

An Improved Energy Efficient TDMA based MAC Protocol for WBAN

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Abstract—Wireless Body Area Networks (WBANs) are particular field of Wireless Sensor Networks (WSNs). It is the important building segments of forthcoming networks. Contemporary health care structure is one of the furthestmost standard WBAN applications. In recent decades, study has focused on channel modeling, energy consumption strategy of well-organized medium access control (MAC) protocols. In this form of network, the number of sensors which are used in the network topology has been significantly reduced than existing WBAN. In this paper, we have evaluated TDMA based MAC protocol performance through several metrics. In this paper TDMA approach is used to avoid packet collision which leads to higher packet loss rate. Clock synchronization is the solution of problem like packet collision. After clocks of WBAN sensor nodes are synchronized, data can be transferred between sensor nodes and sink efficiently and rapidly.

Keywords—TDMA, MAC protocol, Wireless body Area Network, Throughput.

I. INTRODUCTION

Wireless Body Area Network (WBAN) is an application of wireless sensor network (WSN). WBAN therefore forms a comprehensive assemblage of devices which are not only capable of providing continuous information about the health status of a person but also offers helpful details about the activities and environment of the person. It therefore contributes greatly towards gaining a complete understanding of an individual's health and would also enable suitable and appropriate action in case of emergencies. Further the network as a whole is always-on and this permits real-time continuous monitoring [1].

Therefore, information obtained from WBAN is more detailed when compared to traditional monitoring methods and hence provides a better insight. WBANs are unique not only in their inherent features, but are also distinctive in terms of the challenges they pose for deployment, operation, maintenance and security [2]. Although WBAN throws open several interesting applications that benefit diverse groups of the society, the heterogeneous nature of the WBAN participant devices gives rise to foremost tasks that needs to be talked in the design and practical implementation of WBAN in each of the applications [3].

A. Application of WBAN

WBAN supports extensive variety of applications which help in improving an individual's quality of life [4]. WBAN applications are broadly classified as medical and non-medical. Non-medical uses contain consumer electronics,

gaming, social network, military applications etc [5]. The applications of WBAN are discussed briefly in this Section.

- **Healthcare:** WBAN has made a wide range of healthcare related applications possible. It provides an interface for facilitating diagnosis, drug administration, Tele-consultation, Tele-surgery and patient rehabilitation. An important application of WBAN is Remote Health Monitoring (RHM) that enables continuous monitoring of patients. RHM is discussed in greater depth in the next section [6].
- **Lifestyle Applications:** WBANs can assist in various lifestyle applications such as navigation support for tourists in cities, museums, car, etc. [7] Wearable entertainment systems like music, interconnection of various handheld devices etc. are some of the applications that are also possible [8].
- **Fitness and Safety Monitoring:** Monitoring the fitness and performance of sports persons during training and in action is possible by using WBANs. This would give a good insight about the strength and weakness of the person and therefore aid in improving their performance [9]. Fire fighters, mineworkers etc. can also be greatly benefited by WBANs, as their working environment can also be monitored and an alarm can be raised on sensing any impending danger [10].
- **Military Applications:** Sensors embedded in a soldier's uniform can help in monitoring the

physiological and psychological health of the soldier in action [11]. These sensors can be integrated with other gadgets like Personal Digital Assistant (PDA), RF camera etc. to form a network that would help the soldier to mobilize additional help, relay battlefield conditions etc. [12]. WBANs have the potential to help in assessing soldier fatigue and battle readiness and consequently can help in minimizing casualties and improve strategic fighting [13].

- **Gaming Applications:** WBAN sensors can collect coordinate of the player body movement and assist in the correct body position to score a goal; for example, in golf [14].
- **Logistics:** With the help of WBAN the loss of packages can be prevented by fixing the goods and tracking the goods with simple tracking sensors. WSN facilitate the tracking of the goods and updated the stocks of goods present in warehouse [15].
- **Telematics:** In this the streets and roadsides are embedded with the sensors nodes; the sensor nodes give the information of high resolution traffic monitoring. So, in the traffic conditions it assists the vehicles for diversion if required [16].
- **Miscellaneous Applications:** WSN works in our daily life like in refrigerators, microwaves, Air Conditioners and many other appliances that are controlled with remotes [17].

B. Need for Reliable and Secure communication in WBAN

When WBAN is used as health purpose, the collected data has healthiness information. This information must be safe and not being accessed by unauthorized entities. Non-reliable or insecure communication may highly affect health assistance of patient, so the communication must be reliable in wireless body area network (WBAN) [18]. Reliable and Secure communication is also necessary for another application of WBAN.

C. Issues of Secure and Reliable communication in WBAN

There are some issues of Secure and Reliable communication in wireless body area network (WBAN) which are describe below:

- **Data Confidentiality:** WBAN Applications need secure data transfer mechanisms, since an opponent can eavesdrop on the traffic and access receptive information of the user [19].
- **Data Authentication:** It is required that only legal nodes of the WBAN are capable to contribute in the network. Data Authentication ensures reliability of received message. Data Authentication agrees to receiver to authenticate that information really was sent through sender [20].
- **Data Integrity:** When information is transferred from an approved sender, a rival cans calculatedly the message [21].
- **Data Freshness:** Data freshness proposes that information received is latest as well as it confirms in which no rival replayed previous messages in network [22].
- **Location privacy:** Since the nodes in WBAN are worn over the human body the communication between the nodes can help in uniquely identifying a person. So WBAN applications are bound to have inherent Location privacy risks [23].
- **Contextual privacy:** In the breach of contextual privacy, an adversary will be able to co-relate the source and destination, and get the context sensitive information [24].
- **Access Control:** Different users can send and retrieve information to and from WBAN network. It is important to protect private information from unauthorized (may be even for legitimate) parties [25].
- **Non-repudiation:** Repudiation is a threat caused when the sender or receiver denies the responsibility of sending or receiving the messages. So, repudiation must be avoided [26].

The rest of the paper is organized in following order. In section 2, we review related work, while Section 3 describes methodology for this work. Simulation results and analysis are presented in section 4. Finally, section 5 gives conclusion and future scope.

II. RELATED WORK

WBAN is a very active research field and many studies have addressed this issue using a variety of protocols, relaying mechanisms and topology selection [27]. It has also been shown that persons suffering from cardiovascular diseases, asthma (Chu et al 2006), diabetes (Zhao et al 2005) can be monitored using wearable health systems. Ng et al (2004) proposed UbiMon architecture consists of body sensor nodes, a Local Processing Unit (LPU), a Central Sever (CS) as well as a Work Station (WS). This helps the monitored person to receive immediate professional advice / care based on the continuously monitored data. (Chris Otto et al 2006) proposed a general architecture that integrates WBAN into a telemedicine system. For instance, a representation of remote monitoring patient architecture suggested for 5G infrastructure by Oleshchuk V & Fensli R (2010). A notable feature of RHM systems is that they generate huge volume of data that needs to be stored at the medical server. In addition, a patient may generally have many healthcare providers including, primary care providers, therapists, specialists etc.

(Wu et al 2012). Cloud computing has become a promising solution as it could increase the efficiency of data storage and management [28]. A RHM architecture that uses cloud storage (Mukerjee et al 2014) Security is a crucial part of WSN architecture as it is vulnerable to a number of security threats which has variable impact on the network depending on its application (Durresi et al 2004). (Gelbestein 2011) refers to the quality of correctness and is attained by avoiding deliberate or accidental but unapproved modifications, insertions or deletion of information. Wenbo He et al (2008) have proposed WSN nodes sense the same parameter and hence integrity can be validated by comparing data from different aggregation trees. On the other hand, each node in WBAN senses a specific physiological parameter and therefore this scheme would not be suitable for WBANs. Vimal Kumar & Sanjay Madria (2010) has proposed a privacy and integrity preserving algorithm for WSN. Their work is based on Recursive Secret Sharing (RSS). Chen et al (2012) have proposed a method that permits BS for recovering all sensing information from aggregated data sent by other sensor nodes in the network. Wadhwa et al (2013) in their work have proposed a method that assures the integrity of the message. The authors have appended the current date and time to the data and have computed the hash of the same. Sun et al (2013) have proposed a watermarking scheme that does not require additional memory to store the watermark. In their scheme, hash of the sensor data is used as the watermark content. Zu et al (2013) have suggested an aggregation scheme for WSN which also addresses the problem of preserving data integrity. Park & Shin (2004) have proposed a lightweight key management scheme for WSN. Their method is cluster-based and every collection choses a group head (GH). To control security of the Group each GH acts as a key server (KS). For the purpose of keying and intergroup communication all KS belonging to the same network form an internal network among themselves. Wang et al (2006) in their work for assisted living using WBAN have suggested using a USB stick to store the ring of encryption keys that are generated in prior. Wood et al (2006) have used secret keys that have been preloaded in the end-to-end communicating devices for an assisted living and residential monitoring system.

A. Problem Identification

In the literature review, some of the latest and standard paper are discussed in which, it is found that in [1] there is a problem with data lost, in [2] it need some security features, in [3] it discussed a protocol for data aggregation, in [4] it discussed the various security techniques related to data, in [5] it discussed the repudiation threat is defined so as to recover it data integrity is maintained, in[6] it discussed the various security techniques to share the data securely over the network, in[7] it discussed a remote monitoring patient architecture for 5G infrastructure in [8] it need to be discussed different reliability requirements, in [9] It should

be include the design of a stochastic slot allocation scheme, in [10] the delay of signal should be discussed, and overall many performance metrics are not discussed.

III. METHODOLOGY

To attain the goal, step-by-step methodology is used in this research work. Following are the steps used to achieve the proposed work.

1. Initial Phase

Sink broadcasts its location through short information packet. Sensor nodes store position of sink. Every sensor transfers short data packet to sink which holds node ID, its residual energy and location. Sink broadcasts information to all sensors

2. Selection of Forwarder Node

Minimum cost function is used to choose optimal information forwarder. Cost function confirms new forwarder in each round

Cost Function (i) = distance (i) / Residual Energy (i)

3. Scheduling

Forwarder node assigns TDMA schedule to its children node. Children nodes transfer their information in allocated time slot. TDMA scheduling saves energy of sensor nodes.

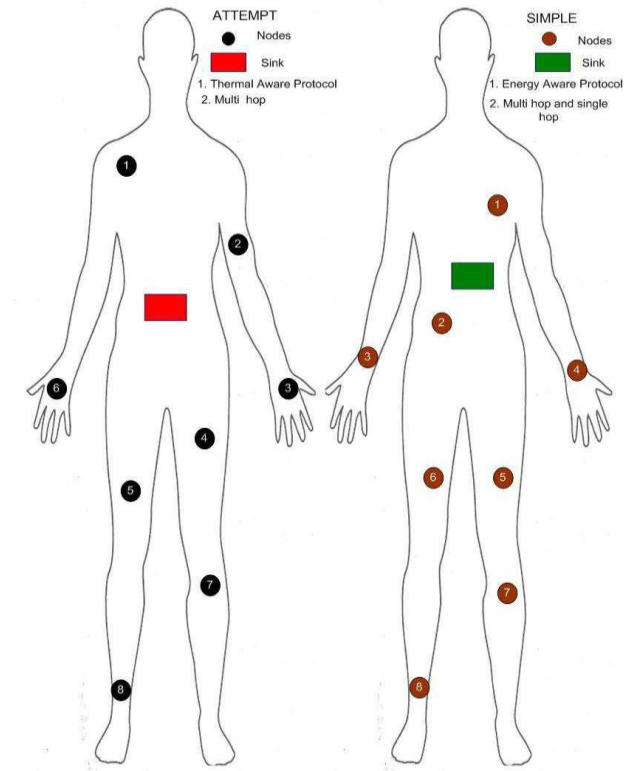
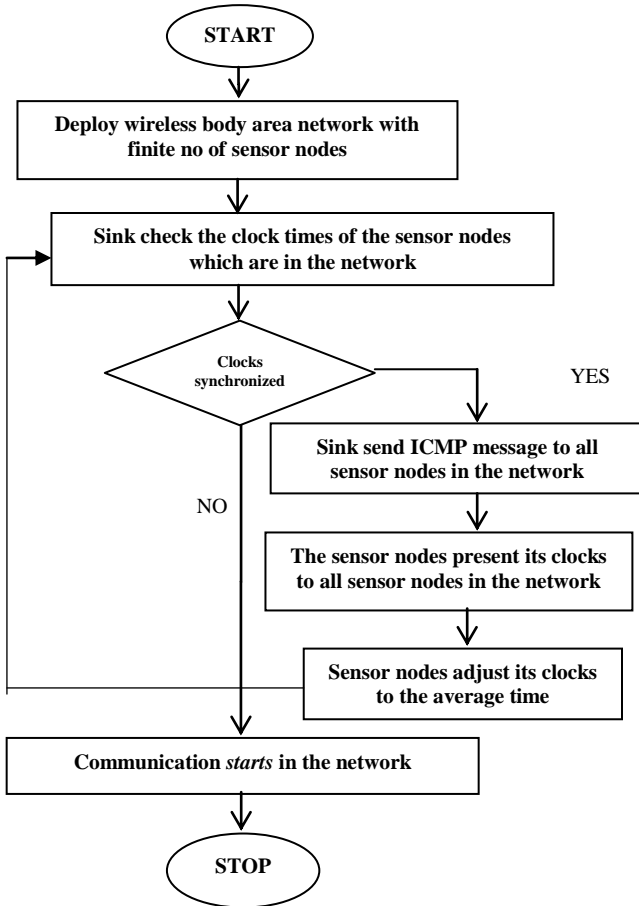


Figure 1. Node deployment

To achieve the Objectives for minimizing the packet loss, improving the throughput and packet delivery ratio using clock synchronization for proposed work the following strategies will be adopted.



IV. SIMULATION RESULTS AND ANALYSIS

We have showed a general set of experimentations using MATLAB R2013a and also calculated the comparison among MAC-SIMPLE Protocol and exciting M-ATTEMPT protocol. The description of performance evaluation metrics are as follow.

A. Network life time

Network lifetime denotes total network time taken till the latest node die. Fig 2 shows that proposed protocol has slower stability period. This is estimated, due to suitable variety of novel forwarder in all rounds. Therefore, in all round of each node obtain approximately identical energy as well as each and every node die almost at the same time. The temperature of forwarder nodes rises, nodes choice slower path that use high energy in M-ATTEMPT. Therefore, these nodes expire initially. Proposed protocol attains 31% additional stability period as well as 0.4% lengthier network lifetime.

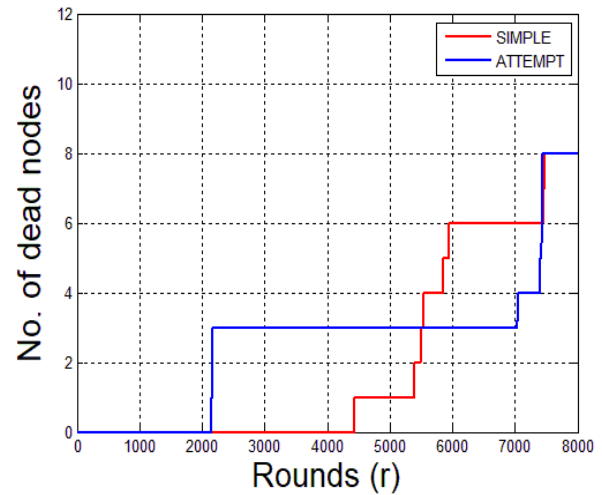


Figure 2. Network lifetime

B. Throughput

Numbers of active nodes notify the no of packets send to the sink. Extra active nodes send extra packets to sink which results rises in throughput of network. SIMPLE protocol attains high throughput in comparison with M-ATTEMPT, as presented in fig 3.

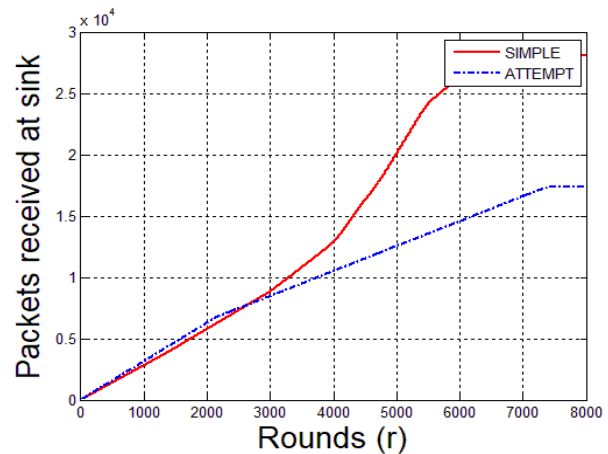


Figure 3. Throughput

The stability period of M-ATTEMPT is smaller than SIMPLE protocol in which no of packets sent to sink diminished. Therefore, SIMPLE protocol realizes great throughput due to extensive stability period. On contrary, throughput of M-ATTEMPT diminished.

C. Residual energy

The proposed model use MAC topology, each extreme node transfers its information to sink over a forwarder node. Forwarder node is chosen by cost function [19]. Choice of

suitable forwarder in each round donates to save energy. To transfer packets to sink, MAC topology takes a different forwarder node in each round, this constrains over loading of particular node. The average energy used up by network in every round is shown in fig 4.

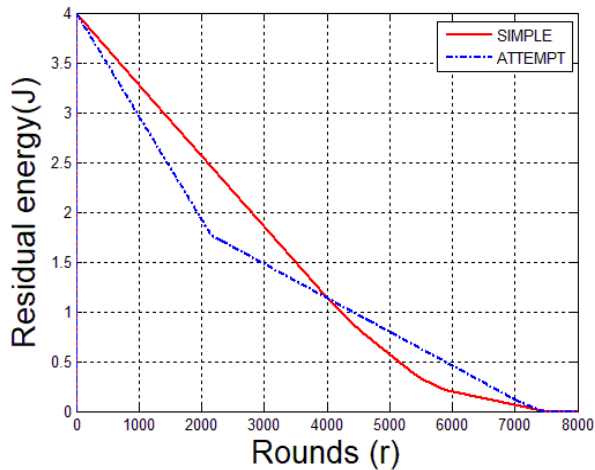


Figure 4. Remaining energy

Simulation results show that M-ATTEMPT, some nodes get exhausted early due to larger amount of traffic. On the other hand, in SIMPLE protocol it uses lowest energy till 70% of replication time. It means, in stability period, more nodes have sufficient energy and they transmit more data packet to sink.

D. Path Loss

Path loss is a utility of frequency and distance [20]. It is designed from its distance to sink with constant frequency. Proposed topology decreases path loss as presented in figure 5.

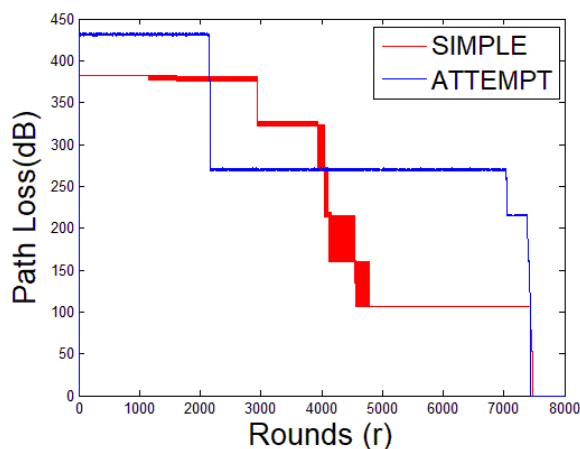


Figure 5. Network path loss

It is due to the fact that MAC transmission decreases distance. Initially SIMPLE protocol implements well. On the other hand, once 2000 rounds, path loss of M-ATTEMPT unnaturally reduced as certain nodes of M-ATTEMPT topology die. Smallest number of active nodes has smallest collective path loss. As proposed protocol has extended stability period and extra active nodes have to extra increasing path loss [21, 22].

V. CONCLUSION AND FUTURE SCOPE

In this paper, we have proposed a novel protocol for WBANs. The proposed technique has modified TDMA based MAC protocol to reduce the required number of sensors required to successfully monitor the environment of body are network. The proposed technique has been designed and implemented in the MATLAB 2013a with the help of wireless communication toolbox. It has been observed that the proposed technique has significantly reduced the required number of servers. Extensive experiments reveal that the proposed protocol outperforms existing one in terms of residual energy, throughput, network lifetime and path loss. In this paper, we have not considered the use of any security attacks on WBANs. Therefore, in near future we will modify proposed technique to handle security attacks.

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REFERENCES

- [1] Mukherjee, S, Dolui, K & Datta, SK 2014, 'Patient health management system using e-health monitoring architecture', In Advance Computing Conference (IACC), 2014 IEEE International, pp. 400-405.
- [2] Sun, X, Su, J, Wang, B & Liu, Q 2013, 'Digital Watermarking Method for Data Integrity Protection in Wireless Sensor Networks', International Journal of Security and Its Applications, vol. 7, no. 4.
- [3] Zhu, L, Zhen Yang, Meng Li & Dan Liu 2013, 'An Efficient Data Aggregation Protocol Concentrated on Data Integrity in Wireless Sensor Networks', International Journal of Distributed Sensor Networks, vol. 2013.
- [4] Wadhwa, N, Hussain, SZ & Rizvi, SAM 2013, 'A Combined Method for Confidentiality, Integrity, Availability and Authentication (CMCIAA)', Proceedings of the World Congress on Engineering, WCE 2013, London, U.K, vol. II.
- [5] Dilbag Singh and Vijay Kumar. "Modified gain intervention filter based dehazing technique." Journal of Modern Optics 64, no. 20 (2017): 2165-2178.
- [6] Chien-Ming Chen, Yue-Hsun Lin, Ya-Ching Lin & Hung-Min Sun 2012, 'RCDA: Recoverable Concealed Data Aggregation for Data

- Integrity in Wireless Sensor Networks', IEEE Transactions on Parallel and Distributed Systems, vol. 23, no. 4.
- [7] Ruoyu Wu, Gail-JoonAhn & Hongxin Hu 2012, 'Secure Sharing of Electronic Health Records in Clouds,' 8th International Conference Conference on Collaborative Computing: Networking, Applications and Worksharing, Collaboratecom 2012 Pittsburgh, PA, United States.
- [8] Dilbag Singh and Vijay Kumar. "Comprehensive survey on haze removal techniques." *Multimedia Tools and Applications* (2017): 1-26.
- [9] Ed Gelbestein 2011, 'Data Integrity-Information Security's Poor Relation', ISACA Journal, vol.6.
- [10] Vladimir Oleshchuk & Rune Fensli 2010, 'Remote Patient Monitoring Within a Future 5G Infrastructure,' *Wireless Personal Communication*, Springer Science.
- [11] Wenbo He, Liu, X, Nguyen, H, Nahrstedt, K & Abdelzaher, T 2008, 'iPDA: An Integrity-Protecting Private Data Aggregation Scheme for Wireless Sensor Networks', IEEE MILCOM, pp. 1-7.
- [12] Chu, HT 2006, 'A Ubiquitous Warning System for Asthma-Inducement', IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing, Taichung, pp. 186-191.
- [13] Dilbag Singh and Vijay Kumar. "Dehazing of remote sensing images using improved restoration model based dark channel prior." *The Imaging Science Journal* 65, no. 5 (2017): 282-292.
- [14] Wood, A, Virone, G, Doan, T, Cao, Q, Selva, L, Wu, Y, Fang, L, He, Z, Lin, S & Stankovic, J 2006, 'ALARM-NET:Wireless Sensor Networks for Assisted Living and Residential Monitoring', Technical Report CS-2006-13, Department of Computer Science, University of Virginia.
- [15] Zhao, YJ 2005, 'A MEMS Viscometric Glucose Monitoring Device', The 13th IEEE International Conference on Solid-State Sensors, Actuators and Microsystems, Pittsburgh, pp. 1816-1819.
- [16] Dilbag Singh and Vijay Kumar. "Dehazing of remote sensing images using fourth-order partial differential equations based trilateral filter." *IET Computer Vision* (2017).
- [17] Ng, JWP, Lo, BPL, Wells, O, Sloman, M, Peters, N, Darzi, A, Toumazou, C & Yang, GZ 2004, 'Ubiquitous Monitoring Environment for Wearable and Implantable Sensors (UbiMon)', In Proceedings of 6th International Conference on Ubiquitous Computing (UbiComp'04), Nottingham, UK.
- [18] Dilbag Singh and Vijay Kumar. "Defogging of road images using gain coefficient-based trilateral filter." *Journal of Electronic Imaging* 27, no. 1 (2018): 013004.
- [19] Ishita Chakraborty, Prodipto Das, "Data Fusion in Wireless Sensor Network-A Survey", *International Journal of Scientific Research in Network Security and Communication*, Vol.5, Issue.6, pp.9-15, 2017.
- [20] Arjan Durrezi, Vamsi Paruchuri, Rajgopal Kannan & Iyengar, SS 2004, 'A Lightweight Protocol for Data Integrity in Sensor Networks', IEEE, ISSNIP.
- [21] Dilbag Singh and Vijay Kumar. "Single image haze removal using integrated dark and bright channel prior." *Modern Physics Letters B* (2018): 1850051.
- [22] Lee, Chong Hyun, Jinho Bae, and Joon-Young Kim. "Novel Implant Device Tracking Algorithm for Wireless Health Monitoring in Wban." *International Journal of Modern Physics B* 25, no. 31 (2011): 4145-4148.
- [23] Zargar, R. A., M. Arora, S. Chackrabarti, S. Ahmad, J. Kumar, and A. K. Hafiz. "Alcohol vapor sensing by cadmium-doped zinc oxide thick films based chemical sensor." *Modern Physics Letters B* 30, no. 12 (2016): 1650244.
- [24] He, Yanan, Bo Zhang, and Jingling Shen. "Performance of terahertz metamaterials as high-sensitivity sensor." *Modern Physics Letters B* 31, no. 26 (2017): 1750240.
- [25] Gaikwad, Sumedh, Gajanan Bodkhe, Megha Deshmukh, Harshada Patil, Arti Rushi, Mahendra D. Shirsat, Pankaj Koinkar, Yun-Hae Kim, and Ashok Mulchandani. "Chemiresistive sensor based on polythiophene-modified single-walled carbon nanotubes for detection of NO₂." *Modern Physics Letters B* 29, no. 06n07 (2015): 1540046.
- [26] Li, Xiangyu, Liang Yin, Weiping Chen, Zhiqiang Gao, and Xiaowei Liu. "A high-resolution tunneling magneto-resistance sensor interface circuit." *Modern Physics Letters B* 31, no. 04 (2017): 1750030.
- [27] Yarn, Kao-Feng. "High sensitive hydrogen sensor by Pd/oxide/InGaP MOS structure." *Modern physics letters B* 20, no. 28 (2006): 1781-1787.
- [28] Sakya, G. and Sharma, V., 2013, January. Performance analysis of SMAC protocol in wireless sensor networks using network simulator (Ns-2). In *International Conference on Heterogeneous Networking for Quality, Reliability, Security and Robustness* (pp. 42-51). Springer, Berlin, Heidelberg.

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