

# Implementation of FMAC in Healthcare System of Wireless Sensor Network

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Abstract — Wireless sensor network is the network of sensor nodes. The nodes transmit data to the sink node. Each sensor nodes have its own battery and ability to communicate with sink node. Network of such nodes is called sensor network. The successful operation of WSN largely depends on MAC sublayer which deals with addressing and channel access control. WSN has varied design constraints such as energy consumption, scalability, delay, traffic control, packet delivery throughput and overheads that need an effective MAC protocol to deal with these problems. Energy must be utilized efficiently in order to increase the lifetime of the Wireless Sensor Network. MAC protocols reduce the cost of energy consumption by providing an efficient communication for transmission and hence improves network lifetime. This paper shows the implementation of FMAC Protocol in healthcare system for different reporting rates. The purpose of the study is to identify the best MAC protocol in Healthcare System. Results for implementation of Hybrid MAC for hospital network are presented in the paper. Results for Data transmission between nodes and sink node has been evaluated to identify Good MAC protocol. Paper represents how low energy consumption can be achieved by combining TDMA and CSMA MAC protocols.

Keywords — Wireless sensor network, Healthcare System, Sink node, Carrier sense multiple access (CSMA), Time division multiple access (TDMA), Federated MAC (FMAC).

# I. INTRODUCTION

Wireless sensor networking is an emerging technology which provides a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration. In wireless sensor networks source node use to send data packets to the destination (Sink) node. In such a network a large number of distributed nodes are present that organize themselves into a multi-hop wireless network. One or more sensors are present in each node, embedded processors and low-power radios, and is normally battery operated. Typically, these all nodes coordinate and communicate each other to perform a common task. Same as other shared-medium networks, medium access control (MAC)is an important technique in WSN that enables the successful operation of the network. Performance of the net- work is depending upon the congestion and collision of the packets near the sink node. Collision avoidance is one of the fundamental tasks of the MAC protocol so that two interfering nodes do not transmit at the same time. There are several MAC protocols that have been developed for wireless voice and data communication networks. CSMA, TDMA, 802.15.4, SMAC are the MAC Protocols of the wireless sensor networks. TDMA is working with slot time allocation mechanism. Performance of the network is depending upon

the congestion and collision of the packets near the sink node. CSMA, TDMA, 802.15.4, SMAC are the MAC Protocols of the wireless sensor networks. TDMA is working with slot time allocation mechanism, where each node gets timeslot for transferring data to the sink node. Performance of the network should be increases for energy consumption and throughput with increasing number of slots. But nodes implementing TDMA needs to wait till it get timeslot. Due to this delay can be introduce and throughput may get decrease [1]. Different kinds of technique can be used for data collection. Centralize data collection technique minimizes the end to end delay and energy consumption [2]. In situation of congestion and heavy traffic load increases in the network. Then the alternative path for data transmission should be used. Alternative paths help for reduce heavy traffic load and congestion in the network [3]. Congestion and collision is the major issue in the wireless sensor networks. Congestion will occur due to the heavy traffic and hidden nodes problem. Due to the hidden node collision should be occurs in the network. Maximum number of packets lost due to the collision. Dropped packets sent using retransmission. So, Queen MAC solve the problem of hidden nodes [4]. For communication purpose mobile sink or static sink should be used. Mobile sink is very good for data collection process in sensor network. But static sink gives better performance



for more quality of services of wireless sensor networks [5]. CSMA- based MAC protocol for wireless sensor networks to be able to save the power consumption, manage the mobility, self- organization, and failure recovery strategies. Both schedules based and CSMA based MAC protocols using in wireless sensor network have advantages and drawbacks. It depends on applications we can choose the suitable protocols. The combination of these two protocols is an efficient way of implementing special MAC protocol for WSN, namely hybrid protocols [6]. By applying WSN technology in the field of industrial monitoring or healthcare monitoring the single CSMA or TDMA protocol cannot meet the requirement of dealing with the urgent data without delay when some accidents occur. In order to solve this problem, author puts forward a hybrid CSMA-TDMA MAC protocol for wireless sensor network, and makes a test in a star network which is made up of one centre node and several sensor nodes [7]. In [8] author has evaluated performance of FMAC for varying the size of packet. In their proposed scenario, packet size is varied from 50 bytes to 250 bytes. The proposed protocol gave better performance for Average packet delivery ratio than TDMA, CSMA and 802.15.4. Also, Average End-to-End Delay less as compare to CSMA and 802.15.4. Average Throughput for FMAC is better as compare to TDMA, 802.15.4 and CSMA. But Average energy consumption is 25% more for FMAC as compare to TDMA and less as compare to 802.15.4 and CSMA. Packet loss ratio of FMAC was very less as compare to 802.15.4 [8]. For practical application of WSN, limited energy source is the major problem along with this problem transmission performance, throughput must be improved too. To tackle both of the issues simultaneously, author has proposed a hybrid TDMA/CSMA MAC layer protocol, by taking the advantages of Time Division Multiple Access (TDMA) and Carrier Sense Multiple Access (CSMA) at the medium access control (MAC) layer of WSN [9].

# II. PROPOSED SYSTEM

In the proposed system scenario of healthcare system is considered where we have deployed 30 wireless sensor nodes. In the same network we classified 30 nodes in two types, among 30 nodes 4 nodes are working as Prior nodes, one is sink node and remaining are normal nodes. In this network excluding prior nodes all remaining nodes works with existing protocol TDMA MAC protocol. In Timedivision multiple access (TDMA) wireless sensor nodes transmit the packets in rapid succession, one after the other, each using its own time slot. But in Hospital network in case of an emergency situation data communication from sensor network must be done with minimum delay. For handling such situation Prior nodes are designed which accesses the channel using CSMA protocol. Here In the proposed method, the communication during the Data Exchange Period can be divided into two parts: the first part is communication in CSMA and the second is in TDMA.

Prior nodes have higher priority to communicate in CSMA, while normal nodes in TDMA. After receiving all the data of prior nodes, the centre node will check the address table, knowing what the other nodes in address table which have not sent data yet are normal nodes. Then the centre node will send synchronization command involving the information of time slot assignment in address order for all normal nodes. Each normal node can pick up its own slot priority from the synchronous command, and then sets exact timing so as to send data in its own slot. During the timing, the sensor falls into a doze to save energy. In addition, if the centre node does not receive any data from a sensor node in three continuous cycles, the sensor node will be considered out of network owing to power exhausted, and its record in the address table will be deleted, meanwhile a sound and light alarm will be given by centre node.

SIMULATOR	Network Simulator 2.35
NUMBER OF NODES	30
AREA	600m x 600m
COMMUNICATION RANGE	250m
PACKET SIZE	512 bytes
INTERFACE TYPE	Phy/WirelessPhy
MAC TYPE	IEEE 802.11, TDMA, FMAC, 802.15.4
QUEUE TYPE	DropTail/Priority Queue
QUEU <mark>E LE</mark> NGTH	50 Packets
ANTENNA TYPE	Omni Antenna
PROPAGATION TYPE	TwoRayGround
ROUTING PROTOCOL	AODV
TRANSPORT AGENT	UDP
APPLICATION AGENT	CBR
SIMULATION TIME	50 Seconds

A. Simulation model for System

Table 1. Simulation model

## B. Network Architecture

Node (0) is sink node, Node (1) is patient ward monitoring node, Node (2) is ICU monitoring node, Node (3) is casualty node, Node (4) is OP node. Node 1,2,3,4 are high priority nodes. All other nodes are normal nodes.



Fig 1. Network Architecture of Healthcare System



# **III. METHODOLOGY**

The FMAC protocol will check whether the data transmitting node is prior node or normal node.

### A. Data transfer in normal nodes

All the sensor nodes in the network transfer the sensed data to the sink node using TDMA protocol. Each node has a time slot to send data. The time is calculated based on packet header length, slot packet length and bandwidth. The normal nodes send their data when the slot time reaches.

#### slot time =

(Header Length/band width) + (slot packet length/band width)

#### B. Data transfer in prior nodes

If the sensor node is priority node (i.e. ICU monitor, patient ward monitors etc.), then the prior node send data to sink node using CSMA protocol. In CSMA, the Back-off delay is provided based on packet length and bandwidth. Then the packet transmitted to sink node.

Transmit time = (8 \* data length) / band width

## C. Flowchart of FMAC Protocol





#### D.Implementation Details

The prior nodes are high priority and they communicate with the center nodes frequently, since it follows CSMA protocol. mac-tdma.cc and mac-tdma.h files have been modified to implement the FMAC protocol. The modification in file mac-tdma.cc is done to check from which node the communication is initiated. If the communicating node is prior node, CSMA MAC protocol will be used for further transmission of data without in delay. But if communicating node is normal node then simple TDMA MAC protocol will be used. Completely generating a new mac layer protocol is not possible, hence we modify the existing TDMA protocol to generate FMAC protocol. The modified protocol is invoked in respective TCL and the modifiers.cc files are added to the ns2.35 package.

## **IV. RESULTS**

Our simulation scenario we have deployed 25 common nodes, 4 prior nodes and one sink node. Ad hoc On Demand Distance Vector Protocol (AODV) Routing Protocol is used. Results are taken for varying reporting rate from 10 packets/seconds to 50 packets/seconds. Data transmission between normal nodes and sink node is observed. Data transfer prior nodes also captured.

#### A. Data transfer in normal nodes

All the normal nodes send the sensed data using TDMA protocol. Each node has allocated a time slot to sends data. All the sensor nodes in the network transfer the sensed data to the sink node. All the normal nodes send the sensed data using TDMA protocol. In TDMA, it provides different time slots to different transmitters in a cyclically repetitive frame structure. For example, node 1 may use time slot 1, node 2 time slot 2, etc. until the last transmitter when it starts over. Each node will send data in allocated time slot.

	Ope									
					test	tr				
	22.2	122-5			100					
	11 5	Loc_p	backet_lei	1_ 150	10					
	12 5	lot_f	acket_le	1_ 150	10					
	13 5	LOC_I	Jacket_Lei	1 1 51	10					
	14 5	Loc_p	backet_lei	1_ 150	10					
	15 5	lot	Jacket_le	1_ 151	10					
1	17 .	lot	acket le	- 151	10					
i sance	19 0	Lot /	acket le	150	10					
	19 6	lot	acket le	- 150	10					
	28 4	lot	acket les	1.54	10					
	21 5	lot	hacket le	- 150	10					
	22 6	lot	acket le	1 150	0					
	23 5	lot	acket le	1 150	8					
	24 5	lot (	backet ler	1 150	0					
	25 5	lot	backet ler	1 150	00					
	26 \$	lot p	backet les	1 150	00					
	27 \$	lot_r	backet_le	1.50	00					
	28 \$	lot_p	backet_le	1_ 150	90					
	29 s	lot_p	backet_le	1_ 150	00					
	30 s	lot_s	packet_le	1.50	90					
	31 5	lot_p	backet_le	1.50	90			-		
	132 0	orna	node(20	) seni	1 data	a 1.	o cordinato	r node		
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	38 n	ornal	node(8)	send	data	to	cordinator	node		
	39									
	40 n	ormal	node(9)	send	data	to	cordinator	node		
	41									
	42 n	ormal	L node(6)	send	data	to	cordinator	node		
	43									
	44 n	ormal	L node(7)	send	data	to	cordinator	node		
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	52 n	rtor	node(1)	iend i	lata 1	to re	ordinator o	ode		
	53						a sendeur in			
	54 0	rtor	node(2)	end e	tata 1	to ce	ordinator n	ode		

Fig 3. Data transfer between Normal nodes and coordinator node

Fig.3 shows data transfer between normal nodes and coordinator node. In Fig. 4 Nodes like node (20), node (6), node (7), node (8) and node (9) are transferring some data packets to coordinator node. Here these nodes are working in TDMA Media access control protocol where each node send packet to sink in the allotted slot only. Since the node is in one hop distance i.e. the node directly send data to destination without the help of intermediate routers.



test.tr	19		result.tr	X .
E130 H "E E. 464000 "H EA "C P.43	1.3444			
2757 N -t 2.424000 -n 22 -e 5.62	1930			
2758 N -T 2.424000 -n 23 -e 1.30	4375			
2759 N -t 2,424000 -n 24 -e 2,70	0168			
2760 N -t 2.424000 -n 25 -e 6.00	4861			
2761 N +t 2.424000 +n 26 +e 6.88	8573			
2702 N -t 2,424000 -n 27 -e 3,04	0910			
2763 N -t 2.424000 -n 28 -e 8.73	2073			
2764 N +t 2.424000 +n 29 +e 6.74	5419			
2705 N -t 2.544000 -n 0 -e 0.055	051			
2766 N -t 2.544000 -n 20 -e 9.15	0922			
2767 N -T 2.544000 -N 0 -e 0.053	1883			
2708 r 2.540361144 _0_AGT	2 CDC 532 [5	0 14 0] [energ	y 0.653883 et 0.000	es 0.000 et 0.001 er 0.0
2709 N -T 2.550000 -N 0 -e 0.053	883			
2770 N -t 2.550000 -n 20 -e 9.14	18580			
2771 N -T 2.604000 -n 0 -e 0.653	883			
2//2 N -T 2.004000 -N 1 -e 0.328	5/5			
2773 N -T 2.604000 -D 2 -e 5.801	815			
2774 N -T 2.004000 -N 3 -e 4.030	10.39			
2775 N -T Z.004000 -n 4 -e 1.581	051			
2770 N -T 2.004000 -N 5 -e 9.522	450			
2777 N -t 2.604000 -n 0 -e 7.430	90Z			
2//8 N -T 2.604000 -N / -e 2.180	1/03			
2//9 N -T 2.004000 -n 8 -e 4.595	800			
2/80 N -t 2.004000 -n 9 -e 2.400	121			
2/51 N -T 2.604000 -N 10 -0 0.05	/411			
2782 N -t 2.004000 -n 11 -e 4.90	5105			
2783 N +C 2.004000 +N 12 +0 4.02	5810			
2/84 N -t 2.604000 -n 13 -e 9.61	7325			
2785 N -T 2.604000 -n 14 -e 5.09	2323			
2786 N -T 2.004000 -n 15 -e 3.38	2934			
2787 N -t 2.604000 -n 16 -e 3.70	6952			
2788 N -T 2.604000 -N 17 -0 1.24	9005			
2789 N +t 2.604000 -n 18 +e 8.65	6724			
2790 N -T 2.004000 -N 19 -e 0.27	/211			
2791 N -t 2.004080 -h 20 -e 9.14	8580			
2792 N -t 2.004000 -h 21 -e 9.45	1344			
2793 N -T 2.004000 -N 22 -e 5.62	1930			
2/94 N -T 2.004000 -N 23 -0 1.30	14375			
2/95 N +T 2.004000 -N 24 +e 2.76	0108			

Fig 4. Data Collection at Sink node

Further at sink node data from nodes are collected and processed as shown Fig.4.

## B. Data transfer in prior nodes

In Emergency condition, the nodes send data as prior nodes using CSMA protocol in MAC layer.

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	test.tr	*	result.tr
410 STATTE	TOT HOUE	U 15 U.UUE330	
419 slot_time	for node	8 15 0.002336	
420 slot_time	for node	6 1s 0.002336	
421 slot_time	for node	8 is 0.002336	
422 slot_time	for node	6 is 0.002336	
423 slot_time	for node	8 15 0.002336	
424 slot_time	for node	0 15 0.002330	
425 slot_time	for node	8 15 0.002330	
420 SLOT_TIME	for node	0 15 0.002330	
427 slot_time	for node	8 15 0.002330	
428 slot_time	for node	0 15 0.002330	
429 SLOT_TIME	for node	8 15 0.002330	
430 802.11:pr	tor node	0 1 - 0 0000000	
431 SLOT_TIME	for node	8 15 0.002330	
432 SLOT_TIME	for node	2 15 0.000400	
433 SLOT_TIME	for node	4 15 0.000400	
434 Stot_time	for node	10 4- 0 000320	
435 slot_time	for node	10 15 0.000400	
430 Stot_tthe	for node	5 is 0.000320	
437 stot_time	for node	5 LS 0.000400	
430 slot time	for node	9 1r 0 000320	
440 slot time	for node	11 1 0 000400	
441 slot time	for node	14 15 0 000400	
442 slot time	for node	17 15 0 000400	
443 slot time	for node	20 15 0.000400	
444 slot time	for node	21 15 0.000400	
445 slot time	for node	22 15 0.000400	
446 slot time	for node	23 is 0.000400	
447 slot time	for node	25 is 0.000400	
448 slot time	for node	2 is 0.000320	
449 slot time	for node	3 is 0.000384	
450 slot time	for node	4 is 0.000320	
451 slot time	for node	7 is 0.000384	
452 slot time	for node	9 is 0.000384	
453 slot_time	for node	12 is 0.000400	
454 slot time	for node	15 is 0.000400	
455 slot_time	for node	16 is 0.000400	
456 slot_time	for node	18 is 0.000400	
457 slot_time	for node	19 is 0.000400	
458 slot_time	for node	24 is 0.000400	
459 slot_time	for node	26 is 0.000400	
460 slot_time	for node	27 is 0.000400	
461 slot_time	for node	28 is 0.000400	
462 slot_time	for node	29 is 0.000400	
463 slot_time	for node	0 1s 0.000384	
ARA MINE BANK	FAR AAAA	F 4 = 8 000304	

Fig 5. Data transfer in prior nodes

Fig.6 shows the data transfer from prior node (1) so node (1) need not to wait for timeslot as node (1) has high priority it will send data packets using CSMA protocol.

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	test.tr		result.tr	
26 slot 27 slot 28 slot 29 slot 30 slot 31 slot	packet_len_ 1500 packet_len_ 1500 packet_len_ 1500 packet_len_ 1500 packet_len_ 1500 packet_len_ 1500			
32 normal 33	L node(28) send dat	a to cordi	nator node	
34 normal	l node(6) send data	to cordin	ator node	
36 normal	l node(7) send data	to cordin	ator node	
38 normal	l node(B) send data	to cordin	ator node	
te normal	l node(9) send data	to cordin	ator node	
41 42 normal	l node(6) send data	to cordin	ator node	
43. 44 normal	l node(7) send data	to cordin	ator node	
ts 16 normal	i node(8) send data	to cordin	ator node	
47 48 normal	l node(9) send data	to cordin	ator node	
49 50 normal	L node(6) send data	to cordin	ator node	
51 52 Drlor	node(1) send data	to condinat	or ode	
53 54 prior	node(2) send data	to cordinat	or node	
55 Sé prior	node(3) send data	to cordinat	or node	
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59	node(2) cand data	to condition	or and	
51	node(2) send data	to corethat	ur nove	
53	node(3) send data	to cordinat	or node	
54 prtor	node(1) send data	to cordinat	or bode	
56 Total 57 Total	dunenergy=0.192814 dunenergy=0.248867	98492421521 96628973661		
Sa Total	dunenergy=8.328987	99196787176		
70 Total	dunener gy=0.435524	67928523719		
71 Total	duneneray=0.469687	38735488299	(	

Fig 6. Prior node sends data to coordinator node or sink node

The transmission of data from prior node to coordinator node is shown in Fig 6. Prior node 1,2 and 3 are communicating with coordinator node.

			8			
	Open 🔻	m				
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	1121122/12221	test.tr	1477168-168	×	result.tr	×
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	17711 N .+	21.000000	-0 20 -	a 0 113078		
	17712 N .+	21,000000	- D 21	0 421560		
	17713 N .+	21.000000	.0 22	a 5 602850		
	17714 N .t	21.000000	.0 23	a 1 287605		
	17715 N +t	21 000000	-n 24 -	a 2 6888888		
	17716 N +t	21 000000	-D 25 -	a 5 989781		
	17717 N .+	21.000000	-0 26 -1	e 6.870693		
	17718 N -t	21.000000	-0 27 -4	e 3.022430		
	17719 N -t	21.000000	-0 28 -4	8.714193		
	17720 N -t	21.000000	-0 29 -4	e 6.726339		
	17721 5 21	.000000000	1 AGT	106 cbr	512 [0 0 0 0] [	energy 0.311
8	17722 r 21	.0000000000	1 RTR	106 cbr	512 0 0 0 0 1	energy 0.311
	17723 5 21	.000000000	1 RTR	0 AODV	48 [0 0 0 0] [en	Prov 0.31129
	17724 N -t	21.018000	-0 0 -0	0.515323	10 [0 0 0 0] [01	ci gj orozzer
	17725 N -t	21.018000	-n 1 -e	0.311295		
	17726 N -t	21.018000	-n 2 -e	5,782735		
	17727 N -t	21.018000	-n 3 -e	4.574762		
	17728 N -t	21.018000	-n 4 -e	1.563171		
	17729 N -t	21.018000	-n 5 -e	9.501648		
	17730 N -t	21.018000	-n 6 -e	7.344486		
	17731 N -t	21.018000	-n 7 -e	2.108191		
	17732 N -t	21.018000	-n 8 -e	4.381766		
	17733 N -t	21.018000	-n 9 -e	2.390905		
	17734 N -t	21.018000	-n 10 -	e 0.676099		
	17735 N -t	21.018000	-n 11 -	e 4.884869		
	17736 N -t	21.018000	-n 12 -	e 4.606736		
	17737 N -t	21.018000	-n 13 -4	e 9.601165		
	17738 N -t	21.018000	-n 14 -4	e 5.076243		
	17739 N -t	21.018000	-n 15 -4	e 3.365054		
	17740 N -t	21.018000	-n 16 -4	e 3.750272		
	17741 N -t	21.018000	-n 17 -e	e 1.234725		
	17742 N -t	21.018000	-n 18 -	e 8.640644		
	17743 N -t	21.018000	-n 19 -e	e 0.260531		
	17744 N -t	21.018000	-n 20 -4	e 9.113978		
	17745 N -t	21.018000	-n 21 -	e 9.431568		
	17746 N -t	21.018000	-n 22 -4	e 5.602850		
	17747 N -t	21.018000	-n 23 -4	e 1.287695		
	17748 N -t	21.018000	-n 24 -4	e 2.688888		
	17749 N -t	21.018000	-n 25 -e	e 5.989781		
	17750 N -t	21.018000	-n 26 -	e 6.870693		
	17751 N -t	21.018000	-n 27 -1	e 3.022430		
	17752 N -t	21.018000	-n 28 -i	e 8.714193		
	17753 N -t	21.018000	-n 29 -i	e 0.726339		
	17754 N -E	21.024000	-n o -e	0.515323		

Fig 7. Prior node communication with Sink node

In Fig 7. prior node (1) send data to sink node (0) through path 1-7-0 as sink node is not directly reachable from prior node (1). After arrival of data at Sink node processes it. In the case of prior node data transmission, the node waits for a time named as back-off time to send data.

# V. CONCLUSION

In proposed Wireless sensor network implementation of Federated-MAC is done by combining Carrier Sense Multiple Access (CSMA) and Time Division Multiple Access (TDMA) protocols. The performance metric for hospital network are evaluated for varying reporting rate. The implemented protocol found very efficient to tackle emergency situation in Healthcare Monitoring System by applying two different approaches for communication in a network. CSMA is used for communication between prior node and sink node to minimize the delay in communication. Whereas, to improve energy efficiency of each node TDMA Mac protocol is used, which allows each sensor node to remain active in their allotted time slot only. In this Proposed protocol works efficiently for quality of service parameters like Energy Consumption, Packet drop ratio, Packet delivery ratio and throughput irrespective of reporting rate. Here modification in a MAC protocol is done which can improve energy-efficiency to extend network lifetime in wireless sensor networks which is a challenging problem in Healthcare system.

## REFERENCES

- [1] Mehmet Yunus Donmmez, Sinan Isik, CemErsoy, " Combined analysis of contention window size and duty cycle for throughput and energy optimization in wireless sensor networks."Vol 57, issue 5,pp.11011112,2012
- [2] Liqi Shi, Fapojuwo," TDMA Scheduling with optimized energy efficient and minimum delay in clustered Wireless sensor Networks". IEEE Transaction MC, Vol 9, no 7, pp.227-240, July 2010.
- [3] C. Cheng, Member, IEEE, C. K. Tse, Fellow, IEEE, and Francis C.M.L., Senior Member, IEEE," A Delay-Aware Data Collection Network Structure forWireless Sensor Networks", IEEE Sensor journals, Volume. 11, Number. 3 M- 2011.
- [4] G. Ekbatanifard, R.Monsefi, M. H. Yaghmaee, S. Hosseini S. "Queen-MAC: A quorum based energy efficient MAC Protocol for Wireless Sensor Networks.", Elsevier, Computer Network, pp.22212236, 2011.
- [5] Dattatray S.Waghole, Vivek S. Deshpande "Techniques of Data Collection with Mobile static sinks in Wireless Sensor Networks: A Survey", IJSER,4(10),501-505, 2013.
- [6] CSMA based Medium Access Control for Wireless Sensor Network
- [7] Dattatray S.Waghole, Vivek S. Deshpande "Performance Analysis of FMAC Protocol for Reporting Rate in Wireless Sensor Networks", Thirteenth International Conference on Wireless and Optical Communications Networks (WOCN),2016
- [8] D. S. Waghole, V. S. Deshpande and P. V. Maitri, "Performance analysis of FMAC protocol for packet size in wireless sensor networks," 2015 International

Conference on Pervasive Computing (ICPC), Pune, 2015, pp. 1-5.

[9] Yang, X., Wang, L., Xie, J., & Zhang, Z., "Energy Efficiency TDMA/CSMA Hybrid Protocol with Power Control for WSN", Wireless Communications And Mobile Computing, 2018, 1-7. doi:10.1155/2018/4168354