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Performance Analysis of Micaz and Telosb Motes to Conserve Energy within Ieee 802.12.4 Wsn

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ABSTRACT

One of the major issues within Wireless Sensor Networks relates with battery lifetime. This research paper has detailed analysis of Energy Efficient parameters of the battery, which has significant impact on performance of IEEE 802.15.4 sensor node in term of Energy consumption. OPNET Modeler 14.5 provides by default support to battery's parameters for Micaz and TelosB i.e. Transmission mode, Receive mode, idle mode and sleep mode. Different battery parameters such as TelosB and Micaz are combined with one another to analyze, the parameters, which has great impact on energy consumption of sensor node. Results have revealed that Micaz receive mode and idle mode values cause high energy consumption, while TelosB sleep mode and idle mode prevents to consume high energy and thus consume less energy as compared to Micaz node. These modes are predefined within IEEE 802.15.4 model for OPNET Modeler. Analysis of Micaz and TelosB batteries is completed by increasing traffic load.

KEYWORDS*:* IEEE 802.15.4, Micaz mote, TelosB mote, Wireless Sensor Network

1 INTRODUCTION

Wireless Sensor Network **(WSN**) is a group of sensor nodes that are deployed in application areas such as health monitoring, industry, military, surveillance area etc. Sensor node is a tiny sensing device which map physical quantity i.e., temperature, humidity, fire detection etc. into measurement quantity. Sensor node has limited battery lifetime. Due to deployment of sensor node into inaccessible areas, it is relatively difficult to recharge and replace its battery. Sensor nodes consume a huge amount of energy during sensing, computation and transferring of data. Clustering of nodes is an effective mechanism to prevent energy consumption of node and prolong its lifetime. [1]

IEEE 802.15.4 standard is defined by IEEE Task Group for Low Rate WPAN (LR_WPAN). LR_WPAN has low rate communication network that allow devices to communicate with application connectivity with limited battery support. Wireless Sensor Node consists of processor and memory. Its main components are as follows: sensing unit, Transceiver unit and Power unit. But some sensor nodes give support to GPS which helps to find out location [2]. This standard is responsible to develop standard for PHY and MAC layers, small flow of data and very complex solution to extend the life time of sensor nodes for a year [3]. IEEE 802.15.4 give support to MICAZ and TelosB. MICAZ mote is one of popular third generation wireless sensor motes, and belongs to crossbow technology products. Micas mote do not provide support on board sensors. Crossbow provide varied set of sensor boards that are connected directly to the Micaz mote and make it capable to measure humidity, light, temperature, barometric Pressure, acoustics, GPS position and magnetic fields. TelosB offers set of multipurpose onboard sensors which consists of light, humidity and temperature sensing sensor.[4] IEEE 802.15.4 standard provide low data rate wireless connectivity between low cost devices. The data rate is 250 kb/s which are high to satisfy some applications and it also provide low scalable 20 kb/s data rate need for sensor communication. Physical layer of IEEE 802.15.4 provides accurate ranging ability that is 1m.IEEE 802.15.4 support two types of function devices, Full Functional Device (FFD)which act as a coordinator and Reduced Functional Device (RFD) which cannot be operating as Coordinator at different frequency bands 868-868.6 MHz , 902-928 MHz and 2400-2483.5 MHz[5] .Rest of the paper is patterned as follows: Section 2 covers Sensor Energy Model, Section 3 presents Micaz and Telos B motes platform in detail, Section 4 represents what other researchers have been done in their perspective area a short review of this area, Section 5 give some overview of simulation Model, Section 6 provide detail description of Experimental setup with different

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scenarios, Section 7 gives results and discussion detail of our experimental work and Section 8 presents conclusion of our work.

2. SENSOR ENERGY MODEL.

In [6] the first order energy model in WSN is described as follow; energy is dissipated at a rate E_{elec}/bit for transmitted and receiving of data, this amount of energy is requested to run the circuitry of transmitter and receiver. In addition, transmit amplifier E_{amp} is used to transfer a bit at a required distance. $_{Eelec}$ =50nJ/bit and Eamp=100PJ/ bit/m2. The loss of energy due to distance is d^m, where m lie between 2<=m<=4, m stands for path loss exponent.

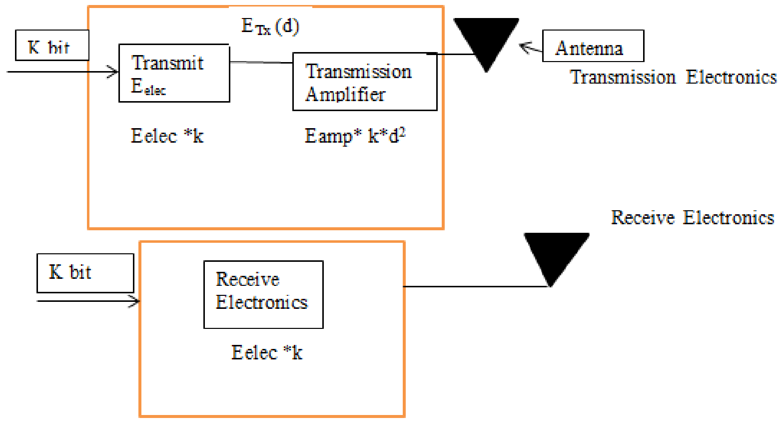

Figure1. Energy Dissipation Model (simplified from [5])

3. MICAZ AND TELOSB MOTES PLATFORM.

Micaz is tiny IEEE 802.15.4 complaint Radio Frequency (RF) Transceiver [7]. Micaz mote is specifically designed for intensely embedded sensor Networks, which provides support to 250 kbps data rate. Micaz motes are used in acoustic, security, videos and indoor building monitoring.

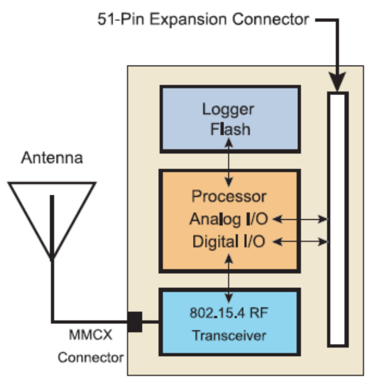

Fig 2. MPR2400CA Platform of Micaz mote (simplified from [7])

Micaz does not provide on board sensor support, all data achievement boards connect to Micaz via 51-pin Expansion Connector. Major specification of MPR2400 platform is:

- MPR2400 depends on low power microcontroller Atmel ATmega 128L.
- MPR2400 support program flash memory 128K bytes.
- MPR2400 IEEE 802.15.4 Micaz radio deals with high speed 250 kbps data rate and AES-128 hardware security.
- It supports RF power -24 dBm to 0dBm.

In [8], TelosB mote is also IEEE 802.15.4 complaint Radio Frequency (RF) Transceiver. TelosB mote is designed for low power research expansion and experimentation purpose. Two models of MEMSIC's TelosB are available: TPR2400 IEEE802.15.4 Processor and radio board, TPR2420 sensor suit mote.

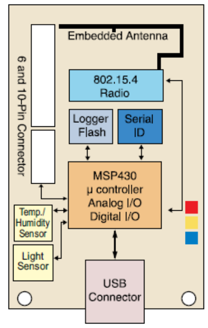

Fig 3. TPR2420 Platform of TelosB mote (Simplified from [8])

TelosB provides support to onboard sensor, integrated on board antenna, Open source Operating system, low consumption of current, programming and data collection are done via USB**.** Major specification of TPR2420 platform is:

- TelosB is also IEEE802.15.4 Complaint Radio Frequency (RF) Transceiver.
- It is supported data rate up to 250 kbps.
- TelosB support ISM band range from 2.4-2.4835 GHz globally.
- It provides integrated light, Temperature and humidity sensor support.
- TPR24200 and TPR2420 both motes have capability to interface with other devices.
- It supports RF power -24 dBm to 0dBm.

4. RELATED WORK.

Wireless Sensor Networks (WSNs) have become the cynosure for the researchers due to its sensing competence. Wireless sensor nodes are deployed in the inaccessible area. So, researchers have exhibited their interest to prolong the lifetime of sensor network and have conserved its energy through suitable battery source. Different researchers have done their research to select efficient battery vendors. Some works of these researchers are as following:

Johnson, M. et al., [4] presents a comparative review of different wireless sensor Nodes, under different parametric analysis. Review also reveals Power specification of Micaz and TelosB in detail. Madan,V. and Reddy, S [9] presents a case study of different Wireless sensor motes, detail analysis of its architecture, its Pros and cons , Application of Micaz and TelosB motes and many other.

Jurdak, R. et al., [10] proposed enhanced RFID impulse with adaptive radio low power of sleep modes which is based on Network's current traffic conditions. They introduce energy's node model which contain components of energy for reception & transmission, radio switching, listening and sleeping. They also analyze energy performance for both TelosB and Micaz, disregarded to energy microcontroller. Comparison between Adaptive low power nodes with IEEE 802.15.4 and BMAC based on two different nodes platform by make changing in data rates. Comparison results reveal that enhanced RFID impulse provides 20 times less energy consumption than IEEE802.15.4 in terms of low traffic. IPPP Hurray Research Group. [11] design WPAN node model that support two node models with 250kbps, 2.4 GHZ frequency and QPSK modulation. MAC layer give support to IEEE 802.15.4 protocol for both beacon enabled and non-beacon enabled mode. This model also provides support to Micaz and TelosB battery module. By default, WPAN model 2003 provides support to Micaz battery module.

In [12], researchers investigate the cryptographic protocol in terms of communication and computation based on Micaz and TelosB sensors. This paper emphasis on the cost of two cryptographic protocols: Kerberos and the ECDH-ECDSA key exchange protocol, result reveals that Kerberos is less costly than ECDH-ECDSA. Communication and commutation cost of both protocols are checked on Micaz and TelosB motes, TelosB has showed less computational cost with increase in communication.

5. SIMULATION MODEL.

OPNET (Optimization Network Evaluation Tool) simulation is selected due to its convenient analysis and technique of presentation task that is not provided by other Network simulation tool. Validity of the

OPNET simulation results and the tools is highly reliable and efficient. OPNET modeler facilitates its user with full GUI support. OPNET Modeler version 14.5 is used in this work to design network and its execution. OPNET technologies offers drag and drop communication environment, Object Palette (icon) which gives support maximum network models and virtual environment for simulation. WPAN model is selected within OPNET 14.5 to check the energy consumption of wireless sensor node.

One of the most significant factors of WSN is to select appropriate less consumption battery module. In [11], IPP Hurray IEEE 802.15.4 Energy module V2.0 gives support to these attributes by default. By default WPAN gives support to MICAZ mote here we discuss attributes for both motes to check its energy consumption rate.

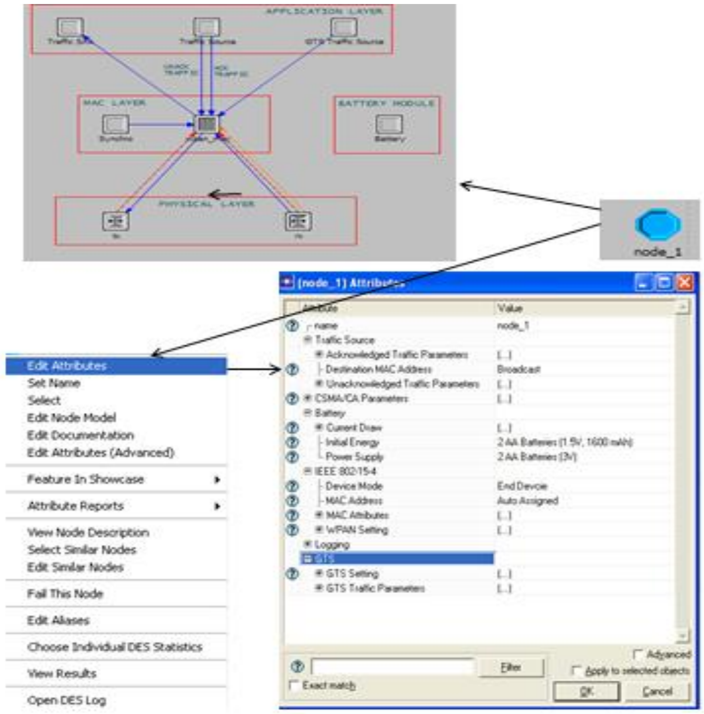

Fig 4. WPAN Simulation Model in OPNET Modeler 14.5 v2.0

Table 1. Parametric values for GTS PAN Coordinator and End devices in Battery Modules

Sr. NO.	Attributes	MICAZ	TelosB
1	Receive mode	27.7 mA	24.8 mA
2	Transmission mode	0 dBm (varies)	0 dBm (varies)
3	Idle mode	35 µA	26.1µA
4	Sleep mode	16 µA	6.1µA
5	Initial Energy	(1.5,1600 mAh)	(1.5,1600 mAh)
6	Power Supply	2AA Batteries (3V)	2AA Batteries (3V)

6. EXPERIMENTAL SETUP

This scenario is designed to check the efficiency of two different Wireless sensor node battery's vendors**.** Here, comparisons between Micaz and TelosB motes are made to check which one consumes less energy. We have made scenario on OPNET Modeler 14.5 which gives support to two battery modules motes i.e. Micaz and TelosB by setting suitable attributes in both cases. Attributes of MICAZ and TelosB that are used in scenario as follows:

Experimental setup consists of 4 GTS end nodes and one PAN node with varies in data rate to check efficiency of the battery modules. Two experimental setup are designed, one is based on all possible parameters combination of Micaz and TelosB battery with constant payload size 100 bits, to check which one combination will provide prolong life time of sensor node. Within second setup, one same WSN model is designed with increase in data packet size 100, 400, 600 and 800 bits for both Micaz and TelosB battery modules to examine the results and efficiency of both modules which has the ability to run for longer period of time.

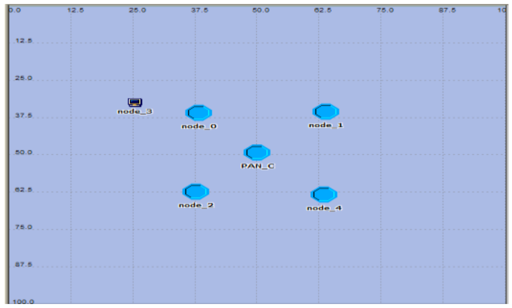

Fig 5.WPAN Model

Table 2. OPNET SIMULATION PARAMETERS FOR SCENERIOS

Parameters	**Value**
Physical & MAC Model	IEEE 802.15.4
Simulation Area	100 *100 m
Number of end nodes	4
Simulation time	1000s
Data rate	250 kbps
Frequency Channel	2.4 GHz
Energy Model	Micaz&TelosB
Payload Size	100bits
Arrival rate	1.0 s

We have built 12 possible scenarios by making possible combination of different battery's Receive mode, sleep mode ,idle mode with selecting appropriate battery's transmission modes (0dBm, -5dBm , -10dBm), to check energy consumption by changing sleep mode, receive mode and idle mode values that is by default specified for TelosB and Micaz mote within WPAN v2.0.

In [13],dBm is an abbreviated of decibel mill watt, which is log measurement of Power ratio of measured power in dB referenced to 1mW.Unit Conversion formula from Power level to Power and vice versa:

Power level conversion Formula:

$$dB = x = 10 \log P_2 / P_1$$

Or $$dB = x = 10 \log P_2 / 1mW$$

Power Conversion Formula:

$$\mathbf{P = 1mW.10^{x/10}}$$

Or $$\mathbf{P = 1000\ \mu W.10^{x/10}}$$

By default WPAN v2.0 model within OPNET Modeler 14.5 provide support3 possible transmission mode (0dBm, -5dBm, -10dBm) values in Power level. We can check its Power by using Power conversion formula, to analyze how much Power is consumed in each power level. Power of Transmission mode at 0 dBm in milliwattmW:

$$\mathbf{P = 1mW.10^{x/10}}$$

As x = 0 dBm

So, $P = 1mW . 10^{0/10}$

$P = 1mW. 10^0$ $\quad\quad 10^0 = 1$

P = 1mW. 1

P = 1mW

Similarly, 3.16mW power at -5 dB and 0.1 at -10mW.These transmission powers indicate that at -5 dBm the transmission power level is high as compared to 0dBm. While -10 dBm shows low transmission power level as compared to both 0 dBm and -5 dBm.Our aim is to design such scenarios to check which combinations of battery module consume less energy. Here, we have made combinations of different transmission and received mode for battery module (Micaz or TelosB) with appropriate selection of sleep mode idle mode.

6.1: Four Possible combinations of each0dBm,-5dBm and -10dBm transmission mode for Micaz and TelosB are as follow:

Combination 1: Both transmission and receiver modes are selected as Micaz transmission and received mode, with appropriate selection of sub-combination of Micaz or TelosB sleep and idle mode values.

Combination 2: Transmission mode of a battery is selected as Micaz value and receiver mode is selected as TelosB value, with appropriate selection of sub-combination of Micaz or TelosB sleep and idle mode values.

Table 3. Combination of Transmission modes at 0dBm,-5dBm and -10 dB

COMBINATION 1: BOTH BATERRY'S TRANSMISSION AND RECEIVE MODES ACT AS MICAZ at 0,-5 and -10dBm				
Category	**Transmission Mode**	**Receive Mode**	**Idle Mode**	**Sleep Mode**
A1	MICAZ (0dB m , -5dBm , -10dBm)	Micaz (27.7mA)	Micaz (35µA)	Micaz (16µA)
B1	MICAZ (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	TelosB (26.1µA)	Micaz (16µA)
C1	MICAZ (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	Micaz (35µA)	TelosB (6.1µA)
D1	MICAZ (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	TelosB (26.1µA)	TelosB (6.1µA)
COMBINATION 2: BATTERY'S TRANSMISSION MODE ACT AS MICAZ TRANSMISSION MODE AND RECEIVES MODE ACT AS A TELOSB RECEIVE MODE at 0,-5 and -10dBm				
A2	MICAZ (0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	Micaz (35µA)	Micaz (16µA)
B2	MICAZ (0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	TelosB (26.1µA)	Micaz (16µA)
C2	MICAZ (0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	Micaz (35µA)	TelosB (6.1µA)
D2	MICAZ (0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	TelosB (26.1µA)	TelosB (6.1µA)
COMBINATION 3: BATTERY'S TRANSMISSION MODE ACT AS TELOSB TRANSMISSION MODE AND RECEIVES MODE ACT AS A MICAZ RECEIVE MODE at 0,-5 and -10dBm				
A3	TelosB (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	Micaz (35µA)	Micaz (16µA)
B3	TelosB (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	TelosB (26.1µA)	Micaz (16µA)
C3	TelosB (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	Micaz (35µA)	TelosB (6.1µA)
D3	TelosB (0dB m, -5dBm , -10dBm)	Micaz (27.7mA)	TelosB (26.1µA)	TelosB (6.1µA)
COMBINATION 4: BOTH BATERRY'S TRANSMISSION AND RECEIVE MODES ACT AS MICAZ at 0,-5 and -10dBm				
A4	TelosB(0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	Micaz (35µA)	Micaz (16µA)
B4	TelosB (0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	TelosB (26.1µA)	Micaz (16µA)
C4	TelosB(0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	Micaz (35µA)	TelosB (6.1µA)
D4	TelosB(0dB m, -5dBm , -10dBm)	TelosB (24.8mA)	TelosB (26.1µA)	TelosB (6.1µA)

Combination 3: Transmission mode of battery is selected as TelosB value and Receiver mode as a Micaz value, with appropriate selection of sub-combination of Micaz or TelosB sleep and idle mode values.

Combination 4: Both transmission and receiver modes are selected as TelosB transmission and received mode values, with appropriate selection of sub-combination of Micaz or TelosB sleep and idle mode values.

6.1.1 Experiment 1: Possible Combination of Transmission mode at 0dBm,-5dBm and -10 dBm:
Here, we have showed all possible combination of Transmission mode at 0dBm , -5dBm and -10dBm with other Micaz or TelosB battery module parameters. We have made these combinations to check at which idle and sleep mode stage battery will show less consumption of energy.

6.2: Experiment 2: Comparison between Micaz and TelosB battery with varies in MSDU size:
Within this scenario, we have analyzed the efficiency of Micaz and TelosB battery with its own parameters: sleep mode, idle mode, receive mode, to check which one's battery show less energy consumption results with change in MSDU size i.e. 100, 400, 600 and 800 bits. We analyze it at 0dBm transmission mode.

Table 4.Parameters Settings For Different Payload Size Scearios

Parameters	Value
Physical & MAC Model	IEEE 802.15.4
Transmission mode	0dBm
Simulation Area	100 *100 m
Number of end nodes	4
Simulation time	1000s
Data rate	250 kbps
Frequency Channel	2.4 GHz
Energy Model	Micaz&TelosB
Payload Size	100,400,600,800 bits
Arrival rate	1.0 s

7. RESULTS AND DISCUSSION.

We have made simple scenario with five active GTS WPAN nodes, one is Coordinator node and other four are end nodes by changing its battery parameters to obtain less consumption of energy among these battery's combinations. Experiment 2 based on comparison between Micaz and TelosB by change in payload size. This section covers the results analysis of both experiments with detail discussion.

Result analysis of combination 1. Combination 1 consists of both battery's transmission and receive mode values as a Micazvalueat 0dBm,-5dBm and -10 dBm.Three graphical Analyses at different Micaz transmission modes i.e. 0dBm, 5dBm, -10dBm, show that at category A1which combination of all Micaz parameters values is: show high energy consumption as compared to other categories. Category B1 is a combination of Micaz transmission mode, Micaz receive mode, and TelosB idle mode and Micaz sleep mode values. Result show that energy consumption at category B1 is less than as compared to A1 at all different Micaz transmission modes (0dBm, -5dBm, -10dBm). As we build combination of Micaz transmission and receive mode values with TelosB sleep mode, drastically change appear graphically, Energy consumption are reduced in category C1 because of adding TelosB sleep mode. Category 4 show less consumption of energy among all three categories, in this case TelosB sleep and idle modes are chosen which will show less amount of energy consumption.

Results reveals that if battery Transmission and receive mode act as Micaz mode values and its sleep mode and idle mode change into TelosB values, battery will consume less energy as compared to other Combination . Results also show that -10dBm transmission mode is best to conserve energy.

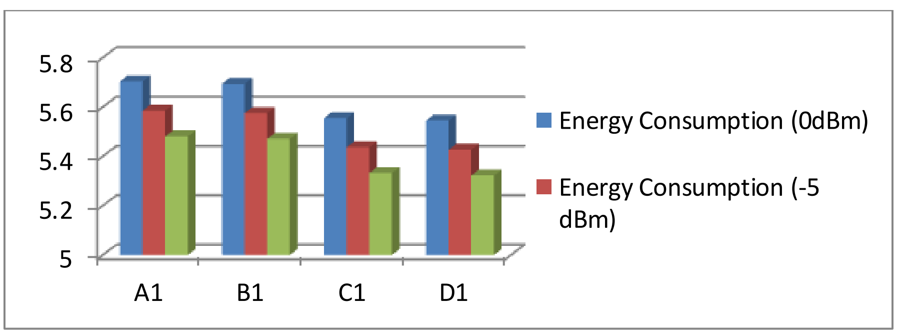

Fig 6. Energy Consumption results of Combination 1

Result analysis of combination 2.

Combination 2 consists of battery's transmission mode as Micaz transmission mode value and receives mode as a TelosB receive modevalueat 0dBm,-5dBm and -10 dBm.

Overall energy consumption result is reduced as compared to Combination 1. C1 show higher graph value 5.7 Joule but C2 show 5.2 higher energy consumption values. Here, we have used Micaz transmission modes with the combination of TelosB receive mode values. Result reveals that by using TelosB receive mode values energy consumption of battery is reduced. Each category of Combination 2 show graphically same result as combination 1 mean category A2 consume higher and D2 consume less energy but total energy consumption is less than Combination1 and still TelosB sleep mode and idle mode reduce the energy consumption values at D2. Again Transmission mode at -10dBm will show less energy consumption results.

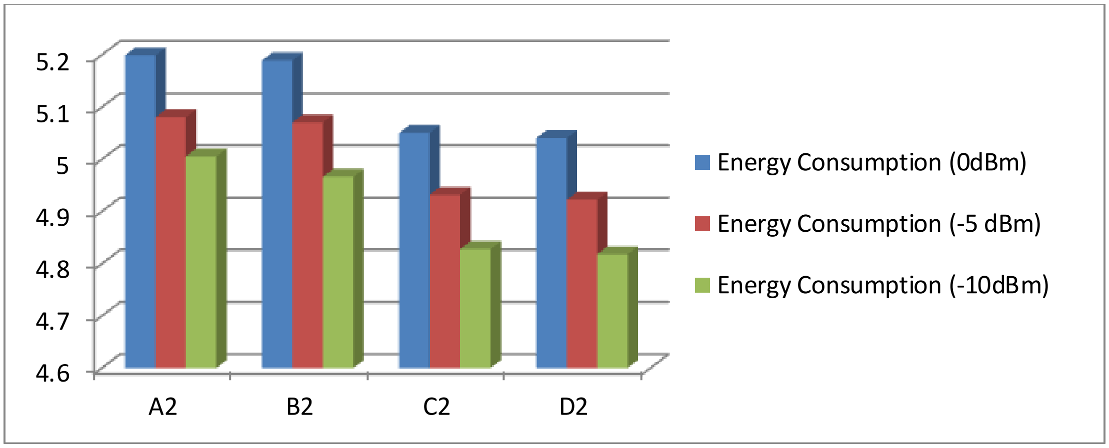

Fig 7. Energy Consumption results of Combination 2

Result analysis of combination 3.

Combination 3 consists of battery's transmission mode as TelosB transmission mode values and receives mode as a Micaz receive mode value at 0dBm,-5dBm and -10 dBm transmission mode. Combination 3 is not showing good result; again graph will show higher consumption of energy. Battery module of Combination 3 acts as TelosB transmission mode and receive mode act as Micaz receive mode value. Results reveals that Micaz receive mode is not good choice for battery; a higher energy consumption result in Micaz mote due to its receive mode value selection. Transmission mode at -5dBm show less consumption of result as compared to other transmission mode but at each category it is showed same result of energy consumption, which is not good choice.

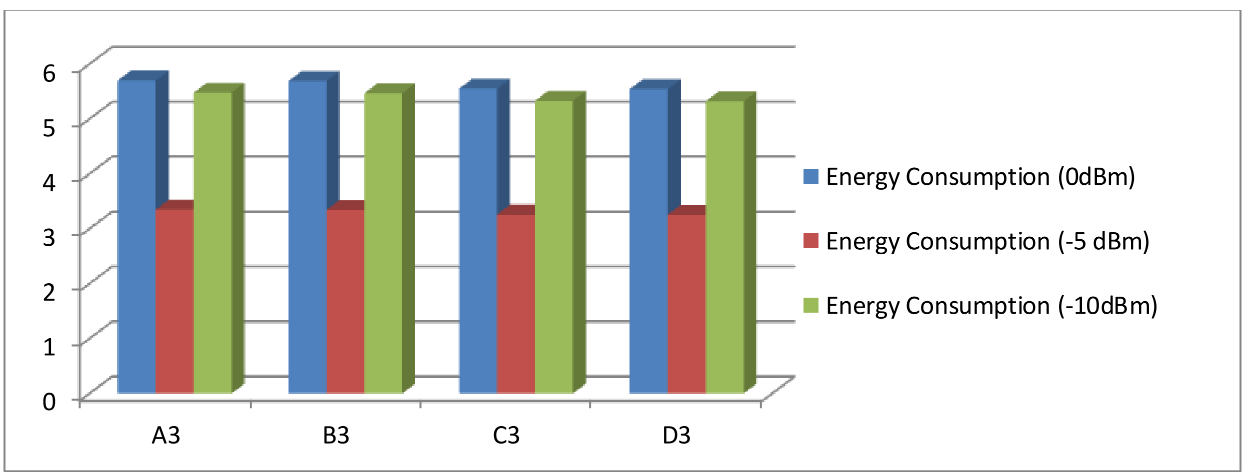

Fig 8. Energy Consumption results of C3

Result analysis of combination 4.Combinations 4 consist of both batteries transmission and receive modes as TelosB value at 0dBm,-5dBm and -10 dBm transmission mode. Combination 4 shows less consumption of energy which consists of all TelosB parameters values. Total energy consumption is reduced and energy efficient results are achieved in case of TelosB battery module at category D4. At -10dBm transmission mode show less consumption of energy at D4.

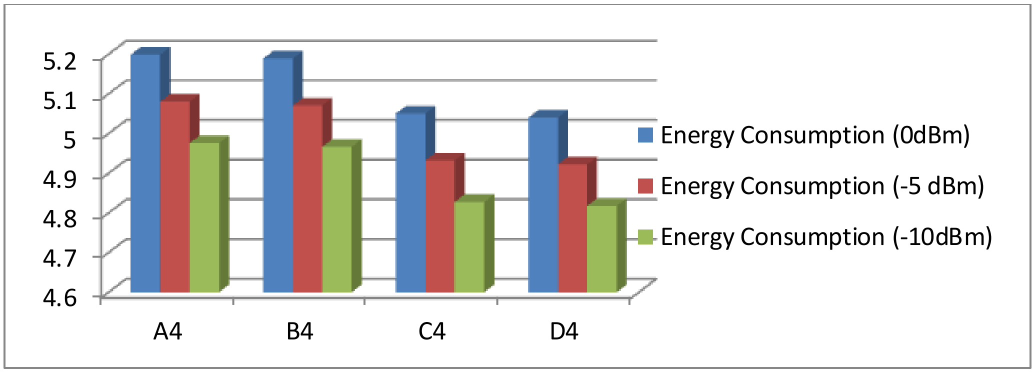

Fig 9. Energy Consumption results of Combination 4

7.5. **Result Analysis Of Comparison Between Micaz And Telosb Battery With Varies In Msdu Size.**

We have increased the traffic load to check the results of two batteries mote which one consume less energy during practically increase in traffic. As traffic is increased in WSN, energy consumption is also increase.

Table 5: comparison between Micaz and TelosB mote

Payload Load (bits)	Micaz Energy Consumption	TelosB Energy Consumption
100	5.00904563	5.040372215
400	7.9462255	7.074731519
600	9.44154778	8.430947501
800	10.93692394	9.78720366

Results reveals that with the increase of traffic load 100 , 400, 600 and 800 bits, energy consumption of Micaznodesbecome5.00904563 , 7.9462255 , 9.44154778 and 10.93692394joule.Whilein case of TelosB, energy consumption become 5.040372215 , 7.074731519, 8.430947501, 9.78720366 Joule. TelosB show less consumption of energy due to its efficient sleep and idle time mode.

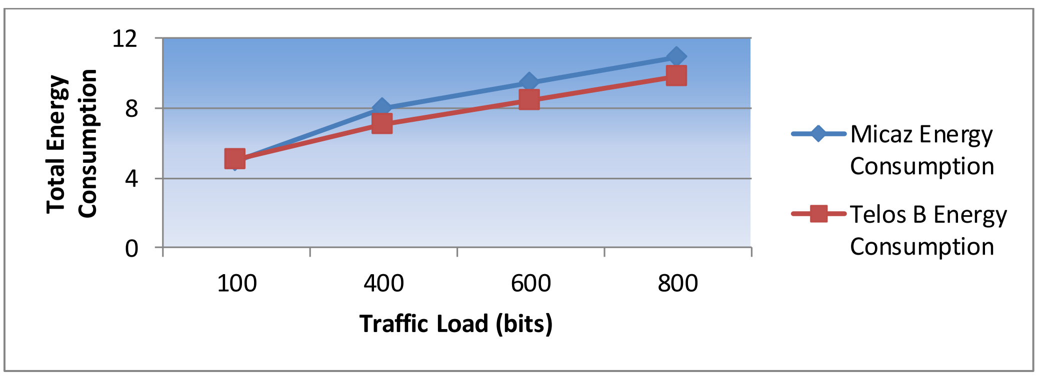

Fig 10. Energy Analysis of Micaz and TelosB mote

TelosB battery is more energy efficient than Micaz mote. Graph show that with the increase of traffic energy consumption also increase but TelosB node show less consumption of energy as compared to Micaz node.

8. CONCLUSION

This paper presented a comparison between two batteries vendors Micaz and TelosB on OPNET Modeler 14.5. We have analyzed two different batteries modules, Micaz and TelosB with alternate combination of its parameters i.e. Sleep mode, receive mode , transmission mode and idle mode to analyze which parameter of battery module cause higher results of energy consumption. Four major combinations are built to perform simulations. Results of Combination 1 reveals that if battery Transmission and receive mode act as Micaz mode values and its sleep mode and idle mode change into TelosB values, battery will consume less energy as compared to other Combination and at-10dBm transmission mode is best to conserve energy. Combination 2 results reveal that TelosB sleep and idle mode values selection with combination of Micaz transmission mode value and TelosB receive mode value show less consumption of results. It means TelosB sleep mode and idle mode values is quite energy efficient than Micaz values and at -10dBm transmission mode of combination 2 consumed less energy. Combination 3 showed large amount of energy consumption results. Combination 3 results have revealed that Micaz node causes high energy consumption due to its receive mode value. All categories results of Combination 3 show higher energy consumption at each transmission mode except at -5dBm but overall energy consumption is high. Combination 4 show excellent results due to TelosB transmission and receive mode values selection.

To check overall Micaz and TelosB results by increasing traffic load, results reveal that the TelosB consume less energy as compared to Micaz node. To control over Micaz receive mode and idle mode values energy consumption results can be controlled easily. TelosB sleep and idle mode make it efficient over Micaz mote.

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