ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 6, Issue 10 , October 2019

# Hybrid Asynchronous Duty Cycle MAC Mechanism for Wireless Sensor Network

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**ABSTRACT**: The implementation wireless sensor network (WSN) generally can be applied in any environment where the MAC layer plays vital role. WSN has countless potential application in many areas due to its easy deployment process, lower installation cost, less cabling required, and high mobility. However, limited energy residue (especially deposited in small size battery) is always a major obstacle in WSN's devices. Researchers discover that the major power consumption are related to their radio transceiver's activities on MAC.This paper proposed mechanism of WSN that used in order to improve power energy using duty cycle in MAC layer. The proposed of asynchronous duty cycle MAC layer using a hybrid duty cycle to identify the performance and capability of the proposed hybrid protocol in term of some parameter.

**KEYWORDS**: MAC Protocol, WiseMAC, L-MAC, Hybrid Asynchronous MAC

## I.INTRODUCTION

Nowadays wireless system is becoming a popular system in industrial technology. It became popular due to their so many applications especially in wireless sensor network (WSN) that can have applied in any environment. The implementation of WSN is considered able to adopt in agriculture business [1], national defence [2], temperature monitoring [3], pollution [4], and many more. WSN has advantages including easy deployment process, lower installation cost, less cabling required, and high mobility [5]. It also offers expected transformation infrastructure for building automation, also process control applications [6]. WSN has expected proper future in market prospective.WSN is a regular of small networks component that contain of distributed particles called sensor nodes. Compared to mobile device, the coverage and communication range for sensor nodes compared is limited due to low power capacities. It consumes power to execute given task(s) as the laying of the sensor. Moreover, sensor node has other duties to collect and transmit data obtained by the sensor to other nodes or access point. WSN usually used a large number of nodes across the hostile and unstable environment. Extending the lifetime of node and sustaining the proper processes of the network are becoming one of issue in this sensor networks.

Furthermore, the energy efficiency becomes the first concern and main objective in designing this system, which can be useful if a user uses it properly and effectively. Those processes consist of sending, receiving, processing, forwarding data, and also processing or forwarding some requests. In other way, useless energy consumption consists of collision, overhearing, control overhead, idle listening, and over emitting [7].

Running in the idle mode (switched on, or also called ready-to-receive mode) as when transmitting or receiving data is also significantly consume high energy consumption. Hence at the MAC layer that control the operation of radio, should avoid the frequent switching. The problems to achieve power efficiency can be solved by the relevant technique in MAC layer called duty cycle.

Most of the existing Duty Cycle for MAC protocols in WSN use synchronous and asynchronous technique. In this paper, we propose a hybrid asynchronous MAC protocol by combines the TDMA concept (L-MAC protocol) with the adaptive wake up preamble (WiseMAC protocol). In order to improve end to end delay while ensuring energy

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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efficiency, firsteach node allows to choose different timeslot, which is not interfering with the communication between other nodes in the network. A wake-up preamble of size equal to the sampling period is transmitted, in front of every data frame. It ensures that the receiver will be awake when the data portion of the packet arrives. By combine scheduling mechanism (LMAC) and Preamble Sampling (WiseMAC), it is possible to reduce the delay and energy of the node.

## II. RELATED WORK

There are various low duty cycle protocols proposed for WSNs, which differ in aspects of synchronisation, number of channels required, transmitter- or receiver-initiated operation etc. There are two different types of protocols, which control low duty cycle protocols: asynchronous and synchronous schemes [8-9].Another variation of low duty cycle protocols such as pQueue-MAC, a new traffic adaptive duty cycle MAC protocol considered for event-driven sensor networks [10] uses the synchronization based preamble sampling to deal with low traffic load in a long period and responds to burst events by dynamically dealing the TDMA slots. pQueue-MAC uses the synchronization based variable preamble (SVP) sampling to handle the low traffic situation .As traffic increases, by inheriting services to deal with burst traffic from the Queue-Mac, the length of the sending queue will be used to tell the receiver to dynamically allocate a time slot to the sender (TDMA) for packet delivery. SVP sampling has high energy efficiency with short channel listening period and dynamically allocated TDMA slots could achieve low transmission delay by making full use of the communication bandwidth according to the traffic load. Moreover, Distributed Slot Scheduling Algorithm for Hybrid CSMA/TDMA MAC [11] offered algorithm for hybrid mac to handle collision during communication. This protocol handles a schedule which bridges the gap between a feasible and an optimal schedule to handle the collision during transmission. First, find out two-hop neighbours of each node, then a particular slot is allotted to each node in order to prepare a feasible schedule using the RD-TDMA algorithm. Finally, the feasible schedule is fine tuned in a novel way to improve the efficiency in handling the collision by reducing the number of allotted slots.

Energy Efficiency TDMA/CSMA Hybrid Protocol with Power Control (TCH-MAC) for WSN reduce the energy consumption and transmission throughput [12].This protocol takes advantages of TDMA and CSMA in the MAC layer by design a novel power control scheme to further reduce the energy consumption and optimize the transmission slots.AP-MAC protocol [13] in WSN can be adaptively updated based on the prediction nodes'wake-up time. To ensure the reliable transmission, the node sends data in order to predict the wake-up time of receiving nodes. Then, it ensures the receiving nodes wake uptimely and establish a connection with sending note. At the meantime, an adaptive update mechanism is conducted in the network according to the dynamic changes of it. PD-MAC (Polling Distribution-MAC) [14] focusing on dynamically adjusting the duty-cycle or channel polling intervals based on the traffic arrival patterns. It use polling interval distributions rather than polling intervals in different traffic types. The influence for using deterministic and exponential polling interval distributions is illustrated by developing an asynchronous MAC protocol PD-MAC (Polling Distribution-MAC). The receiver initiated Mac protocol such as Enhanced receiver-initiated MAC (EnRI-MAC) was proposed to support various traffic types in WSN. It decreases two important contributor energy depletion which are duplicated transmission and retransmission [15]. The duplicated transmission decreases by assigning a rendezvous time. Meanwhile, for receiving broadcast, multicast, and also retransmission is reduced by decreasing collision.

## III. PROPOSED HYBRID ASYNCHRONOUS MAC

Generally, this protocol designed to achieve energy efficiency and delay WSN applications that combined technique time division multiple access (TDMA) with CSMA Asynchronous. Here TDMA concept used LMAC protocol [16] and then CSMA concept is used like WiseMAC Protocol [17].

The free timeslots of each channel are calculated by performing the OR operation between its local vector and the vector found from its neighbour. A node is allowed to transmit by using its controlled timeslots and can receive from any timeslot of any channel by switching the interface between different free timeslot as well. Therefore, the transmitter has the option to choose the best timeslot between the two and hence the delay of packet advancing decreases dramatically. Figure 1 shown the idea of Hybrid Duty Cycle MAC WSN done in this paper.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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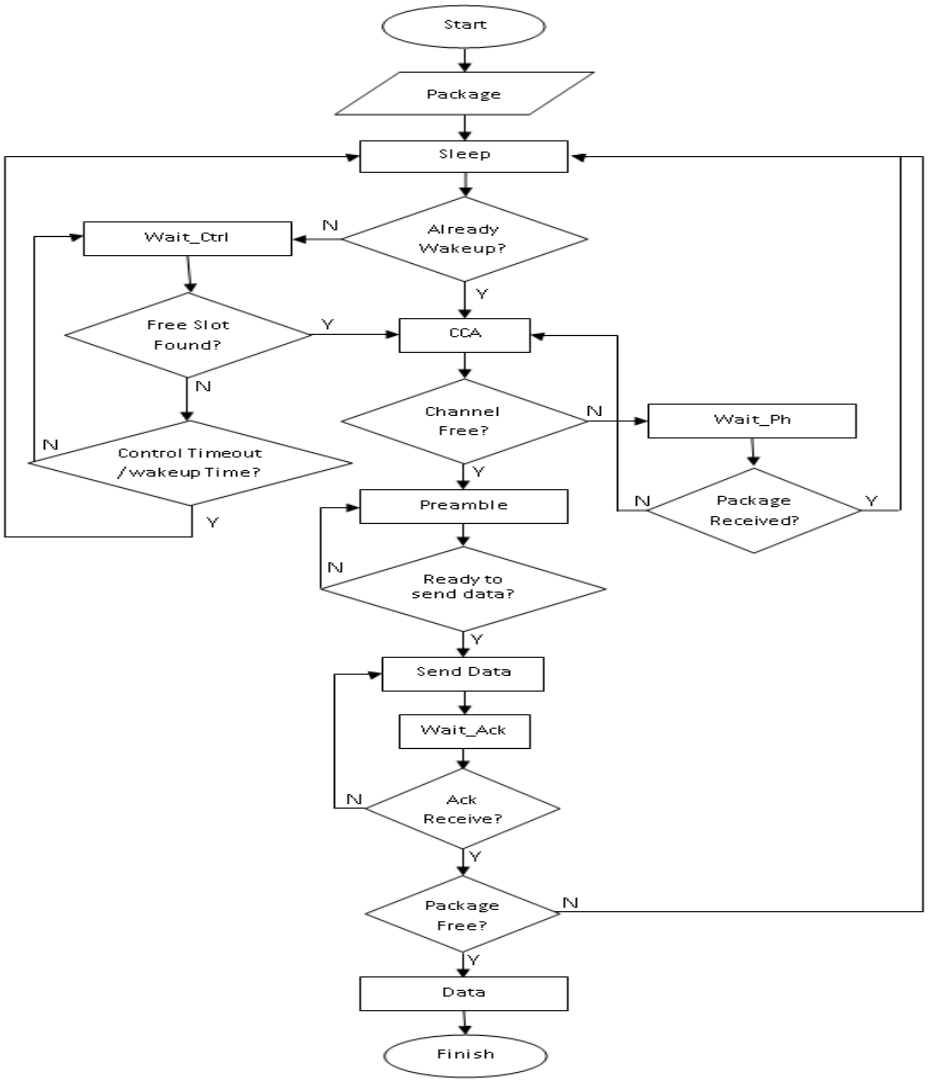


Fig. 1 Flowchart of Proposed Enhanced Hybrid Duty Cycle MAC

Based on Figure 1 is a flowchart has been formulated to enhance the energy efficiency and reduce delay in this new model of Hybrid Duty Cycle MAC. When the package needs to send data, this model finds a free wakeup node. If all nodes are busy, then the package needs to wait in WAIT_CTL and schedule its turn. If the package cannot get their free slot in WAIT_CTL. Therefore, it expectedly goes back to sleep in order to save the energy.

Free wakeup node implemented to do clear channel assessment (CCA) to find free channel. If the channel busy, it uses to wait until there is a free channel do preamble. In preamble, package initiates the readiness of their neighbour to send the data. Then after sent the data, it waits for an acknowledgement to confirm that the data has been send successfully. If the package received the acknowledgement then the package become free, otherwise it will redo the sending process. Furthermore, in Figure 2 shown that when the node is not wakeup yet, thus wait control will schedule the slot for package that being transmit, then continue to CCA. If the slot had been used by other package, then wait control will try to find another free slot.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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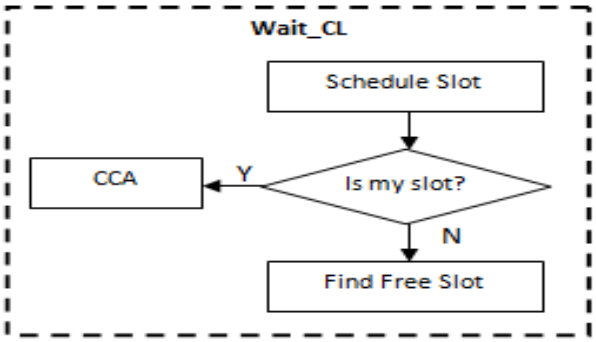


Fig. 2 Wait control (WAIT_CTL) Mechanism

## VI. OPERATIONAL CYCLE OF THE PROPOSED HYBRID ASYNCHRONOUS DUTY CYCLE MAC

This operational cycle in begin when a node wants to send the data. All nodes start from sleep state then it will indicate priority slot which already wakeup. If the wakeup slot is not for the node, then it will wait their scheduled slot in WAIT_CTL. If the wakeup slot is for the node, thus it will do clear CCA in order to find free channel. If the channel is busy, it will wait their turn in wait package then going back to sleep. If the channel free, then it will do preamble to send the data. Then it will check the acknowledge status. If the ack is true, means that the wait ack does not receive any acknowledgement then it will go back to sleep. If the ack is false means it will broadcast, then go to sleep. It shown in Figure 3 as follows:

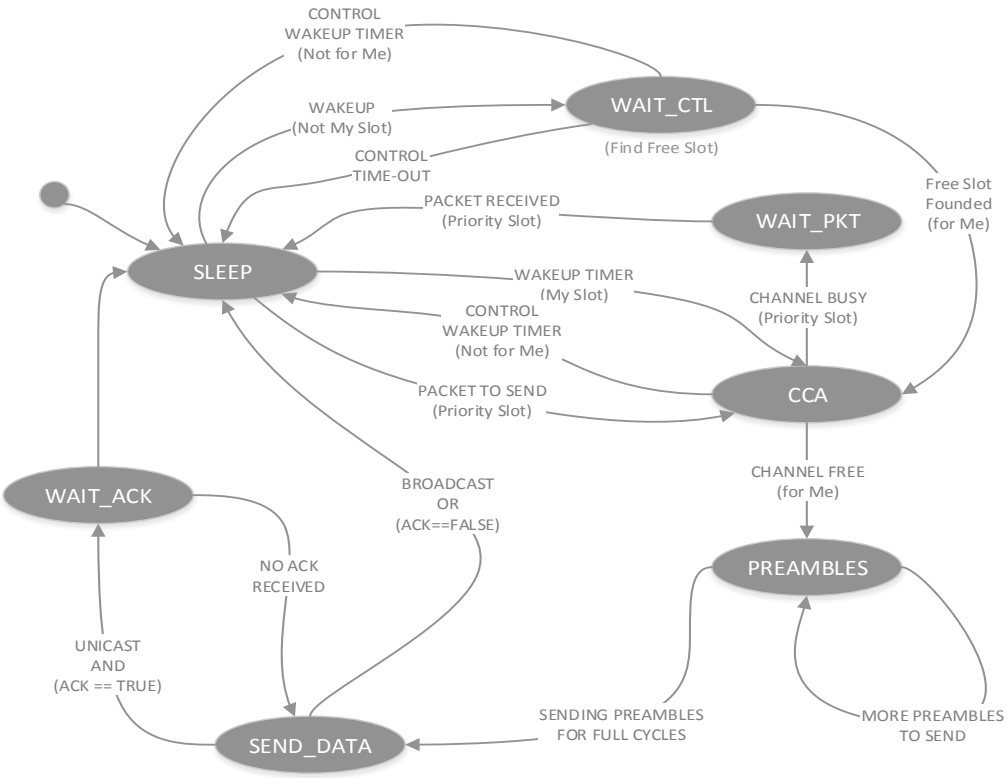


Fig. 3Overall Operational Cycle Hybrid Asynchronous Duty Cycle MAC

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International Journal of Advanced Research in Science, Engineering and Technology
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## V. EXPERIMENTAL RESULTS

### A. Energy Consumption

Energy consumption values are the main focus in this simulation. In this simulation will be calculated energy consumption value of the prototype realistic model that has been made. Calculation of the value of energy consumption will involve the energy process wasted during the process of idle listening, collisions, overhead protocols, overhearing, transmitting, receiving, listening and sleeping. The result of energy consumption is shown in Table 1.

As shown in Table 1, the obtain result of energy consumption-based simulation implementation with different nodes. The highest achieve the energy consumptions in any nodes is L-MAC that reach 0.1626 in 10 nodes and in nodes 50 get until 0.2582. However, the lowest is different among each node between WiseMAC and Hybrid ADC MAC. In nodes 10 and 20 the lowest is WiseMAC where for nodes 10 the value is 0.1551 and nodes 20 the value 0.1922. Meanwhile, in other nodes WiseMAC is higher energy consumption than Hybrid ADC MAC. The Hybrid ADC MAC has the lowest energy consumption in nodes 30 that reach 0.2128, nodes 40 with 0.2334 and nodes 50 with value 0.2497. In averages, the Hybrid ADC MAC has the lowest energy consumption compare with other.

Table 1. Result of Energy Consumption of Proposed MAC

| MAC Protocol | Node(s) | | | | |
|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 |
| WiseMAC | 0.1551 | 0.1922 | 0.2148 | 0.2347 | 0.2507 |
| Hybrid ADC MAC | 0.1554 | 0.1930 | 0.2128 | 0.2334 | 0.2497 |
| L-MAC | 0.1626 | 0.2027 | 0.2230 | 0.2415 | 0.2582 |

### B. Throughput

Throughput is calculated to get the value of the rate of successful message delivery over the prototype. The result of network throughput is measured in bits per second (bit/s or bps). Below is the value of network throughput of each MAC protocol obtained from the simulation results in Table 2:

Table 2. Result of Network Throughput (bit/s or bps)of Proposed MAC

| MAC Protocol | Node(s) | | | | |
|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 |
| WiseMAC | 51946.14 | 110046.79 | 209743.23 | 251531.23 | 324813.45 |
| Hybrid ADC MAC | 52233.28 | 121261.44 | 219743.36 | 266535.89 | 334316.83 |
| L-MAC | 53573.57 | 132326.16 | 228243.74 | 287591.44 | 347253.14 |

Table 2 also revealedthat L-MAC is the highest that has values around 53573.57 bps in nodes and in the highest nodes 50 L-MAC reach until347253.14 bps. The second highest throughput result in simulation is Hybrid ADC MAC that the lowest nodes (node 10) the result is 52233.28 bps and in nodes 50 the value is 334316.83 bps. Following the WiseMAC as the third highest with 51946.14 bps in nodes and in highest nodes is 347253.14 bps.

### C. Latency

Latency measured from time interval between the stimulation and response, or, from a more general point of view. The time delay between the cause and the effect of some change in the system being observed, in this case is the reaction of each activity of each node and each of the states in the prototype model that used during the message delivery process.

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International Journal of Advanced Research in Science, Engineering and Technology
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Table 3 shows of latency of each benchmarked MAC protocols obtained from the simulation results:

Table 3. Result of Latency in Second of the Proposed MAC

| MAC Protocol | Node(s) | | | | |
|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 |
| WiseMAC | 0.0060 | 0.0144 | 0.0114 | 0.0110 | 0.0119 |
| Hybrid ADC MAC | 0.0046 | 0.0135 | 0.0111 | 0.0101 | 0.0113 |
| L-MAC | 0.0015 | 0.0120 | 0.0091 | 0.0082 | 0.0100 |

Table 3 also shows that WiseMAC has the highest latency in any nodes from nodes 10 with value 0.0060 until nodes 50 with value 0.0119, Then, the lowest latency in this network is L-MAC with 0.0015 for nodes 10 and 0.0100 for nodes 50. Hybrid ADC MAC value with nodes 10 is 0.0046 and in nodes 50 around 0.0113. Then, the lowest latency in this network is L-MAC with 0.0015 for nodes 10 and 0.0100 for nodes 50.

### D. Packet Delivery Ratio (PDR)

The last is Packet Delivery Ratio (PDR) value also be taken from the result of this simulation is defined as the ratio between the received packets by the destination and the generated packets by the source. This PDR value is used to performance evaluation of the protocol prototype. The PDR value of each MAC protocol obtained from the simulation as follows:

Table 4. Result of percentage of PDR of the Proposed MAC

| MAC Protocol | Node(s) | | | | |
|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 |
| WiseMAC | 0.9998 | 0.9971 | 0.9993 | 0.9969 | 0.9977 |
| Hybrid ADC MAC | 0.9988 | 0.9928 | 0.9932 | 0.9937 | 0.9940 |
| L-MAC | 0.9955 | 0.9885 | 0.9832 | 0.9867 | 0.9882 |

In Table 4, the highest and the lowest are slightly different in packet delivery ratio (PDR). In nodes 10 the highest value is WiseMAC 0.9998 and the lowest is L-MAC with 0.9955. Then, in nodes 20 the highest is also WiseMAC with 0.9971 and the lowest in this node is L-MAC is 0.9885. Meanwhile, in nodes 30 the highest value is 0.9994 and the lowest also L-MAC with value 0.9832. Furthermore, in nodes 40 the highest PDR value is WiseMAC with 0.9969 and the lowest is also L-MAC with 0.9867. Then, in nodes 50 the highest PDR value is also WiseMAC 0.9977 and the lowest is L-MAC with value number 0.9882.

## VI. CONCLUSION AND FUTURE WORK

This paper presents the development of hybrid asynchronous duty cycle model in MAC WSN. One of point in development is to measure the power energy in term improve or delay process. This proposed the implementation hybrid asynchronous duty MAC WSN as the guidance of the point. It is describing the evaluated of MAC protocols of WSN that used parameters in term of energy consumption, throughput, latency and PDR. For future work, another parameter is anticipated to propose in order to obtain the effectiveness MAC protocol performance.

ISSN: 2350-0328

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