IMPACT OF PACKET SIZE ON THE PERFORMANCE OF IEEE 802.15.4 FOR WIRELESS SENSOR NETWORK

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ABSTRACT

This paper investigate the impact of packet size on the performance of 802.15.4 for Wireless Sensor Network based on various packet size scenario like packet size 300, 600 and 900.The comparative results have been reported for the performance metrics like Battery energy consumed, Traffic sink end to end delay and Traffic received. Packet size optimization is an important issue in energy constrained wireless sensor networks. These papers conclude that Packet size is mostly dependent on the type of data that is disseminated to the destination.

Keywords- Battery Energy, End To End Delay, FFD, IEEE 802.15.4, Packet Size, RFD, Traffic Received

I. INTODUCTION

Wireless Sensor Networks consists of individual nodes that are able to interact with their environment by sensing or controlling physical parameter; these nodes have to collaborate in order to fulfill their tasks as usually, a single node is incapable of doing so; and they use wireless communication to enable this collaboration [1].The IEEE 802.15.4 standard targeted to low power, low data rate wireless network application for example military, health, home, education, space, commercial applications etc.WSN are different from other wireless and adhoc network in many ways[2]. The main attractiveness of IEEE 802.15.4 WSN is to setup self-organizing networks capable of adapting to diverse topologies, node connectivity and traffic conditions. Typical applications of IEEE 802.15.4 WSN usually consists of tens or hundreds of simple battery powered sensors nodes which periodically transmit their sensed data to one or several data sinks(PAN Coordinator).

In a wireless sensor network packet size has the direct effect on battery energy consumption, end to end delay, traffic received and performance of communication between wireless nodes, so there is need to have an optimal packet size for wireless sensor networks. For instance having long packet size in a WSN network can cause data bits corruption and in turn increases the data packets retransmission. On the other hand, short packet sizes may increase data transmission reliability since the chances of bit errors over the link are less, but too short a packet size may not be efficient in the context of data payload carrying capacity because of the standardized data packet overhead [3].

There are many techniques developed yet to get an optimal packet size for the wireless sensor networks most of which are suggesting that there must be a fixed packet size as in [4]. Few others are promoting the use of dynamic packet length [5] i.e. variable size of data packets in a wireless sensor network.

The objective of this paper is to analyze the impact of packet size on the performance of IEEE 802.15.4 for WSN. The novelty of the work resided in the evaluation of key performance parameters that can be influenced by the packet size. The impact of Packet size has been analyzed through extensive simulation to capture the behavior of key performance parameters. These investigations are usable to select a suitable optimal packet size for IEEE 802.15.4 WSN.

This paper is organized as follows: Section 1 give brief introduction of packets size of WSN and objective of this paper. Section 2 constitutes the system description. Section 3 presents the result and discussions. Finally, the Section 4 summarizes the main conclusion of the paper.

II. SYSTEM DESCRIPTION

The Simulation model implements Physical and Media Access Control (MAC) layers defined in IEEE 802.15.4standard.The OPNET Modeler is used for developing its sophisticated graphical user interface.

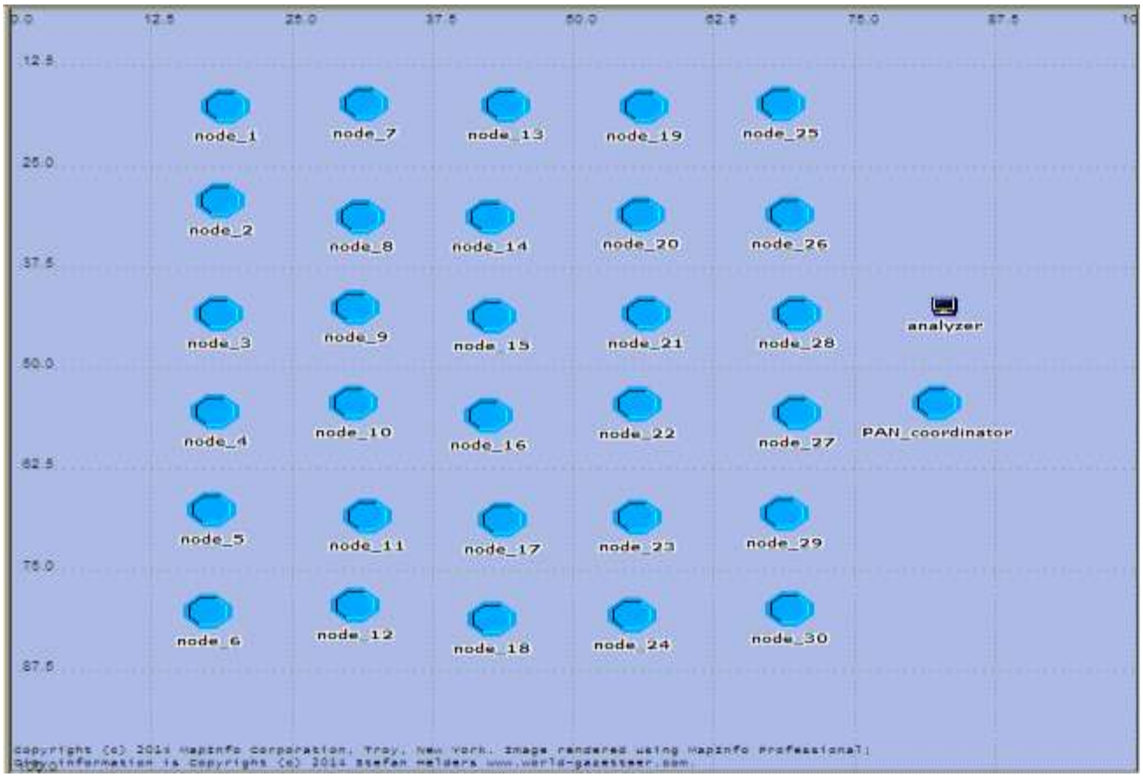


Figure 1: Network Scenario of Packet Size 300,600 And 900.

This simulation model support three different scenario of different packet size .i.e packet size 300,600 and 900.In these three different scenarios, communication is established between the end devices and a PAN Coordinator.

Fig.1 shows the network scenario of three different packet size 300,600 and 900 which contains one PAN Coordinator, one Analyzer and thirty end devices.PAN Coordinator is a Fully Functional Device (FFD) which manages their local networks and communicate with each other. End Device is a Reduced Functional Device (RFD) operating with minimal functionalities. End Devices are always associated with FFD. In order to communicate all these thirty nodes have to communicate with the PAN coordinator first and then PAN coordinator communicates to the destination end device.

2.1 Simulation Parameters

The network designed consists of basic network entities with the simulation parameters presented in table.

Parameter \ Scenario	**PAN Coordinator**			**End Devices**		
Modulation	Packet 300	Packet 600	Packet 900	Packet 300	Packet 600	Packet 900
Acknowledged Traffic Source						
Destination MAC Address	Broadcast			PAN Coordinator		
MSDU Inter arrival Time(sec)	Bernoulli(1.0)			Bernoulli(1.0)		
MSDU Size (bits)	Constant			Constant		
Start Time(Sec)	0.1			0.1		
Stop Time	150			150		
Unacknowledged Traffic Source						
MSDU Inter arrival Time	Bernoulli(1.0)			Bernoulli(1.0)		
MSDU Size(bits)	Constant			Constant		
Start Time(Sec)	0.1			0.1		
Stop Time(Sec)	150			150		
CSMA/CA Parameters						
Maximum back-off Number	4					
Minimum back-off Number	3					
IEEE 802.15.4						
Device Mode	PAN Coordinator			End Device		
MAC Address	Auto Assigned					
WPAN Settings						
Beacon Order	9			9		
Super frame Order	9					
PAN ID	0					
Logging						
Enable logging	Enabled					
GTS Settings						
GTS Permit	Enabled					
Start Time	0.1					
Stop Time	150					
Length (slots)	5					
Direction	Receive			Transmit		
Buffer Capacity	1000			1000		
GTS Traffic Parameter						
MSDU Inter arrival Time(Sec)	Bernoulli(1.0)			Bernoulli(1.0)		
MSDU Size(bits)	Constant			Constant		
Acknowledgement	Enabled			Enabled		

III. RESULT AND DISCUSSION

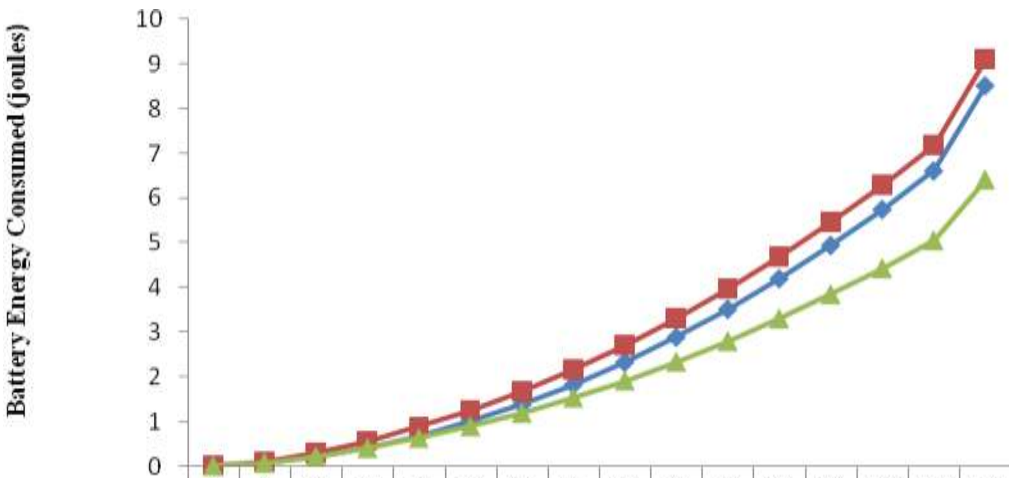
In this section various results have been presented and discussed to show the impact of different packet size on the performance factors like Battery energy consumed, end to end delay, traffic received etc.

3.1(a) Battery Energy consumed at Fully Functional Devices –PAN Coordinator

Lifetime of wireless sensor node is correlated with the battery current usage profile. Minimizing energy consumption and size are important research topics in order to make wireless sensor networks (WSN) deployable. As most WSN nodes are battery powered, their lifetime is highly dependent on their energy consumption.

Fig. 2(a) shows that the battery energy consumed at the fully functional device by the three different scenarios: “Packet 600”, “Packet 300” and “Packet 900” is 9.1, 8.5 and 6.4 Joules respectively. It is observed that minimum energy is consumed in case of “Packet 900” because larger is the packet size within it’s range (1 – 1024 bytes), lesser will be the number of packets generated for a given amount of data to be transmitted and lesser will be the number of times a channel will have to switch between transmit, receive, idle and sleep modes as most of the energy is consumed in switching from one mode to another mode and also in large packet sizes,the supposed overheads are somewhat less and will consume a smaller amount of energy at the intermediate node in the networks and lesser will be the delay in the delivery of the packets up to the destination. Hence, lesser will be the energy consumption for the packets of larger sizes as compared to the packets of smaller or medium sizes in IEEE 802.15.4.

Also, it has been observed that maximum energy is consumed in case of “Packet 600” because it is of medium size with in it’s range of 1byte to 1024 bytes. Since it’s of medium size, it is spending some time on the channel i.e. it is using the energy of the channel to stay on it, also more is the time spent on the channel, more is it susceptible to the collisions and it can cause data bits corruption and in turn increases the data packets retransmission. As most of the energy in a IEEE 802.15.4 Wireless Sensor Network is consumed in data transmission towards sink node.



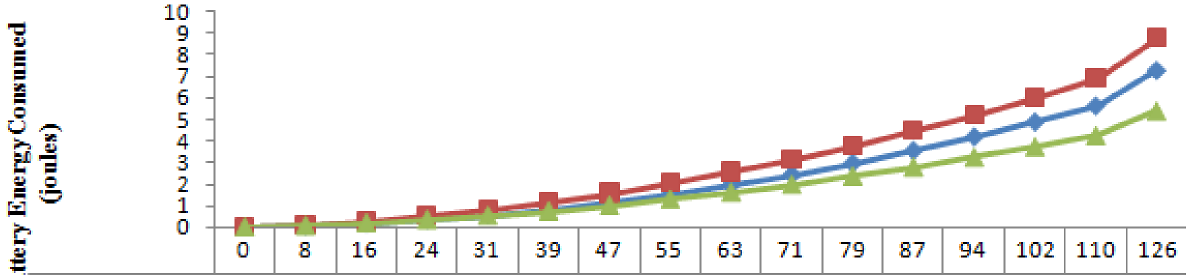
	0	8	16	24	31	39	47	55	63	71	79	87	94	102	110	126
Packet 300	0	0.0	0.2	0.4	0.6	0.9	1.3	1.8	2.3	2.8	3.5	4.2	4.9	5.7	6.6	8.5
Packet 600	0	0.1	0.3	0.5	0.8	1.2	1.6	2.1	2.7	3.3	3.9	4.6	5.4	6.2	7.1	9.1
Packet 900	0	0.0	0.2	0.4	0.6	0.8	1.1	1.5	1.9	2.3	2.7	3.3	3.8	4.4	5.0	6.4

Time(sec)

Figure 2(A)

3.1(b) Energy consumed at Reduced Functional Device-End Device

Fig. 2(b) represents the battery energy consumed at the reduced functional device by the three different scenarios: “Packet 600”, “Packet 300” and “Packet 900” i.e. 8.76, 7.28 and 5.42 Joules respectively. It is observed that minimum energy is consumed in case of “Packet 900”. Also, It is observed that maximum energy is consumed in case of “Packet 600”.



	0	8	16	24	31	39	47	55	63	71	79	87	94	102	110	126
Packet 300	0	0.05	0.16	0.33	0.54	0.81	1.13	1.51	1.94	2.42	2.96	3.55	4.19	4.88	5.63	7.28
Packet 600	0	0.08	0.26	0.50	0.79	1.14	1.55	2.02	2.55	3.13	3.77	4.46	5.21	6.01	6.87	8.76
Packet 900	0	0.06	0.18	0.33	0.52	0.74	1.00	1.29	1.62	1.97	2.36	2.79	3.25	3.74	4.27	5.42

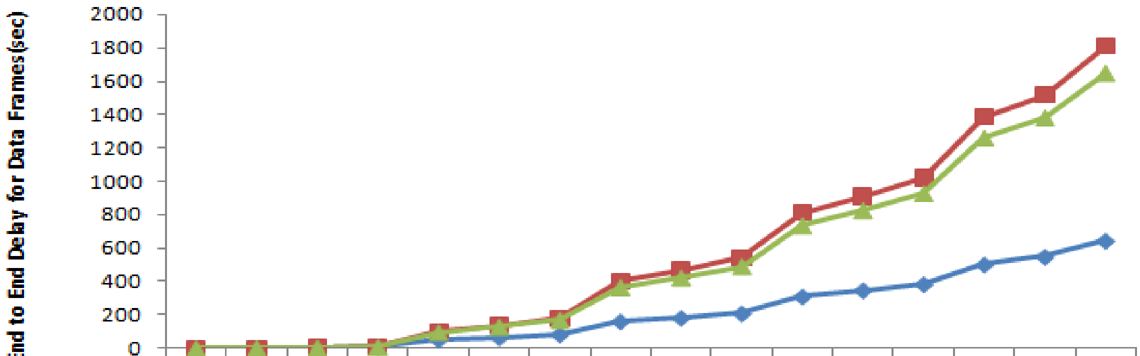
Time (Sec)

Figure 2(B)

From the Fig. 2 (a & b), it is concluded that if the battery energy consumed at any type of device in IEEE 802.15.4 is to be taken into consideration then packet size should be as large as possible within it’s range. Packet size is mostly dependent on the type of the data that is disseminated to the destination. If the link has a sufficient bandwidth to carry the large packets, data is easily carried up to the destination.

3.2 (a) Traffic Sink-End to End Delay at Fully Functional Devices – PAN Coordinator

End-to-End delay refers to the time taken by a packet to be transmitted across a network from source node to destination node that includes all possible delays caused during route discovery latency, retransmission delays at the MAC, propagation and transfer times.Fig. 3(a) shows that the end to end delay at Fully Functional Device in three different scenarios:”Packet 300”, ”Packet 600” and “Packet 900” is 642,180 and 164 seconds respectively .It is observed that minimum end to end delay has occurred in case of “Packet 900” because larger is the packet size,



	0	2	12	23	33	44	54	65	75	86	96	107	117	128	138	150
Packet 300	0	0.1	0.9	5.8	49.	63.	81.	159	180	206	308	346	382	500	547	642
Packet 600	0	0.3	1.9	5.0	102	136	179	401	468	543	812	911	102	138	151	180
Packet 900	0	0.3	1.6	7.0	95.	128	168	365	422	489	735	825	927	125	138	164

Time(sec)
Packet 300 Packet 600 Packet 900

Figure 3(A)

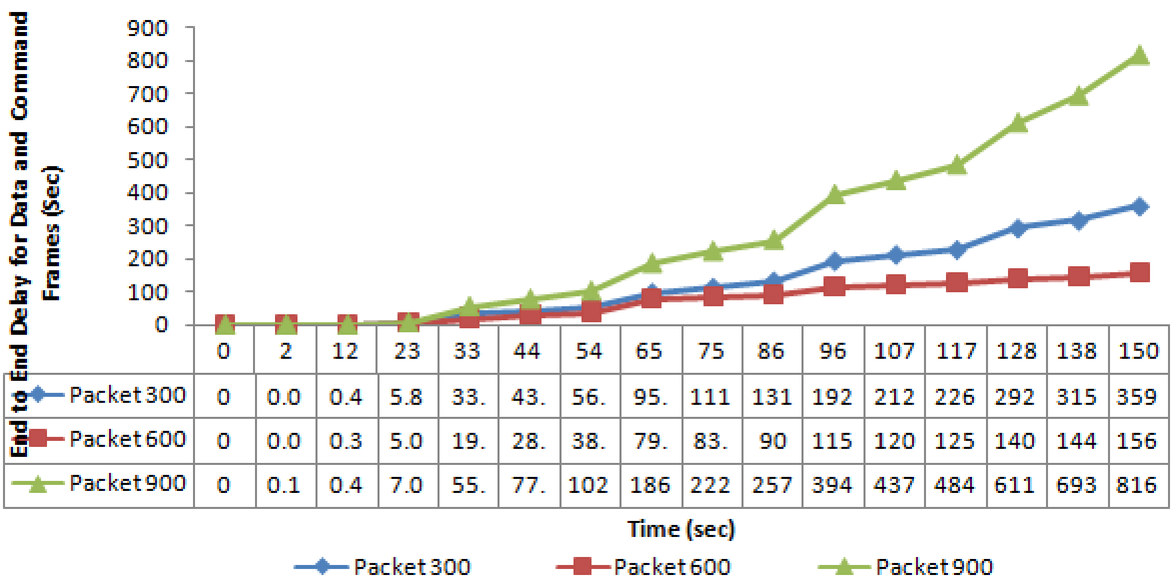
lesser is the number of packets generated for a given amount of data to be transmitted and lesser is the channel utilization. If channel is less utilized then most of the time channel is free and there is less chance of collision and congestion which mostly occurs near the Pan Coordinator; so data will take less time to be delivered to their destination point and will reduce the end to end delays to minimum.

Also, it has been observed that maximum end to end delay has occurred in case of "Packet 300" within its range of 1 byte to 1024 bytes. When the packet size is small, the main contribution of transmission delay is made by the channel access delay. This is due to the sensor nodes having to transmit small size data packet in a very short time interval, the channel become extremely busy. Subsequently, sensor nodes have to backoff more periods to compete to access the channel. This will cause larger channel access delay which result in maximum delay of end to end delay.

3.2(b) Traffic Sink-End to End Delay at Reduced Functional Devices–End Device

From Fig. 3(b), represents the end delay at reduced functional device (RFD) in three different scenarios. "Packet 300" "Packet 600" and "packet 900" i.e. 359, 156 and 816 second respectively. It is observed that minimum end to end delay has occurred in case of "Packet 600" as the packet are of optimal size within the IEEE 802.15.4 specified range i.e. 1-1024 bytes. Since RFD has a reduced functionally, it transmits/receives data occasionally not continuously like FFD. Therefore lesser will be the channel utilization if the data is sent/received occasionally. The channel will be in use only during transmission Reception; therefore chances of collision are reduced as the channel remains free. Also the number of attempts to access the channel will be reduced as compared to smaller size packets. Obviously, the end to end delay will be reduced to minimum in case of "Packets 600" as numbers of accesses to medium as well as collision are minimum.

From the Fig.3(b), it has also been observed that maximum end to end delay is in "Packet 900" because longer is the packet size within its large of 1 to 1024 bytes, more will be the time taken by it over the transmission channel. It will increase the collision on the channel as the other packet may try to access the claimed during that time slot since the



	0	2	12	23	33	44	54	65	75	86	96	107	117	128	138	150
Packet300	0	0.0	0.4	5.8	33.	43.	56.	95.	111	131	192	212	226	292	315	359
Packet600	0	0.0	0.3	5.0	19.	28.	38.	79.	83.	90	115	120	125	140	144	156
Packet900	0	0.1	0.4	7.0	55.	77.	102	186	222	257	394	437	484	611	693	816

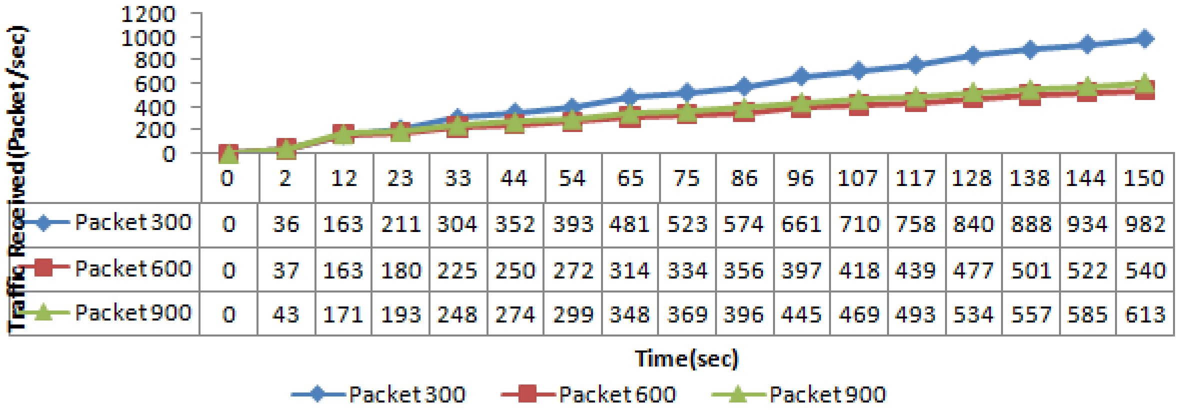
Figure 3(B)

number of collision increase the end to end delay will also increase as it may take time to overcome collisions to reach the destination.

From the Fig.3 (a & b), it is concluded that if end to end delay in IEEE 802.15.4 is to be taken in to consideration for the performance improvement then at the FFD the packet size should be as large as possible and at the RFD the packet size should be optimize with in its specified range of 1-1024 bytes.

3.3 (a) Traffic Received at Fully Functional Devices-Pan Coordinator

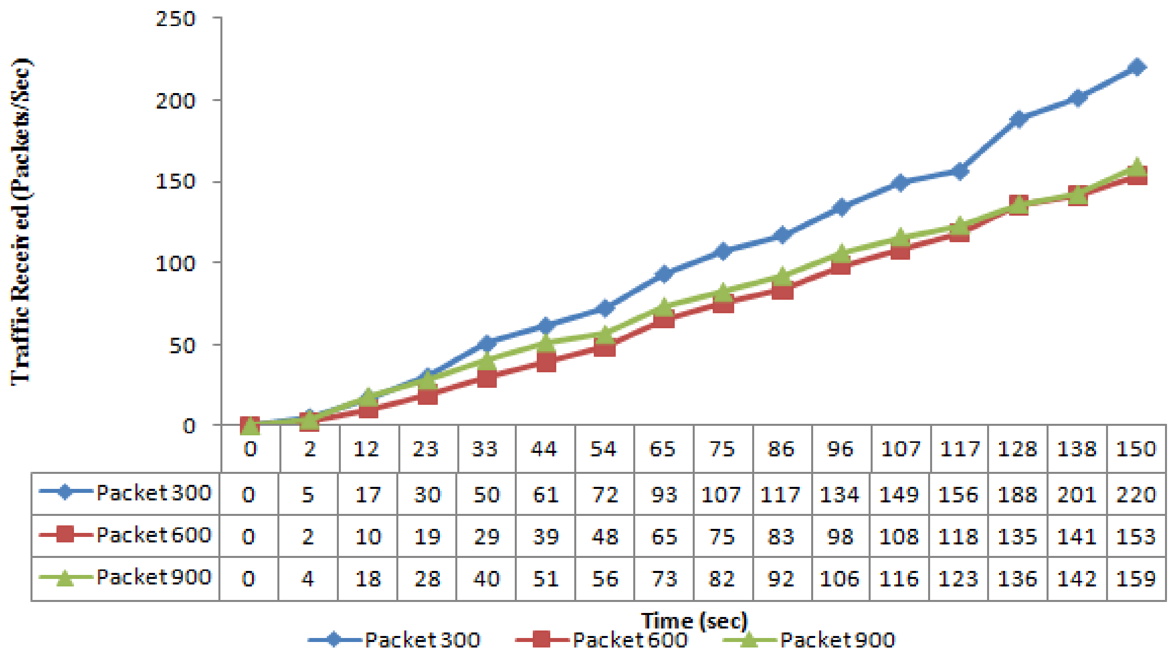
Traffic Received can be defined as number of bits of the data received per unit time. Fig. 4(a) show that the traffic received at fully function device in three different scenarios “Packet 300”, “Packet 600” and “Packet 900” i.e. 982,540 and 613 packets/seconds respectively. It is observed that maximum traffic is received in case of packet 300 because lesser will be the time during for which the channel will be occupied. Since it is a fully Functional Device and communicates with all the RFD’s. If shorter is the duration for which the channel is occupied by one RFD with the FFD. Then shorter will be the queues, lesser will be the waiting time and obviously lesser will be the collisions and more will be the traffic received by the receiver. It has also been observed that the traffic received is minimum in case of “Packet 600” i.e. moderate/medium size as the channel. Switching as well as the overheads are more in this case which reduces the traffic received by the receiver.



Time(sec)	0	2	12	23	33	44	54	65	75	86	96	107	117	128	138	144	150
Packet300	0	36	163	211	304	352	393	481	523	574	661	710	758	840	888	934	982
Packet600	0	37	163	180	225	250	272	314	334	356	397	418	439	477	501	522	540
Packet900	0	43	171	193	248	274	299	348	369	396	445	469	493	534	557	585	613

Figure 4(A)

3.3 (b) Traffic Received at Reduced Functional Devices-End Device



Time (sec)	0	2	12	23	33	44	54	65	75	86	96	107	117	128	138	150
Packet300	0	5	17	30	50	61	72	93	107	117	134	149	156	188	201	220
Packet600	0	2	10	19	29	39	48	65	75	83	98	108	118	135	141	153
Packet900	0	4	18	28	40	51	56	73	82	92	106	116	123	136	142	159

Figure 4(B)

Fig.4(b) represents the traffic received by the RFD in three different scenarios: "Packet 300","Packet 600" and "Packet 900" respectively and they further show 220,153 and 159 packets /sec traffic received by the receiver. It is observed that maximum traffic is received by the "Packet 300" because RFD communicates with the FFD that too occasionally not continuously and is free most of the time. Therefore, lesser channels of collisions shorter queue and channel remains free most of the time. Also smaller is the size of the packet more will be the number of packets generated from the given amount of data. Obviously more will the number of packets successfully received by the receiver and more will be the throughput. It has also been observed that traffic received at RFD is minimum in case of "Packet 600" i.e. moderate/medium sized packet because in this case channel switching is also high as well as packets generated are neither less.

From Fig. 4(a &b) , it is concluded that if the performance of IEEE 802.15.4 for WSN's is to enforced keeping in view the traffic received by the RFD at its receiver, then the packet size should be as small as possible within its specifications. Also, it has been observed that the packets should not be of medium size if the packets received at receiver are to be taken into consideration at the RFD.

IV. CONCLUSION

In this paper we simulated IEEE 802.15.4 to find the performance of packet size in wireless sensor networks in terms of three different packet size 300,600 and 900 scenario, where battery energy consumed, end to end delay and traffic received were analyzed as performance metrics. The analysis of simulation results provides some insight for optimizing the packet size in IEEE802.15.4.A key finding is that packet size is an important factor for creating energy efficient wireless sensor networks. Packet size should be as large as possible within it's range in battery energy consumed in FFD and RFD. To reduce the end to end delay, the packet size should be as large as possible at the FFD and at the RFD the packet size should be optimize with in it's specified rang. Another finding is that to improve the performance of WSN the packet size should be as small as possible with in its specification in RFD at its receiver.

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