Optimal Transmit Power for Channel Access Based WSN MAC Protocols

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Summary
Wireless Sensor Networks-most prevalent application-based networks today, are networks using cost-efficient sensing, computing and communication in physical world scenarios like Disaster Management, Environmental observation, Armed forces surveillance to Industrial process control monitoring, Patient remote vitals monitor via bio-instrumentation and emergency situations. Sensor Network literature review suggests that Designing PHY & MAC functionalities for nodes with low duty cycle and optimal transmit power in dense network is major research issue and requires utmost researchers' attention to find out ways for solving it efficiently. This Paper first highlights about WSN protocols stack and design issues of each layer. An important MAC protocols classification based on four channel access methods namely Contention, Scheduling, Polling and Hybrid is presented. All methods are classified on the basis of Type, Energy Efficiency, synchronization, Adaptiveness and Scaling to give easy reference for applications. Further, performance of Channel access based BMAC protocol with varying transmission power is examined in terms of energy consumption, data packet transmission & reception, data forwarding and preamble transmission & reception. In Last, Present research trends focusing on combined enhancement of different layers are discussed. The ultimate target in MAC protocols research is towards realization of less delay, improved QoS, reduced overheads and efficient power consumption mechanisms

Key words:
Channel Accessing, Contention, Scheduling, Polling and Hybrid, BMAC protocol, transmission power, Research Challenges

1. Introduction

In present world of Wireless communication, Use of Wireless sensor network in almost every application has become unavoidable. WSNs use cost-efficient sensing, computing and message components called nodes. These nodes message each other directly or via other nodes and collect data for further monitoring and controlling of parameters in physical world scenarios, for example, Biological system and IT framework.
Based on environment area of the physical scenario being monitored, WSNs can be spread in some thousands of nodes for measuring temperature, light, and heat or other physical quantities [1]. Among such huge number of nodes, some are Gateway nodes (Sink) which can communicate user directly or via fixed wired networks as shown in Fig. 01.

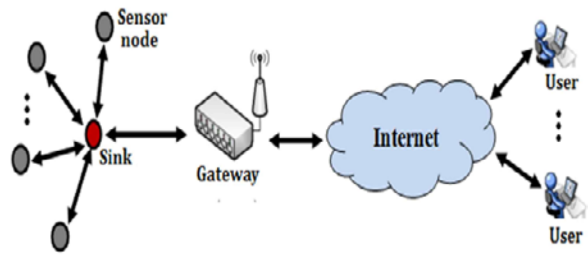

Fig. 1 Wireless sensor network Architecture

From Disaster Management, Environmental observation, Armed forces surveillance to Industrial process control monitoring, Patient remote vitals monitor via bio-instrumentation and emergency situations, WSNs handles all different situations in variety of fields but bound to maintain life time of batteries, Real-time, Fault tolerance, Scalability, Programmability, Maintainability, Security, Production cost & QoS [2-4]. It is realized the fact that in WSNs communication consumes more energy than computation and that's why the prime objective is always towards maximizing node's life time and achieve energy efficiency. For such purpose, WSNs employ novel MAC protocols to achieve energy efficiency since MAC protocols govern radio activities of nodes [5].
Sensor Network literature review suggests that Designing PHY & MAC functionalities for nodes with low duty cycle and optimal transmit in dense network is major research

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issue and requires utmost researchers' attention to find out ways for solving it efficiently [6]. [7] termed optimal transmit power as node life time decider and presented application designs for various environments. Holland [8] used transmit energy parameters along with distance and modulation scheme for maximum transmission with extended life time of the network over noisy channel. In [9] Author worked on Transceiver to obtain improved Dynamic range, Sensitivity, Linearity, Noise figure, Working frequency and band width, Channel selectivity, Power consumption, blocking performance and modulations. [10] presented minimal transmit power for network connectivity with each link having similar propagation path loss and termed interference as source of power loss and reduced life time of nodes in radio channel. This Paper is presented as: Section II describes basic WSN protocol stack, Section III describes Classification of MAC Channel access methods. Section IV describes Optimal Transmit power Analysis and Last section describes research trends and followed up by Conclusion in Section VI

2. WSN Protocol Stack

WSNs use two arrangements to gather useful sensed of certain phenomenon under observation for communication with the user. First nodes are in close contact with each other and sink with minimal peer to peer contact. Followed by second arrangement communication which importantly uses less energy than first one, where sink receives useful information being routed back to itself via data passing among a different number of nodes.
The WSN protocol stack is similar to the traditional protocol stack with five layers and extra three management layers for monitoring power, movement and task distribution in nodes. The five layers in protocol stack include Physical Layer, Data Link Layer, Network Layer, Transport, and Application Layer. Three management layers include Power management plane for reducing power consumption, Mobility plane for recording movement of nodes and maintaining a data route to the sink and Task plane for balancing and planning the sensing tasks given to the sensor field. Protocols developed so far must address all three planes [11]. Fig.02 depicts a generic protocol stack. WSN protocol stack, Layered wise is explained.

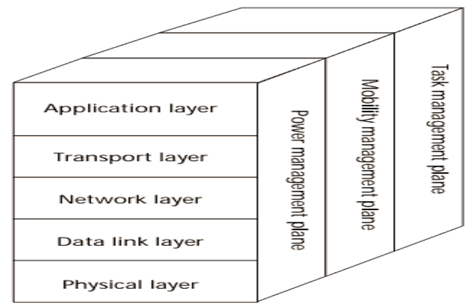

Fig. 2 Generic WSN protocol stack [11]

2.1 Physical Layer

Frequency choice, carrier frequency generation, signal detection, modulation, and encryption are all tasks this layer performs. Further, these layers focus on lessening energy ingestion by making an appropriate selection of parameters mentioned where the secondary task is to deal with common challenges like other wireless networks face. This layer also plays an important role in transmitting a wireless signal over distance d with minimum power usage with multi-hop communication and high node density [12]. WSNs Physical layer design has been most challenging since these networks occupy common band –ISM along with other standards like 802.11b and Bluetooth. As a result, interference and cross talk major concern all network face.
The most important research factors to work upon in physical layer design are:

- Power Consumption Minimization.
- Minimal Transmission and Reception range.
- Robust against interference from systems in common band.
- Minimal implementation complexity and costs
- Low duty cycle, i.e. When Sensor nodes are not in use, must be switched off.
- Low data rates for more extended periods and high data rate for shorter periods of time.
- Low-cost transceivers with optimal sensitivity values, less power consumption and simple modulation schemes to provide required service [4].

2.2 Data Link Layer (DLL)

The responsibilities of this layer include Multiplexing of data streams, data frame detection, medium access and error controls. DLL also makes sure a reliable point-to-point and point-to-multipoint connections where ever required in the network [11]. Within OSI reference model,

Data link layer has two sublayers namely MAC and Logical Link Control (LLC).
Mac Layer divides wireless medium among nodes and assists the nodes present about energy aware related operations. LLC provides facilities such as link management, error reduction, flow control and framing. Further, MAC protocol deals with the management of the shared-medium and develops/makes a basic singular network so as nodes remain interconnected and can transfer data with each other in a collision-free way.
Novel protocols always focus to deal Radio control at Mac Layer properly which is the most power consuming activity and can help to extend node's life time and network at all. MAC protocol, in short guides radio usage pattern by nodes, channel common occupancy, collision freeness in dense nodes communication, timely response to the inquirer, and a long life time of the nodes.
A MAC protocol for WSNs deals with energy conservation issues, in addition to that as per application requirements, providing timeliness, reliability, scalability, through put, stability, fairness whereas non-synchronized operations may also play a significant role in scheming a MAC protocol. This protocol sits directly above the physical (PHY) layer, therefore, is directly predisposed to effects mentioned here. Consequently, designing a MAC protocol for WSNs involves a trade-off among several and often differing factors.
Additionally, WSNs also inherent some common problems such as attenuations, noise, intrusion, fading, path loss and miscalculations due to broadcasting in the wireless medium. Research work relating to the MAC designing mostly focuses energy efficiency and trades off latency, packet delivery ratio and scalability.

2.3 Network Layer

This layers functions to route sensed data from source nodes to sink(s). In Dense WSNs, nodes are closely placed to each other to sense phenomenon of interest, and they always look for easy and efficient multihop path to send data to sink. An efficient routing protocol is always required at this stage by a source node [09]. Another designing issue at this layer includes power efficiency; WSN is data-centric network along with attribute-based addressing and location awareness. This layer decides which node to talk to whereas LLC manages how any two nodes communicate each other.
In common design: flooding, each data receiving node repeats it data by sharing to every neighbor node till either life time of data for the max hop is reached or destination is receiving node its self. This design is the simplest one, with cheap topology maintenance and easy route finding. In weaknesses implosion, overlap and resource blindness are major. Implosion takes place with two nodes (X and Y) sharing multiple (n) neighbors. Node X will air data to all n of these neighbors. Node Y will then get a copy of the data from all neighbors, Where as in overlap, two nodes allocated the same sensing region. In case of a stimulus, both nodes will report it. Resource blindness is also a major problem to deal with.
Flooding ignores energy resources available, so gossiping is used in flooding place. In gossiping, Node after receiving data randomly selects a neighbor to send data to it. Gossiping does not face implosion, but face the other two concerns and ads to the latency of the network.

2.4 Transport Layer

Communication with the outside world brings this layer in active use. With no global addressing and attribute-based naming for destinations of data packets in use, WSN faces a crucial problem in the sink to user communication. Lots of research needs to be done at this layer [12].

2.5 Application Layer

These layer protocols perform query broadcasting, node localization, time synchronization, and network security. This layer uses Sensor management protocol (SMP) for software operations to execute a number of tasks, like, swapping location-related data, synchronizing sensor nodes, moving & scheduling sensor nodes, and maintaining a queue with the status of nodes [13].

3. Classification of MAC Channel Access Methods

Designing Efficient MAC protocols which are solely responsible for radio utilization, channel occupancy, and Collison free broadcasting communication among nodes for a maximum life time, has always been challenging for Researchers. Apart from this, MAC protocols also devise strategies and techniques to reduce energy waste via Idle Listening (Receiver radio on without message), collisions (Frames collisions resulting in retransmissions), Overhearing (receiving a packet destined to other node and process leading to miscommunication), Control packet overhead (Minimal or well-balanced number of Control packets with data bytes required to reduce waste of energy), Over emitting (Deaf ness of node or not ready to receive status of node) and Complexity of protocol related with the design of algorithm.
Use of channel accessing methods is very helpful to deal with sharing medium in broadcasting transmissions. There exist many MAC protocols that strictly focus developing specialized accessing techniques. Fig no 03 presents

classification of MAC Protocols based on Four Channel accessing techniques.

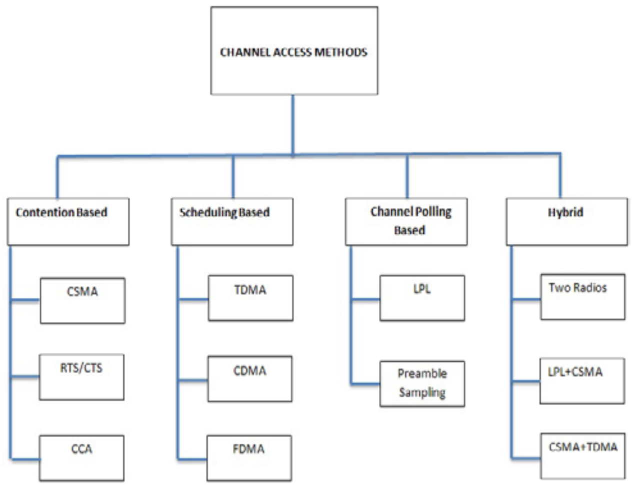

Fig. 3 MAC Protocols Categories

3.1 Contention-based MAC Protocols

Using CSMA scheme, Node that transmits has to compete with nearby nodes to get access on the channel for transmission. A transmitting node transmits only with an idle carrier; in case of no idle carrier it stops broadcasting for some arbitrary period. Back off algorithm is used to calculate the arbitrary period. Protocols with this approach use minimum processing means and are the right choice for event-driven WSN applications. Here information related to Clustering and topology is not required through network scaling and dynamics. In this Access technique where the sender controls transmission completely, collisions, eavesdropping, radio on for when no message available and minimal throughput can take place as result of Hidden and exposed terminal problem.

To minimize above problems in CSMA, RTS/CTS handshake has been the most common approach to use, resulting in an additional increment in the size of control packet with overhead with lesser efficient against above problems. This approach is initially performed between the sender and the receiver, and then the actual data packet is sent [5].

Sensor-MAC (S-MAC) [14] sets nodes in listening and sleep periods (LSP) using scheme mentioned in [5] for unicast messages and achieves reduced idle listening, collisions, and overhearing first time in Sensor networks. S-MAC cannot deal with changing traffic conditions due to its inflexible means to adjust the LSP' Length. Due to this reason it is suitable for a limited set of workloads or preset workloads. If S-MAC follows multiple schedules, it also wastes more energy in idle listening and overhearing.

Time-out MAC (T-MAC) [15] uses the technique to reduce listen period flexibly in adaptable traffic conditions and proves to be more energy efficient than S-MAC. Under variable loads, T-MAC has better results. T-MAC solves node early sleep problem with synchronization of active periods with in virtual cluster. This leads to less consumption of power as compared to S-MAC with collision free ness, but T-MAC faces synchronization and scaling problems.

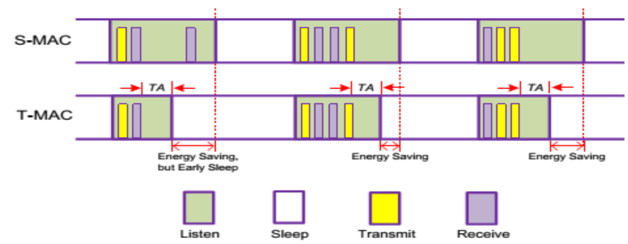

Fig. 4 SMAC vs. TMAC [4]. Here For a TA period, If T-MAC finds no activation event, it automatically stops node's listen period. This Early stopping of the node to awake can cause loss of packet with minimal throughput and maximal latency.

Dynamic S-MAC (DSMAC) [16] analyses the traffic and energy conditions first and then changes duty cycle values for the node according to which is an improvement over S-MAC' Latency. This protocol attains a minimal throughput in case of high traffic because of using less frame duration. Using flexible duty cycle in virtual cluster at high loads of traffic also adds size to the synchronization overhead.

3.2 Schedule-based MAC Protocols

In this scheme, each node in the neighborhood is given collision free links during the initialization phase. Preferably time slots (TDMA) used for scheduling methods. With TDMA approach, time consumed by system is distributed into time slots, and each one is assigned to a node in the neighborhood. Here schedule decides time for resource utilization for different contestants with minimum collisions, less overhearing, and indirectly escaping from idle listening. The central authority regulates scheme, and that can be permanent or calculated on demand (or a hybrid). They also provide a bounded and higher queuing as a node has to wait for its assigned timeslot. Overhead, extra traffic for synchronization, variable traffic handling and topology orders, low scalability and throughput [5] are challenges for this scheme.

LEACH (Low-Energy Adaptive Clustering Hierarchy) protocol [17] manages a dense and homogeneous Sensor network with clusters, where the head of the cluster guides the rest. Head of cluster created under randomized rotation mechanism, creates, maintains TDMA schedules and communicates with its cluster members, and then sends the received messages to sink node. In LEACH, head of the cluster efficiently manages the nodes with its continues ON state, so is maximum likely for cluster head to die comparatively earlier before other nodes. In this protocol, data has to be always sent by the nodes during their assigned time. This leads to the channel under-utilization.

TRAMA, which stands for Traffic Adaptive Medium Access protocol [18], shares the total system into cycles of random access Period RAP and period of schedule access SAP. RAP has a collection of signaling and SAP has slots for transmission data. The positive features of TRAMA include Reuse of time slots, utilizing neighborhood and traffic information, and hybrid scheme. TRAMA makes a two-hop communication in neighbored of Dense WSN which is sure going to be very large enough resulting in more computation, long delays due to queues and wastage of memory and channel use. Therefore, TRAMA is suitable for less delay sensitive and resourceful networks.

SMACS – Self-organizing Medium Access Control for Sensor networks protocol [19] uses flat topology method where nodes quickly find out their nearby nodes and exchange schedule for their transmission and reception. SMACS has no clustering but shows properties like distributive and infrastructure building. SMACS first combines phase discovery of nearby node and with the phase of channel assignment and immediately allows a channel to link after link discovery. These links use random FDMA or CDMA pattern to avoid collisions between links. By using a local scheme, this protocol has less computation and communication overhead for information transmission regarding neighborhood to a central node.

3.3 Channel Polling Based or Low Power Listening MAC Protocols

In this scheme, extra prefix bytes called a preamble are put in data packets by sending node and sent over the channel. Preamble sent verifies that receiver destined node’s radio would be active before the actual payload is sent by the receiver. If radio activity is sensed on a wake-up, the destined node switches its radio on for data packets reception. In another case, a node switches and continues to sleep till next polling time. To deal with this deafness, Transmitting node uses longer preamble equal in size to check interval of the receiver for ensuring that receiving node must wake up and executes channel sampling in the duration of time preamble is sent at least once [20].

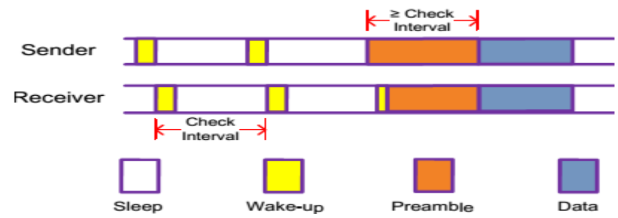

Fig. 5 WSNs: Channel Polling [5]. First, Transmitting nodes a long preamble which is equal or more in size of check interval of receiving node for confirmation that receiving node will active in time for actual data packet reception.

No common active/sleep schedules, so any synchronization or clustering is not required. For the little wake up period, Receivers consume less energy, but senders expend more energy while forwarding extended preambles resulting in unnecessary utilization of energy, overhearing at receivers that are not target, and unnecessary latency at each hop. Another issue with channel polling is the lowering the duty cycle prolongs the check interval leading to increased transmission cost due to long and extended preambles at the sender. These problems can be solved by using a small length of preambles, flexible duty cycles and shortening redundancy [21].

Berkeley MAC (B-MAC) protocol uses LPL channel polling [20]. Here each node has check interval duration which is the sum of free awake and a sleep period, each node has. Node has a preamble with packet of Data that would be bigger than check interval of receiving node in transmission. Nodes in each awake period, sample medium for short duration. If it notices a preamble, it stays awake to accept complete preamble. Wake time is lengthened more to accept data packets in case if preamble is coming for this node, in other case sleep mode activates. With large size of preamble, a transmitting node is sure that receiving node will be active and reply back the preamble at any time of transmission.

B-MAC uses Clear Channel Assessment with an outlier detection method to increase the quality. In outlier detection method, Transmitting node first uses a portion of channel to find outliners. When detection completes, Protocol considers channel as free and available for use since detection always take place above noise floor. In case outlier detection fails for number of samples, Protocol regards channel is not available for use. B-MAC lessens duty cycle and reduces idle listening during no packet exchanges with an extended preamble. It favors on-the-fly tuning of services by arranging bidirectional interfaces to permit or reject services.

Use of comparatively longer preamble than check interval of receiver, latency at each hop and energy consumption, not only for the transmitter and the intended receiver but also for non-targeted receivers, increases.

The WiseMAC [22], working on non-persistent CSMA (np-CSMA), enables a node to learn about the neighbors' wake up periods. As receiving node is about to wake up, sensing node sends a preamble. This leads to the use of smaller preamble length. The receiving node then places its awake time period schedules in the ACK frame. In a case medium is not free due to channel sampling, a node keeps on listening to the medium up till node gets a data packet or medium turns to be idle again. Here nodes have independent LSPs and remain unsynchronized while regular medium sampling for cycle duration. Whereas Protocol has adaptable preambles, not fixed ones. Like it uses small preambles for regular traffic but for infrequent communication, it uses longer preambles. For very low traffic loads, this takes data frame again instead of the lengthy preamble.

Over-emitting is dependent upon the preamble and data packet size. Normally it occurs when the receiver is not ready for reception when preamble finishes. Factors such as interference or collision are obvious reasons causing over emitting. To solve this problem, transmitter remains awake for extended time till neighbor node gets synchronized, resulting in higher energy consumption and latency. Plus WiseMAC is not efficient to handle varying traffic patterns.

AREA-MAC- Asynchronous Real-time Energy-efficient and Adaptive MAC protocol [21] introduces a stream of preambles with ACK mechanism in transmission and performs its sampling for packet-based radios. Sensor nodes remain sleeping and become active for short duration of the time interval to seek preamble availability on the channel. In case preamble is discovered leading to matched destination address, sender receives a Pre-ACK frame and receiver's radio starting receiving data packet till preamble becomes unavailable. Small preambles + Pre-ACK frame can be used in place of long preambles resulting in energy efficiency, no over hearing at other nodes and reduced latency per hop.

3.4 Hybrid MAC Protocols

These protocols combine two or more MAC schemes to; mostly used is the combination of a synchronized protocol with an asynchronous one to get a combined enhancement.

LR-WPAN – Low-Rate Wireless Personal Area Network uses IEEE 8021.5.4 [23], provides simple, Cheap, less power to consume, and with the low data-rate communication network. This provides easiness in installation, extended node's battery time and consistent data transfer within 10 meters.

The PHY layer of 802.15.4 controls the status of radio transceiver on and off, Energy Detection, Link Quality Indication for packets received, selection of channel frequency, CCA and physical layer transmissions and receptions. The radio uses bands of 868 MHz, 915 MHz, and 2.4 GHz. MAC layer characteristics include beacon management, channel access, Guaranteed Time Slots (GTS) management, and frame validation, acknowledged frame delivery, association, and disassociation of nodes.

Moreover, the MAC sublayer offers hooks for realizing application appropriate security mechanisms. The coordinator helps protocol in selecting one of the two modes, the protocols support. In the first one, called non-beacon-enabled mode, MAC is governed by non- slotted CSMA/CA where as in the second one, called beacon-enabled mode, Coordinator sends beacons time to time to bring associated nodes into the line. MAC super frame format, given by PAN coordinator (FFD) is depicted in fig. 06

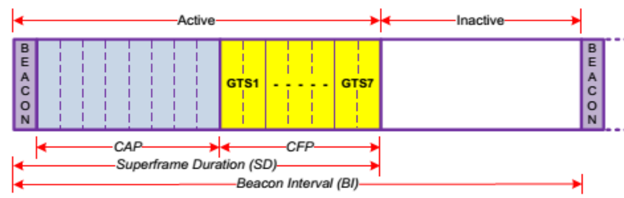

Fig. 6 MAC super frame structure [5]. A super frame sized in 16 equal slots with the active and inactive portion.

The super frame has one Contention Access Period (CAP) and other Contention Free Period (CFP) as two parts. Devices communicating in CAP period use a slotted CSMA/CA method to contest with other devices. For low-latency or specific data bandwidth required for particular applications, PAN coordinator may allot contention-free TDMA-like GTS portion of the CFP to devices. The CSMA and TDMA grouped, create 802.15.4 MAC a hybrid protocol.

Zebra MAC or simply Z-MAC [24] is a traffic adaptive hybrid scheme protocol that uses the TDMA and CSMA together while counterweighing their flaws. In case of low contention, the protocol uses CSMA to attain high channel utilization and low delays. And in case of high contention, Protocol uses TDMA to attain high channel utilization, fairness, and fewer collisions. A node uses a random back off for contention within the time slots of other nodes. Thus, Z-MAC switches to CSMA when nodes need to communicate in TDMA slots of other nodes which are not being used by their owner.

With two-hop synchronization scheme, this protocol is strong enough against timing failures, time-varying channel conditions, slot assignment failures and changes in topology. Problems to deal with in Z MAC include synchronization overhead, complexity in maintaining both modes, contention among nodes for accessing the slots owned by other nodes, collisions, and bandwidth under-utilizations.

SCP-MAC-Scheduled Channel Polling MAC [25] uses channel sampling with TDMA and achieves reduced preamble length. Periodic Channel polling synchronized sampling times and nodes sleep under no traffic on a channel using this protocol.
Two separate contention phases are used with SCP-MAC to achieve low collision probability. Results shown in [25] suggest that SCP-MAC has comparatively high lifetime by a factor of 2-2.5.

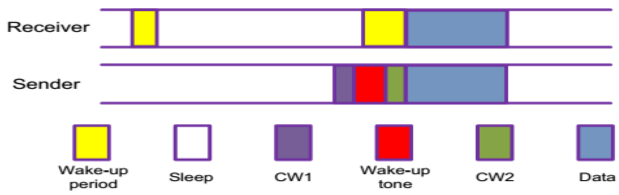

Fig. 7 SCP-MAC

With use of small preambles, it can further reduce delay and duty cycle by a factor of 10. This protocol can also enable or disable RTS/CTS handshake. When SCP-MAC disables the handshake and examines the destination address from the packet header which results in overhearing. This protocol has also Adaptive listening feature which helps channel to handle additional traffic. User can look all schedules of other nodes and can select fast-path schedule allocation to avoid any scheduling based delays. Main challenges at this stage in SCP-MAC protocol are to deal with higher latency and energy consumption due to channel sampling and TDMA modes.
With a lot of MAC protocols for WSNs already developed in last years, proper MAC protocol selection usually depends on the application. Protocols' comparison based on energy efficiency, timeliness, and asynchrony, additivity, and scalability factors is given in Table 1.

Table 1: MAC protocols Comparison

MAC Variant Name	Type	Energy Efficient	Delay Efficient	Synchronousness	Adaptive	Scaling
S-MAC	CSMA	✓1	✓1,5	✓2	✓1	x 2
T-MAC	CSMA	✓1	x	✓2	✓3	x 2
DSMAC	CSMA	✓3	✓1	✓	✓	x
LEACH	TDMA	✓	x	✓	x	x
TRAMA	TDMA	✓1	x	✓	✓	x
SMACS	TDMA	✓1	x	x	✓1	✓
BMAC	LPL	✓1	x	x	✓1	✓
Wise-MAC	LPL	✓1	✓1	x	✓	✓1
AREA-MAC	LPL	✓	✓	x	✓	✓
802.15.4	Hybrid	✓1	✓1	x 4	x	✓4
Z-MAC	Hybrid	✓	x	✓	✓	x
SCP-MAC	Hybrid	✓1	✓1	✓	✓	✓

[1]Optimul, needs improvement [2]has common listen periods [3]Trades-off with another parameter [4]topology Dependent [5]Supports partially

4. Optimal Transmit Power Analysis

Transmission power is a deciding factor to maintain network connectivity, to decrease the number of retransmissions so as save the total energy in data reception and to minimize the probability of error. Use of high power lessens the lifetime of the nodes but also brings together excessive interference, Whereas Use of low power leads to network disconnectivity. It is in the best research interest to select optimal transmit power that should be sufficient enough to guarantee network connectivity.

4.1 Simulation Design

In this research BMAC is used, it is suitable for low traffic, low power and widely used protocol. This protocol is also part of TinyOS. Sensor network is built in MiXiM (Fig 8) with this Protocol under different no of nodes, topologies (Grid and Random, Fig 09) and parameters mentioned in Table 02.

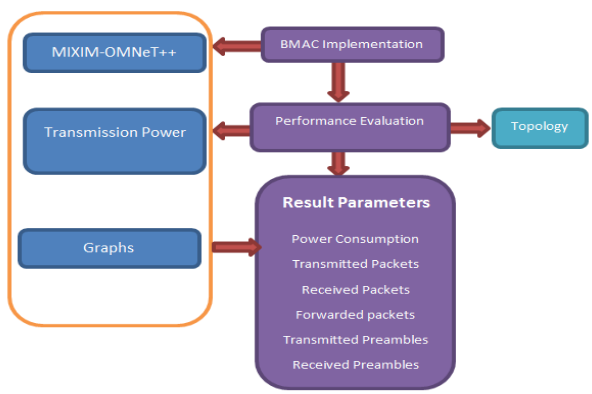

Fig. 8 Simulation Design

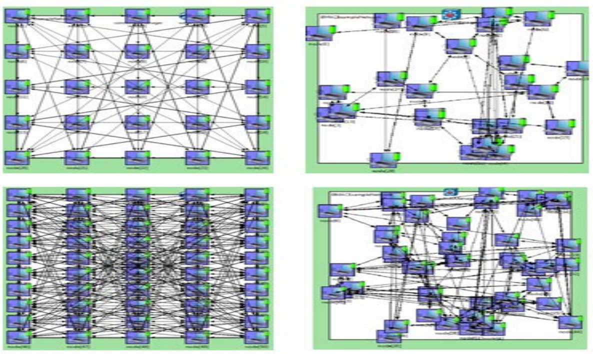

Fig. 9 Grid and Random topologies with 25 and 50 nodes

4.2 Results and Analysis

Grid set up: Results in fig.10 suggest that lesser transmit power leads to lesser connectivity among nodes, leading to worse results for all six metrics considered. Nodes at edge in case of minimum powers (for example 25mw) being used, have high values of all metrics as compared to rest of nodes in same network due to multi hoping they use or their distance is maximum w.r.t Sink

Table 02 Simulation Parameters Used.

Simulation Parameters	Values
Network	BMAC
Playground Dimensions	400,400,0 & 400,450,450
Deployment	Grid, Random
Sink	01(Node # 00)
Nodes	25,50
Simulation Time	500 sec
Carrier Frequency	2.4 GHz
Bitrate	15360bps
Header Length	24bit
Queue Length	02
Battery Voltage	3.3v
Network Type	Wiseroute
Mobility Type	Stationarymobility
Application Type	Sensorappllayer
Thermal Noise	-100dbm
Max Channel Power	150mW
Attenuation Threshold	-84dBm
Check Interval	0.1s
Duty Cycle	1s
Path Loss Coefficient	Alpha= 1.6
Transmission power	25mw,50mw,100mw,150mw
Propagation model	Simple Path Loss
Radio sensitivity	-84dbm

Results at transmit power of 100mw are far better in terms data transmission, reception and mean power. Above 100mw, there is strong connectivity and good nodes' coverage area that reduces data packets forwarding, also Data Reception is limited by noise figure with increased power and mean power consumption increases.

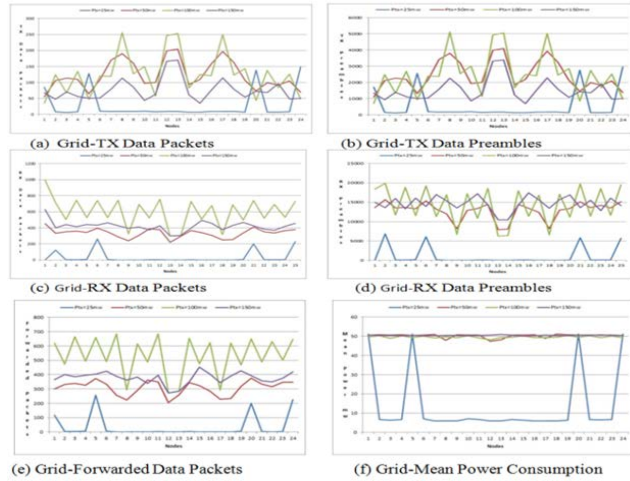

Fig. 10 Transmit Power Effect Results (Grid)

Random set up: Almost results in fig 11 have same variation pattern as previous, except RX data packet, forwarded packets and RX preambles for high power case. This is due sink node position in random scenario. Sink node is located far away from other nodes, require more power for connectivity. This results in more forwarding and more RX data packets and preambles reception. False positive detection is another for high values in this case.

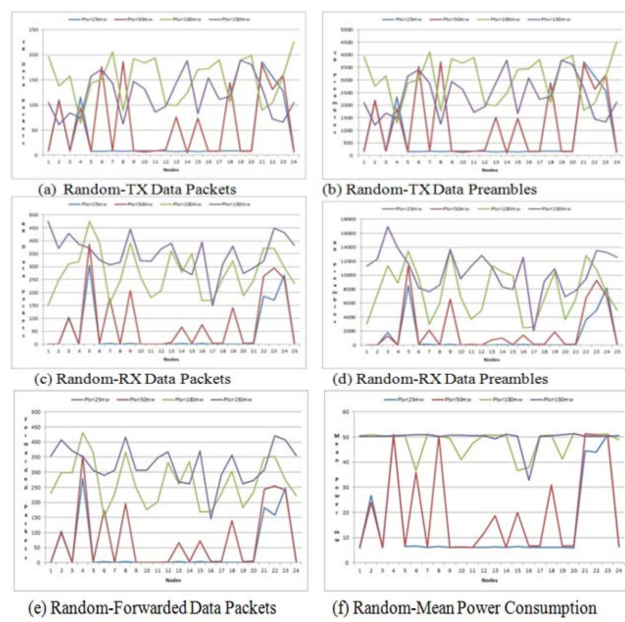

Fig. 11 Transmit Power Effect Results (Random)

5. Research Trends

WSNs have very diverse applications, and MAC protocols are designed accordingly. As a result, there have been many protocols proposed so far yet no one is fixed as standard. Application designed MAC work only in defined application. Even though, A lot of research needs to be on MAC protocols to deal with mobility issues and topological problems. In research Physical layer, is often ignored or used with fixed parameters which also delays standardization process of lower layers. Working for combined enhancement of different layers is also promising and challenging. As a single layer is in efficient for decision making, For example, best routing path selection is based on information from MAC layer about collisions. Further Layering of protocols is also challenging since it has many issues like overhead sizes, energy inefficiency, and latency

6. Conclusion

Diverse considerations must be considered in developing protocols for WSNs. In WSNs, QoS by any means should be reduced to save energy and extend the network life. The Design process must aim at the functionality of the entire network instead of considering what is best for each node. Factors at every layer must be considered to save energy, permit network reconfiguration, and adapt tasks according to the available resources. This research work has reviewed present researched channel access techniques with their merits and demerit in a simple manner for promoting more research in direction. Further, performance of Channel access based BMAC protocol with varying transmission power is examined in terms of energy consumption, data packet transmission & reception, data forwarding and preamble transmission & reception. The ultimate target in MAC protocols research is towards the realization of less delay, improved QoS, reduced overheads and efficient power consumption mechanisms.

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