Energy Efficient Cross Layer Design Protocols using Distributed Method of Information sharing in Wireless Sensor Networks- A review

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***Abstract* -** In Wireless Sensor Network nodes are densely deployed and are prone to failure and the topology of sensor network changes very frequently. Sensor nodes are tiny devices limited in power, computation capacity, memory, sensing range and mobility. The major factors responsible for energy consumption in WSN's are idle listing, collision, overhearing, overhead, congestion and unnecessary high transmission range.

In this paper we reviewed the various cross layer designs using distributed method of information sharing among the layers and came to the conclusion as MR (MAC-ROUTING) is the best approach to design easily with good results in various parameters of network throughput, end to end delay, energy consumption, overhead, packet loss and residual energy compared to other cross layer approaches. Here we also observed that MAC layer plays a vital role in minimizes the energy consumption in various types of cross layer approaches.

***Keywords* -** Cross Layer Approaches, Distributed Method, Multi Hop, Single Hop, WSN.

I. INTRODUCTION

SENSORS could form a wireless network called Wireless Sensor Networks (WSN). Sensors are limited in mobility, less energy resources, computational capacity and memory [7].When these extreme limitations are combined with strict traditional architecture both the network performance and lifetime are compromised by consuming more amount of energy. Network lifetime is the fundamental concern of WSN, due to the fact that each node in network operates with an extremely limited energy. Recent research has shown that the Open System Interconnection (OSI) model is not necessarily the correct approach for some modalities of wireless systems. Researchers have made modification to communication protocols which violates the OSI model, but achieve specific optimization goals [14] these modifications are termed "Cross Layer Design" [26].

Cross layer design allows direct communication between protocols at nonadjacent layers or sharing variables between layers. Such violation of a layered architecture is cross layer design with respect to the reference architecture [26]. Figure 1.1 shows an example of wireless sensor network.

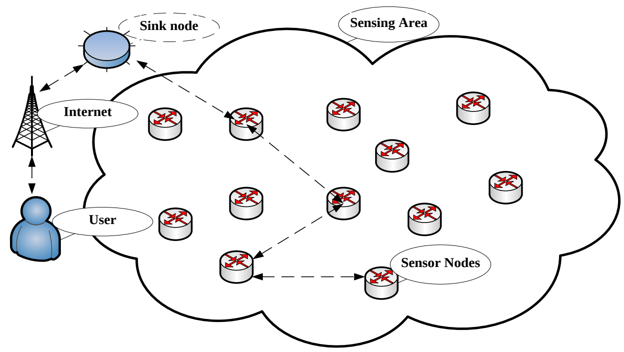
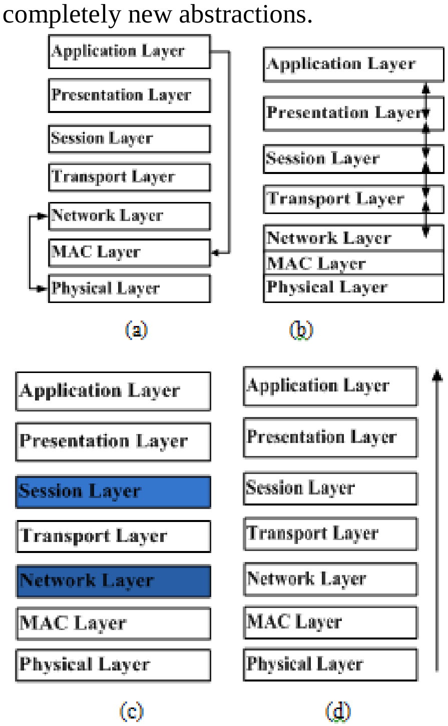


Fig 1.1: A Typical sensor network structure

[26] Illustrated cross layer design proposal as- Creation of new interfaces, Merging of adjacent layers, Design coupling without new interfaces, Vertical calibration across layers as shown in Figure 1.2 and also gave cross layer interaction can be implemented and placed in three categories- Direct communication between layers, A shared database across the layers and completely new abstractions.



(a) New Interface (b) Merged Layers (c) Co- designed Layers (d) Inter-layer Calibration

Fig 1.2: Classes of Cross-Layer Design

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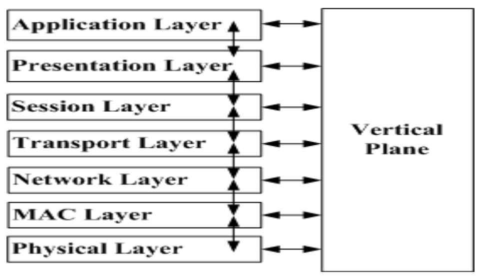
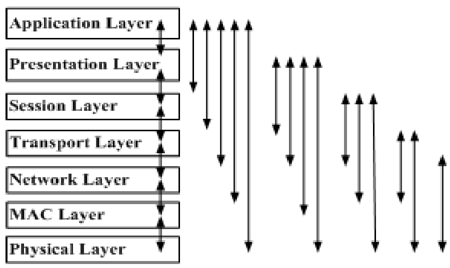
In paper [1] Classified cross layer designs by two ways, by how to share information among five layers, cross layer designs can be classified into two categories: non-manager method manager method. On the other hand, by the organization of the network, cross layer designs can be classified into two categories: centralized method and distributed method as shown in Figure 1.3 (a) and (b) respectively.



(a)



(b)

Fig 1.3 Cross Layer (a) Centralized and (b) Distributed sharing of information method

[20] [24] Proposed packets are subject to interference from other transmission, resulting in errors, since packet errors will cause retransmission; require more energy from the sensors. Moreover, retransmission will affect delay and data throughput, also affecting QoS. The use of error control techniques can prevent retransmission, however at the cost of introducing energy consumption. In order to address these problems cross layer solutions are required simultaneously.

In this paper review is done on cross layer designs using distributed method [1][8][9][11][26] of sharing information between layers to minimize the energy consumption in WSN due to collision, overhearing, control packet overhead, and ideal listening and over emitting using single hop and multi hop communication .

The remainder of this paper is organized as follows: Section 2 discusses in detailed review of various cross layer distributed method of sharing information between layers using single hop and multi hop communication and Figure 2.1 gives the various cross layer approaches. Section 3 discusses the results of various cross layer approaches along with advantages and disadvantages of respective approaches. Section 4 discusses the conclusion of this review as well as future work.

II. Cross Layer Optimization Approaches

2.1. PHY-MAC-ROUTE (PMR) Cross Layer approaches

2.1.1 Collision Aware Routing Protocol (CARP)

Proposed Collision Aware Routing Protocol (CARP) [27] uses collision degree and energy level as the basis of routing and route adjustment. CARP uses the residual energy and initial energy to calculate the energy level. So CARP will choose the more residual energy nodes as the relay nodes. Thus it minimizes network energy consumption and prolongs network lifetime. CARP adopts the on-demand way to carry on route discovery and maintenance, the collision aware information is perceived from the computation of related parameters of each layer. The energy level reflects the residual energy of node and it is obtained through calculating the ratio of initial energy and the sum of the initial energy and the residual energy.

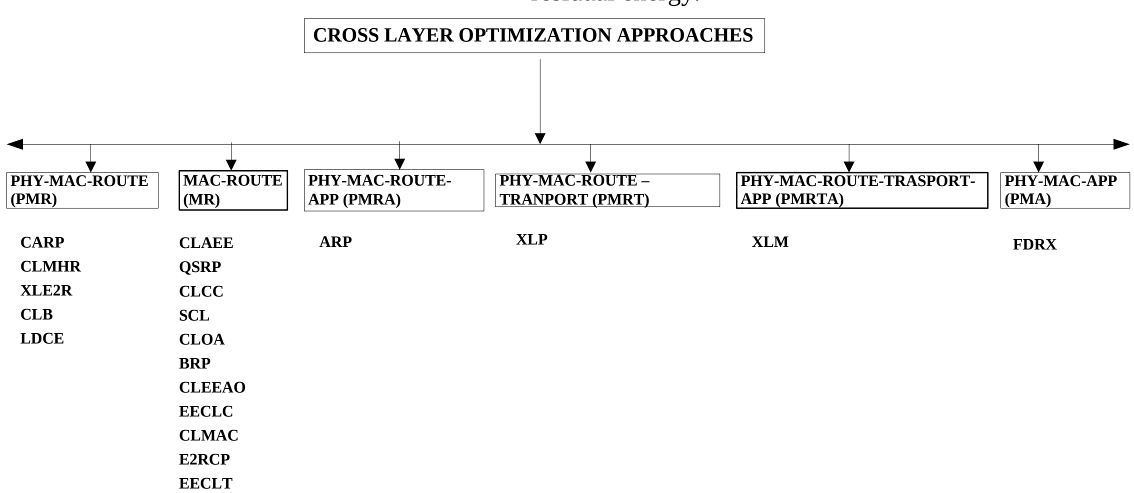


Fig. 2.1 Cross Layer Optimization Approaches

2.1.2 Cross Layer Routing Protocol for Multi-Hop (CLMHR)

In [5] Proposed Cross Layer Routing Protocol for Multi-Hop (CLMHR) WSN. Here the information both a node's residual energy and the distance from it to the next hop node are considered with different equilibrium weight factors. When a node wants to select a new route, it will choose those nodes whose residual energy is higher and the location is closer to destination node to be a relay node as its next hop. This could avoid the disequilibrium of the node's energy consumption and an overlong propagation route. So here important tradeoff between node's residual energy and the distance to the destination could be considered seriously.

2.1.3 Cross Layer Energy Efficient Routing (XLE2R)

Wireless sensor network (WSN) is a fast emerging field and it is gaining lots of attention from research group and the real time users [15]. [19] Paper focused on reducing the power consumption in WSN due to collision, overhearing control packet overhead, and ideal listening and over emitting. To reduced long delay in the system, here they used cross layer optimization between PHY, MAC and the Network layer for the routing process. Here they used the Cross layer energy efficient routing (XLE2R) protocol to overcome with the problem of maximum consumption of power for static nodes and showed the results using OPNET.

2.1.4 Cost Link Based (CLB)

This Paper focused on drawing benefits from interaction of physical, MAC and routing layers by defining a new cross layer scheme CLB(Cost link Based) for Routing [16]. Here, showed that use of multiple paths between each sensor node and the sink node can be improve network lifetime by efficiently routing (i.e., balancing) the traffic inside the WSN. Link distance highly depends on the network topology and Link cost is based on the cross layer design that rejects the paths with nodes, having less battery support than the specified threshold i.e. <50%.

2.1.5 Link Distance link Cost link Error (LDCE)

Link distance has been considered for power saving and here authors have used the concept of sending the packet to the maximum farthest intermediate nodes only. In this paper [17], the use of multiple paths b/w each sensor nodes and sink node is considered. It is showed that the network lifetime can be improved by efficiently routing the traffic inside the WSN. Minimum energy path selection technique to define Link Distance link Cost link Error (LDCE) that can be used to increase the operational lifetime of the network.

2.2. PHY-MAC-APP (PMA) Cross Layer approaches

2.2.1 Fair and Delay aware cross layer data Transmission (FDRX)

Here [13] Proposed scheme is called as Fair and Delay aware cross layer (FDRX) data Transmission scheme. FDRX implements application layer data prioritization technique to control medium access of sensor nodes and provides fairness by periodically yielding to other nodes to access the medium. Fair and Delay aware approach initially executes delay assessment, if the estimated delay higher than the delay requirements of the application. Then the node is given higher priority to access the channel by reducing its Clear Channel Assessment (CCA) duration.

2.3. MAC-ROUTE Cross Layer approaches(MR)

2.3.1 QSRP (Quality of Service Routing Protocol)

This paper proposed protocol provided the required QoS in terms of end to end delay and reliability in an energy efficient way considering the joint functionalities among the routing and MAC layers. Proposed protocol supported application with diverse QOS requirements, classified these requirements into four different classes concerning both delay and reliability [12]..

2.3.2 SCL (Hybrid Access protocol based on clustering routing scheme)

Here proposed SCL to improve the channel utilization of WSN using a hybrid access protocol (contention based-CSMA, contention free-TDMA) to deal with the intra cluster communications after dividing the whole network into several cells [21]. TDMA is used when the networks are under high traffic or contention. CSMA is used during the cluster setup phase as well as low contention scenarios.

2.3.3 CLCC (Cross Layer Congestion Control)

In [31] Presented Cross Layer Congestion Control (CLCC) strategy in WSN to control the congestion effectively using multipath routing can remove congestion of one node immediately by forwarding packets to other nodes. The rate adjustment can control congestion fundamentally and it includes application oriented design to control congestion.

2.3.4 BRP (Balanced Routing Protocol)

A cross layer strategy for energy conservation that considers routing and MAC layers jointly [4]. At the routing layer, balancing the traffic through the WSN by sending the traffic generated by each sensor node through multiple paths instead of using a single path allows significant energy conservation. At the MAC layer, to control the retry limit of retransmission over each wireless link by efficiently adjusting the retry limit for each link, further energy conservation can be achieved, improving thus the network lifetime.

2.3.5 CLOA (Cross Layer Optimization Approach)

Data collection techniques in WSN suffer from heavy congestion particularly at nodes closer to the sink node in order to combat this problem, they introduced the multiple tree algorithm is a novel cross layer optimization approach that assumes a very simple MAC protocol and make use of both routing and MAC layers information to reduce congestion, improve delivery ratio and minimize energy consumption. In the routing layer part, they guaranteed that every node in the network can send its data to the sink by constructing multiple data collection trees [2].

*2.3.6 CLAEE (*Cross Layer Approach for Energy Efficient MAC layer protocol)

MAC layer design is critical for energy efficiency in wireless sensor networks. Here [29] presented an approach to reduce the time spending on data moving. The amount of data moving drops a lot by only passing the fields necessary to the network layer for processing and finding a route. In this way, the nodal processing time drops dramatically and thus energy consumption is reduced accordingly. End to End delay can be reduced with decreased of nodal processing time as well; this technique can integrate with any other MAC protocols without any difficulty. This cross layer approach will target to reduce the data moving between the MAC layer and the network layer.

2.3.7. CLPEE (Cross-Layer Protocols for Energy-Efficient WSN)

In Paper [3] focused on reducing the energy loss due to idle listening, control signaling congestion hot spots, packet collision and to conserve the battery power using Extended Power Aware Random scheduling algorithm (EPARS) and showed results using Tiny OS.

2.3.8 CLEEAO (Cross Layer Energy Efficiency Analysis and Optimization in WSN)

Proposed and analyzed a cross layer efficiency model , which taken routing layers, MAC layers, data link layers, hardware circuitry and battery discharge continuity into account. In order to solve the above mentioned problems along with the successfully delivery of all data generated by source nodes to the sink node they introduced minimal energy consumption using PPM and FSK [25]. For minimizing the network energy consumption ,the time slot assigned to each link is optimized and the optimal routing are derived for dense WSN and a general WSN.

2.3.9 EECLC (Energy Efficient Cross-Layer Clustering Scheme for WSN)

Here proposed the cross layer approach to average the energy consumed by the nodes closer to the base station taking a cluster scheme that the cluster head nodes could be chosen based on the residual energy. The proposed scheme can be divided into two distinct phases in routing; the setup phase and reconfiguration phase, steady state phase [19]. The residua energy and the average energy are better in cross layer clustering scheme compared to AODV.

2.3.10 E2RCP (Energy Efficient Cross Layer Routing Protocol)

Cross layer optimization algorithm with the integration of MAC and routing layer to minimize the energy consumption by wireless network to maximize the lifecycle of the entire wireless network [30]. E2RCP detailed description of agreement contains; Network Conditions as defined, Construction of tree based routing table algorithm described in detail with following 4 phases as- determined preview node, The formation of node link path, Data transmission strategy, The reliability of transport mechanism path.

2.3.11 CL-MAC (Cross Layer MAC)

CL-MAC(Cross Layer-MAC) exploiting the routing layer information to decide which nodes are involved in actual data transmission and solved the problem of forced wake-up in adaptive S-MAC.CL-MAC proposed in this paper mainly aims to increase energy efficiency by keeping nodes continuously remaining in their sleep mode. Sleeping nodes are not included in the routing path. Thus only a few nodes concerned of the actual data transmission are asked to wake up the CL-MAC protocol [10].

2.3.12 EECLT (Energy Efficient Cross-Layer protocol using Token)

In this paper proposed energy efficient cross layer design of MAC and routing protocol namely efficient cross layer design protocol by using token passing mechanism for WSN. Token ring is a combination of both contentions based and scheduled based protocol. The proposed algorithm is implemented in three main phases- (Sector id) Group Formation, Token passing, Routing. Token is the control packet that circulates within group of nodes. Token network is hierarchically formed into groups. Each group have a token, node with token can only transmit its data. After every T_H time token is passed to its next neighbor. All the nodes in the group are equally given chance to transmit its data [28].

2.4. PHY-MAC-ROUTE-APP (PMRA)Cross Layer approaches

2.4.1 ARP (Adaptive Routing Protocol)

In paper [18] has proposed and analyzed an adaptive routing metric which minimizes the overall energy consumption of the network and which respects the application QoS requirements taking into account the unequal transmission energy consumption of the sensor nodes. Thus, the routing metric selected optimum path which not only helps in meeting the deadlines (end-to-end) but minimizes the overall energy consumption of the network.

2.5. PHY-MAC-ROUTE–TRANPORT (PMRT) Cross Layer approaches

2.5.1 XLP (Cross Layer Protocol)

Here presented XLP by assumed first protocol that integrates functionalities of all layers from PHY to Transport into a cross layer. A design principle of XLP is a unified cross layering such that both the information and the functionalities of 3 fundamental communication paradigms (Medium access, Routing and Congestion control) are consider in a single protocol operation.

Based on the initiative determination concept, XLP serves as a proof of concept and performs receiver based contention; initiative based forwarding, local congestion control, and distributed duty cycle operation to realize effective and reliable communication in WSN’s. Denoting the initiative as *I*, it is determined as follows [22];

$$I=\begin{cases} 1, & if \begin{cases} \xi_{RTS} \geq \xi_{Th} \\ \lambda_{relay} \leq \lambda_{relay}^{Th} \\ \beta \leq \beta^{max} \\ E_{rem} \geq E_{rem}^{min} \end{cases} \\ 0, otherwise \end{cases} \quad \text{……………….... (1)}$$

2.6.PHY-MAC-ROUTE-TRASPORT-APP (PMRTA) Cross Layer approach

[23] Summarizes the surveyed architecture in terms of energy consumption, protocol size, cross layer communication overhead, adaptability to channel conditions, and compatibility with a layered architecture. An ideal architecture design results in network protocols with low to moderate energy consumption, moderate memory requirement, low to moderate cross layer communication overhead, adaptability to channel conditions , and compatibility with the layered architecture. A single architecture not exhibits all these characteristics.

2.6.1 XLM (Cross Layer Module)

Cross Layer Module (XLM), a node initiate’s transmission by broadcasting RTS packet to indicate its neighbors that it has a packet to send upon receiving RTS packet, each neighbor of node decide to participate in the communication or not this decision is given through initiative determination. The initiative determination is set to one if all the four following condition are satisfied-Signal to noise ratio of an RTS packet is above some threshold for a node to participate in communication, Prevent congestion by making less traffic, Node does not experience any buffer overflow and hence, also prevents congestion, Residual energy of a node stays above a minimum value [6]. The nodes inside the feasible region perform initiative determination by broadcasting the RTS packet.

III. Results And Discussion Of Various Cross Layer Approaches

In comparing the results of CARP (Collision Aware Routing Protocol) with AODV (Adhoc on Demand Routing Protocol) the energy consumption is very less because CARP takes collision degree as one of the routing metric, so it can avoid the high collision areas. So [27] gave summery that by avoiding the high collision areas using the layers of communication of ROUTE to MAC and PHY, to minimize energy consumption. Communication among these cross layer also minimizes the average end to end delay when compared to AODV.

The results of LAR (Location Aided Routing) with (CLMHR) Cross Layer Routing Protocol for Multi-Hop energy consumption is very less due reduced number of repeatedly transmitted communication data and survival time is twice better [5] . By analyzing these results CLMHR protocol is more advantaged than LAR protocol. (Tradeoff Condition-α=0.5,β=0.5) . [15] gave good results by minimizing energy consumption but approach performs better in scenarios where the nodes are static than the mobile.

Data delivery ratio improved in CLB by 2% when compare to AODV. Delay in average time is more when compare to AODV for 100 nodes [16]. Results by comparing LDCE with AODV and gave energy saving up to 30% to 70% [17]. All these above protocols are based on distributed sharing of information among the layers PHY-MAC-ROUTE (PMR) and comparison of various parameters as shown in Table.1 and came to the conclusion that CLMH is the best PMR cross layer approach.

TABLE I
COMPARISION OF PHY-MAC-ROUTE (PMR) CROSS LAYER APPROACHES

Approach	Protocol	Simulator	EC	PL	OH	TP	EtED	RE	Strength	Weakness
PMR (PHY-MAC-ROUTE)	CARP [27]	NS-2	L	L	L	H	L	H	Select more residual energy node as relay node.	Difficult to obtain routing metric
	CLMH [5]	MATLAB	L	L	H	H	L	H	Avoids the disadvantages of some nodes excessive energy consumption and transferring data	Good lifetime of network especially in large scale network
	XLE2R [15]	OPNET	L	L	H	H	H	H	Selects the farthest sensing intermediate node in the sensing range	Performs better in static scenario than mobile
	CLB [16]	NS-2	L	-	L	H	H	H	Rejects the paths with nodes, having less battery suppose (<50%)	Through put will improve for small and lightly loaded network
	LDCE [17]	NS-2	L	L	L	H	H	H	Rejects the paths with nodes, having less battery suppose (<50%)	Through put will improve for small and lightly loaded network

EC-Energy Consumption, PC-Packet Loss , OH- Overhead, TP- Through put, EtED- End to end delay, RE-Residual Energy, L- Less, H-High

Percentage of data packet received by PAN coordinator from an individual node versus number of nodes data delivery performance of FDRX improved 2% for 10 nodes, 4% for 20 nodes, 8% for 30 nodes and by 10% for 40 nodes compared to default setting. The energy consumed in the transmit mode is slightly higher when implemented FDRX scheme. This protocol having advantage to efficiently address the fairness issue of DRX (Delay aware cross layer data Transmission) while delivering high priority packets with reduced latency and having disadvantage to improve the data delivery performance while slightly increases the energy consumption [13].The above protocol is based on distributed sharing of information among the layers PHY-MAC-APP (PMA) and comparison of various parameters as shown in Table.2 and came to the conclusion that FDRX is the best PMA cross layer approach.

TABLE II
COMPARISION OF PHY-MAC-APP (PMA) CROSS LAYER APPROACHES

Approach	Protocol	Simulator	EC	PL	OH	TP	EtED	RE	Strength	Weakness
PMA (PHY-MAC-APP)	FDRX [13]	Qual Net	(H/Tr) L	L	H	H	L	-	Delay estimation and data prioritization before data transmission	Improves data delivery slightly increasing the energy consumption

EC-Energy Consumption, PC-Packet Loss , OH- Overhead, TP- Through put, EtED- End to end delay, RE-Residual Energy, L- Less, H-High

In [21] mentioned the advantages of SCL, where both the average throughputs of system and per sending node throughput almost have improved from 50kbps to 100kbps for 100 nodes and average throughput per node almost linearly decreased from 2.5kbps to 9kbps for nodes form 10 to 60 nodes and remains constant till 100 nodes compare to LEACH-C. Average time spent for transmitting one packet using SCL is lower than LEACH-C.SCL Protocol has about 40% more idle time slots to transmit information under low contention. This is indirectly reflects the property of higher channel utilization by using SCL. The evaluation gave that CLCC has a better performance and can control congestion effectively. CLCC has advantage of using multi-path routing can removes congestion of one node immediately by forwarding packets to other node and the rate adjustment can control congestion fundamentally. CLCC has disadvantage of more control over head leads more energy consumption [31].

Energy consumption of Balanced Routing Protocol (BRP) is very less compare to basic protocols (HST) Hop based Spanning Tree and (ETX) Expected Transmission count metric. Balanced routing enables significant improvement of the network life time compared to the basic scheme HST routing by two times (Balanced routing life time-3193s, HST-1551s) [4]. Balanced routing enables retry limit mechanism achieves further improvement in the network lifetime (Ring Topology). Balanced routing captures the real behavior of WSN’s by considering the wasted energy due to idle listening, overhearing and retransmission.

CLOA (Cross Layer Optimization Approach) improved data delivery ratio up to 40% without increasing the energy consumption of the nodes in addition to this also reduced the average packet delay up to 70%. By reducing the work load on each tree, reduced the energy waste due to collisions and energy consumption of the nodes reduced by 30% of the original value. [2] CLOA has advantage, unlike scheduling based MAC protocols; this approach does not required strict synchronization and also more scalable with network size when compared to scheduling based algorithm.

In [29] Proposed protocol gave result showed that nodal processing delay of IEEE 802.11 DCF is seventeen thousand times more compare to CL-MAC, end to end processing delay for a network with100 nodes of IEEE 802.11 DCF is seventy-eight thousand times more compare to CL-MAC and end to end processing delay for a network with 800 nodes of IEEE 802.11 DCF is twenty three thousand times more compare to CL-MAC. Proposed protocol has advantage of easily integrated into many MAC protocols since it does not contradicted with any other techniques in MAC layer designs and the amount of data moving drops a lot by only passing the fields necessary to the network layer for processing and finding a route. It has disadvantage of only applicable for real time application.

EPARS (Extended Power Aware Random scheduling algorithm) saves energy by avoiding collisions (and thus retransmission) and energy consuming control signaling. Turning off while no neighbor is in sent mode saves additional energy. Comparing EPARS [3] with other TDMA schemes does not need Global Time synchronization or signaling for scheduling states, which represents a significant amount of additional power saved. This proposed algorithm has disadvantage of requiring accurate time synchronization between any pair on neighboring nodes, is very difficult to maintain.

The result [25] showed that the multi hop routing is more energy efficient than single hop routing in general WSN, while single hop routing is more beneficial in dense WSN. For single hop uniform routing as a reference, the cross layer model with optimal routing shows a noticeable decreasing of network energy consumption, which is 99% for PPM and 93% for FSK.PPM performs better compare to FSK in terms of energy conservation in both dense and general WSN. This protocol has disadvantage of channel not utilized during sleep mode.

In paper [19] results showed that there is a delightful progress in energy conservation for the sensor network, and the performance of each node closer to the base station is better than before and has disadvantage of more energy required for computation at Custer Head and more overhead to maintain the setup and reconfiguration phase. [30]Showed the success rate of data E2RPC algorithm for the scenario of 2 or 4 intermediate node failed for the same node set, α, β values of different E2RCP algorithm performance did not differ. Simulation result showed that, E2RCP able to work in harsh environment, WSN routing protocol provides higher data transfer rate by provided multiple independent communication paths and has disadvantage of control overhead and comparatively more energy required to maintain routing table.

The adaptive S-MAC will consume more energy by forced wake-up. So, the proposed CL-MAC [10] results in less energy consumption than the adaptive S-MAC as the number of nodes increases.

In paper [28] here protocol, avoids lots of collisions at any point of time by making only a single node (from the whole group) is allowed to transmit the data. Sensor node gets a packet, it will see it is forwarded only if it from the higher level. This makes the flow of data only towards the base station not away from it and has a disadvantage of maximum control overhead and there is always a chance that the token frame may be lost due to several reasons.

All these above protocols are based on distributed sharing of information among the layers MAC-ROUTE (MR) and comparison of various parameters as shown in Table.3 and came to the conclusion that CLAEE and CLPEE are the best MR cross layer approaches.

TABLE III
COMPARISION OF MAC-ROUTE (MR) CROSS LAYER APPROACHES

Approach	Protocol	Simulator	EC	PL	OH	TP	EtED	RE	Strength	Weakness
MR (MAC-ROUTE)	QSRP [12]	C++	L	L	-	H	L	-	Prioritized traffics according to the requirements.	Routing decreased to protect the traffic from dropping
	SCL [21]	NS-2	L	H	H	H	L	-	use hybrid MAC protocols to improve the performance under various traffic condition	The achieved channel utilization cannot be accurately determined
	CLCC [31]	NS-2	L	L	H	H	-	-	Multi path and rate adjustments removes the congestion	More control over head
	BRP [4]	NS-2	L	L	H	H	-	H	Sending the traffic generated through multi paths instead single path	More control over head
	CLAEE [29]	OPNET	L	L	L	H	L	H	The amount of data moving drops a lot by only passing the field necessary	This approach is meaningful for real time application
	CLPEE [3]	Tiny OS	L	L	L	H	L	H	Turning off battery while no neighbor is in sent mode and avoids collision.	Requires accurate time synchronization between any pair on neighboring nodes, is very difficult to maintain
	CLEEAO [25]	-	L	L	-	-	-	-	(PPM-99%) and (FSK-93%) lower network energy consumption than single- hop routing	During sleep mode wireless channel is not utilized.
	EECLC [19]	NS-2	L	L	H	H	-	-	cluster head nodes could be chosen based on the residual energy to maximize network life time	energy require is more for computation at Custer Head
	E2RCP [30]	NS-2	L	L	H	H	-	-	Provide high data transfer rate by provided multiple independent communication paths.	control overhead and comparatively more energy required
	CL-MAC [10]	NS-2	L	L	-	H	-	-	No forced wake up problem and maximize sleep duration of sensor nodes	Suitable for dense network
	EECLT [28]	MATLAB	L	H	H	H	-	-	Avoids lots of collision by making only a single node is allowed to transmit	Maximum Control overhead to assign nodes sector id

EC-Energy Consumption, PC-Packet Loss , OH- Overhead, TP- Through put, EtED- End to end delay, RE-Residual Energy, L- Less, H-High

The proposed routing metric performs well under different application deadline cases as it takes into account the effect of congestion on a particular path by periodically estimating the delay values and the uneven energy consumption on different paths by using LQI (Link Quality Indicator) value [18].

The above protocol is based on distributed sharing of information among the layers PHY-MAC-ROUTE-APP(PMRA) and comparison of various parameters as shown in Table .4 and came to the conclusion that ARP is the best PMRA cross layer approach.

TABLE IV
.COMPARISION OF PHY-MAC-ROUTE-APP (PMRA) CROSS LAYER APPROACHES

Approach	Protocol	Simulator	EC	PL	OH	TP	EtED	RE	Strength	Weakness
PMRA (PHY-MAC-ROUTE-APP)	ARP [18]	NS-2	L	L	H	H	L	H	proposed routing metric performs well under different application deadline cases	This is well suitable for heterogeneous systems.

EC-Energy Consumption, PC-Packet Loss , OH- Overhead, TP- Through put, EtED- End to end delay, RE-Residual Energy, L- Less, H-High

Analytical performance evaluation and simulation experiments results showed that XLP significantly improves the communication performance and outperformance the traditional layered protocol architecture in terms of both network performance and implementation complexity [22].The above protocol is based on distributed sharing of information among the layers PHY-MAC-ROUTE-TRANSPORT(PMRT) and comparison of various parameters as shown in Table.5 and came to the conclusion that XLP is the best PMRT cross layer approach.

TABLE V
COMPARISION OF PHY-MAC-ROUTE-TRANSPORT (PMRT) CROSS LAYER APPROACHES

Approach	Protocol	Simulator	EC	PL	OH	TP	EtED	RE	Strength	Weakness
PMRT (PHY-MAC-ROUTE-TRASPORT)	XLP [22]	C++	L	L	L	H	-	-	Single communication module that is responsible for each networking layer	Implementation complexity

EC-Energy Consumption, PC-Packet Loss , OH- Overhead, TP- Through put, EtED- End to end delay, RE-Residual Energy, L- Less, H-High

The overall performance of XML reveals that routing layer performance alone does not provide efficient communication in WSN's, and other effects such as link quality, contention and congestion levels necessitate a cross layer approach in route selection for overall network efficiency.

The above protocol is based on distributed sharing of information among the layers PHY-MAC-ROUTE-TRANSPORT-APP (PMRTA) and comparison of various parameters as shown in Table.6 and came to the conclusion that XLM is the best PMRTA cross layer approach.

TABLE VI
COMPARISION OF PHY-MAC-ROUTE-TRANSPORT-APP (PMRTA) CROSS LAYER APPROACHES

Approach	Protocol	Simulator	EC	PL	OH	TP	EtED	RE	Strength	Weakness
PMRTA (PHY-MAC-ROUTE-TRASPORT-APP)	XLM [6]	C++	L	-	L	H	H	-	Singles communication module that is responsible for each networking layer	Unified cross layer ,implementation complexity

EC-Energy Consumption, PC-Packet Loss , OH- Overhead, TP- Through put, EtED- End to end delay, RE-Residual Energy, L- Less, H-High

IV. CONCLUSION

As we are all aware of OSI layer is a defined standard. But switching over to cross-layer based solutions approach in wireless sensor networks in general and in particular handling energy efficiency issues with cross-layer approach is fascinating and challenging one. On carrying out a near to comprehensive review of different cross layer design protocols using distributed method of information sharing in WSN. An interesting phenomenon that came to our observation is irrespective of different combinations of layers used, predominantly all papers reviewed for energy efficiency considerations (by taking parameters such as: retransmission due to collisions, overhearing, control packet overhead, idle listening and unnecessary high transmitting power.)Has 'MAC-layer' as a common member in literature of different researchers. Among them MR (MAC-ROUTING) based cross-layer designs were found to provide good results over their counterparts. We as authors are confident that the literature provides a platform for most of the research aspirants in area of wireless sensor networks particularly considering cross-layer designs

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