VOLCANO ERUPTION ESTIMATION & SENSOR HEALTH ESTIMATION OF NODES IN WSN

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ABSTRACT : Because of many upcoming real-time applications in Wireless Sensor Network (WSN), it has become one of the emerging areas for research. For applications such as monitoring natural disasters like volcano eruption, earthquake, Forest fire etc., or applications like healthcare, checking of soil moisture, machine surveillance etc., an energy-efficient and reliable protocol is required. In such applications, the situation needs to be handled urgently and reliably when the temperature of the region crosses the threshold value. As we are moving forward into an era of human-centric safety-critical applications, it is particularly important to make sure that a networked system offers a reliable and deterministic performance despite all possible temperatures changes over its deployment lifetime. It is important to learn the properties of such natural disasters to provide warning well in advance. Temperature affects the performance of the sensor nodes. In our work, we have implemented a system that will monitor the variation in temperature and its effect on sensor nodes. In our work, we will observe the effect of the rise in temperature on the functionality of the node. The change in temperature affects the RSSI value which is used as an indicator for detection of volcano eruption.

Keywords: Board-temperature, Localization, Sensor Node, RSSI, WSN, Zigbee

I. INTRODUCTION

Wireless Sensor Network (WSN) nodes have become omnipresent as their applications are increasing day by day. WSN is formed by a network of tiny shaped wireless computers referred to as nodes that sense some physical phenomenon of the environment such as temperature, moisture, humidity, temperature, vibration etc. They vary in numbers from few to many depending on applications. Sensor nodes in WSN are resource-constrained in terms of memory, processing and battery power, size, cost etc. Normally nodes in WSN are powered by non-rechargeable battery hence specific power management strategies are required.

Temperature affects the performance of the sensor nodes and impacts at the device level. However, this impact of the temperature on network performance needs to be given more attention. Energy harvesting has been an intensive research area in wireless sensor networks (WSNs). The temperature variation impacts the charging process of rechargeable cells.

Temperature strongly affects the operation of integrated circuits, and its impact has been largely investigated on a device level. However, the impact of temperature variations on networks of

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multiple devices is far less understood and requires investigation. We aim to close this gap and analyze the impact of temperature fluctuations on low-power wireless sensor networks, a key enabling technology of pervasive computing. As we are moving forward into an era of human-centric safety-critical applications (e.g., smart health and intelligent transportation systems), it is particularly important to make sure that a networked system offers a reliable and deterministic performance despite all possible temperatures changes over its deployment lifetime.

Localization is a very important aspect in WSN where the exact location of the node needs to be finalized. There are two ways to know the location of nodes in WSN. The first is Range-based localization and the second is range-free type of localization. To check the health of nodes it is important to know their location correctly. In the proposed work. Both the types of localization schemes are used. Received Signal Strength Indicator (RSSI) from a range-based and hop count from range free type of localization.

The change in temperature affects the electronic properties of the node. When temperature increases RSSI value of the received node also changes. If the temperature goes beyond threshold value, wrong RSSI values are received which indicates that sudden rise in the temperature which ultimately detects the presence of volcano eruption [1-3].

II. LITERATURE SURVEY

Christos Laoudias et al. [4] considered the problem of target (event source) tracking using a binary Wireless Sensor Network (WSN). For tracking the sensor node in WSN, detection of the presence of a node in an area around it must use the localization information which is received by individual nodes. Using this information, the localization of the new node is confirmed. However, any adversary attacks, software and hardware malfunction, energy scarcity etc. make localization of node very challenging. Authors, in their work, have investigated three algorithms which have estimated the health of the sensor node along with its localization. They have concluded that to improve fault tolerance in binary WSN, a reliable and accurate state of sensor i.e. whether it is healthy or faulty must be estimated correctly.

Rafael Lajara et al. [5] have used rechargeable batteries of Telosb nodes to show the process to acquire node’s training data along with its generation and validation of experimentation. In their methodology, they have generated a model which estimates SoH of rechargeable batteries of WSN nodes. Though their method gives accurate SoH evolution, it increases the computational cost. Their model is suitable for simple motes and small networks. However, if the complexity of nodes and networks increases it will consume more battery and computational power.

Shaobo Mao et al. [6] in their paper, studied the energy allocation for sensing and transmission in an energy harvesting sensor node with a rechargeable battery and finite data buffer. In their work, authors have worked to get optimum throughput of a sensor node in context to energy availability in the battery, channel fading and time-varying energy harvesting rate. They have proposed an optimal

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energy allocation (OEA) algorithm with dynamic programming by considering the energy allocation problem as a sequential decision problem. In simulation, it is observed that OEA algorithm gives optimum throughout.

Carlo Alberto Boano et al. [7] have analyzed the effect of temperature fluctuations in low power WSN nodes. In their work, authors have used infrared heating lamps which vary the temperature of the sensor board in a repeatable manner. They have proved that variation in temperature affects network performance. Wireless link quality gets degraded when temperature affects the performance of the radio receiver. They have used signal strength information to quantify and parameterize the performance degradation of link quality due to variation in the temperature.

III. EFFECT OF TEMPERATURE ON NODES IN WSN

Major applications of WSN sensor nodes are in an outdoor environment where it monitors natural phenomena such as forest fire, volcano eruption earthquakes etc. and civil infrastructure like road tunnels, bridges, industrial production processes, heritage buildings etc. After experimentation, it is concluded that the temperature of sensor nodes that are packaged in airtight enclosures can vary up to 82ºC in different seasons and 56ºC from day to night. It has been further studied that this temperature variation strongly affects the efficiency of batteries and electronics of the WSN nodes. It also affects the synchronization process for duty-cycled Medium Access Control (MAC) protocols. These temperature variations have a strong impact on battery capacity and lifetime WSN node [8] [9].

The research area where the study of the impact of temperature on the functionality of sensor nodes has got little less attention. The variation in temperature which is mentioned earlier affects the RSSI values also which ultimately reduces the packet reception rate from 100% to 0%. Reduction in RSSI values affects the routing protocols at the network layer which will further reduce the energy efficiency, throughput and increase in delay.

It is difficult to get a clear picture of the impact of temperature on routing protocols using the real-world applications of WSN node deployment. It is difficult to conclude the impact of temperature on outdoor WSN real-world deployments. Also, the atmospheric conditions at the placement are not the same at the same time of a specific period of the year. In our work, we have experimented with the effect of temperature on sensor nodes and verified how RSSI values change with the variation in the temperature and also how it affects the networking protocol.

The study we have carried out is to check the change in temperature at the time of the volcano eruption. It uses the property of change in RSSI value due to temperature change for detection of Volcano eruption. If temperature goes beyond the threshold value, an error in RSSI values will be received which can be considered as an indicator of the presence of volcano eruption [10].

IV. IMPLEMENTATION:

Our aim is to detect the environment temperature near volcano

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eruption areas which are closer to residence. Here we are going to detect temperature of board as well environment temperature where lava may explode frequently. After every 5 sec we will receive temperature (environment) + temperature (board) + battery charging level (%) from routers to coordinator node. As the temperature of processor exceeds above 85°C , its efficiency decreases and its electrical parameters changes drastically. And it leads to corruption of data in processor & process noise within the original data. Thus we can conclude that the data received by the router node whose temperature is above its tolerance level, gives us garbage value. Using this conclusion we can neglect the data from such nodes.

1. Methodology:

The proposed work can be implemented with the methodology as shown in block diagram shown in Fig.1. The arrangement of the nodes are shown in pictorial form in Fig. 2.

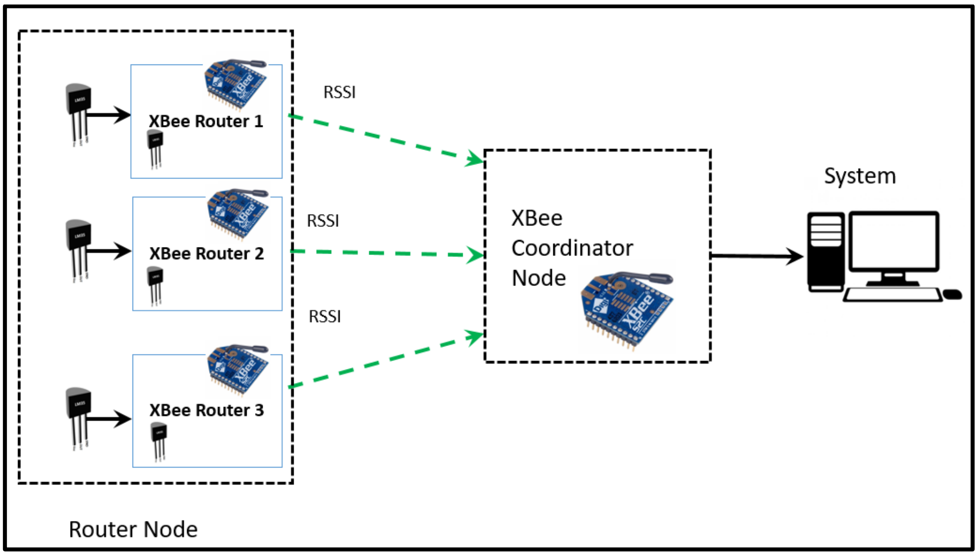

Fig.1: Block diagram of proposed work

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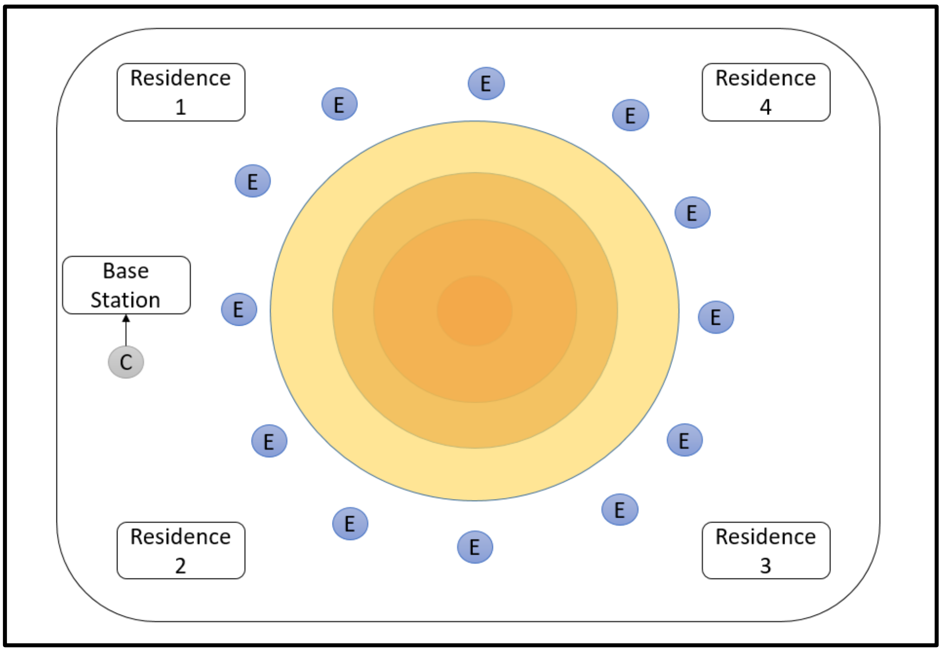

Fig. 2: Schematic of Node Deployment

a. Node-

- It is a basic unit of WSN. Fig. 3 gives the idea about it.
- Contains on board sensors, micro-controllers, memory, transceivers, and power supply.
- Wireless Sensors have limited sources in memory, computation power and energy(battery).
- With small size it can be easily embedded in the physical environment.
- Wireless communication, avoids lots of wiring and makes network design less complex.
- Accessed through centralized node called base station.

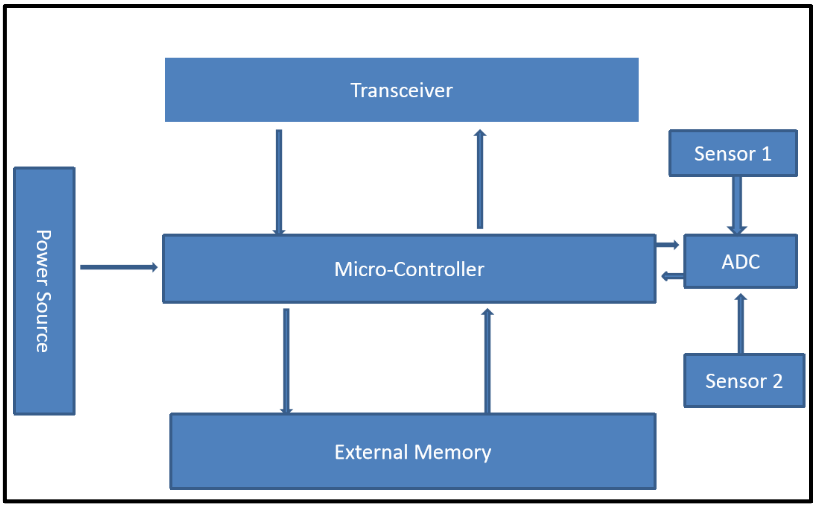

Fig.3: Block Diagram of Sensor Node

b. Why Board Temperature?

- As the temperature of the processor exceeds above 85°C, its efficiency decreases and its electrical parameters change drastically.

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- And it leads to corruption of data in the processor & process noise within the original data.
- Thus we can conclude that the data received by the router node whose temperature is above its tolerance level, gives us garbage value.
- Using this conclusion we can neglect the data from such nodes.
- As we are using Zigbee node for communication the breif details of it are shown in Fig. 4 [11][12].

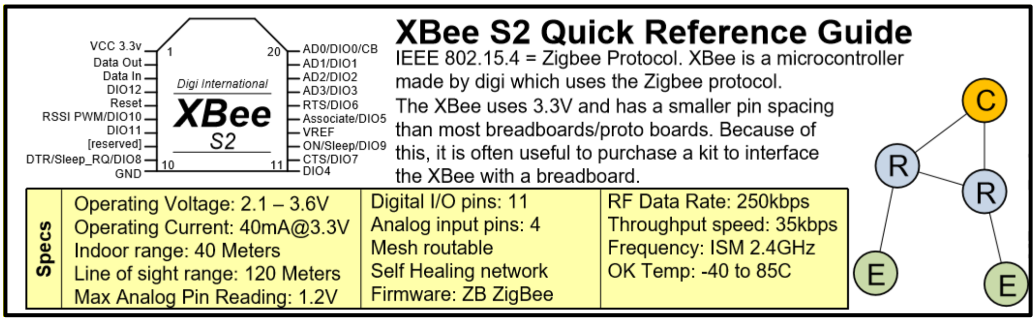

Fig 4: Board Temperature Range

c. Algorithm:

Coordinator Algorithm

- Initialize UART of Microcontroller.
- If data is available at serial port, make sure the Frame is all there.
- Check for first byte of frame 7E (Start Delimiter).
- Discard next 11 bytes.
- Read and store 13^{th} and 14^{th} byte of frame in variables as 16 bit Source Address.
- Discard next 5 bytes of the frame.
- Read and store 20^{th} and 21^{st} bytes as analog MSB and analog LSB
- Calculate Temperature as:
- Analog Value = analog LSB + (analog MSB * 256)
- Temperature = analog Value *(AVDD* 1000/1024)
- Print 16 bit Source Network Address on Serial Monitor.
- Print Temperature on Serial Monitor.
- Serial Print "+++" to enter in command mode.
- Read the OK confirmation then Serial Print "ATDB" read the DB parameter stored in the Xbee.
- Print and store RSSI = DB parameter.
- Serial Print "ATCN" to Exit Command Mode.
- Repeat 1 to 14 for 15 min
- Find the maximum RSSI (RSSImax) :
- RSSImax = Max [all RSSI received in 15min]
- Repeat 1 to 14.
- If (RSSI > RSSImax)
- Then {
- Declare for Attack
- Repeat 17 and 18.

Attacker Node Algorithm

- Set AT Commands DL & DH to 00 for data to send to Coordinator.
- Initialize UART of Microcontroller.
- By Using PAN ID of network Attacker Node enters in the Network.
- Update the DL & DH parameter of Target Node :

DL+ DH = Attacker's own 64 bit MAC Address

- If data is available at serial port, make sure the Frame is all there.

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- Check for first byte of frame 7E (Start Delimiter).
- Discard next 19 bytes of the frame.
- Read and store 20th and 21st bytes as analog MSB and analog LSB
- Analog Value = analog LSB + (analog MSB * 256)
- Serial Print analog Value to transmit to coordinator.
- Repeat 4 to 9

Router Setting

1.DL & DH = 00
2.D3 = ADC[2] (pin 17)
D2= ADC[2] (pin 18)
D1= ADC[2] (pin 19)

3.IR$_{R1}$ = 2710
IR$_{R2}$ = 3A98
IR$_{R3}$ = 4E20

V. OUTPUT:

The output of the system is as shown in the Figs. 5, 6 7. Fig. 5 shows that if temperature increases, RSSI value reduces.

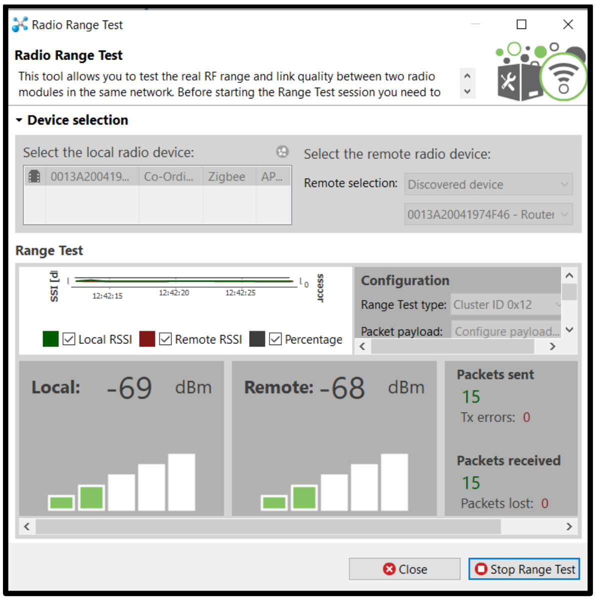

Figure 5: RSSI Range Test of Router 1

Fig. 6 and Fig. 7 show the output when temperature is within a range and when it exceeds beyond the threshold value respectively. The threshold value we have considered as 60°C. So when temperature goes beyond 60°C, some garbage values are displayed which is shown in Fig. 7. [13-16].

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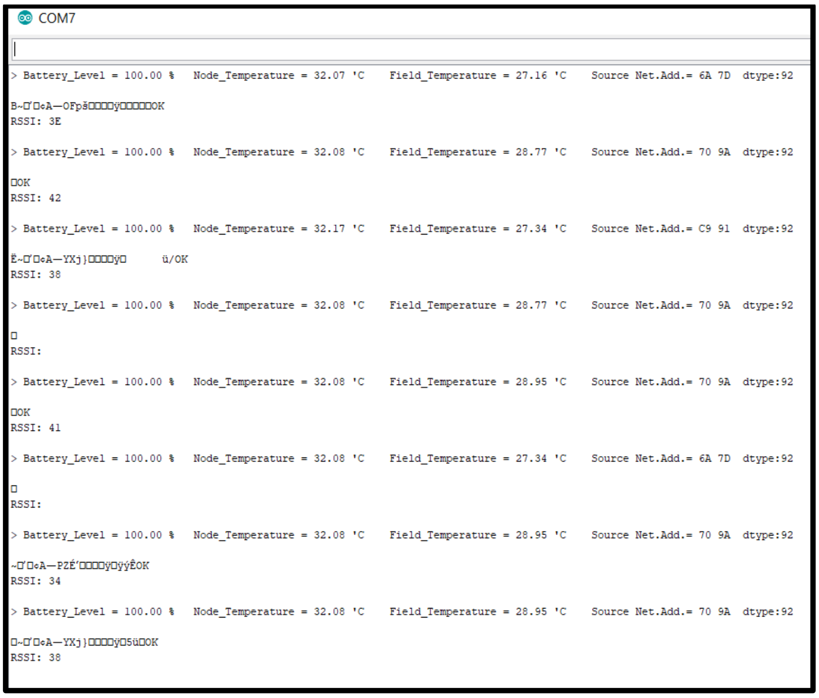

Figure 6: Result without attack

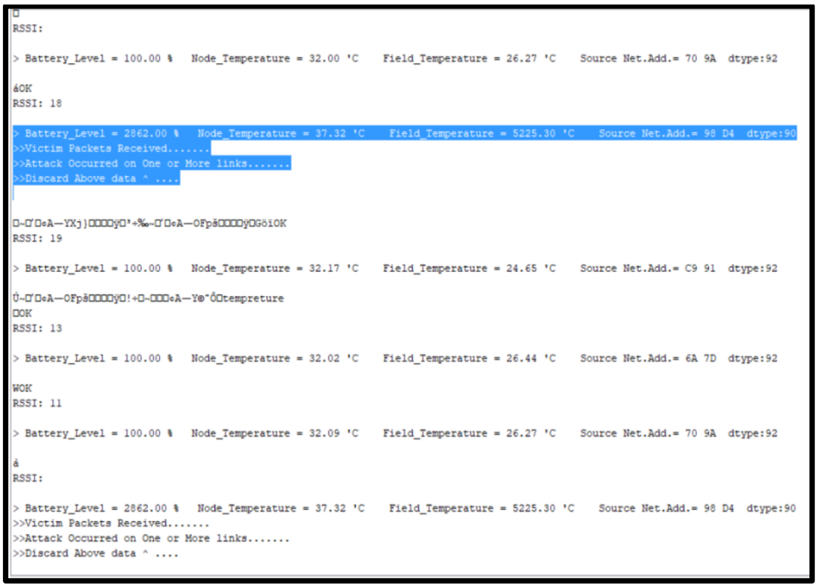

Figure 7: Result with attack

VI. CONCLUSION

In real world applications of WSNs, sensors often fail and report erroneous observations for various reasons, thus compromising the trust of people towards WSNs technologies. In this paper, we investigate the use of a sensor network for detecting, identifying and tracking the change in temperature at extreme rise in the temperature. We present a fault tolerant tracking algorithm which is a low complexity, distributed method suitable for real-time applications in WSNs. We verify the efficiency of our tracking method through simulations, even when a large percentage (25%) of the nodes report erroneous observations due to various

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reasons, such as random sensor faults. For simulation, Cooja simulator is used which has support to various types of nodes.

We have concluded that as the temperature goes beyond 60^{o}C then there is a risk of lava spreading near our observation area, thus giving an alarming signal to the residents to rescue themselves. We have also concluded that the data received at 80^{o}C from XBee nodes is corrupted data and it should be considered as a garbage value. Since the normal working temperature condition for XBee is 85^{o}C.

REFERENCES

[1] Soeharw into , Emerson Sinulingga and Baihaqi Siregar,Remote Monitoring of Post-eruption Volcano Environment Based-On Wireless Sensor Network (WSN): The Mount Sinabung Case International Conference on Computing and Applied Informatics 2016 IOP Publishing IOP Conf. Series: Journal of Physics: Conf. Series 801 (2017) 012084 doi:10.1088/1742-6596/801/1/012084

[2] Ms. Snehal Deshmukh, Dr. S. S. Sonavane, “Security Protocols for the internet of Things: A Survey”, 2017, 978-1-5090-5913-3/17/$31.00_c 2017 IEEE. **DOI:**10.1109/ICNETS2.2017.8067900.

[3] M Ozaki, Y. Adachi, Y. Iwahori, and N. Ishii, Application of fuzzy theory to writer recognition of Chinese characters, *International Journal of Modelling and Simulation, 18(2),* 1998, 112-116.

[4] Christos Laoudias, Michalis Michaelides, Christos G. Panayiotou, Sensor health state estimation for target tracking with binary sensor networks, Article in IEEE Transactions on Mobile Computing · June 2014 DOI: 10.1109/TMC.2013.2297319

[5] Rafael Lajara et al., Predicting the batteries the State of Health in Wireless Sensor Networks applications, 2018, *IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS.*

[6] Shaobo Mao et al., An Optimal Energy Allocation Algorithm for Energy Harvesting Wireless Sensor Networks, 2012, *IEEE ICC 2012 - Ad-hoc and Sensor Networking Symposium.*

[7] Carlo Alberto Boano and Kay R¨omer et al., Demo Abstract: A Testbed Infrastructure to Study the Impact of Temperature on WSN, 2014, *2014 IEEE International Conference on Pervasive Computing and Communications Demonstrations.*

[8] J. Yang et al., Onboard state-of-health estimation based on charging current analysis for LiFePO4 batteries, 2017, *IEEE Energy Conversion Congress and Exposition (ECCE), Cincinnati, OH, 2017, pp. 5229-5233*.

[9] Mrs. Snehal Deshmukh Bhosale, Implementation of 6 LowPan Border Router (6BR) in the Internet of Things, 2018, *International Journal of Innovations & Advancement in Computer Science IJIACS ISSN 2347 – 8616 Volume 7, Issue 3 March 2018.*

[10] M. Berecibar et al., Critical review of the state of health estimation methods of Li-ion batteries for real applications, Renewable, and Sustainable Energy Reviews, 2016, *Volume 56, April 2016, Pages 572-587, ISSN 1364-0321*.

[11] Ahmad Farhat et al., Impacts of wireless sensor networks strategies and topologies on prognostics and health management, 2017, *received: 6 February 2017 / Accepted: 16*

ISSN (Print): 2204-0595
ISSN (Online): 2203-1731

November 2017©Springer Science Business Media, LLC, part of Springer Nature 2017.

[12] V. Quintero et al., State-of-charge estimation to improve energy conservation and extend the battery life of wireless sensor network nodes, 2017, *Ninth International Conference on Ubiquitous and Future Networks (ICUFN), Milan, 2017, pp. 153-158.*

[13] Agnelo Silva et al., Power-Management Techniques for Wireless Sensor Networks and Similar Low-Power Communication Devices Based on Non-rechargeable Batteries,2012, *Hindawi Publishing Corporation Journal of Computer Networks and Communications Volume 2012, Article ID 757291, 10 pages.*

[14] Mrs. Snehal Deshmukh-Bhosale, Dr. S. S. Sonavane, "Design and Implementation of RSSI Based Intrusion Detection System for RPL based IoT Network", Web of Science Journal, IJCSNS International Journal of Computer Science and Network Security, VOL.19 No.12, December 2019

[15] http://www.eecs.harvard.edu/˜konrad/projects/shimmer/references/Tmote-sky-datasheet.pdf

[16] Ing Pietro Gonizzi and Simon Duquennoy. Hands-on Contiki OS and Cooja Simulator: Exercises (Part II). https://team.inria.fr/fun/files/2014/04/slides_partI.pdf, 2013. [Online; accessed January 2019].

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