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Power Consumption Analysis of Wireless Sensor Networks with Different Modulation and Routing Techniques

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Abstract: The sensors are used to sense and convert the one physical quantity to another quantity and when these sensors are attached with processing devices and connecting through a network, it becomes as a wireless sensor network technology. The sensor network is the combination of sensor nodes and all the sensor nodes are battery operated. The battery replacement or recharging is difficult, so power consumption is the major issue for wireless sensor networks with modulation techniques such as MSK and OQPSK16 and routing techniques such as Converge cast Routing Technique (CRT) and Dummy Routing Technique (DRT) [7]. In this paper power analysis has been reported for both modulation techniques in static and mobile wireless sensor networks. Experiment is performed for 802.15.4 physical layer energy consumption with modulation type (MSK & OQPSK16), routing techniques such as Convergecast Routing Technique (CRT)[12] and Dummy Routing Technique (DRT)[5].

Keywords: Power Management, Converge-cast Routing (CRT), Dummy Routing Technique (DRT), Static Nodes, Mobile nodes, modulation types (MSK & OQPSK16), Sensor Networks

I. Introduction

In the Wireless sensor networks, large numbers of sensors nodes send the data to the sink node or cluster head node. The communication between sensor and sink node had been done according to the IEEE 802.15.4 standard, it's a low power and low data-rate standard [9][11]. Thus IEEE 802.15.4 will play a major role in WSN applications with various types of network topologies.

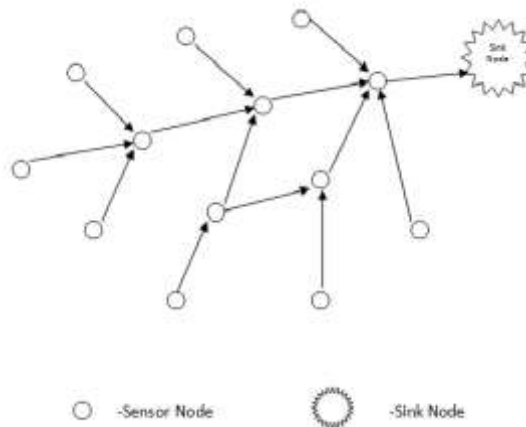


Figure-1 A Typical Wireless Sensor Network

In the converge-cast routing(CRT) and Dummy Routing Technique(DRT) all the sensor nodes send the short data unit (frame) containing the information acquired by the sensor node to sink node. The transmission between sensor node and sink node is performed inside the 2.4 GHz ISM band, at 250kbps with modulation types (MSK, OQPSK16) and exploiting one of the 16 channels [2].For each sensor node of the network, the sink node dedicated with the frame time interval. It is the time between two frames (data unit) and the value of this frame time interval is affect the power consumption of whole network. The paper is organized as follow: section giver general introduction to wireless sensor network while section II describe system description and simulation scenario with modulation types and routing techniques. In last the conclusion has given in section III.

II. System Description

The simulation model implements physical and medium access layer defined in IEEE 802.15.4 standard. The OMNet++ is used for developing 802.15.4 wireless sensor networks (WSNs)[10].

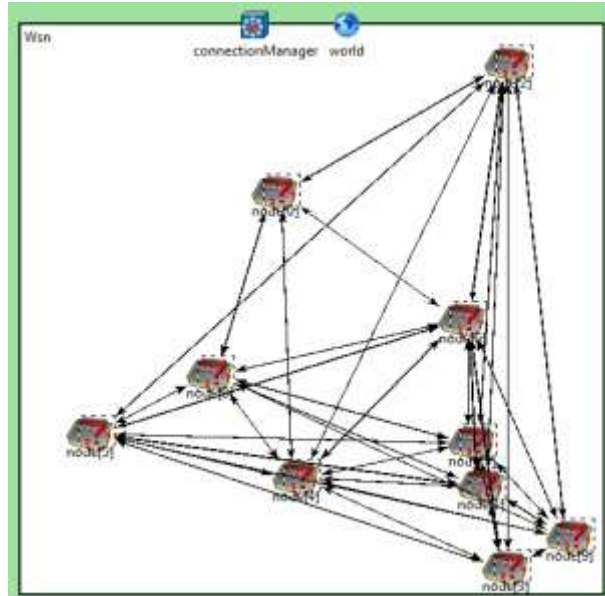


Figure 2 Wireless Sensor Network

A number of routing schemes have been proposed that attempt to maximize the efficiency of WSNs. Although many schemes are derived from a combination of others, they can be loosely grouped into the categories of minimum hop routing, minimum energy routing, loading balancing routing and potential based routing. In this paper power measurement has been done for routing techniques such as Convergecast Routing Technique (CRT) and Dummy Routing Technique (DRT) with modulation techniques such as MSK and OQPSK16. The result has been presented according to the routing protocols and modulation formats.

III. Power Consumption for Static Nodes

The power consumption on each static sensor node is simulation time of 10 seconds and 10 nodes in the wireless sensor network (WSN). This simulation is run with minimum shift keying (MSK) and offset quadrature phase shift keying (OQPSK16) modulation format and routing techniques such as Convergecast Routing Technique (CRT)[4] and Dummy Routing Technique (DRT)[1].

IV. Power consumption for Convergecast Routing Technique (CRT) with OQPSK16 and MSK.

The wireless sensor Network is evaluated against static nodes for Convergecast Routing Technique (CRT) with OQPSK16. In the convergecast routing all the sensor nodes send the data to the sink node. In this routing technique data packets are sent through the optimal and non-optimal paths for energy balancing. The simulations are run with 10 nodes in the network with 10s of simulation time. In this network every node sent the 5 to 50 packets over the network.

Table No.1

STATIC NODES		
Convergecast Routing Technique (CRT)		
OQPSK16		
Tx Packets	Rx Packets	Avg. Power Consumption (APC)
5	21	33.33
10	41	61.12
15	70	96.05
20	92	127.05
25	100	143.14
30	131	162.53
35	147	165.91
40	177	174
45	186	178.45
50	208	194.3

According to that number of received packets and power consumption by every node had been observed as shown in table no. 1 and figure 3, 4.

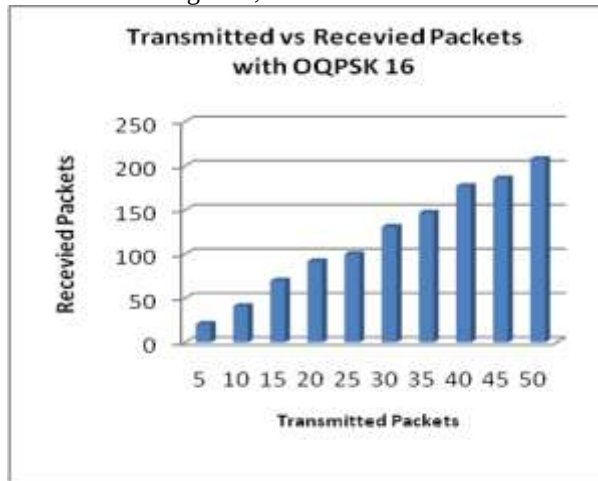


Figure No.3

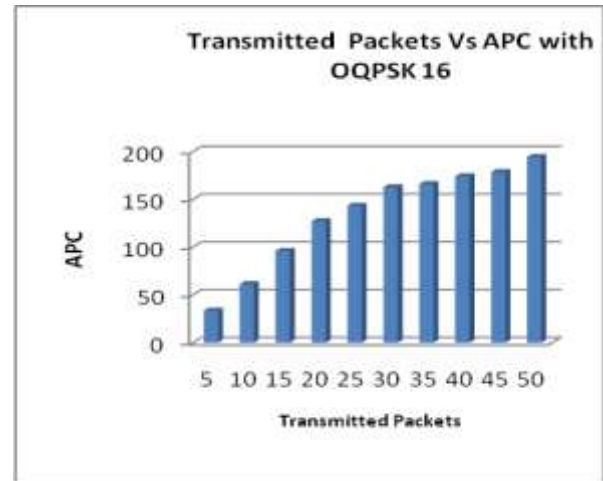


Figure No.4

The wireless sensor Network is evaluated against static nodes for Convergecast Routing Technique (CRT) with MSK. The simulations are run with 10 nodes in the network with 10s of simulation time. In this network every node sent the 5 to 50 packets over the network. According to that number of received packets and power consumption by every nodes had been observed as shown in table no. 2 and figure 5, 6.

Table No.2

STATIC NODES		
Convergecast Routing Technique (CRT)		
MSK		
Tx Packets	Rx Packets	Avg. Power Consumption (APC)
5	18	31.5
10	35	51.79
15	58	85.91
20	78	107.71
25	93	134.14
30	106	149.52
35	130	156.88
40	159	163.07
45	172	169.94
50	181	178.06

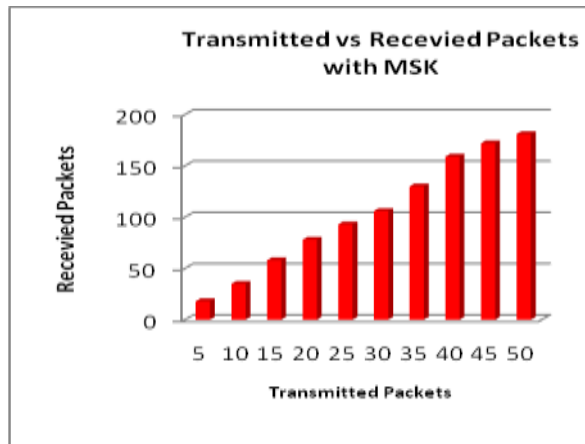


Figure No.5

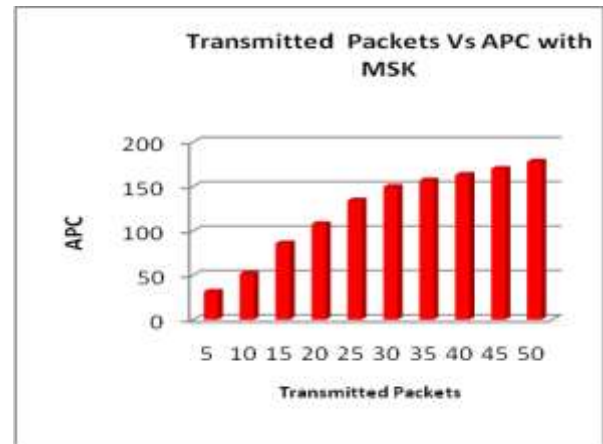


Figure No.6

V. Power Consumption for Mobile Nodes

The wireless sensor Network is evaluated against mobile nodes for Convergecast Routing Technique (CRT) with OQPSK16.[13] In the convergecast routing all the sensor nodes send the data to the sink node and sensor nodes changes their position w.r.t. each other and sink node with the constant speed. The simulations are run with 10 nodes in the network with 10s of simulation time. In this network every node sent the 5 to 50 packets over the network.

Table No.3

MOBILE NODES		
Convergecast Routing Technique (CRT)		
OQPSK16		
Tx Packets	Rx Packets	Avg. Power Consumption
5	23	558.1
10	46	557.8
15	63	557.69
20	95	557.38
25	112	557.14
30	133	557.05
35	156	557.02
40	162	556.69
45	204	556.9
50	226	556.78

According to that number of received packets and power consumption by every node had been observed as shown in table no. 3 and figure 7, 8.

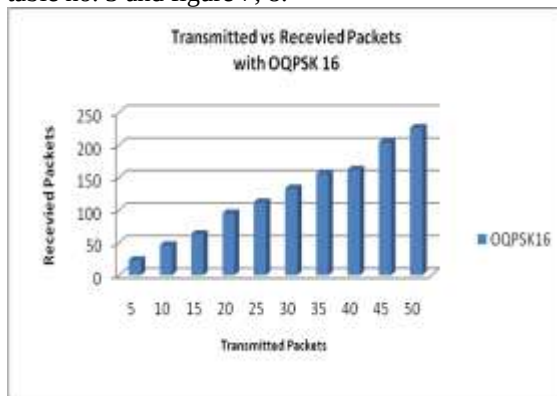


Figure No.7

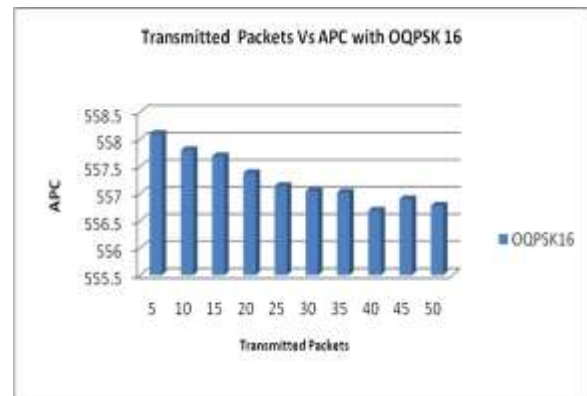


Figure No.8

The wireless sensor network is simulated with MSK modulation format against mobile nodes. In this convergecast Routing Technique (CRT) is used with mobile nodes. The simulations are run with 10 nodes in the network with 10s of simulation time. In this network every node sent the 5 to 50 packets over the network. Power consumption by every node had been observed as shown in table no. 4 and figure 9, 10.

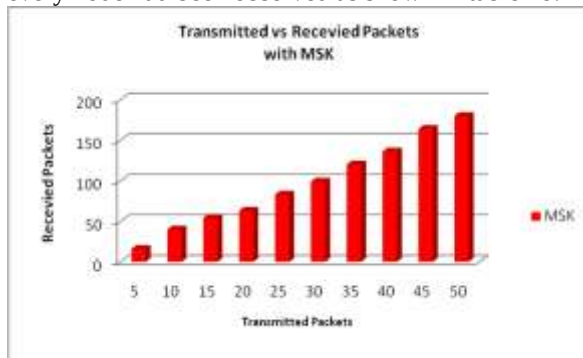


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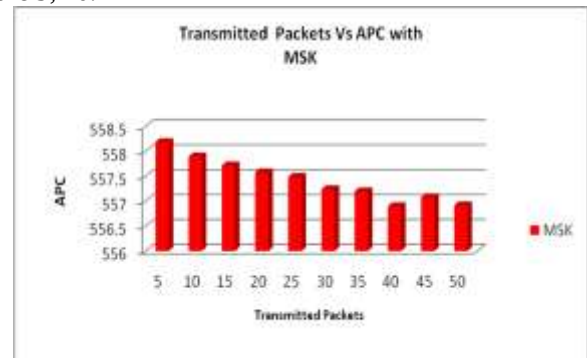


Figure No.10

Table No. 4

MOBILE NODES		
Convergecast Routing Technique (CRT)		
MSK		
Tx Packets	Rx Packets	Avg. Power Consumption
5	16	558.19
10	40	557.9
15	54	557.72
20	63	557.58
25	83	557.49
30	99	557.24
35	120	557.2
40	136	556.9
45	164	557.08
50	180	556.92

From the above simulation results, In case of static nodes, we concluded that with msk modulation format the wireless sensor network consume less power as compare to oqpsk16 modulation format. To save the maximum energy for the wireless sensor network, msk modulation format is better than oqpsk16. But with oqpsk16 modulation format, number of received packets is greater than msk format. So we can ignore this received packets difference because in the wireless sensor network energy saving is more important. In case of mobile nodes with both modulation formats, the network consumes almost same power with minor's variations. In the mobile sensor nodes, the transmitted packets and received packets are almost same with very small difference in the received packets as compare to the static sensor nodes. With oqpsk16 modulation format, number of received packets is greater than msk format. So oqpsk16 modulation format is better than the msk format. So the static nodes are better than the mobile nodes. Power saving is more in case of static nodes with minimum shift keying (MSK) modulation format. The power saving efficiency can be improve with Dummy Routing Technique (DRT) as explained in the next section.

VI. Power Consumption for Dummy Routing Technique (DRT) with Minimum Shift Keying (MSK)

A wireless sensor network contains number of sensor nodes and a coordinator that is sink node. All the sensor nodes send the information to the sink node. In the Dummy Routing Technique (DRT), [6] every sensor node filters the data frame and route only required data to the destination node. This way it is decreases the power consumption during the data transmission between nodes. It is improve the real data delivery ratio and decrease data overhead load on the network [3]. The Dummy Routing Technique (DRT) decreases the data packets collision and data packet loss. It is improving the network efficiency. The simulations are run with 10 nodes in the network with 10s of simulation time. In this network every node sent the 5 to 50 packets over the network. Power consumption by every node had been observed as shown in table no. 5 and figure 11, 12.

Table No.5

STATIC NODES		
Dummy Routing Technique (DRT)		
MSK		
Tx Packets	Rx Packets	Avg. Power Consumption(APC)
5	23	6.07
10	53	12.56
15	64	16.44
20	85	20.53
25	106	25.45
30	131	32.37
35	136	34.11
40	165	38.74
45	188	46.29
50	207	50.36

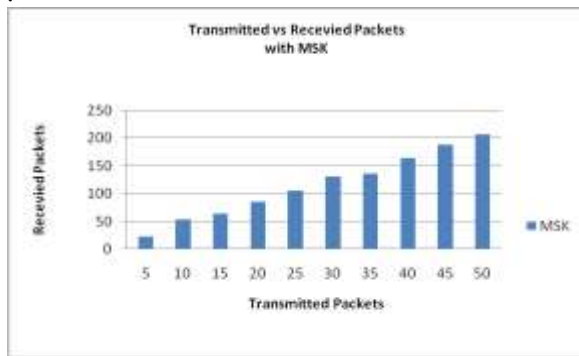


Figure No.11

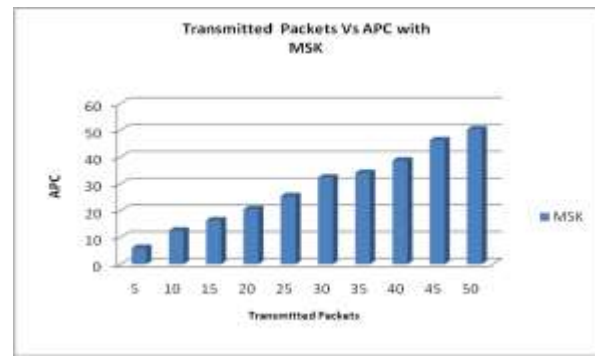


Figure No.12

VII. Conclusion

Simulation has been performed to find the optimal value of the IEEE standard 802.15.4 physical layer energy consumption. It is concluded that static sensor nodes are more efficient than mobile sensor nodes. In the comparisons of both static sensor nodes, 81.2% more life-time than the mobile sensor nodes with convergecast routing. The Dummy Routing Technique (DRT) increases the network efficiency than the Convergecast Routing Technique (CRT) with the MSK modulation format. The network efficiency is improved by Dummy Routing Technique (DRT) up to 82% than the Convergecast Routing Technique (CRT).

VIII. References

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