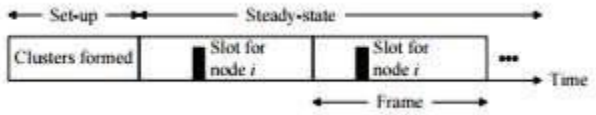


**Fig -2**: LEACH Protocol Process

LEACH protocol process is shown in Figure 2.

At the first stage (clusters formed), the decision to be cluster-head is made by node i choosing a random number between 0 and 1.

If value < t(n), node becomes cluster-head; this number to the threshold values t(n), if the number is less than t(n), then it becomes cluster head in this round, else it becomes common node.

- Using this threshold, each node will be a cluster head in 1/P rounds;
- Nodes that are cluster-heads in round 0 can't be again for next 1/P rounds;
- After 1/P -1, T=1 and 1/P rounds, all nodes are eligible again to become cluster-heads;
- After 1/P-1 round, all nodes which have not been head nodes will be selected as head nodes with probability 1;
- When 1/P rounds finished, all nodes will return to the same starting line.

**Setup Phase**

Each node that elected itself a cluster-head for current round as explained in the first stage (clusters formed), broadcasts advertisement message to the rest of nodes.

They use a CSMA MAC protocol: All cluster-heads transmit advertisement using the same transmit energy. Non-cluster-head nodes must keep receivers on during this phase to hear advertisements.

**Steady Phase**

- After node picks cluster, it must inform cluster-head using CSMA MAC protocol again;
- Cluster-head then creates a TDMA schedule telling each node when it can transmit (broadcast back to nodes in cluster, probably using CSMA);
- Allows radio components of each non-cluster-head node to be turned off during its transmit time, thus minimizing energy dissipated in individual sensors;

$$t(n) = \begin{cases} \frac{p}{1-p*(r \bmod \frac{1}{p})} & \text{if } n \in G, \\ 0 & \text{if } n \in /G. \end{cases}$$

| Parameter | Description |
|---|---|
| t(n) | threshold |
| P | desired percentage of cluster head node |
| r | current round |
| G | set of nodes not cluster head in 1/P rounds |

TABLE I
DESCRIPTION OF LEACH PARAMETERS

- In this step, Cluster-head has all data from the nodes in its cluster, aggregates data and transmits to base station;
- When nodes pick cluster, all cluster-head nodes must keep receivers on.

### 2.2 Hybrid Spread Spectrum Approach

Telecommunications with spread spectrum are a radio trans-mission technique where the signal is transmitted over a greater spectral width that the bandwidth of the original signal when it was transmitted by conventional modulation methods. The spread spectrum is a transmission technique of spreading the energy of a telecommunication signal over a bandwidth which is much greater than the information rate. In the work reported in (7), the originality of this hybrid approach compared to others spread spectrum methods is that can remedy the insufficiency of FHSS by combining it with THSS to reduce the energy consumption. So we used this method for scheduling on our cross layer approach to evaluate the cost effectiveness and energy efficiency in WSN by a simulation in two WSN platforms. Figure 3 explained in more details this approach.

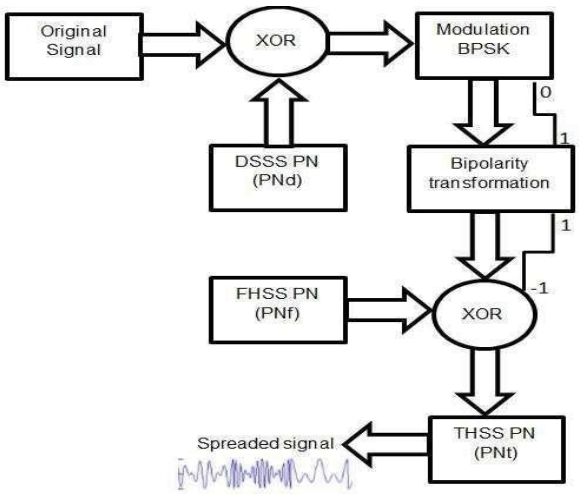


**Fig -3**: Hybrid Spread Spectrum Approach

## 3. CONTRIBUTION

In this section, we will describe our pro-posed cross layer approach and we will give its formalization to be more clear.

### 3.1. Description:

The cross-layer approach proposed in this paper preserves traditional layered structure and considers the interaction between (Physical, Mac and Network) protocol layers. So, the mechanisms of each layer still stay intact, while each layer is informed about the conditions of other layers. Our protocol named (PCP-PMN: Power Consumption Protocol-Physical, Mac and Network) uses the cross-layer Wireless

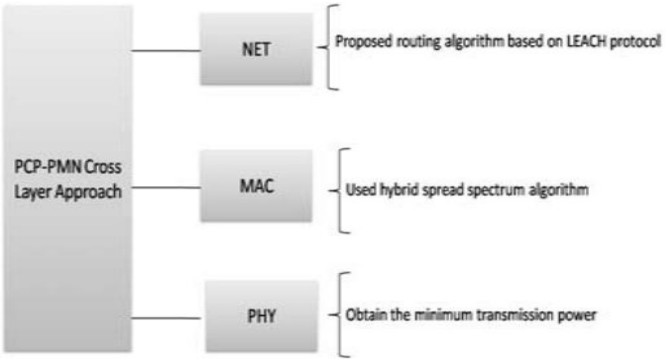


**Fig -4**: Major Parts of our PCP-PMN Contribution

Sensor Networks which uses three layers (Physical, Mac and Network) to treat the cost effectiveness and energy efficiency.

Figure 4 shows the major parts of our contribution; our first idea is to treat transmission power parameter because the communication energy represents the largest portion of the energy consumed by a sensor node. When the transmission power is high, the energy consumed will be higher, so:

1) At the physical layer: PCP-PMN obtains the minimum transmission power that requires minimum communication energy and gives this node a higher priority.

2) At the network layer: PCP-PMN proposed the routing algorithm based on LEACH protocol to choose the optimal path by using the parameter obtained at the physical layer.

The decision to be cluster-head is made by choosing the node that requires the minimum power transmission obtained at the physical layer. For the next round, obtaining the minimum power transmission to be elected as a cluster-head.

3) At the mac layer: PCP-PMN used hybrid spread spec-trum algorithm to treat transmission power, transmission rate and link schedule to maximize the network life.

In the scheduling phase, nodes use proposed hybrid spread spectrum to palliate the weaknesses of Time Division Multiple Access (TDMA).

Our cross layer approach between PHY, MAC and NET layers built a scheduling and routing mechanism in the WSN by using proposed network protocol based on LEACH and hybrid spread spectrum protocol to achieve the energy efficiency.

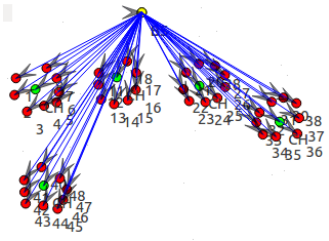

**Fig -5**: Simulation of Data Transmission

### 3.2. Experimentation Results

Firstly, at the physical layer we aim to obtain the minimum transmission power and giving this node a higher priority.

Secondly, at the network layer, we used this parameter as a metric to make improvement of the proposed routing algorithm based on LEACH protocol.

Thirdly, at the mac layer, making scheduling by using the proposed hybrid spread spectrum.

Finally, we simulated by running our PCP-PMN algorithm,

evaluated and compared the results of the estimated energy obtained through the simulation between the two systems (With PCP-PMN algorithm and Without PCP-PMN algorithm on NS-3 Simulator).

In initial state, before applying the PCP-PMN, we observe the initial energy efficiency as shown in Fig6. During the execution of the PCP-PMN, the efficiency goes up.

Fig6 shows a graph between the obtained values for the two systems. We can show that there is a lot of difference in the energy spent before and after applying our PCP-PMN algorithm.

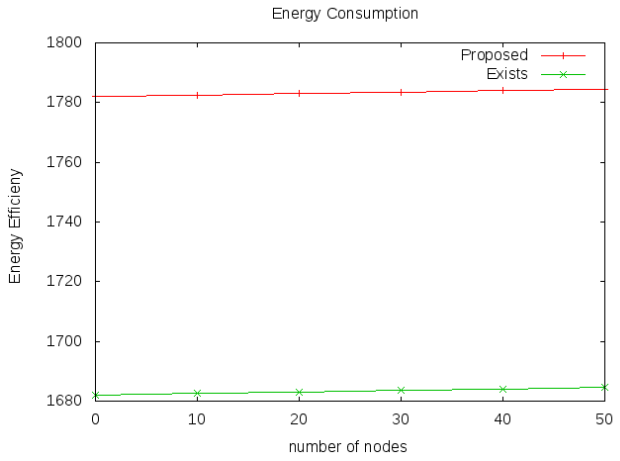


**Fig-6**: Graphical Representation of Energy Consumption

In figure 7, the graph is plotted such that number of nodes on the X-axis, network overhead on the Y-axis, we can see that in the existing system as the number of nodes increasing the network overhead increases but using our PCP-PMN algorithm we can reduce the network overhead .

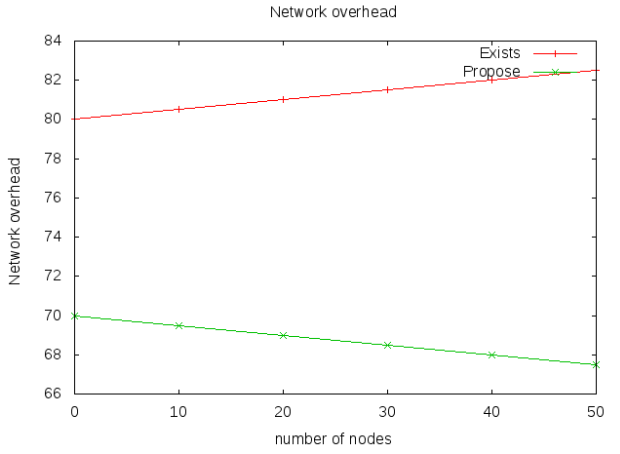


**Fig-7**: Graphical Representation of Network Overhead.

## 4. CONCLUSION

This paper work presents a Power Consumption Protocol-Physical, Mac and Network (PCP-PMN) based on cross-layer for Wireless Sensor Networks which uses three layers (Physical, Mac and Network) with the aim to study the energy consumption. Energy efficiency is the major factor that determines the lifetime of WSNs.

The main contribution of our work, an energy optimization approach for wireless sensor networks is present, named PCP-PMN based on a Cross-layer approach between physical, MAC and Network layer. PCP-PMN obtains at the physical layer the minimum transmission power and gives this node a higher priority. Then used this parameter as a metric to make improvement of proposed routing algorithm based on LEACH protocol at the network layer and to perform scheduling by using proposed hybrid spread spectrum at the mac layer.

Our algorithm improves reliability of communications, saves energy and uses bandwidth more efficiently.

## 5. REFERENCES

[1] N. A. Sangeetha, Dr.Binu G S, energy management in wireless sensor networks: cross layer approach brief review, international journal of advanced research in electronics and communication engineering (IJARECE) Vol. 5, No. 4, April 2016.

[2] T. Alkhdoura, U. Baroudib, E. Shakshukic, S. Selim, "An Optimal Cross-Layer Scheduling for Periodic WSN Applications" ,The 4th International Conference on Ambient Systems, Networks and Technologies (ANT ), 2013.

[3] Y. Bai, S. Liu, M. S. Yang Lu and C. Xu, "An Energy Optimization Protocol Based on Cross-Layer for Wireless Sensor Networks", Journal of Communications, vol. 3, no. 6, November 2008.

[4] Ri. Madan, S. Cui, S. Lall, and A. Goldsmith, "Cross-Layer Design for Lifetime Maximization in Interference-Limited Wireless Sensor Networks", IEEE INFOCOM, 2005.

[5] O. B. Akan and I. F. Akyildiz, "A Cross-Layer Protocol for Wireless Sensor Networks", IEEE/ACM Transactions on Networking, vol. 13,Issue 5, pp. 1003-1016, 2005.

[6] W. Su, O. B. Akan, E. Cayirci, Communication Protocols for Sensor Networks, Kluwer Publishers, in Wireless Sensor !etworks, Chapter 2, 2006.

[7] N. Rouissi, H. Gharsellaoui, S. Bouamama, "A hybrid DS-FH-THSS approach anti-jamming in Wireless Sensor Networks", SERA 2016, 21 July, 2016.

[8] H. B. Salameh, T. Shu, M. Krunz, "Adaptive cross-layer MAC design for improved energy-efficiency in multi-channel wireless sensor networks", Ad Hoc Networks, 5 pp-844-854, 2007.