International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 3 | ISSN : 2456-3307

Performance Analysis with Modulations in Web Server of IEEE 802.15.4 for WSNs

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ABSTRACT

The major purpose of this paper is to study and find effects of modulation techniques namely MSK, DPSK and QAM_64 on performance of IEEE 802.15.4 which is predefined mechanism in case of Wireless Sensor Network (WSNs). Further, modulation techniques are studied & compared on the basis of various parameters like collisions, end-to-end delay, traffic sent & traffic received. Parameters at different layers i.e. physical, MAC layer and application layer are considered and the results were analyzed. Overall, depending upon the expectations from system there is a tradeoff between the three modulation scenarios.

Keywords: Wireless Sensor Networks (WSNs), MSK, DPSK, Wireless Personal Area Network (WPAN), and QAM_64

I. INTRODUCTION

Wireless sensor networks are experiencing an exponential growth and are likely to follow the trend in near future as well. The increasing number of nodes and the services being expected from WSNs need continuous improvements in the performance of these networks, in form of higher throughput, low energy consumption, low value for BER and delays etc.

The digital modulation techniques can help us in boosting the performance of these networks. One can select the kind of modulation depending upon the kind of requirements one's network demands, as there is not any single correct choice which applies to all the cases. The differences in channel traits, choices of certain parameters and expected performance shall help make an informed decision for modulation scheme to be followed. The IEEE 802.15.4 standard used for WSN applications intends to give less cost & low power wireless sensor association between various mobile as well as stationary sensor nodes.

Various researchers have worked on making the IEEE 802.15.4 standard efficient based on various parameters. Some researchers have worked on possible radio configuration in permanent broadband wireless networks with focus on power efficient (Coudert et al. 2010).Some have estimated SNR for Orthogonal Frequency Division Multiplexing (OFDM) systems (Wang & Zhang, 2010). While, few researchers utilized SNR in order to intellect spectrum in radio networks (Wu et al. 2010). Moreover, researchers had even projected SNR using presumptive information (Nie et al. 2009). Coupling of load for different applications has also been tried (Negra et al. 2008) and some have studied load balancing for wireless mesh networks (Bejerano et al. 2007).

However, none of them have so far evaluated the Web Server performance metrics in IEEE 802.15.4 WSNs with modulation formats. Then the option of the digital modulation system in IEEE 802.15.4 appreciably influences the production load at the various kinds of devices in wireless sensor communication scheme. In this paper, a comparison of different modulation techniques (MSK, DPSK and QAM_64) has been done, so as to find out the aptness of the system depending upon the kind of device. The device may be a fully functional or a reduced functional device. We considered parameters for making comparison.

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II. SYSTEM DESCRIPTION

OPNET Modeler 14.5 along with open-zb simulation model were utilized for building 802.15.4 WSNs. Figure 1 depicts the view for 3 scenarios: MSK, DPSK & QAM_64. All three scenarios contain contains one web server, one router, 1 PAN Coordinator, 1 analyzer & twelve end devices all are GTS activated. WEB SERVER is a FFD which receives the sensed data through the ROUTER. PAN_COORD (PAN Coordinator) is a FFD that handles the operation of whole network. Further there exists a device called ANALYZER, which gathers the performance statistics of the network as a whole and of the individual objects in the network. EDs (End devices) are the permanent stations which converse with the PAN manager in peer to peer manner. All three scenarios are identical in each respect except the modulation schemes.

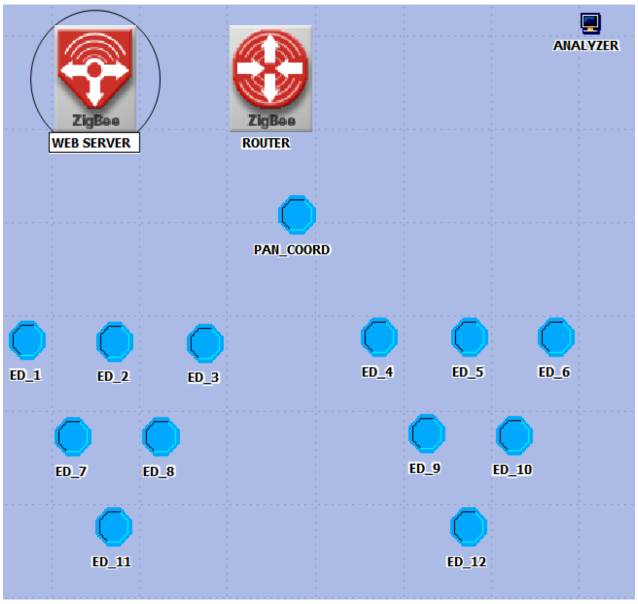

Figure 1. PAN Coordinator model

Figure 2 depicts the node structures for 3 kinds of Wireless PAN tools utilized for modelling 802.15.4 schemes. Web Server has the node model as depicted in figure 2(a), PAN Coordinator & End Devices contains the similar node structure as exposed in figure 2 (b) whereas the node structure intended is shown in figure 2 (c) for analyzer.

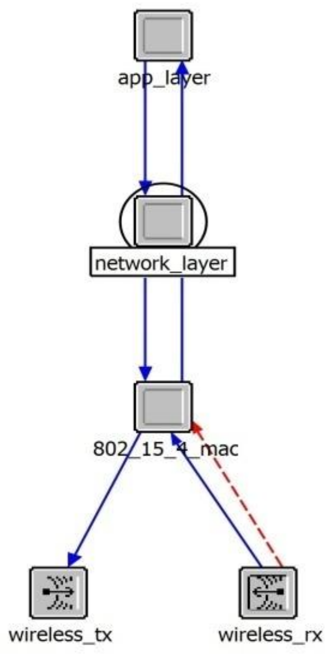

Figure 2(a). Web Server Node model

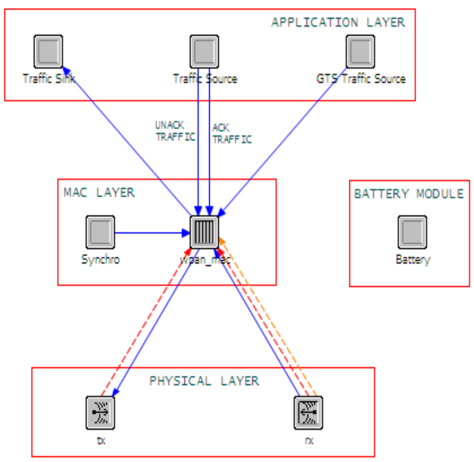

Figure 2(b): PAN Cordinator & End devices with node model

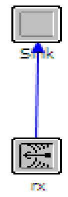

Figure 2 (c): Analyzer

A node model for Web Server has four layers: PHY, MAC, NETWORK and APP layer whereas, a node structure for GTS ends device & PAN Coordinator has three layers: PHY, MAC and APL layers. A node structure by the analyzer contains sink & radio receiver.

III. ATTRIBUTE SETTING

Performance of IEEE 802.15.4 for WSNs with appropriate values to the attributes of different types of devices is dependent on the modulation format used. The attributes that significantly affects efficiency of IEEE 802.15.4 for WSNs are: GTS traffic, CSMA/CA, WPAN settings etc. as shown in the table 1:

Table 1. Attribute settings for Web Server, PAN Coordinator, GTS End Device in BPSK, MSK & QAM_64 Schemes.

Attributes	**PAN Coordinator (PAN_COORD)**			**GTS Enabled End Device (ED)**			**WEB SERVER**		
Modulation	DPSK	MSK	QAM_64	DPSK	MSK	QAM_64	DPSK	MSK	QAM_64
Acknowledged Traffic Source									
End Point MAC Address	Web Server (PAN Coordinator)			PAN Coordinator			All Nodes		
MSDU	Exponential(1.0)			Exponential (1.0)			Exponential(1.0)		

Interarrival Time (sec)			
MSDU dimension (bits)	Exponential(0.2)	Exponential(0.2)	Exponential(912)
Launch Time (sec)	0.1	0.1	1.0
End Time (sec)	50		
Non-acknowledged Traffic Source			
MSDU Interarrival Time (sec)	Exponential(1.0)	Exponential(1.0)	Exponential(1.0)
MSDU Size (bits)	Exponential(0.2)	Exponential(0.2)	Exponential(912)
Initiation Time (sec)	0.1	0.1	1.1
End Time (sec)	50		
CSMA/CA Parameters			
Greatest Back-off Number	4		
Least amount Backoff Exponent	3		
IEEE 802.15.4			
Machine Mode	PAN coordinator	End Device	
Medium Access Control Address	1	Self Assigned	
WPAN Settings			
Beacon Order	13	13	6
Superframe Order	7		0
PAN ID	0		
Logging			
Activate Logging	Activated		

GTS Settings			
GTS authorize	Activated		
set up Time	0.1	0.1	Infinity
End Time	50		
Length (slots)	4		0
Direction	Transmit	Transmit	
Buffer Ability (bits)	10,000	1000	
GTS Traffic Attribute			
MSDU Interarrival Time (sec)	Exponential(1.0)		Exponential(0.1)
MSDU Size (bits)	Exponential(0.2)		Exponential(0.2)
Reply	Activated		Activated

IV. RESULTS AND PERFORMANCE ANALYSIS

Simulations are performed in case of 3 various schemes of IEEE 802.15.4 WPAN: Quadrature (QAM_64), MSK & DPSK. In this segment fallout for the various performance metrics at the web server is shown & summarized.

Physical Layer:
Bottom most layer in charge for the transmission of data from the starting point to the immediate next destination. Also responsible for the other functions like: modulations at the transmitter, receiver etc.

4.1 Packets Marked Noise (Radio Receiver)

The proportion of data-packets that are marked noise to the total number of packets arriving at a receiver of the web server.

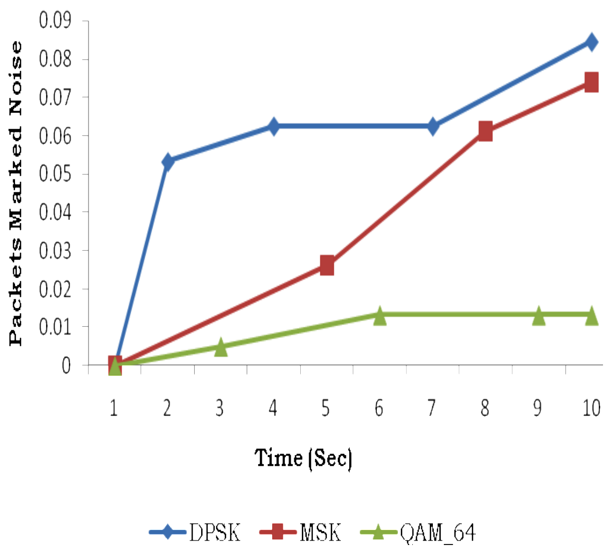

Figure 3. Packets Marked Noise at Radio Receiver of Web Server

Figure 3 shows that the Packets marked along with the Noise for DPSK, MSK and QAM_64 are 0.084499145937, 0.073918287833 and 0.013307833333 respectively. Further, observations are also made that the packets marked with noise are maximum for DPSK whereas it is least for QAM_64.

Therefore, it is concluded that if packets marked noise are to be considered, then QAM_64 should be preferred as packets marked noise are minimum incase of QAM_64.

Collision Status (Radio Receiver)

Collision Status is the amount of collisions taking place at the radio receiver of the web server while receiving the data.

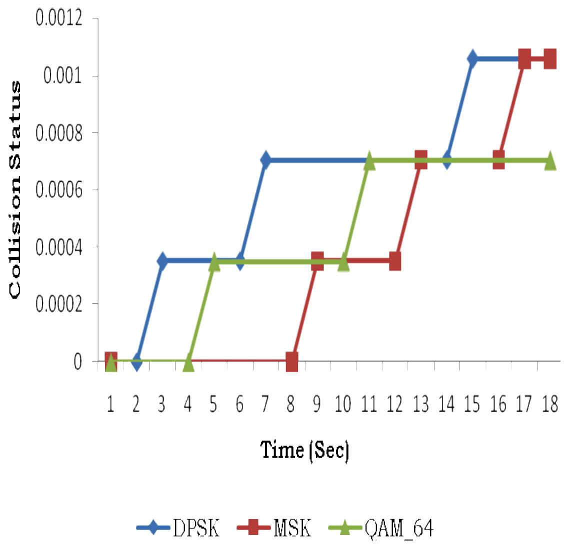

Figure 4. Collision Status at Radio Receiver of Web Server

The Figure 4 depicts the 0.001056, 0.001056 and 0.000704 collisions that the radio receiver respectively. Moreover, observation is also made that collisions occurs more for DPSK and MSK while the least in case of QAM_64. This is due to the fact that QAM_64 hikes the performance of communication by using together the amplitude & phase variations. QAM helps in making the system immune to noise as it allows the signal vectors to differ in both phase and amplitude. Therefore, if the collision status at the radio receiver of web server is to be considered, then in that case, QAM_64 should be favored.

MAC Layer:

Layer that lies on the apex of the physical layer is the MAC layer. It is responsible for accessing the medium for the transmitting the data from source to destination. Also, it is responsible for error detection and correction.

4.3Control Traffic Received

Control Traffic received is the quantity of management traffic received per unit time by the MAC layer of web server either from the physical layer or from the network layer in addition to the actual data to be transmitted.

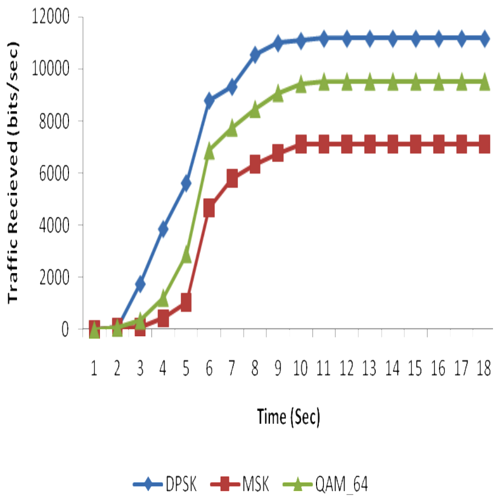

Figure 5: Control traffic recieved

Figure 5 depicts that the control traffic received at the MAC layer of Web Server is: 11176, 7128 and 9504 bits/sec respectively. It is noticed that the traffic received is maximum in case of DPSK while it is minimum in case of MSK. It may be attributed to the fact that DPSK is a Differential Phase Shift Keying modulation scheme which is able to modulate 40 Gbit/sec and also each transmission in DPSK depends upon the previous. Therefore, if the control traffic received on the MAC layer of web server is to be taken into consideration then the DPSK modulation scheme should be preferred.

4.4Control Traffic Sent

Control Traffic sent is the amount of management traffic sent per unit time by the MAC layer of web server either to the physical layer or to the network layer in addition to the actual data to be transmitted.

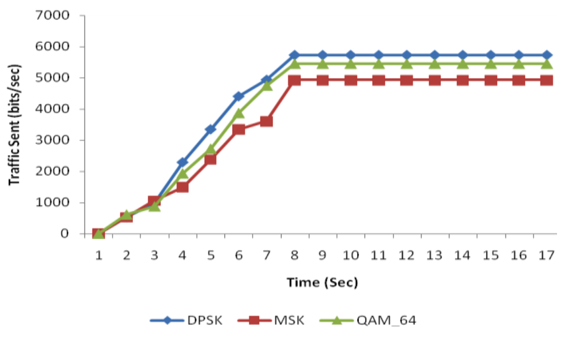

Figure 6. Control Traffic Sent from MAC Layer of Web Server

Figure 6 shows that the control traffic sent in case of DPSK, MSK and QAM_64 is: 5720, 4928 and 5456 bits/sec respectively from the MAC layer of web server. It is observed that the maximum control traffic is sent in case of DPSK while minimum is sent in case of MSK. This is also for the similar reasons as outlined in section 4.3. Therefore, it is concluded that if the control traffic sent at the MAC layer of the web server is to be taken into consideration then DPSK should be preferred.

4.5MAC Media Access Delay

MAC Media Access Delay is the time taken while trying to get the access of the channel on which the data is to be transmitted either to the physical layer or the network layer from the MAC layer i.e. the extra time taken for getting the access to the channel in excess to the normal time.

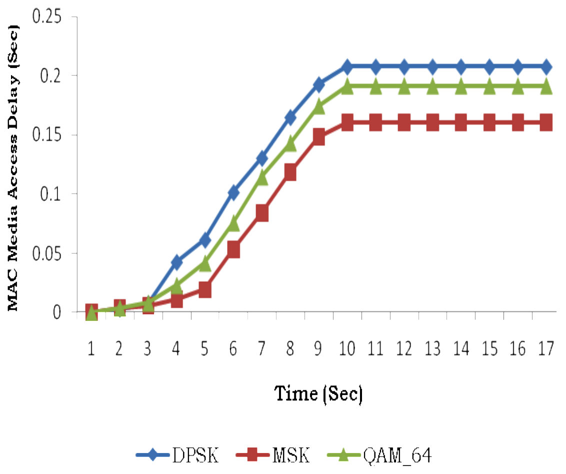

Figure 7. MAC Media Access Delay at MAC Layer of Web Server

Figure 7 depicts that the Media Access Delay in case of DPSK, MSK and QAM_64 is: 0.207816732375, 0.160374311421 and 0.191712106513 sec respectively at the MAC layer of web server. It is noticed that delay is minimum for MSK while maximum for DPSK. It may be because MSK is a linear as well as non-linear modulation scheme. It is spectrally better because of its good BER, Auto-synchronizing and constant envelope potential. It even suffers low from the neighboring signal interferences because it contains soft phase shifts at the symbol boundaries that outputs in the lower side lobes in comparison to the other modulation schemes. Because of such reasons, the latency is minimized in MSK. Furthermore, QAM_64 decisions are quite close among one another which may increase the noise and collision susceptibility and add to delay. In case of DPSK, each transmission in DPSK depends upon the previous which may add to delay. Therefore, it is concluded that if the MAC delay is to be considered then MSK should be preferred at the MAC layer of the web server.

Application Layer:

Top most layer of the protocol stack, which interacts with the client directly. It is responsible for inputs / outputs to / from lower layers.

4.6 End to End Delay

End to End latency is the extra time used (in addition to the specified time) in reaching of the packet / frame from the original source to the final destination.

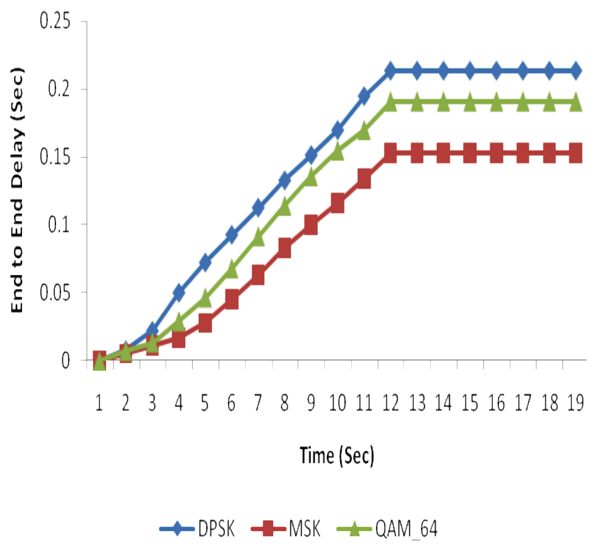

Figure 8. End to End Delay at Application Layer of Web Server

Figure 8 depicts that the end-to-end delay in case of DPSK, MSK and QAM_64 is: 0.213367198157, 0.152932122297 and 0.191065417522 sec respectively at the application layer of the web server. End-to-End latency is more which is found in case of DPSK while minimum in case of MSK. For similar reasons outlined in 4.5, the end to end delay is least in MSK as end to end delay takes into account MAC media access delay as well. Therefore, if MAC media access delay is more, then end to end delay is also more. Hence, it is concluded that if the end to end delay at the application layer is to be considered then MSK modulation scheme should be preferred.

V. CONCLUSION

We have evaluated the performance of web server based IEEE 802.15.4 WSNs in different modulation formats i.e. DPSK, MSK and QAM_64. Following conclusions for different attributes have been derived regarding the performance of the web server. If the *collision status* at the radio receiver of web server is to be considered than QAM_64 must be favored. Moreover, *packets marked noise* at the radio receiver are to be measured, then QAM_64 must be favored as packets marked noise are minimum in case of QAM_64. If the *control traffic received* and *control traffic sent* on the MAC layer of web server is to be taken into consideration, then the DPSK modulation scheme should be preferred. If the *MAC delay* is to be considered, then MSK should be preferred at the MAC layer of the web server. Similarly, if the *end to end delay* at the application layer is to be considered then MSK modulation scheme should be chosen. Generally, it is concluded that if the performance of the web server is to be enhanced then there has to be trade-off between the use of modulation schemes.

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