ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 4, April 2013

Scalability of Multi-Timeslot Allocation Protocol for WSN

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Abstract: In wireless sensors network applications like habitat monitoring large-scale industrial monitoring & urban population monitoring require years of operation period with low rate data transmission. Providing a reliable data transmission & efficiency in energy usage are critical in order to prolong the network period of time. Our technique solves the problem's that commonly occurred in Wireless Sensor Network (WSN) like idle listening, overhearing & hidden terminal problem. By introducing a Time slotting communication mechanism, wherever node only transmits in its own timeslot & sleep in different timeslot if there's no activity. Proposed approach alleviates transmission collisions by using virtual grids that adopt Latin squares characteristics to time interval assignments. Proposed algorithmic rule derives conflict-free time schedules without incurring global overhead in scheduling.

Keywords: E-LMAC Protocol, S-MAC, EC-MAC, L-MAC, AI-LMAC, DRAND, TDMA, GLASS, Wireless sensing element networks.

I. INTRODUCTION

Wireless sensor network (WSN) consists of spatially distributed autonomous sensors like temperature, pressure level, etc., & to cooperatively pass their information through the network to a main location. Lot of trendy network's are duplex, additionally facultative management of device activity. The event of wireless sensor network’s was impelled by military applications like field surveillance; Today such networks are utilized in several industrial & management, machine health monitoring. Wireless sensor networks perform poorly once the applications have high bandwidth requirement for data transmission and stringent delay constraints. There are some performance deficiencies that hamper the deployment of wireless sensor networks (WSNS) in critical monitoring applications. Such applications are characterised by considerable network load generated as a results of sensing some characteristics of the monitoring system. Excessive packet collisions cause packet losses & retransmissions, resulting to significant overload prices & latency. so as to handle this issue, we introduce a distributed & scalable scheduling access theme that mitigates high data loss in data-intensive sensor networks & may also handle some quality. Our technique will with efficiency handle sensor mobility with acceptable data loss, low packet delay, & low overhead. This thesis also proposes the Slotted Beaconless Medium Access management (SBMAC) protocol for WSN. SB-MAC relies on the construct of Distributed Time Division Multiple Access (DTDMA). It consists of 3 components, particularly time interval assignment in spatial TDMA, distributed time interval synchronization, and collision-free channel access. This protocol is straightforward, cheap, and effective in channel access whereas minimizing packet collisions.

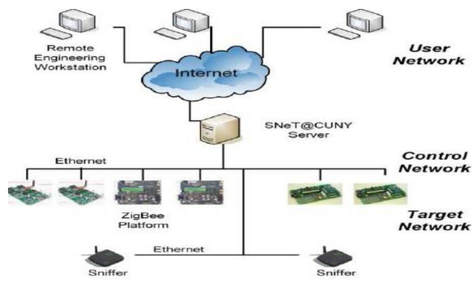

Fig 1. Wireless sensor Networks

II. CONTENTION-BASED MAC PROTOCOLS PROBLEM

Traditional MAC protocols like ALOHA CSMA and IEEE 802.11 are a unit designed supported contention-based approach. These random access protocols aren't appropriate to be enforced in sensor nodes because of its demand to listen to the channel endlessly. As a result, node’s radio has to be within the receiving mode, endlessly waiting to receive possible packet from its neighbour, creating the node attracts an huge amount of wasteful energy. This drawback is named idle listening drawback. Sensor-MAC (SMAC) protocol tried to introduce active-sleep cycles within the presence of random access channel. Nodes execute a variant of IEEE 802.11 contention-based MAC protocol throughout active amount, while turn its radio off throughout sleep amount. Though SMAC with success reducing the idle-listening problem, collisions still will happen since its basic

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ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
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medium access mechanism is contention-based approach. The collision drawback happened once a node receives over one packet at an same time, even if they overlap only partly. The packet collision at the supposed receive node typically caused by hidden terminal drawback. during this case, Fig.2. Node A and node C discover that channel is idle. Collision happens at node B whereas it tries to receive every packet sent from node A and Node C. SMAC and its variant solve this drawback by adopting the contention technique applied in IEEE 802.11. Node broadcasts a Request-to- Send (RTS) message before causing the applying packet and if the supposed receiver replies aren't busy, it ought to reply with Clear-to-Send (CTS) message. Using this methodology, the rule solves another energy potency drawback referred to as over-emitting that happened once a node transmits a packet whereas the supposed receiver isn't in receiving mode. What is more, SMAC implements neighbours' info variables referred to as Network Allocation Vector (NAV) for its collision turning away technique. Node checks the NAV worth before causing the RTS message. This methodology is thought as virtual carrier sense technique. However, these contention-based approaches still suffer from overhearing drawback that happened once node receives a packet that's not destined to it.

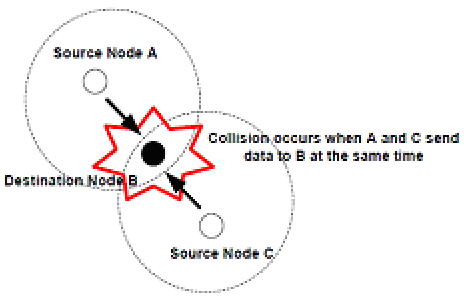

Fig 2. Hidden Nodes Problem

III. RELATED WORK

Sensors MAC may be a static-scheduling primarily based energy saving protocol. For avoiding energy wastage from idle listening, Collisions, & retransmissions, this protocol permits neighbouring nodes to sleep for long periods & wakeup, each in synchronic technique. Broadcast data packets don't use RTS/CTS that will increase collision likelihood. Adaptive listening incurs overhearing or idle listening if the packet isn't destined to the listening node sleep & listen periods square measure predefined & constant that decreases the efficiency of the algorithmic program below variable traffic load. In EC-MAC [2], Energy conservation is that the major criterion in EC-MAC. It also supports totally different traffic type. It provides totally different levels of service quality for information measure allocation. This protocol supports combination of both reservation & scheduling mechanisms. This protocol has totally different part viz., Request update part, new user part, and downlink & transmission part. The request/update part reduces the collision. The new user part that is variable long permit user registration with the base station. This part is operated in contention mode using slotted aloha protocol. Downlink & transmission knowledge part reduces turnaround & collision. EC-MAC doesn't think about the state transition delay. If the frame length is simply too short, the wireless network interface might not be ready to go sleep owing to the transition delay. To understand high power efficiency, the frame length should be considerably increased, which can increase the queuing delay. Power consumption will considerably reduced by lowering the transmission power & transmission the packet over a long period of your time. In L-MAC [1], Light-weight MAC implements a distributed timeslot scheduling rule for collision-free communications. Time is split into slots & sensor nodes broadcast data, about time slots, which, as they believe, they control. Neighbouring sensor nodes can avoid carrying those slots & option for alternative slots to control. The goal of collision avoidance is achieved at the control overhead & listening time. LMAC latency & throughput degrades at low loads. A distributed TDMA mechanism node chooses its timeslot consistent with its neighbourhood information. In every node within the network owns a timeslot. Beacon packet is sporadically been transmitted at the start of controlled timeslot. Its mainly use TDMA based mechanism only allows one timeslot access per user. The LMAC protocol is latency of data transmission is affected by timeslot length & number of timeslot per frame. In AI-LMAC [3], Adaptive and Information|-aware lightweight weight medium access protocol may be a TDMA based mostly protocol that's associate degree adaptive and information aware version of the LMAC protocol. Time is split into timeslots that nodes will use to transfer knowledge while not having to contend for the medium or having to deal with energy wasting collision throughout transmissions. AI-LMAC it doesn't support the high knowledge load. In DRAND [4], DRAND is an efficient scalable and scheduling rule. DRAND could be a distributed implementation of RAND, a centralized channel reprocess scheduling rule. The slot assignment, every node reuses its appointed slot sporadically in each preset amount, known as frame. A node appointed to a timeslot associate degree owner of that slot & the others the non-owners of that slot. They will be over one owner per slot as a result of DRAND permits any 2 nodes on the far side their two-hop neighbourhoods to possess an equivalent timeslot. This option reduces information packet collisions. DRAND provides reliable information transmission. The algorithm should be run frequently to ensure delivery reliability in case of dynamic topology changes. The algorithm ensures information delivery by distribution collision-free time slots to detector nodes. but transmissions will still collide within the DRAND slot assignment section as a result of irregular transmissions & channel contentions. In TDMA [5], TDMA protocol should be energy efficient by reduced the potential energy wastes and send senses data to the sink while not additional delay. TDMA protocols cut back the info retransmission as a result of collision doesn't occur in TDMA protocol. The sensor network traffic that has got to be handled by TDMA protocol. This protocol conserves the energy. Energy is saved by reducing the state transition from sleeping to wakeup state & from wakeup to sleeping state. This also dramatically reduces the value of the clock synchronization. This protocol also reduces time delay as a result of slots square measure reused. This protocol is finding the clusters that have contention with one another & allot completely different timeslot to them. Due to slot reprocess co-channel interference is occur if two contended clusters use same timeslot. In EMAC'S [6] EYES Medium Access management (EMACS) protocol could be a TDMA-based protocol designed for European research EYES. EMACS could be a distributed TDMA-based MAC protocol wherever node selects its own controlled time interval by gathering the neighbourhood data. Anytime slot is split into 3 parts; Communication Request (CR), control (TC), and data section. within the CR section, node that includes a request to the time slot owner sends request message at a random begin time so as to avoid request collision with different nodes. The time interval owner continuously transmit a TC message within the TC section so as to tell its neighbour what communication can occur within the information section. Neighbour nodes which will not participate in information section enter sleep mode to stop from idle-listening drawback. EMACS uses TC message for network synchronization and neighbourhood control information. Node randomly selects a free time slot encoding from the bitmap information provided in TC message. Collision will still happen in EMACS and LMAC protocol if over one node, option for constant time slot. These protocols don't give a collision detection mechanism to overcome this drawback. What is more, in EMACS, collision most likely happened within the short CR section caused by constant begin time choice selection for the request message. EMACS and LMAC need the supposed receiver to remain in receive mode for the total data section although the projected packet is already been received. In Traffic adaptive Medium Access Control [6] (TRAMA) is planned to extend the use of classical TDMA in associate degree energy efficient manner. A transmitter among every two-hop neighbours is chosen by election algorithm so as to eliminate the hidden terminal downside and therefore ensures that each one nodes within the one-hop neighbour of the transmitter received the info with none collision. Time is split into 2 amounts; random-access amount and scheduled-access period. Higher percentage of sleep time and fewer collision likelihood are achieved. TRAMA clearly achieves the goal of distributed TDMA for improved energy efficiency without a centralized coordinating base station. Transmission slots are unit set to be seven times longer than the random-access amount that is employed for schedule exchanges. Hence, while not considering the transmission and reception, the duty cycle is a minimum of twelve.5 percent that is significantly high value. The control information exchange in random access amount remains susceptible to collisions.

IV. EL-MAC PROTOCOL DESCRIPTION

EL-MAC protocol combines regular primarily based MAC into mechanism and adaptive multi-time slot allocation. Our approach alleviates transmission collisions by using virtual grids that adopt Latin Squares characteristics to time slot assignments. Our algorithmic rule derives conflict free time slot allocation schedules while not acquisition world overhead in scheduling. This protocol solves the idle listening, hidden terminal problem, & over hearing problem. It's higher than the protocol. Channel access in sensor networks are often classified into scheduling-based & random access classes. For wireless sensor network's which require to support continuous and/or periodic traffic hundreds, it's a lot of acceptable to use the scheduling approach is generally adopted into a structure, Time-Division Multiple Access(TDMA). Time division multiple access primarily based mechanism commonly reduces the channel utilization owing to the limitation in channel assessment. Nodes are only allowed to transmit an information only in a very single timeslot. The latency of the information transmission is suffering from the length of timeslot & the amount of timeslot in a very frame. EL-MAC time interval length depends on the duty cycle organized by the appliance module low duty cycle operation will increase the timeslot length. Hence, reduces the channel utilization. EL-MAC solves this problem. By victimisation adaptive Multi-Time slot Allocation (AMTA) theme that permits a node to occupy variety of timeslots in a very frame in step with the traffic demand. For each n variety of frames, EL-MAC calculates the usage of the timeslot in a very frame. This can be critical as a result of it sick alternative nodes to occupy the unused timeslot. packets are often transmitted a lot of times as a result of in a very frame, nodes are ready to use a lot of numbers of timeslots. Thus, the allowable transmission rate at MAC layer will increase. It uses Active/sleep mechanism for economical energy usage with predefined duty cycle. it's levelled timeslot synchronization. It uses adjective Multi-Timeslot allocation(AMTA). Adaptive Multi-Timeslot Allocation is used to reduce transmission latency. It allows a node to control multiple timeslot per frame. Our projected EL-MAC, a distributed TDMA-based MAC protocol custom-made from LMAC protocol . In LMAC protocols, receivers have to be compelled to keep in receiving mode till the top of active mode though it already received the regular packet, hence, introducing idle- listening and over-hearing issues that cause nodes to draw a wasteful energy. EL-MAC handles these issues by introducing extra flag field within the knowledge packet header referred to as MORE_PACKET flag, accustomed indicate if the sender has additional packets to be transmitted to the meant receiver. By victimisation the MORE_PACKET flag, the meant receivers will forthwith enter the receiving mode

ISSN (Print) : 2319-5940
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International Journal of Advanced Research in Computer and Communication Engineering
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when receiving all packets destined to it. A in close EL-MAC protocol is split into a Max-Time Slot slots. every slot has 2 operation amounts; wakeup amount and sleep period. The beacon signal within the wakeup amount, if the remaining wakeup amount is larger than time needed sending the meant packet. Node enters sleep mode forthwith when finished sending or receiving a packet. The time interval choice for every node is assigned by distributed manner. The EL-MAC protocol starts the operation with initial state, wherever node unendingly listens to the channel for a beacon signal. in contrast to LMAC, nodes in EL-MAC keep in initial state for a Max-Listen Frame frames amount when receiving the primary beacon signal. In wait state, node selects a random variety of frames before getting into the discover state so as to reduce the possibility of nodes getting into the discover state at an equivalent time and increase risk the likelihood the chance of nodes choosing an equivalent time interval. If node lost the synchronizing beacon for a sequent a Max-Lost Beacon time, node returns to initial state once more. In discover state, node discovers the unused time interval by grouping the knowledge of unused time interval from CONTROLLED_TIMESLOT field within the beacon packet transmitted by its neighbours.

A. EL-MAC Distributed Timeslot Allocation:

Our EL-MAC protocol inherits the distributed timeslot assignment mechanism from LMAC protocol with same simplification. In LMAC protocol, the process of obtaining a timeslot by a sensor node is divided into four state, initial state, waiting state, discovery state & active state. EL-MAC differs from the method applied in the LMAC protocol where the waiting state & the discovery state have been combined together as illustrated in Fig 3. when a new node enters a network, it starts the algorithm in initial state where node listens to the channel in order to find a beacon signal from its neighbourhood. Node turns into wait & discover state when it receives a beacon signal which enables it to start frame synchronization. Node shall wait for a random frame delay before selecting a free timeslot & at the same time it shall also discover its neighbouring nodes status by collecting the information from the received beacon signal. At the end of this state, not shall use Equation 1 to find unoccupied timeslot.

$$Z_{OR}(X_1, X_2 \text{----------} X_N) = X_1 \vee X_2 \vee \text{--------} \vee X_N \qquad (1)$$

The value of x_i is the i th occupied timeslot collected from the beacon message as previously mentioned in table 1, while v is an OR operation. The resultant bitmap pattern from this operation will be in terms of 1's and o's where 1's indicate occupied timeslot, while o's indicate the vacant ones. Hence , a node randomly chooses its timeslot identification from the list of vacant ones(indicated by 0's).

TABLE I

BEACON MESSAGE STRUCTURE FOR EL-MAC

	Field timeslot	**Size(byte)**
8	Level	1
9	Occupied timeslot	1
10	Destination Node	2
11	Transmit Delay	2

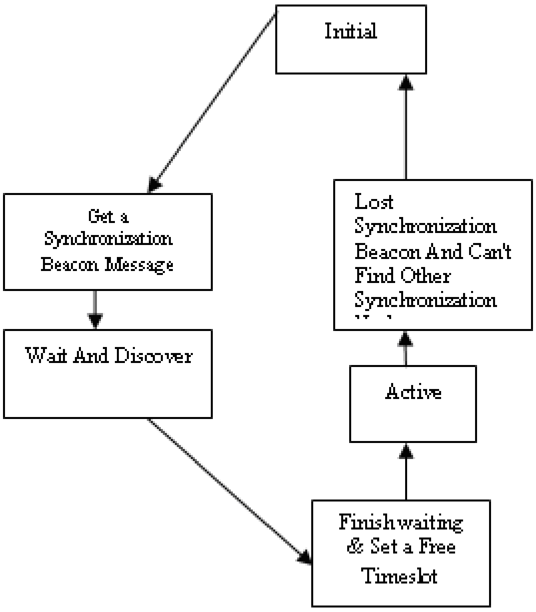

Fig 3. State Diagram

Node enters active state when it successfully selects timeslot. It also needs to listen to the channel at the beginning of other timeslot in order to be able to listen for a beacon message from its neighbouring nodes. Node enters sleep node in two scenarios. First after transmitting a beacon message and no more data packet scheduled to be transmitted. Second if received beacon message from its neighbouring node indicates no incoming data packet. A TDMA based MAC protocol requires nodes in the network able to synchronize with each other. For our EL-MAC protocol, we implement hierarchical timeslot synchronization where node will refer its slot timer to another neighbouring node's beacon signal with lowest level. This information can be gathered from beacon message transmitted by each neighbouring nodes. The base station or sink node of the network will start with level 0. our timeslot synchronization mechanism also is robust to the time drifting problem caused by imprecision clock system condition in sensor node, which would feasibly cause misalignment on beacon transmitting & listening period. Listening node needs to wake up from sleep mode earlier then the expected beacon transmission which is known as guard period.

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It easily adapts to different traffic conditions:

1. Increase number of controlled timeslots when high data transmission.
2. Decrease number of controlled timeslot when low data transmission.

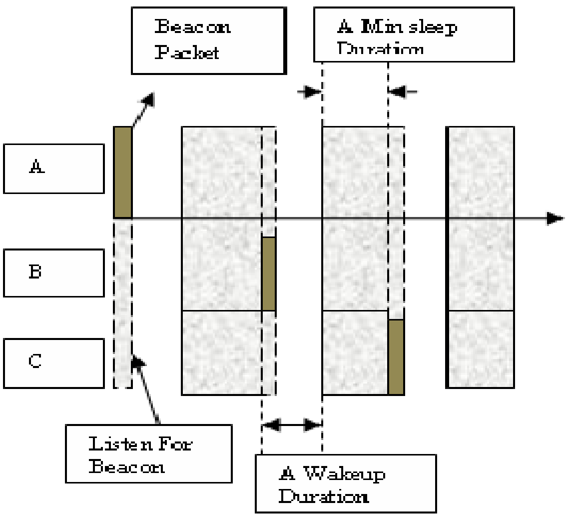

Fig 4: Timeslot Architecture in EL-MAC

V. SIMULATION RESULT

A. Data Rate Vs Success rate

By comparing both GLASS Protocol, and EL-MAC (Enhanced Lightweight Medium Access Control) protocol, EL-MAC has higher Success rate than GLASS protocol. Fig 5: Shows the performance of the given protocols under unicast traffic condition. The GLASS protocol still performs the best compared to other EL-MAC protocol. GLASS protocol still suffers degradation in success rate under high traffic load. Nevertheless, the EL-MAC performs greater than but slightly lower than GLASS. The increment of success rate is helped by the implementation of AMTA (Adaptive-Multi-timeslot Allocation) mechanism. The GLASS protocol consumed less than half of the average power used in EL-MAC protocol. The used of timeslot length twice longer helps the node to minimize the use of power by staying in power down mode more frequently. The average energy used by EL-MAC protocol is slightly increased due to the increment of packet transmission. This factor is of not too much concern for GLASS & EL-MAC because the ratio of the node stay in power down mode is higher than in transmission or reception mode. Fig 7: That all MAC protocols degrade exponentially with EL-MAC produces higher energy usage per bit received compared to others for the last graph. Only GLASS experiences an increases in average energy usage. This is due to the poor performance of GLASS protocol.

B. Size Vs Throughput

By comparing both GLASS Protocol, and EL-MAC (Enhanced Lightweight Medium Access Control), EL-MAC has higher throughput than GLASS protocol.

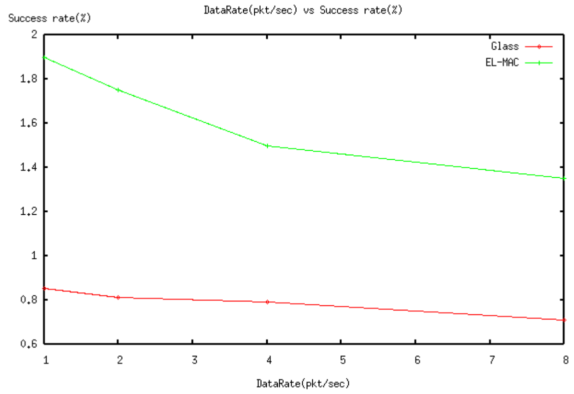

Fig 5: Data Rate (Packet /Sec) VS Success rate(%)

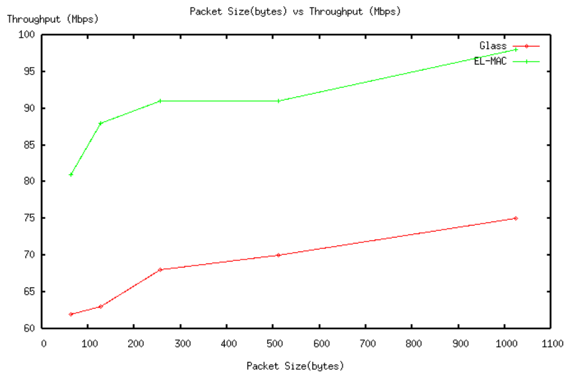

Fig 6: Packet Size (bytes) VS Throughput (Mbps)

C. Simulation Time Vs End-End Delay

By comparing both GLASS Protocol, and EL-MAC (Enhanced Lightweight Medium Access Control), EL-MAC has higher End-End delay than GLASS protocol.

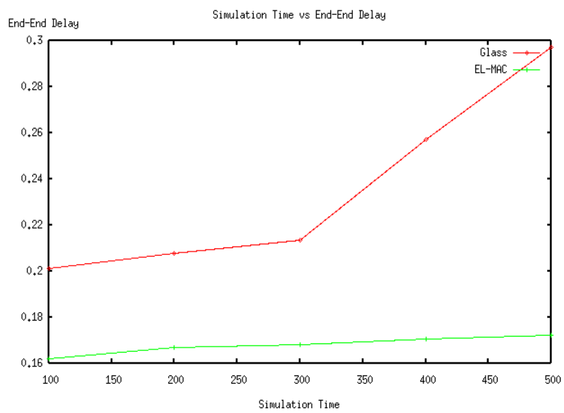

Fig 7: Simulation time Vs End-End Delay

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 4, April 2013

VI. CONCLUSION

In this paper, an EL-MAC protocol with AMTA (Adaptive Multi-timeslot allocation protocol) is proposed for WSN. This protocol alleviates transmission collisions by using virtual grids that adopt Latin Squares characteristics to time slot assignments. Our algorithmic rule derives conflict free time slot allocation schedules while not acquisition world overhead in scheduling. This protocol solves the idle listening, hidden terminal problem, & over hearing problem. It's higher than other MAC protocols. Simulation Result shows that this protocol implements active-sleep scheme in terms of success rate, throughput and End to End-delay.

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BIOGRAPHY

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