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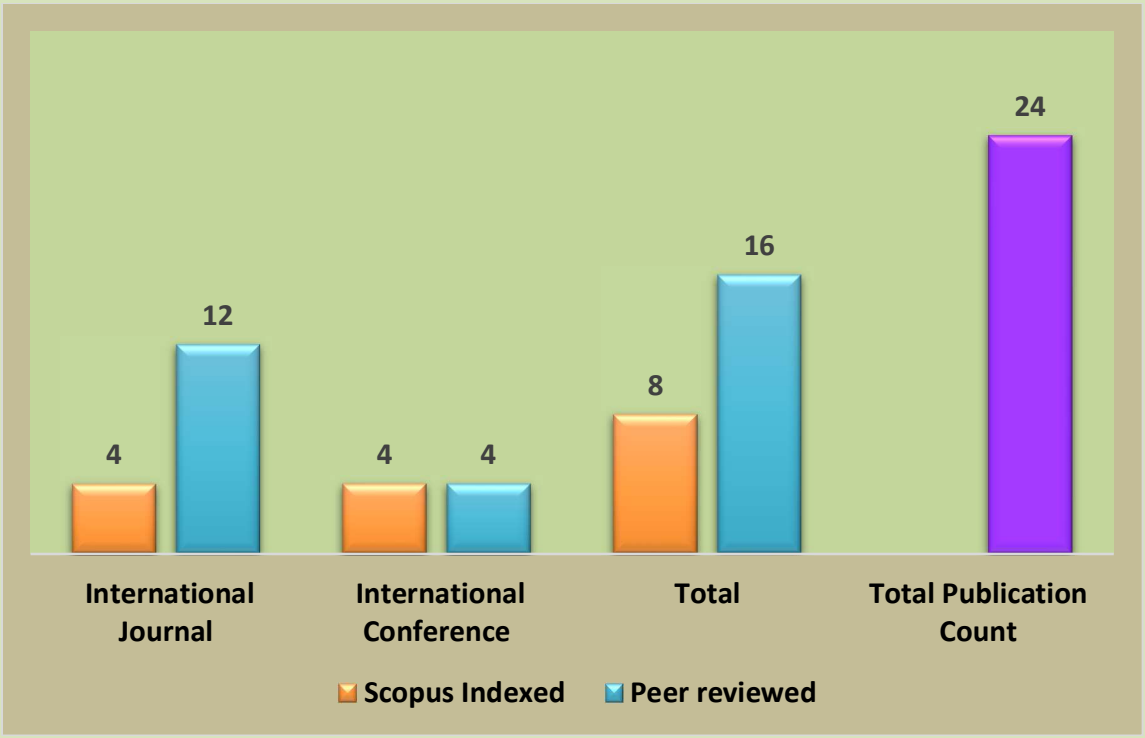
Summary of Faculty Paper Publications for the Academic year 2019-2020

Journal/Conference	Scopus Indexed	Peer reviewed
No. of papers published in International Journal	04	12
No. of papers published in International Conference	04	04
Total	08	16
Total Publication Count		24



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3	Microstrip Array Antenna for 24GHz Automotive RADAR	Banuprakash R, Neha R N Janani, Raghav K K, Sudha M	Seventh "IEEE Virtual International Conference on Smart Structures And Systems-ICSSS-2020" 23rd -24th July 2020, at Saveetha Engineering College, Chennai
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7.	A miniaturized multiband antenna using SRR and DGS for cognitive radio applications	Banuprakash R, Hariprasad S A	Journal of Xidian University, Volume 14, Issue 7, 2020, pp. 1180-1188, https://doi.org/10.37896/jxu14.7/133
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12.	Evanesco-An Ultrasonic Repeller using UAV	Raghunandan.G.H , Ninaada M S , Keerthana R	IJETT, ISSN: 2231-5381 Vol 68 Issue 6 June 2020, https://ijettjournal.org/Volume-68/Issue-6/IJETT-V68I6P206S.pdf

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Edited by

Dr. Thejaswini S
Assistant Professor
Dept. of ETE
BMSIT&M

Biosc.Biotech.Res.Comm. Special Issue Vol 13 No 13 (2020) Pp-185-193

BBRC
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Analysis and Performance Evaluation of Selective Channel Assignment Method in Cognitive Radio System

Mallikarjuna Gowda C. P[1] and Vijayakumar T[2]

[1]*Department of Electronics and Communications Engineering, SJB Institute of Technology, faculty at BMS Institute of Technology and Management, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, India.*

[2]*Department of Electronics and Communications Engineering, SJB Institute of Technology, Bengaluru, Affiliated to Visvesvaraya Technological University, Belagavi, India.*

ABSTRACT

An issue of realizing dynamic spectrum access in cognitive radio network is the design of an efficient channel assignment mechanism. In this work, a selective channel assignment method is proposed to divide the channels between the Primary Users (Pus) and Secondary Users (SUs). There is need to build two first fit assignment models in one single model to treat each of the PU and SUs separately. Also, there should be a flexibility to decide which part of the channel to be centered around for the allocation of PU and SUs, an attempt is made to design such a model. The performance of the model is tested on the network that has converters and also on network that does not have any converters installed. The percentage of PU calls over all the calls is also varied to determine the change in blocking probabilities. Extensive simulation results show that the proposed selective channel assignment method performs better with respect to performance parameters such as the blocking probabilities, throughput and the channel usage frequency, when compared with the existing channel assignment methods such as first fit assignment and uniformly distributed random assignment methods.

KEY WORDS: THROUGHPUT, COGNITIVE RADIO NETWORKS, BLOCKING PROBABILITY, QUALITY-OF-SERVICE (QOS), CHANNEL ASSIGNMENT.

INTRODUCTION

People's approach of life and thinking are changing due to exponential growth of wireless devices and applications. Also, the demand for electromagnetic radio spectrum has increased. Cognitive radio technology has been proposed as an operational way to facilitate dynamic spectrum access (DSA) to increase spectrum utilization efficiency in cognitive radio networks (CRN). The kinds of nodes in cognitive radio network are known as licensed primary users (PUs) and unlicensed cognitive or secondary users (SUs). Cognitive radio (CR) enables the radio devices with the perception capability to learn the surrounding radio environment and adjust their configurations to increase the spectrum utilization.

According to the predictions study made by Cisco on global wireless networking metrics, by 2023, there will be 5.7 billion more mobile users, 13.1 billion more mobile connections and faster mobile speeds of 43.9Mbps, when compared to 5.1 billion users, 8.8 billion mobile connections and 13.2 Mbps mobile speeds in the year 2018. Rajeev Ranjan, et.al.(2020), have explored thought-provoking features of co-channel and adjacent channel interference to increase the performance of the network and to provide QoS to both primary and secondary nodes

ARTICLE INFORMATION

*Corresponding Author: cpmallikarjunagowda@bmsit.in
Received 11th Oct 2020 Accepted after revision 29th Dec 2020
Print ISSN: 0974-6455 Online ISSN: 2321-4007 CODEN: BBRCBA

Thomson Reuters ISI Web of Science Clarivate Analytics USA and Crossref Indexed Journal

Clarivate Analytics

crossref

NAAS Journal Score 2020 (4.31)

Online Contents Available at: http//www.bbrc.in/
Doi: http://dx.doi.org/10.21786/bbrc/13.13/26

in a cognitive radio network. Using interference index as an important feature, reduced co-channel interference among secondary nodes, which indirectly impacts adjacent channel interference to them.

By limiting the interference lower than the acceptance threshold of 10dBm to primary users, the concept of interference index with the distributed greedy algorithm is successful in maximising the cognitive radio network capacity with an average value 60%. Secondary users transmit power always maintained lower than the primary transmit power of 30dBm as a pride of primary users. Also, interference index can be used to deal statistically by experimenting at algorithm level as interference management, with high traffic loads, during emergency services and disaster reliefs, to discuss between the mobility of the secondary users in cognitive radio network and channel vacating parameter as interference limit indicator as a future work.

Yousuf Aborahama and Mohamed S. Hassan (2020), have inspected in cognitive radio networks, the extent of time with which a secondary user can hold a primary channel and the average quantity of data that can be transmitted. To emulate reality, the activity levels of primary users and secondary users, the primary channels identical and non-identical distribution of time were derived in closed form probabilistic expressions. Haythem Bany Salameh, et.al.(2020), developed an in-band full-duplex(IB-FD) routing protocol, which aims at maximizing the end-to-end network throughput subject to interference constraints for a given set of routes among a cognitive radio source destination pair.

Xiukui Li and Seyed A. (Reza) Zekavat (2009), estimated the PU and SU traffic by using a prediction algorithm. The probability of allocation of a channel to a SU was predicted and it was related to the channels meant for PUs. However, these methods have higher computational complexity. There is also another methodology by X. Li S.A. (Reza) Zekavat (2010), proposed to predict the PU traffic. The research was focused on the methods to improve the predictability of PU traffic. Cooperative spectrum sharing was also proposed by some researchers. Cooperative spectrum sharing involves sharing of static CR nodes of various service providers proposed by R. Kaniezhil and C. Chandrasekar (2012).

Muhammad Rehan Usman, et.al (2017), have proposed, two channel assignment techniques, in variable channel assignment method (VCAM), based on either time sharing or interference created by secondary nodes, variable sharing can be adjusted dynamically and in reserved variable channel assignment method (RVCAM), channels are reserved separately for primary users. The blocking probability of the primary users and secondary users are managed dynamically by using channel sharing. According to the traffic conditions, by regulating the channel sharing between primary and secondary nodes, blocking probability of the primary users can be controlled. The drawback of the reserved variable channel assignment method is secondary users cannot use the channels which are reserved for primary users, when they are not in use also.

Vamsi Krishna Tumuluru, et. al (2013), have investigated the cognitive radio network with centralized and distributed architectures for the prioritized unlicensed users traffic by reserving sub-channels and the spectrum hand-off prioritization using dynamic spectrum access systems. For performance evaluation, the parameters considered are the call completion rate and the mean handoff delay for the two priority classes in the secondary node traffic, blocking probability and forced termination probability. Sandeep Mavuduru Kannappa and Mohammad Saquib (2010), proposed a novel spectrum assignment scheme to reduce the call dropping probability of the secondary users in cognitive wireless networks by dynamically assigning the service rates to the secondary nodes depending on the existing network spectral resource. Developed an 2D Markov chain to analyse the spectrum sharing policies, by increasing their maximum allowable service rates, lower call dropping probability of six to seven times is achieved by the proposed scheme when compared to the existing one.

Yan Zhang (2008), proposed and analyzed a new dynamic spectrum access scheme to avoid direct blocking of secondary node with and without buffering in cognitive radio wireless networks. Developed a Markov approach to analyse for both primary and secondary system, spectrum sharing policies based on bandwidth size. Also, forced termination probability, blocking probability, non-completion probability, interrupted probability and waiting time as performance metrics for secondary node and it is found that the buffer is able to decrease the secondary node blocking probability and non-completion probability with small rise in forced termination probability. Amir Sepasi Zahmati, et.al (2009), developed a model for N secondary users and one primary user to analyse spectrum usage in a heterogeneous cognitive radio network.

Authors Zeljko Tabakovic and Mislav Grgic (2016), have addressed the frequency assignment issue in the cognitive radio networks. Authors have treated the frequency assignment issue in cognitive radio network as a graph coloring problem. In the frequency assignment decision process instead of channel selection authors have proposed frequency and bandwidth selection. An objective minimizing network interference and maximizing network throughput is achieved by assigning channels to secondary nodes in cognitive radio network through the use of centralized and distributed sequential algorithms. It is possible to compute the individual interference mechanisms and cumulative interference with the use of interference weighting and categorization scheme which is useful to the cognitive radio network performance and results in more efficient spectrum usage and a reduced mutual influence between terminals of around 2.5 –12 times less when compared with binary interference model.

Murtaza Zafer and Eytan Modiano (2006), established a novel channel assignment algorithm that decreases blocking probability by spatially re-using the frequencies in a well-organized way. Also deliberated on the blocking probability behaviour of the connection oriented traffic for multi-hop wireless line and grid topologies by focussing on the influence of communication range of the nodes. It is shown that the line topology using a large communication range significantly decreases blocking probability with the dynamic channel assignment algorithm.

In methodologies proposed by I. Ketzela, M. Nagheshineh (1996), S.K. Das, S.K. Sen, R. Jayaram (1996), H.Jiang, S. Rappaport (1996), J.C.I. Chuang, R. Mathar (1993), J. Mattfeldt, G. Cao, M. Singhal (1993), S. A. El-Dolil, W. C. Wong, and R. Steele (1989), channel assignment was performed at a central location. The centralized channel allocation can be made with a mobile switching center. The mobile switching center has all the details about how and when a particular channel was used and its current status. The current status is obtained by the mobile switching center by getting the information from the local networks as soon as a channel was assigned to a PU or SU call. With this method, the mobile switching center has all the required information to avoid interference of the calls there by reducing the blocking probabilities to minimum or zero. In case the mobile switching center fails, then it leaves a chaotic situation and the network will go out of control in terms of interference. Hence proper care and maintenance should be undertaken on periodic basis to avoid the single fault failure of the centralized channel allocation system.

To overcome the above problem, many designs of decentralized channel allocation system have been proposed. The decentralized channel allocation system does not suffer the drawback of single fault failure. The entire cognitive radio system is divided into cells and each cell is equipped with a base station. The purpose of a base station in a cell is to manage the PU and SU traffic of that cell. The base station allocates a channel based on the information present at the point of time about that particular node. It will not have any dependency from other cells while allocating the channels and completely dependent only on the local information about the channel's status. There is also a model where the channels of one cell are allocated by base stations of other cells. In such a case, whenever as channel of a cell is assigned by a base station; it informs the decision to allocate a channel to all other base stations so that other base stations will not assign the same channel.

In this work, three channel allocation methods are discussed. All the allocations are carried out in a base station of a cell. The channel assignment methods like first fit, random assignment and selective assignment methods are implemented and compared. The selective channel assignment specifically suitable for a case like cognitive radio system where there is more than one type of calls in the network. As per the literature analysis, it is observed that most of the channel assignment methods are either first fit or uniformly distributed channel assignment methods. The first fit assignment is much superior to random assignment method. But the first fit assignment also leads to 100% blocking probability in some cases. Therefore, there is a need to develop a new channel assignment method that reduces the blocking probability. This is very essential for the case of cognitive radio system where there are two types of calls, namely, PU and SUs.

In this work, a new channel assignment, namely, selective channel assignment method is proposed to divide the channels between the PU and SUs. In other words, there is need to build two first fit assignment models in one single model to treat each of the PU and SUs separately. Also, there should be a flexibility to decide which part of the channel to be centered around for the allocation of PU and SUs. In this work, an attempt is made to design such a model. The performance of the model is tested on the network that has converters and also on network that does not have any converters installed. The percentage of PU calls over all the calls is also varied to determine the change in blocking probabilities. In the next section, details of selective channel assignment method are discussed. In Section III, simulation results are presented for cases like with and without conversions, type of channel assignment method and percentage of PU calls. Finally, in Section IV, the conclusions are presented.

II. Selective Channel Assignment: In selective channel assignment, when a call arrives, it will be assessed if it is a PU call or an SU call. In case if it is a PU call then that call is assigned to the lower order nodes and if it is an SU call, it is assigned to higher order nodes. There will be some channels around the chosen center nodes both for PU and SU calls. For example, if the channel 2 is chosen as center node for PU, then nodes 1, 3 and 4 are the surrounding nearby nodes. All the PU calls will be assigned to channel 2 first if it is free and to channel 1 or 3 if 2 is not free. Then if channels 1, 2 and 3 are busy, then channel 4 is assigned. If channels 2, 3 and 4 are busy and if channel 1 becomes free, then channel 1 is assigned to the next new call. This way only freely available channels in the lower order are utilized for allocation. Similarly, when an SU arrives, if the center node chosen for SU call is 12, then nodes 13, 14 and 15 are the surrounding nodes. In this work, channels 1 and 15 are chosen as the center nodes. The algorithm has the flexibility to choose the center node. Higher the gap between the center nodes between PU and SU, lower the blocking probability and higher the throughput.

2.1 Selective Channel assignment algorithm with and without conversion: The algorithm for the selective channel assignment is provided below for conversion and no conversion of wavelength.

Step 1: Initialize the variables OCC-CHAN-TIME = 0, CHAN-USG-FREQ = 0 and CNT-CAL-BLK = 0.

Step 2: Initialize the selective channel algorithm variables CENTER-POINT = 0.1 and SPREAD = 0.1.

Step 3: Determine if arrived call is a PU or SU.

Step 4: Identify free channels in the first link.

Step 5: Arrange free channels in ascending order.

Step 6: Generate random number between 0 and 1 using Gaussian distribution with mean = CENTER-POINT, standard deviation = SPREAD.

Step 7: If call is a PU, then Channel = Number of channels * random number

Step 8: If call is an SU, then Channel = Number of channels – [Number of channels * random number]

Step 9: Assign the selected channel to the call

Step 10: Update CHAN-USG-FREQ.= CHAN-USG-FREQ + 1

Step 11: Update OCC-CHAN-TIME = TIME-HOLD-CALL

Step 12: DIFF = OCC-CHAN-TIME – TIME-NEXT-CALL

Step 13: If DIFF > 0, then OCC-CHAN-TIME = OCC-CHAN-TIME – TIME-NEXT-CALL for the next call.

Step 14: If DIFF <= 0 then OCC-CHAN-TIME = 0.

Step 15: If the first link free, then assign the next call, else call is blocked.

Step 16: Check all the previous calls and if the next link is not free, the call is blocked.

Step 17: If the first link free, then assign the next call, else find the free channel in the first link.

Step 18: Convert the wavelength to the wavelength of free channel and assign the call.

Step 19: If all the channels are busy in the first link, then call is blocked.

Step 20: Check all the previous calls and if the next link is not free, find the free channel in the next link

Step 21: Convert the wavelength to the wavelength of free channel in the next link.

Step 22: If all the channels are busy in the next link, then call is blocked.

Step 23: Update CNT-CAL-BLK = CNT-CAL-BLK + 1.

Step 24: Continue counting the time until a new call arrives.

Step 25: Repeat steps 3 to 24 except steps 17 to 22 for no conversion of wavelength method and steps 3 to 24 except steps 15 and 16 for conversion of wavelength method.

Step 26: Blocking probability = CNT-CAL-BLK /Total number of calls.

Step 27: Throughput = 1.0 - Blocking probability

2.2 Probability of Unnecessary Handover: The unnecessary handover probability can be derived for the case of call getting handed over unnecessarily to another network. The overall probability of call getting blocked is the product of unnecessary handover probability and blocking probability.

$$P_{unsuccessful} = Unnecessary\ Handover\ Probabability\ X\ Blocking\ Probability \quad (4)$$

$$\begin{aligned}
&Unnecessary Handover\ Probability \\
&= P_{n1}P_{n2/n1}\sum_{j=L}^{B_2}\prod_{2,B_2-j}\sum_{k=0}^{j-L}\prod_{1,B_1-k}\xi_1(k,r,D) \\
&\bullet\sum_{i=0}^{B_1}\prod_{1,B_1-i}\sum_{k=i+L}^{B_2}\prod_{2,B_2-k}\psi_2(k,r,D) \\
&+P_{n1}P_{n3/n1}\sum_{m=L}^{B_3}\prod_{3,B_3-m}\sum_{k=0}^{m-L}\prod_{1,B_1-k}\xi_1(k,r,D) \\
&\bullet\sum_{i=0}^{B_1}\prod_{1,B_1-i}\sum_{k=i+L}^{B_3}\prod_{3,B_3-k}\psi_3(k,r,D) \\
&+P_{n2}P_{n1/n2}\sum_{j=L}^{B_1}\prod_{1,B_1-j}\sum_{k=j-L+1+1}^{B_1}\prod_{1,B_1-k}\psi_1(k,r,D) \\
&\bullet\sum_{i=0}^{B_2}\prod_{2,B_2-i}\sum_{k=0}^{i+L-1-1}\prod_{2,B_2-k}\xi_2(k,r,D) \\
&+P_{n2}P_{n3/n2}\sum_{j=L}^{B_3}\prod_{3,B_3-j}\sum_{k=j-L+1+1}^{B_3}\prod_{3,B_3-k}\psi_3(k,r,D) \\
&\bullet\sum_{m=0}^{B_2}\prod_{2,B_2-m}\sum_{k=0}^{m+L-1-1}\prod_{2,B_2-k}\xi_2(k,r,D) \\
&+P_{n3}P_{n1/n3}\sum_{m=L}^{B_1}\prod_{1,B_1-m}\sum_{k=m-L+1}^{B_1}\prod_{1,B_1-k}\psi_1(k,r,D) \\
&\bullet\sum_{i=0}^{B_3}\prod_{3,B_3-i}\sum_{k=0}^{i+L-1-1}\prod_{3,B_3-k}\xi_3(k,r,D) \\
&+P_{n3}P_{n2/n3}\sum_{j=L}^{B_2}\prod_{2,B_2-j}\sum_{k=0}^{j-L}\prod_{3,B_3-k}\xi_3(k,r,D) \\
&\bullet\sum_{m=0}^{B_3}\prod_{3,B_3-m}\sum_{k=m+L}^{B_2}\prod_{2,B_2-k}\psi_2(k,r,D)
\end{aligned} \quad (5)$$

The notations and definitions of the quantities expressed in Eq.5 can be found in author's paper C P Mallikarjuna Gowda et. al (2018).

III. Simulation Results: Blocking probabilities are derived for tandem networks with conversion and without conversion. The converters are used when there is a call blockage. The converters are assumed to be installed at all nodes. Both type of calls, namely, primary unit calls and secondary unit calls are treated in these simulations. When calls arrive, three types of assignment methods, such a first fit assignment, uniformly distributed random assignment and Selective channel assignment are used in these simulations to allocate a channel to the calls. Hence the following models based on type of channel assignment and conversion is developed.

PU-SU-NC-FF: First fit assignment method with no conversion and both types of calls

PU-SU-NC-RANDOM-ASSIGN: Random assignment method with no conversion and both types of calls

PU-NC-SEL-ASSIGN: Selective channel assignment method with no conversion and only PU calls

SU-NC-SEL-ASSIGN: Selective channel assignment method with no conversion and only SU calls

PU-SU-C-FF: First fit assignment method with conversion and both types of calls

PU-SU-C-RANDOM-ASSIGN: Random assignment method with conversion and both types of calls

PU-C-SEL-ASSIGN: Selective channel assignment method with conversion and only PU calls

SU-C-SEL-ASSIGN: Selective channel assignment method with conversion and only SU calls.

Figure 1: Blocking Probability of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations, and 70% of PU calls with no conversion.

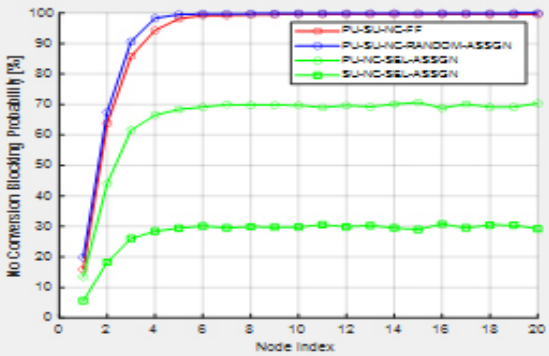


Fig.1 shows the blocking probability of first fit assignment, uniformly distributed random assignment and selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 70% of PU calls with no conversion. It can be observed that blocking probabilities of selective channel assignment method is much lower than that of first fit assignment and uniformly distributed random assignment methods. The blocking probabilities of PU-NC-SEL-ASSIGN and SU-NC-SEL-ASSIGN are 70% of PU-SU-NC-FF and PU-SU-NC-RANDOM-ASSIGN models. This is attributed to the reason that in selective channel assignment, the assignment is made near the channels towards the end of lower order (near channel 1) for PU calls and towards end of higher order (near channel 15) for SU calls.

Fig. 2 shows the channel utilization of first fit assignment, uniformly distributed random assignment and selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 70% of PU calls with no conversion. It can be noticed that in first fit (FF) assignment method, the only channels near lower order is assigned most. In case of random assignment (RANDOM-ASSGN) all channels are assigned uniformly. In case of selective channel (SEL-ASSGN) assignment, channels near 1 and 15 are assigned most.

Figure 2: Channel utilization of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 70% of PU calls with no conversion.

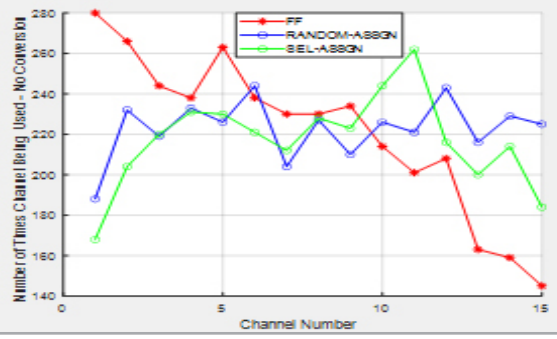


Figure 3: Blocking Probability of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 70% of PU calls with conversion.

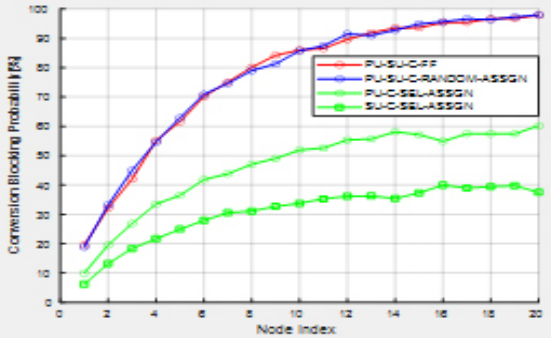


Fig.3 shows the blocking probability of first fit assignment, uniformly distributed random assignment and selective channel assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 70% of PU calls with conversion. It can be observed in this case also, blocking probabilities of selective channel assignment method is much lower than that of first fit assignment and uniformly distributed random

assignment methods. Similar to the no conversion models, in selective channel assignment, the assignment is made near the channels towards the end of lower order (near channel 1) for PU calls and towards end of higher order (near channel 15) for SU calls, whereas all the calls are assigned only near lower order in First fit and uniformly across all channels in random assignment methods. Hence the blocking probabilities of PU-C-SEL-ASSIGN and SU-C-SEL-ASSIGN are nearly 60% of PU-SU-C-FF and PU-SU-C-RANDOM-ASSIGN models. It can also be observed that when conversion is used it does not matter if the first fit or random assignment methods are used since both yield almost similar blocking probabilities. This is due to the reason that call blockage is eliminated with the help of converters irrespective of assignment method.

Figure 4: Channel utilization of assignment methods for a load 15 Erlangs per link, 20 nodes, 15Channels, 4000 iterations and 70% of PU calls with conversion.

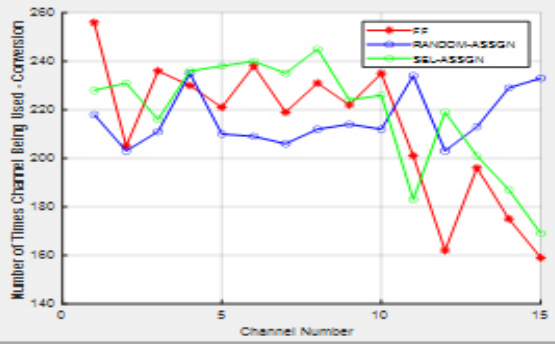


Figure 5: Blocking Probability of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 70% of PU calls with and without conversion.

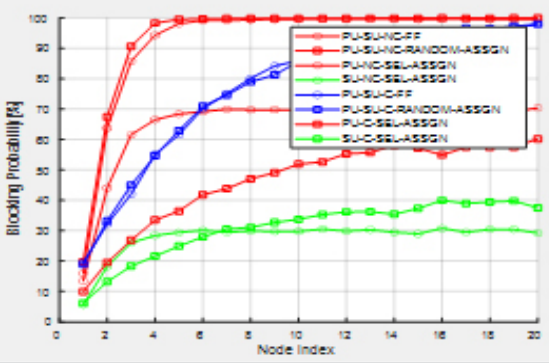


Fig. 4 shows the channel utilization of First fit assignment, uniformly distributed random assignment and Selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 70% of PU calls with conversion. In this case also, the pattern of channel utilization is also most similar to that of no-conversion models. First fit (FF) assignment method has only channels near lower order assigned most and random assignment (RANDOM-ASSGN) has all channels assigned uniformly. In selective channel (SEL-ASSGN) assignment, channels towards the end of lower order and higher order are assigned most.

Figure 6: Throughput of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 70% of PU calls with and without conversion.

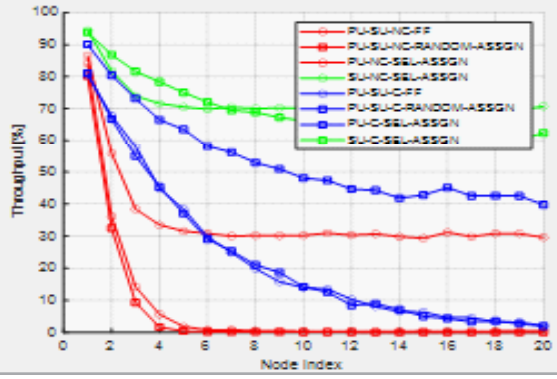
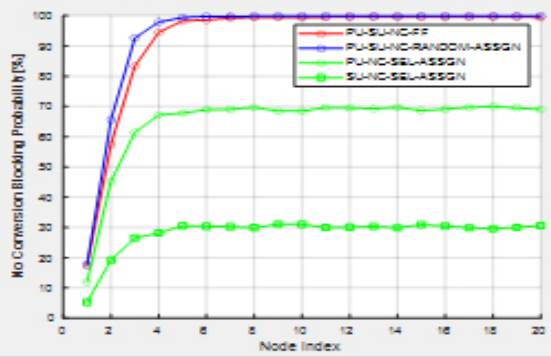


Fig. 5 and 6 shows the blocking probability and throughput, respectively, of First fit assignment, uniformly distributed random assignment and Selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 70% of PU calls with and without conversion. Blocking probabilities of first fit assignment (PU-SU-NC-FF) is 99% at the node index 20, whereas it is 100% at node 20 in case of uniformly distributed random assignment (PU-SU-NC-RANDOM-ASSIGN) method. These blocking probabilities can be reduced by using converters at all the nodes. The Blocking probabilities of first fit assignment (PU-SU-C-FF) are reduced to 94% and to 94% at node 20 in case of uniformly distributed random assignment (PU-SU-C-RANDOM-ASSIGN) method.

Figure 7: Blocking Probability of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 60% of PU calls with no conversion.



The blocking probabilities can be further reduced with and without converters using selective channels assignment. With no converters, the selective channel method (PU-NC-SEL-ASSIGN and SU-NC-SEL-ASSIGN) yields approximately 70% blocking probability and with conversion (PU-C-SEL-ASSIGN and SU-C-SEL-ASSIGN), it is approximately 50% on average.

Figure 8: Channel utilization of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 60% of PU calls with no conversion.

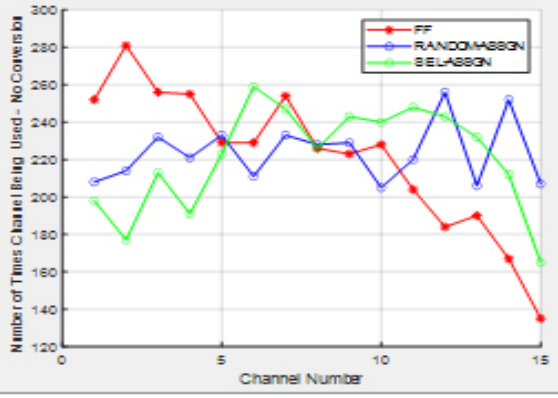


Figure 9: Blocking Probability of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 60% of PU calls with conversion.

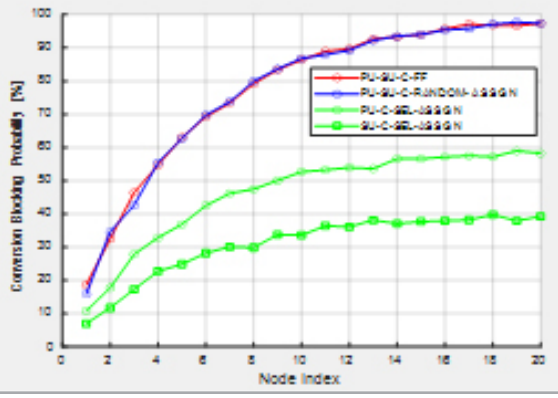


Fig.7 shows the blocking probability of First fit assignment, uniformly distributed random assignment and Selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 60% of PU calls with no conversion. When the PU calls are set at 70% of total calls, the blocking probability for the PU calls is 70% with PU-NC-SEL-ASSIGN and that for SU calls is 30% with SU-NC-SEL-ASSIGN model. In case of PU-SU-NC-FF and PU-SU-NC-RANDOM-ASSIGN models, the blocking probabilities are near 99% and 100% respectively when no converters are used.

Fig.9 shows the blocking probability of First fit assignment, uniformly distributed random assignment and Selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 60% of PU calls with conversion. When there are 60% PU calls in the total calls, the blocking probabilities for the PU is usually higher than that of the SU calls. The same can be noticed in Fig. 7. With conversion, there is no difference between the first fit or random assignment methods. The blocking probabilities of PU-SU-C-FF and PU-SU-C-RANDOM-ASSIGN are nearly 97% at the node 20. When the selective assignment models are used, it is brought down to 60% and 40% respectively with PU-C-SEL-ASSIGN and SU-C-SEL-ASSIGN models.

Figure 10: Channel utilization of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 60% of PU calls with conversion.

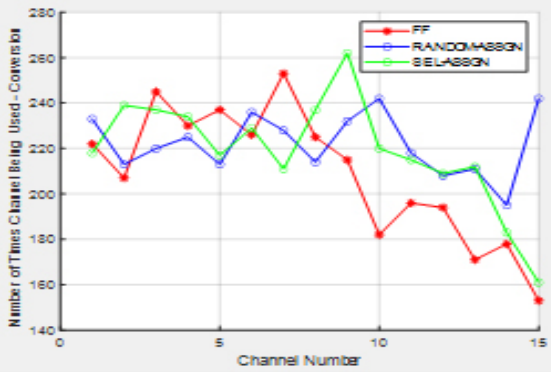


Figure 11: Blocking Probability of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 60% of PU calls with and without conversion.

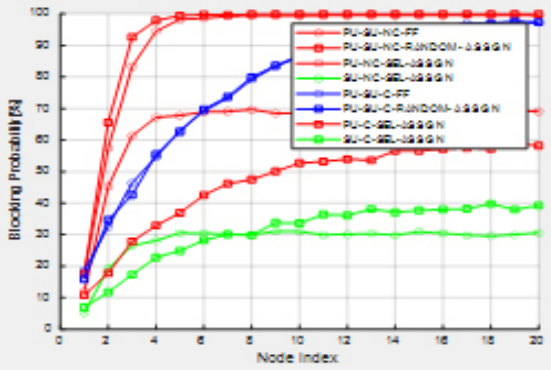


Figure 12: Throughput of assignment methods for a load 15 Erlangs per link, 20 nodes, 15 Channels, 4000 iterations and 60% of PU calls with and without conversion.

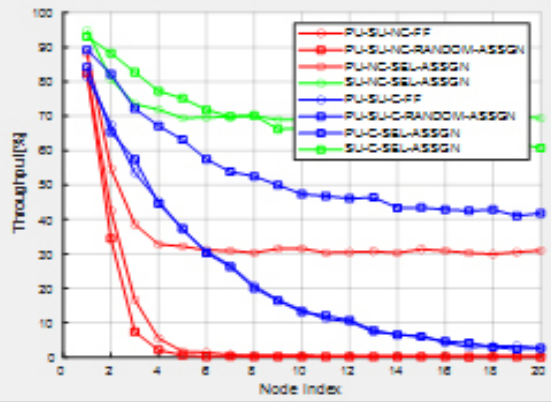


Table 1. Summary of all the 8 models

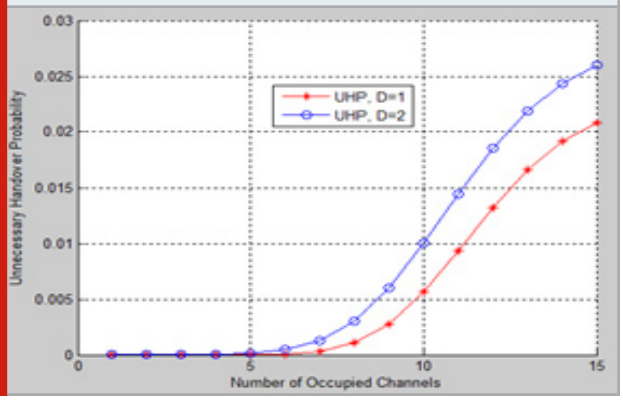
Percentage PU calls	Model	Blocking prob. at Node 20
60%	PU-SU-NC-FF	100%
60%	PU-SU-NC-RANDOM-ASSIGN	100%
60%	PU-NC-SEL-ASSIGN	70%
60%	SU-NC-SEL-ASSIGN	30%
60%	PU-SU-C-FF	97%
60%	PU-SU-C-RANDOM-ASSIGN	97%
60%	PU-C-SEL-ASSIGN	60%
60%	SU-C-SEL-ASSIGN	40%
70%	PU-SU-NC-FF	100%
70%	PU-SU-NC-RANDOM-ASSIGN	100%
70%	PU-NC-SEL-ASSIGN	70%
70%	SU-NC-SEL-ASSIGN	30%
70%	PU-SU-C-FF	96%
70%	PU-SU-C-RANDOM-ASSIGN	96%
70%	PU-C-SEL-ASSIGN	60%
70%	SU-C-SEL-ASSIGN	28%

Fig. 6 and 12 shows the blocking probability and throughput, respectively, of First fit assignment, uniformly distributed random assignment and Selective channel assignment methods for a load 15 Erlangs per link and with 20 Links (nodes), 15 Channels, 4000 iterations and 70% of PU calls with and without conversion. The Fig. 12 shows the overall summary of all blocking probabilities with all the 8 models developed as part of this work. Blocking probabilities of first fit assignment (PU-SU-NC-FF) and of uniformly distributed random assignment (PU-SU-NC-RANDOM-ASSIGN) method are 99% and 100% respectively at the node index 20. Blocking probabilities could be brought down to 97% and to 95% at node 20 by using converters at all the nodes with first fit assignment (PU-SU-C-FF) and uniformly distributed random assignment (PU-SU-C-RANDOM-ASSIGN) methods.

When selective channel assignment methods are used, the blocking probability is 70% with PU-NC-SEL-ASSIGN model and 30% with SU-NC-SEL-ASSIGN model. With conversion, that is when PU-C-SEL-ASSIGN and SU-C-SEL-ASSIGN are used it yielded approximately 60% and 40% of blocking probability respectively. Throughput for all the above discussed models are shown in the fig 12 and it is found that the throughput of the proposed method i.e., selective channel assignment method is superior than the considered existing methods.

From the summary presented in Table 1, the selective channel assignment methods, namely, PU-C-SEL-ASSIGN and SU-C-SEL-ASSIGN yield the best results both for 60% and 70% PU call cases.

Figure 13: UHP Vs occupied channels for B1 = 15, B2=15 and B3 = 15.



CONCLUSION

In this paper, authors have developed the models to simulate for the blocking probabilities with conversion and without conversion. Also, the percentage of PU calls over all the calls is varied. Two cases, one with 60% PU calls and 70% PU calls are simulated. The assignment methods, namely, first fit assignment, uniformly distributed random assignment and Selective channel assignment methods are used in the simulations. It has been observed that the blocking probabilities are nearly 100% when the first fit and random assignment methods are used for a network with 15 channels, 20 links and 15 Erlangs. of load.

This is true for both 60% and 70% PU calls. When the selective channel assignment method was used, the blocking probabilities are around 70% and 30% for 60% PU calls case and 70% and 30% for 70% PU calls case when there were no converters in the network. When converters are used, the blocking probabilities are around 60% and 40% for 60% PU calls case and 60% and 28% for 70% PU calls case. Hence it is concluded that selective assignment method has outperformed over the first fit assignment and uniformly distributed channel assignment methods in conversion and no conversion as well as 60% and 70% of PU calls.

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Development of a Novel Protocol for Improvement of Qos Inwireless Sensor Networks: P-Rpeh

Sowmyashree M S, C S Mala

Abstract*: *The Wireless Sensor Networks (WSN) plays an important function in wireless communication because of its top notch utility and benefits. Wireless Sensor Networks have thousands or hundreds of potential nodes, which are minute computer like, and areable of measuring the physical characteristics of the neighboring environment location and thentransmit the gathered information using wireless radio links. This paper proposes an efficient scheme for resource allocation used for the transmission of data using priority in the nodes. The protocol, Medium Access Control (MAC) has been devisedfor evaluating the performance. The parameters considered are bandwidth, energy consumption, delay, throughput andpacket delivery ratio. A new MAC protocol,"P-RPEH"(Priority that is based on the Residual Power and Energy Harvesting rate), using priority in nodes with maximumenergyis proposed. The proposed method is compared with the PRIN (Priority in Node) and PRIMA (Priority based MAC)existing protocols. The results obtained from the new protocol proves that, the newproposed protocoloutperforms the existingmethods in terms of bandwidth, delay, energy, throughput and the ratio of packets delivered.

***Index Terms*: *Wireless Sensor Networks*, QOS, Medium Access Control, Priority.**

I. INTRODUCTION

The Wireless Sensor Networks (WSNs) has enormous number of sensors which are distributedin a random manner. These small/tiny sensor nodes are made up of a sensor unit, a processor, a power unit and communication capacities. These effective nodes makecommunication with each and every other nodeand are successfulinsharing and transmitting the sensed parameters such as humidity,temperature, motion detection etc. The communication reaches the collectingstation at once or through different intermediate nodes. The Quality of Service (QOS) which is important in the Wireless Sensor Networks is dependent on many parameters. Some of the parameters considered in proposed work to increase the efficiency are as follows:

i. Bandwidth
ii. Energy Consumption
iii. Delay
iv. Throughput
v. Packet Delivery Ratio

Bandwidth and Energy efficient routing protocols are required for obtaining the QOS.Further, there is a requirement for the standardized protocolin order to obtainthe information which is required by the sensors and are normallyavailable in the equipment of networking [1]. Prioritizing the nodes help in increasing the network performance which in-turn improves bandwidth andenergyefficiency.

Another parameter of importance is delay. In the process of collection of information, huge data statistics requirementshas to be gathered and accumulatedintime.Accumulatingrequired amount of data resultsina delay which may becomelonger. In this process, because of theinherent quality of the hyperlink used for the wireless transmission, thepackets which holds theinformation may get lost. This leads to a greater challenge in the transmission of real-time data, within therequired time frame.Some industrial applications allow delay-tolerance withinaspecifiedtime constraint [2].

If the packets are misplaced, the data has to be retransmitted again, which leads to a protracted postponement. In some situations such as monitoring, a long put off will delay the timing of obtaining data which causes extra losses. It is also crucial that a device makes a decision before the records are complete. This results in lack of information in some portions of the data.So care must be taken in such a manner that less delay is obtained. [3].

The other important evaluation parameters include the throughput and packet delivery ratio. There are numerous researches going on for the standardization of these factors to improve the QOS.

The QOS challenges differ in different WSNs with respect to resource constraints such as node deployment, real time traffic, scalability, data redundancy, topology changes, and contention window size so on.

The paper is arranged into 5 sections: in which Section 1 introduces the parameters considered for QOS. Section 2 discusses on the prior art in MAC protocols. Section 3throws light on the proposed method *P-RPEH* protocol.Theresults of the proposed methodology are discussed in section 4.The summary/conclusion of the present work and future enhancements are discussed in section 5 and 6.

II. RELATED WORK

From the survey of literature which ambitions to explore on the different types of MAC protocols that are used in WSNs to achieve better bandwidth and energy efficiency with respect to priority based allocation for QOS. Time Division Multiple Access (TDMA) and Carrier Sense Multiple Access (CSMA) are the different types of MAC protocols that are usually used for transmission ofdata through the wireless networks.

PRIN based MAC protocol is one of the existing methods to improve the QOS. The PRIN uses static priority in source as well asin the intermediate nodes.AnandaKumarSubbramanya et al have assigned the highest priority to that node which maybeonly one hop away from sink node which aims to achieve a very good QOS parameters[4].

Revised Manuscript Received on September 25, 2019.
Sowmyashree M S, BMS Institute of Technology & Management
C S Mala, BMS Institute of Technology & Management

The amount of energy that is consumed is reducedby assigning differentpriority to all the incoming packets. This hasincreasedthethroughput to some extent only.

Another methodisPRIMA, which is based on two phases. In the phase one, clusters are formed and in the phase two the channel is accessed. The clustering technique is used in MACto handle the issues related to network scalability in a better fashion.Jalel Ben-Othman et al [5], have used PRIMA protocol where in the channel access composes of the hybrid method where both TDMA and CSMA are used. TDMA controls the data and CSMA communicates with control messages. Thishas minimized the packet collision which the author claims to have reduced the energy consumption.

AQ-MAC is another Asynchronous MAC protocolwhich is usedfor obtaining the QOS inthe sensor networks, the efficiency of energyis obtainedby organizingthe incoming data into numerous static priorities.Fafoutis, Xetal[9], have discussed in detail the AQ-MAC protocol. The authors were able to moderately improve energy efficiency.

Bandwidth plays an important role in achieving good QOS. Bandwidth reduces congestion by assigning priority to the nodes. This is done using cluster formation. In the cluster formation process, the highest priority is assigned to theheadof clusters.The members of thecluster and the cluster head nodes communicate with single hop step, while the cluster head and the sink communicates with multiple hops. The data is sent using TDMA time slots inorder to utilize the bandwidth efficiently. [6]

D Mathavanet al have worked on the density of traffic. They have obtained a better bandwidth performance by creating adefinedpath tree. The path was based on the density of traffic. They have also separated the highest priority from the lowest priority in the tree. The author's claim that by doing so congestion can be avoided [7].

To identify the class traffic,SSridevietal [10], have usedEWMAmethod.Inthis method, traffic classifier is inserted into the appropriate queue depending on the traffic. Then Priority is assigned to each queue. Depending on the priority the packets are scheduled. High and low priority is assigned depending on the source and transit traffic. The authors claim that by doing so, more bandwidth has been used.

Timeliness and also reliability has a greater impact on the performance of QOS. To obtain the timeliness of the data the delay during the transmission over the wireless network should be less which also yields efficient transmission [11].

III. PROPOSED METHOD

WSNs have wide applications which include homeautomation, defense, health, environment and many other areas. To work in all these complex fields a good augment support system is required. To fulfill the WSNs capacity, QOS requirements must be enhanced. This can be achievedbysetting priorities in the existing MAC protocols.

In the present work P-RPEH has been developed to enhance the QOS. In this method, the minimum and maximum nodes taken are 25 and 125 and are presented in the figures 1 and 2 respectively. The proposed methodology is presented in figure 3.All the mobile nodes deployed are in random fashion in the real time environment.The routing protocol used for implementation is Ad-Hoc On-Demand Distance Vector (AODV). The other protocols which are generally used for routing have energy constrains and flooding, which is overcome by using AODV. AODV establishes routes to destination on demand.

Then the priority to the nodes is assigned depending on the maximum Residual Power and Energy Harvesting rate.If in case the residual power is large and the rate of energy harvesting is small, then the priority is not assigned to the node. Or with small residual power and large energy harvesting rate, the priority is still not assigned. The priority is assignedonly when both residual power and energy-harvesting rate is maximum.
The other nodes which lack these criteria go to the sleep state. For transmission of data through wireless network TDMA is used .

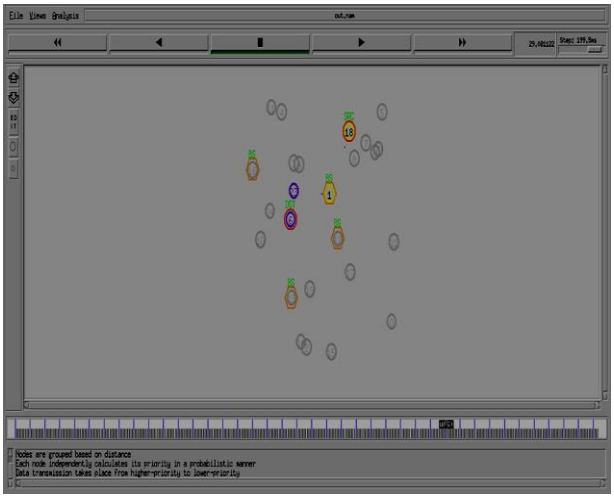


Fig 1: WSN Structure with minimum 25 nodes

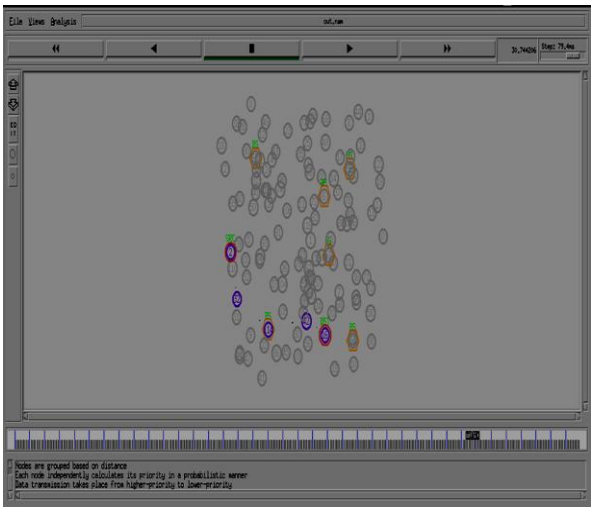


Fig 2: WSN Structure with maximum 125 nodes

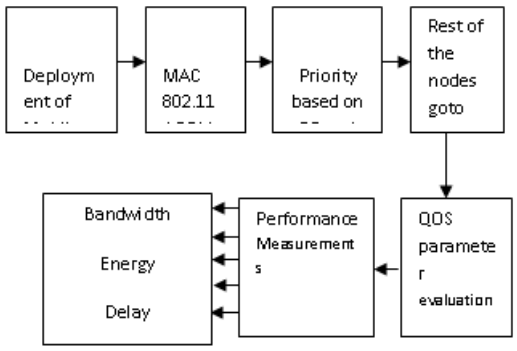


Figure 3: Proposed Methodology

The QOS performance parameters which are considered for the evaluation is listed below:

3.1 Bandwidth :

Bandwidth is calculated based on the RREQ (Route Request)Packets. These packets arethen sent to the destination node. These RREQ packets by the total amount of simulation time in the network, is expressed in equation (1) which denotes allocation of bandwidth.The source node at the initial stage checks theavailability of bandwidth. The RREQ packet is sent by the source if there exist a minimumof one time slot that is free at that instant of time, then the source sends a RREQ packet. If there isresponse within a fixed time period, then thenode which is the source node again sends the RREQ packet. If in case the response packet (RREP) is received, the path is set up for transmission. Once the path is set,the source node is responsible for allocating the time slots for starting thetransmission. During the process of path set up if there are three consecutive failures in finding thepath between source and destination, the source node aborts itself in sending the RREQ packets.

$$Bandwidth = \frac{B}{N} \quad \ldots\ldots\ldots (1)$$

Where Bdenotes the RREQ Packets sent to the destination nodein kbpsand$N$ is the total simulation time in seconds.

3.2 Energy Consumption:

If there are more number of nodes,the energy consumption is also more. A node drops some amount of energy for every packet transmitted orreceived, which is presented in equation(2)

$$Energy = \frac{E}{N} \ldots\ldots\ldots (2)$$

Where E is the amount of energy drop in joulesforthe transmission of each packet and N is the total simulation time in seconds.

3.3 Delay:

Delay is computed by the formula presented in equation 3, delay is nothing but the time that is taken by each packet hop from the sender to the receiver node.

$$Delay = \sum_1^n \quad Time\ spent\ on\ each\ Hop \ldots (3)$$

n = number of hops.
The unit for delay measurement is in seconds.

3.4 Throughput:

Throughput is computedas the number of total packets that are received by the destination node tothe total value of network time, aspresented in equation (4).

$$Throughput = \frac{T}{N} \ldots\ldots\ldots\ldots (4)$$

Where T is total number of received packets at the destination node. N is the total simulation time in seconds. It is measured in kilo bytes per second.

3.5 Packet Delivery Ratio:

The packet delivery ratio is calculated based on the number of packets that are actually sent from the source node to the number of packets that are received by the destination node. Equation (5) presents the same.

$$\text{Packet Delivery Ratio} = \frac{S}{W} \times 100 \ldots. (5)$$

S: The number of packets which are sent by the source node
W: Thenumber of packets that are received by the destination node.
It is obtained in terms of percentage.

The simulation procedure used for the proposed scheme:

Begin
1. Spread out all the nodes randomly in the real time environment.
2. Apply AODV routing Algorithm
3. Then apply the concept of priority to nodes.The priority is assigned based on P-RPEH method.
4. The remaining nodes goes to sleep state.
5. Evaluate the QOS performance parameters.
6. Generate the graphs respectively.

End

Following the above procedure, the QOS graphs were generated. The parameters used for simulation are indicated in the Table 1

Routing algorithm	AODV
Priority based on	Residual Power +Energy Harvesting Rate
Simulator used	NS2
Simulation start time	0.000000000 sec
Simulation End time	50.00000000 sec
Random Mobility Model	Random Way point
Propagation Model	Two-ray Ground
Traffic Model	Constant bit Rate (CBR)
Number of mobile nodes (Fixed Nodes)	25, 50, 75, 100 and 125

Channel Model	Omni Antenna
Packet Size	512
Network Interface types	Wireless ad-hoc
MAC Type	MAC/802_11, TDMA
Performance parameters	Bandwidth by RREQ packets, Delay, Energy Consumption and Throughput

Table 1

IV. SIMULATION RESULTS

Here in section four the simulation results are discussed. The PRIN MAC and PRIMA Protocols were compared with P-RPEH, the present work.

The parametersconsidered for comparison are:

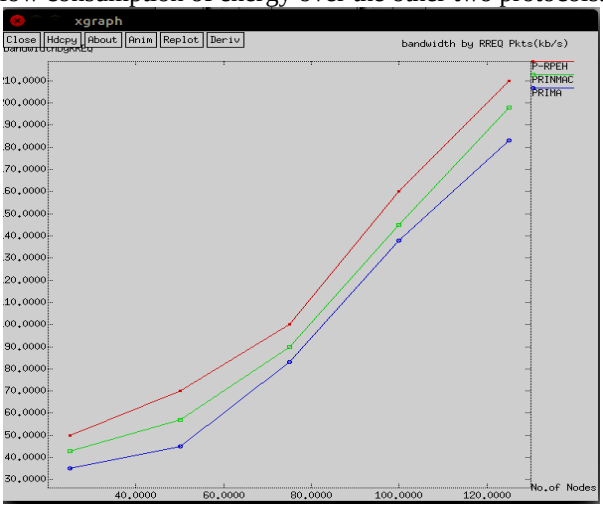
a. Bandwidth versus Number of Nodes
b. Energy versus Number of Nodes
c. Delay versus Number of Nodes
d. Throughput versus Number of Nodes
e. Packet delivery Ratio versus Number of Nodes.

4.1 .Bandwidth v/s Number of Nodes:

The allocation of resource such asbandwidth for the nodes which are of different sizes in the real time environment for various protocols wastaken into consideration. They were compared with the proposed new protocol. The comparison of graph is presented in the figure 4. It is clear from the graph that by varying the size of the nodes the size of bandwidth hasalso increased. The point to note here is that our present work gives a significant rise in bandwidth over the other two protocols.

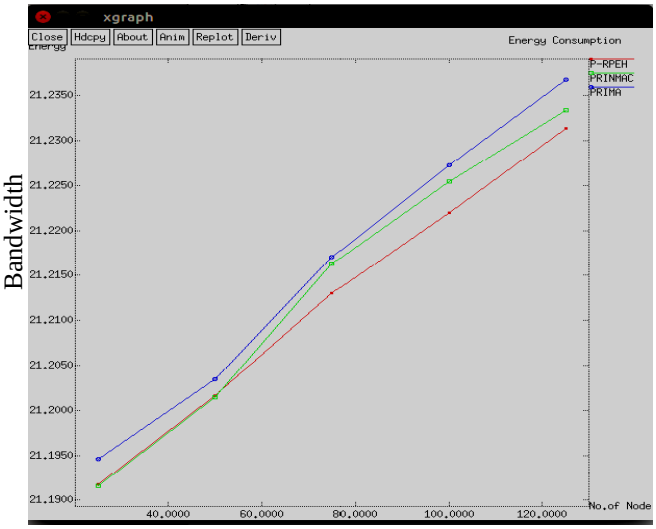
4.2 . Energy v/s Number of Nodes:

The consumption of energy likewise for various protocols was taken into consideration, and compared with PPREH, the proposed protocol. The graph with respect to energy v/s Nodes for different protocols isshown in figure 5. It is evident from the graph that asthere is increase in the size of the nodesthere is a decrease in the energy consumption.It also clearly indicates that the P-REPH protocol gives a significant low consumption of energy over the other two protocols.



No of Nodes

Figure 4: Number of Nodes *vs*Bandwidth



Bandwidth

No of Nodes

Figure 5: Number of Nodes *vs*Energy

4.3Delay v/s Number of Nodes:

The delay versusthe node Number for different protocols is presented in figure 6. It can be observed that as the number of nodes are increasing,delay decreases in general. Until 110 nodes the delay decreases greatly for P-RPEH protocol. There after there is a marginal increase in delay compared to PRIMA, but it is still better than PRINMAC. This result is further discussed in the bar graph at a later point in this paper.

4.4Throughput v/s Number of Nodes:

The next parameter throughput may also be considered as one of the important parameters to measure QOS. The graph for the nodes of different sizes in the real time environment for various protocols is present in figure 7. It is evident from the graph that as the node size increases the throughput also increases.The inference we draw from the graph is that there is a significant increase in throughput from the newalgorithm when compared with the other two existing protocols.

4.5 Packet Delivery Ratio v/s Number of Nodes:

The results of packet delivery ratio v/s the number of nodes is presented in figure 8. When the results of Packet delivery ratio of P-RPEH is compared with the PRINMAC and PRIMA protocols.The graph illustrates that asand when the size of the nodeincreases, the packet delivery ratioalso increases.Up tonode 100 there showsan increase in the packet delivery ratio for the protocol that is newly proposed, but after that the level of increase for the algorithm that we have developed is almost same when compared with the other two protocols.

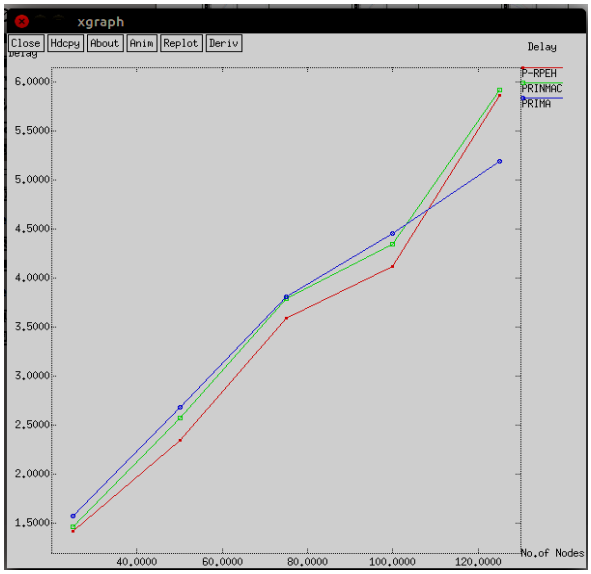


Figure 6: Number of Nodes *vs*Delay

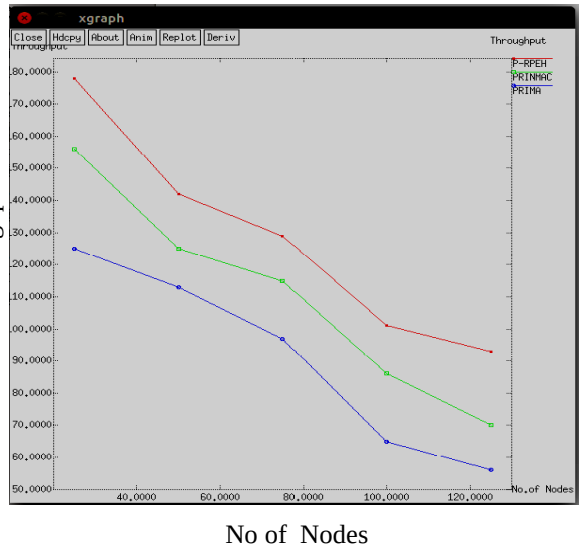


Figure 7: Number of Nodes *vs*Throughput

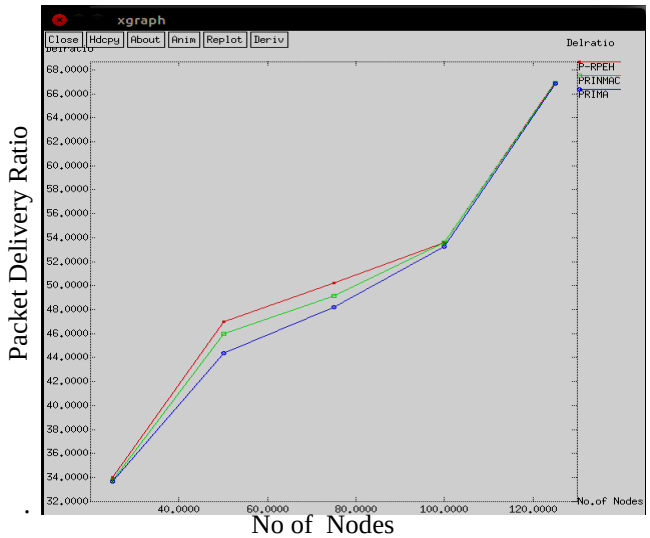


Figure 8: Number of Nodes *vs*Packet Delivery Ratio.

The QOS parameters for all approaches are compared. After the comparison it is observed that the QOS parameter of our work yieldssignificantly better results than the existing ones which are PRINMAC and PRIMA protocols. The QOS parameters of interest of the newly developed protocol compared with the existing ones are presented in bar graph from figure 9 to figure 13. It is clearly evident from the figures that ournew proposed protocol outperforms better in the QOS parameter terms such as Bandwidth, Energy, delay, throughput and the packet delivery ratio in our prioritized method.

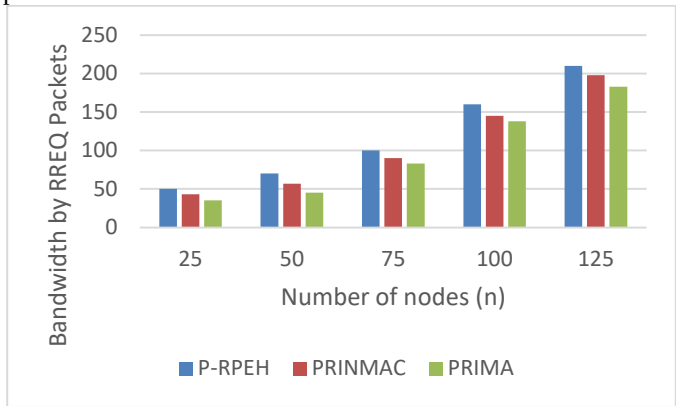


Figure 9: Comparison of *Bandwidth*

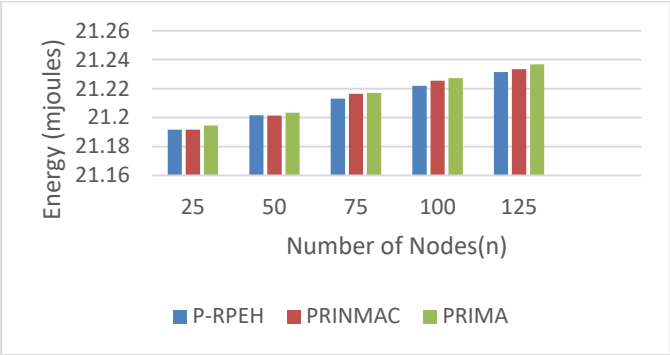


Figure 10: Comparison of *Energy*

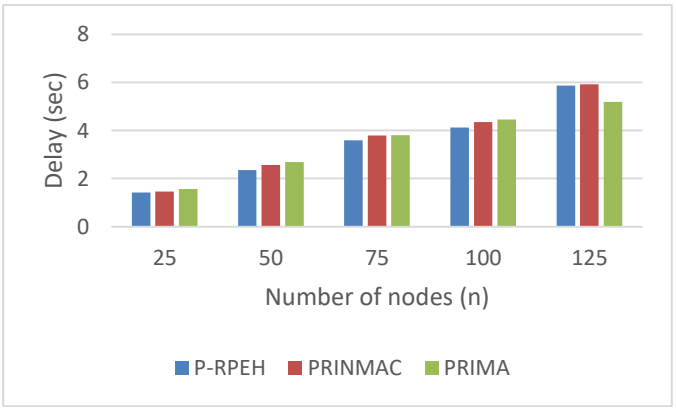


Figure 11: Comparison of *Delay*

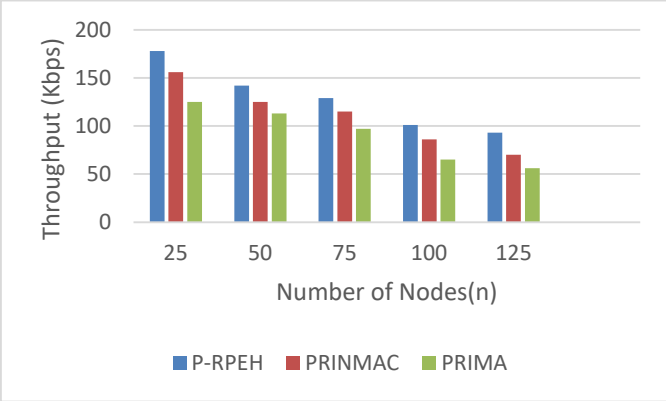


Figure 12: Comparison of *Throughput*

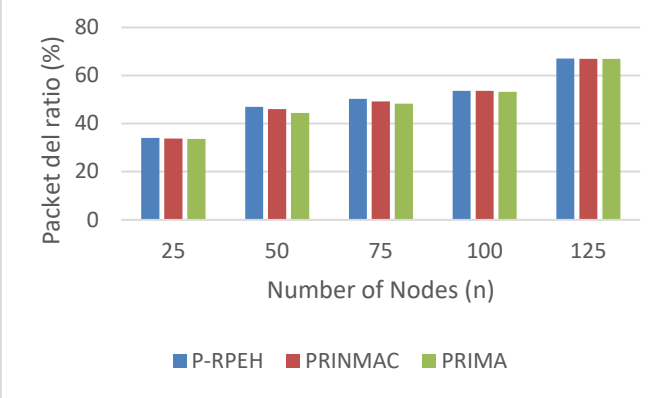


Figure 13: Comparison of *Packet Delivery Ratio*

The improvement in Performance of P-RPEH with the existing PRINMAC is presented in Table 3. Similarly,P-RPEH with that of PRIMAis presented in table 4.

No of Nodes	Parameters	P-RPEH	PRINMAC	Percentage improvement (P-RPEH with PRINMAC)
25		50	43	16.28
50		70	57	22.81
75		100	90	11.11
100		160	145	10.34
125	Bandwidth	210	198	6.06
25		21.19174	21.19457	0.01
50		21.20165	21.20345	0.01
75		21.21302	21.21631	0.02
100		21.222	21.22541	0.02
125	Energy	21.23134	21.23334	0.01
25		1.4127	1.4567	3.11
50		2.3456	2.5678	9.47
75		3.589	3.789	5.57
100		4.117	4.3452	5.54
125	Delay	5.8687	5.9234	0.93
25		178	156	14.10
50		142	125	13.60
75		129	115	12.17
100		101	86	17.44
125	Throughput	93	70	32.86
25		33.987	33.756	0.68
50		46.986	45.978	2.19
75	Packet	50.234	49.156	2.19
100	delivery	53.589	53.578	0.02
125	Ratio	66.998	66.912	0.13

Table 2

No of Nodes	Parameters	P-RPEH	PRIMA	Percentage improvement (P-RPEH with PRIMA
25		50	35	42.86
50	Bandwidth	70	45	55.56
75		100	83	20.48
100		160	138	15.94
125		210	183	14.75
25		21.19174	21.19456	0.01
50		21.20165	21.20343	0.01
75		21.21302	21.21703	0.02
100		21.222	21.22723	0.02
125	Energy	21.23134	21.23678	0.03
25		1.4127	1.567	10.92
50		2.3456	2.6789	14.21
75		3.589	3.8077	6.09
100		4.117	4.4567	8.25
125	Delay	5.8687	5.189	-11.58
25		178	125	42.40
50		142	113	25.66
75		129	97	32.99
100		101	65	55.38
125	Throughput	93	56	66.07
25		33.987	33.654	0.99
50		46.986	44.345	5.96
75	Packet	50.234	48.234	4.15
100	delivery	53.589	53.234	0.67
125	Ratio	66.998	66.845	0.23

Table 3

V. CONCLUSION

In this paper, we presented the P-RPEH, which is aQOS MAC protocol which improves the bandwidth as well as energy efficiency using priorityfor the wireless sensor networks. P-RPEH has combined the benefits of the residual power and energy harvesting rate,which aims to achieve significant amount of resource savings. To guarantee the Quality of Service, priority approach is used.

To conserve resources, P-RPEH protocol enables the nodes with maximum energy to transmit the data and lower priority nodes to go to sleep state. This avoids wasting of resources and uses TDMA schedule to transmit the data for communication process.

A great amount of work was carried out on P-RPEH Protocol. Its performance was analyzed through Simulation. The QOS parameters were compared with PRIMA and PRINMAC protocols. From the results obtained we conclude that the proposed work with a new protocol outperforms the other existing ones in terms of bandwidth, energy, delay, through-put and packet delivery ratio.

FUTUREENHANCEMENTS

The number of nodes considered in the present work is from 25 to 125. The work can be enhanced to greater number of nodes.The delay in the system can also be further decreased.

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AUTHORS PROFILE

Mrs.Sowmyashree M S completed B.E (ECE), from Oxford college of engineering, Bangalore, M.Tech (Electronics and communication) from MVIT Bengaluru, and Pursuing Ph.D (WSN) from Visvesvaraya University, Belagavi. she has 12 years of teaching, 4 years of research experience. At Present, working as Asst.Professor, ETE Dept.,BMSIT, Bengaluru. Member for professional bodies, ISTE & IETE. Organized and attended many Workshops, FDPs and STTPs. Guided UG Projects . Published 11 Technical papers in National \ International journals \ Conference.

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Dr C S Mala,is currently working as professor in ECE department. She has 32+ years of Teaching, Administration and Industry experience. She has also worked as special officer in VTU, headed the department of ECE in various colleges. She was also member, Board of Examiner ECE\TE in 2018-19. Also served as senior manager in in MANWISH Infotech Ltd. AS a researcher she has published papers in various National and International journals. She is also reviewer and session chair for National and International Conference.

Wireless Personal Communications (2020) 112:2663–2684
https://doi.org/10.1007/s11277-020-07169-6

Link Aware Routing Protocol for Landslide Monitoring Using Efficient Data Gathering and Handling System

M. S. Sumathi[1] · **Gowda Sheshadri Anitha**[2]

Published online: 10 February 2020

Abstract
The landslide phenomenon's has become a serious problem in Himalayan regions to killed many people and also thrashed their whole living areas. All these tragedies triggered by environment changes and gathered by sensor nodes. Due to some reasons, sensor nodes are not possible to transfer sensed data to base station. The link failure is a major problem which creates data losses in the wireless sensor networks. In this paper, we propose an efficient lossless landslide monitoring (LLM) system. The proposed system consists of two phase, such as data gathering and handling phase. In data gathering phase, we use modified gray wolf optimization algorithm for clustering technique, which provides link aware routing. In data handling phase, we use an iterative dichotomize-3 (ID-3) based decision making algorithm for landslide prediction. The proposed system tested with the five different environmental sensors, such as rain gauge, incline meter, crack meter, tilt meter, and piezo meter for gathering environmental information's. The simulation result shows that the delivery ratio of proposed LLM system is 30% higher, drop ratio is 27.5% lower, energy consumption is 11.25% lower, routing overhead is 13% lower and throughput is 19% higher than existing systems.

Keywords Link aware routing (LAR) · Modified gray wolf optimization · Iterative dichotomiser-3 (ID-3) · Lossless landslide monitoring (LLM)

1 Introduction

Wireless sensor networks (WSNs) invigorate a wide assembling of occupations, for instance, target following, home computerization and trademark checking [1]. A space of these applications may be administered or connected with the transmission of talented media data over WSNs [2]. Existing WSNs, in any case, have objectives in supporting these video/sound spilling applications in light of the contraption, for instance, cameras enough little to be showed up on sensor centers, information exchange cutoff of the structure, and

✉ M. S. Sumathi
sumathi.m@bmsit.in

[1] Department of Telecommunication Engineering, BMS Institute of Technology, Bangalore, Karnataka 560064, India

[2] Department of EEE, RVCE, Bangalore 560 059, India

power supplies of sensor centers [3]. The impelling advances of remote advances, indicated structures, sight and sound source coding procedures and unpalatable mechanical social event, for instance, CMOS cameras, enhancers, et cetera have pulled in the refinement in sensor frameworks, over which blended media data streams are transmitted [4]. In like way, new applications are made, for instance, sharp media perception [5], most remote inspiration driving conceivably immense activities [6], propel keeping up a key segment from [7], began restorative affiliations transport [8], modernized help for the elderly and family screens [9], and so forth.

Organization together quality is required for an unrivaled impression of the conditions, more especially, an awe inspiring thankfulness on the connection oversee plans mind blowing affiliation quality. Everything considered, an unthinkable relationship for directing needs to guarantee low centrality use, a high throughput, a low engineering overhead, and time endeavored ways when retransmissions are open [10]. Clearly, it should be responsive, figured out how to imagine short and whole approach interface threats, stable in time, extremely far affiliation quality, should rely on key estimation, or to have change predefined cutoff centers to isolate conflicting neighbors. Particular strikes [11] concentrating on the administering framework to partake in the structure, it can hurt the controlling procedure by fundamentally dropping the packs it gets for sending, i.e. denying to genuinely empower in the arranging structure. Another easily implementable strike is package change [12]. Careful ask for of controlling strikes screen the direct of their neighbors taking a gander at the good fashioned objective to audit their undaunted quality, with respect to specific lead edges called trust estimations [13]. Those sort of masterminding traditions not fitting for the profitable application like huge slide checking structure.

Flooding slides are gravitational improvements of soil or shake down affinities that can affect astounding capacity essential to structure. Particular fatalities and dire frustrated need caused by structures for lavish slides have been tended to in the midst of the time [14]. It achieved by the geotechnical instrumentations, for instance, inclinometers, extensometers, and piezometers. The instruments are once in a while showed up on the survey and wired to PC structures band together with data examination programming. Regardless, interface based looking are over the best, require dependable help, and are obliged in their correspondence flexibility [15]. To beat these detainments, remote sensor structures are an achievable elective change [16]. Front line remote flooding slide checking structures amass trademark data from the blueprint and forward it to related PC systems for picked keep [17]. The shielded information recuperation from any subset of sensors, at an optional blueprint of time, should be guaranteed and excitedly resources the merging condition, while understanding among its obsessions is meanwhile observed [18]. The remote inductor-capacitor (LC) full circuits [19] used to screen the water-content in head building material. An alternating direction of multipliers (ADMM) and a heuristic distributed linear programming (DLP) enable check [20] are other than used for relentless review. A trademark watching structure using WSN made by centrality getting, quality concerning clearing class of disturbs and unending change as showed up by the framework topology [21, 22]. A computational data count [23] used to move the goliath use in a trademark watching structure to the degree water level estimations in overpowered zones.

1.1 Our Contributions

An efficient lossless landslide monitoring (LLM) system consists of data gathering and handling phase. In data gathering, the efficient clustering technique designed by the

modified gray wolf optimization algorithm, which maximize the link quality. An Iterative Dichotomize-3 (ID-3) based decision making algorithm used to improve the data handling phase.

The rest of this paper is organized as follows: Sect. 2 describes the recent works related to our contributions; Sect. 3 summarizes the problems and system model of proposed LLM system; Sect. 4 describes the detailed explanation of proposed LLM system. Simulation results are discussed in Sect. 5. Finally, the paper concludes in Sect. 6.

2 Related Works

Prabakaran et al. [24] have analyzed inside point perplexity and center thickness issues in prop indicated checking structure. The conviction joining remote and physical contraptions related with minor sensor center obsessions share with each other to plot the gatherings and the most clear obsession point go about as cluster head (CH). The party head began in light of its battery quality whose beating impacts rest of the trades. This structure obliging the errand of CH using exchange centers, for instance, participatory contraptions and the broken obsessions are seen over Poisson undertaking which watches the bobble probability without impacting correspondence and lessened resource use.

Jiang et al. [25] have proposed a dynamic converge cast tree algorithm (DCTA) in light of a tree-like topology for watching structure. The WSN estimation using the information of the got hail quality sign and skip check to really change the building structure for each sensor center point. This estimation joins a flexible booking based approach for the medium access control custom to guarantee higher transmission consistency of the sensor data. This figuring dependably gather trademark data, focal strong data move rates of the entire tried structures with various flexible obsession centers are refined. This checking structure furnished with the DCTA and outfits the standard estimations with better spatio-transient resolutions.

Reducing et al. [26] have proposed the head watching structure, which redesigned comfort and submitted quality. The social occasion of information into a specific zone was a standard errand and computerization can diminish work stray pieces. This setup approach for the thing structure required specific decisions to be made in light of commitment and data. The weighty reasons why there are a wide anchoring of ways to deal with oversee manage sort out manage engineer coordinate control complete a required driving forward quality with programming, each execution having certain focal obsessions and weights.

Wu et al. [27] have proposed a trademark checking with the data require achieved by the least mean square (LMS) twofold measure count with hail start measure by impacting the mean-square difference (MSD). An amassed principal component analysis (PCA) structure used to play out the weight and recovery for the anticipated data on the CHs and the sink. This framework reestablished the correspondence cost and looks mean square shocking and this present reality data show up and this structure focal and persevering. In like way, the measure check gives better execution concerning need exactness, alliance together speed and correspondence diminishment.

Lesta et al. [28] have proposed a ZIGBEE WSN with perpetual motes for terrestrial snail activity monitoring. The approach has been made with WSN test structure which pays staggering identity to honest to goodness conditions as an uneven space of bits clear streams amassed by the sun energized cells of the bits. An up-scaling to more fundamental living structures is conceivable to the degree hugeness and more clear houses would oblige

to weave more power figuring and fittingly more apparent batteries and sun made cells in the base/facilitator bit to administer more information.

Ueyama et al. [29] proposed an adaptable and reliable wsn based system for flood monitoring system. The key issues and necessities for ensuring that an exhibited WSN system bolstered by and large fitted concentrated on structure application and contraption make. The key issues and necessities are given through the remote standard that orchestrated in the wake of sending a WSN-based stream checking structure for quite a while. The versatile approach clear by the nonexclusive structure that got with a wide remains of programming, for instance, phones and WSN center focus interests.

Muduli et al. [30] have proposed a WSN deployment scheme for environmental monitoring in long-wall coal mines. The working most remote compasses of this technique in setting of the probabilistic event zone approach for complete level of the checking zones in long-divider coal mines. The virtual power thinking related with keep the having a go at covering zones of the sensor center obsessions by gets straightforwardness of the structure. Likewise, the having effect can be settled by the probabilistic event presentation approach.

Bar et al. [31] have proposed a binary tree-based data aggregation and routing for real time monitoring system. This protocol reduces the packet loss and energy dissipation which occurs due to unsuccessful packet delivery. The joined tree based data mix out performs concerning the parameters end to end delay, sensible degree and total centrality use. This spreading out headings sensor lively, remote, zone and cloud benefits as a specific unit for solid indoor condition seeing did in the school get a couple of information about office to consider the execution concerning time and centrality utilize.

3 Problem Methodology and Network Model

3.1 Problem Methodology

Ju et al. [32] have shown a real-time monitoring network with a computer-aided early warning system (EWS) for titanic slide seeing. A four-level incited criteria structure has been joined into the changed endeavor process, and a period of star judgment is in like way included to keep up a key bundle from false alarm. The rich slide had been picked as a case application for the gave practicality. It ought to be seen that several containments should be considered in proceeding on use. To a stunning degree far unavoidably pays unprecedented identity to degrees of progress of the connection between checking information and overpowering slide event. The structure was should have been a versatile, if focal, purposes behind control can be changed by the sensible condition. The request game plan of sensible sensors for the checking structure is focal issues, which are everything considered managed by the accuracy, lifetime and bit of transmission. The notice structure messages are on a to an awesome degree critical level seen as a potential risk, not an advancing toward reliability. From exiting works [24–32], authors have mainly focused on data handling systems as well as corresponding warning system, not the data gathering phase. A real-time monitoring system according to the modern WSN is mainly affected by the data gathering phase [24, 25]. The security is a main problem, which affects the link between sensors. For this reason, a lossless landslide monitoring (LLM) system will required, so we concentrate on both data gathering and handling phase. Additionally, security is an important factor for WSNs, which breaks the link between sensor nodes when sensor nodes have limited power,

computational capability, and transmission range. The limited resources nature of WSN posts a great challenge to any proposed security solution.

The proposed LLM system combines the Link aware routing (LAR) and efficient decision making algorithm. In data gathering phase, we use new constraints such as received signal strength, cooperation, and vacant rate used to compute the quality of Link. The modified gray wolf optimization algorithm used to perform clustering process. This algorithm inspired from the conventional gray wolf optimization (GWO) algorithm [33]. The clustering consists of two processes such as cluster formation, and cluster head (CH) selection. In data handling phase, we use an Iterative Dichotomize-3 (ID-3) based decision making algorithm for landslide detection with false-less results. Similar to real-time monitoring network [32], the proposed LLM system describes warning levels as 1, 2, 3, and 4. Finally, the proposed LLM system with LAR protocol based data gathering is simulated in Network Simulator (NS-2) tool and gather environmental factors such as rainfall, horizontal angle strata, vertical angle strata, displacement of strata, and the pore water pressure. Then, the gathered information's are analyzed to predict the landslide using the efficient decision making i.e. iterative dichotomize-3 (ID-3) algorithm.

3.2 Network Model of Proposed Lossless Landslide Monitoring (LLM) System

The data gathering phase performed with the different sensors such as rain gauge, incline meter, tilt-meter, crack meter, and piezometer for gathers the rainfall, horizontal, vertical angle strata, displacement of strata, and the pore water pressure respectively. The link aware routing (LAR) protocol is designed by cluster formation and CH selection. The network of proposed system consists of higher density sensors and each node embedded with real time sensors like [34]. First, frame the cluster using position and velocity. Then, compute the CH using new constraints such as received signal strength, cooperation, and path vacant rate. The proposed LAR protocol guaranteed to forward gathered environment data to the Base station (BS). Figure 1 shows the network model of proposed work.

The gathered environment factors further handled in an Iterative Dichotomize-3 (ID-3) algorithm for detect the landslides in network. The gathered factors are rainfall (mm), horizontal angle strata (degree), vertical angle strata (degree), displacement of strata (mm), and the pore water pressure (Kg/cm^2) using rain gauge, inclinometer, tilt meter, crack meter, and piezometer respectively. The gathered information from sensors is forward to the base station (BS) by the proposed LAR protocol. The gathered environment factors are effectively handled in data handling phase using ID-3 algorithm, which computes the situation of network in terms of four different levels. The level 1 describes the normal safe situation; level 2 defines the seasonal variations caused by human activity; level 3 mentions the landslide activity due to prolonged rainfalls; and level 4 defines the seasonal fluctuation, it is final/danger level. For each detection, our proposed system gives the reply like warning mark-1 for level 1; warning mark-2 for level 2; warning mark-3 for level 3; warning mark-4 and warning mail to authorized person for level 4.

4 Proposed Lossless Landslide Monitoring (LLM) System

The proposed lossless landslide monitoring (LLM) system consists of two phase, first the data gathering phase describes in Sect. 4.1 and the data gathering phase discuses in Sect. 4.2.

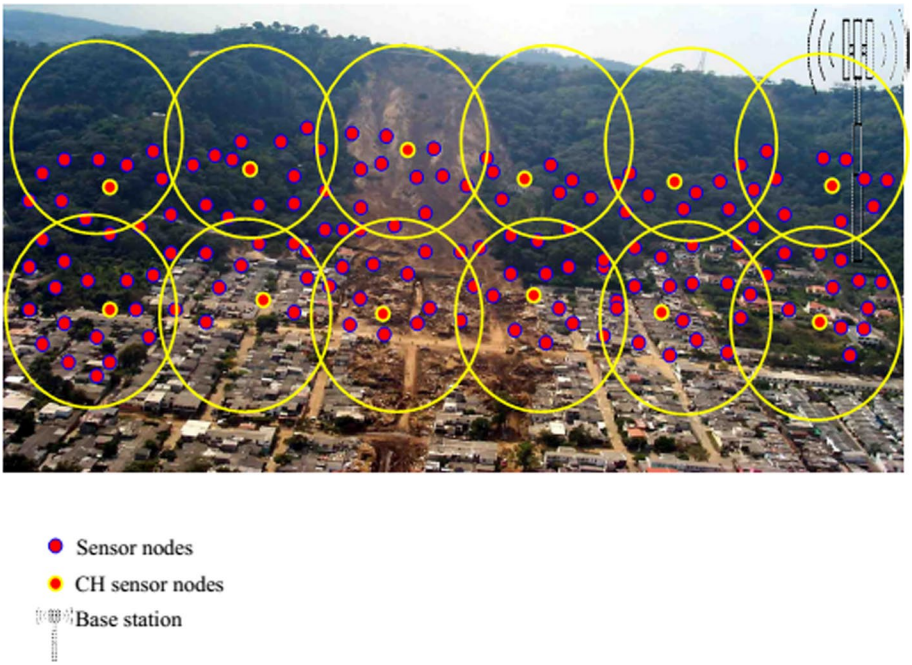


Fig. 1 The network model of LLM system with LAR protocol

4.1 Data Gathering Using LAR Protocol

The data gathering in possible networks done by the five different sensors are rain gauge, inclinometer, tilt meter, crack meter, and piezometer. The sensors equipped with the each nodes in our testing network. The data gathering will mostly affected by the link failure, which caused by the unwanted attacks. Here, we improve the data gathering process by proposing the new protocol named as link aware routing (LAR) protocol. The protocol consists of cluster formation and CH selection process. The clustering will performed by the modified gray wolf optimization algorithm, and collect performance metrics from each node such as received signal strength, cooperation, and vacant rate for compute the CHs. The path between the sensed nodes to BS is done via the CH nodes only, which defends against the attacks to reduce the data losses.

4.1.1 Clustering Using Modified Gray Wolf Optimization Algorithm

Grey wolf optimizer (GWO) [33] is another metaheuristic vivified by the drive rise structure, what's constantly the looking for after down after part found in reduce wolves. The decreasing wolf confining for after direct is general maneuvers again into three phases: following, circumnavigating and striking the prey. The balanced dull wolf streamlining virtuoso pushed from the general GWO estimation and the wolves consider the prey a zone, through an iterative structure. The figuring starts with a people of shockingly made wolves. The measure of tenants in self–self-unequivocally made wolves tends to plots. Like the lessening wolves' prompt, the measure of tenants in wolves thinks about the

perfect approach through an iterative structure. The three best compass for after expert, for instance, alpha, beta and delta are used to pull in whatever is left of the cautious structure's zone. Solution tracking represents the exploration phase by attacking the prey. The wrapping conduct is numerically showed up as takes after:

$$\vec{\chi} = \left| \left(2\vec{r}_1\right) \vec{X}_p(t) - \vec{X}(t) \right| \tag{1}$$

$$\vec{X}(t+1) = \left| \vec{X}_p(t) - 4\vec{a}\,\vec{r}_1\,\vec{r}_2 \; - \; 2\vec{a}\,\vec{r}_1 \right| \tag{2}$$

where $\vec{\chi}$ pays special mind to the package between the position vector of both the prey $\vec{X}_p$ and a wolf $\vec{X}$, $\vec{r}_1$ and $\vec{r}_2$ are sporadic vectors between 0, 1 and t addresses the present cycle number. The conditions (1) and (2), a wolf can self–self-no uncertainty on the planet restore the situation in the space around the prey. The three best plans are figures as takes after:

$$\vec{\chi}_\alpha = \left| \left(2\vec{r}_1\right) \vec{X}_\alpha(t) - \vec{X} \right| \tag{3}$$

$$\vec{\chi}_\beta = \left| \left(2\vec{r}_1\right) \vec{X}_\beta(t) - \vec{X} \right| \tag{4}$$

$$\vec{\chi}_\delta = \left| \left(2\vec{r}_1\right) \vec{X}_\delta(t) - \vec{X} \right| \tag{5}$$

The other search agents are computes as follows:

$$\vec{X}_1 = \vec{X}_\alpha - \vec{A}_\alpha \left(\vec{\chi}_\alpha\right) \tag{6}$$

$$\vec{X}_2 = \vec{X}_\beta - \vec{A}_\beta \left(\vec{\chi}_\beta\right) \tag{7}$$

$$\vec{X}_3 = \vec{X}_\delta - \vec{A}_\delta \left(\vec{\chi}_\delta\right) \tag{8}$$

Then

$$\vec{X}(t+1) = \frac{\vec{X}_1 + \vec{X}_2 + \vec{X}_3}{3} \tag{9}$$

The conditions (3)–(9) can be seen that the situation $\vec{X}$ of any wolf is controlled by the condition of the three best structures. The breaking down for after down after closes by ambushing the prey, this change pays unmistakable character to the abuse makes. It is performed by lessening the estimation of $\vec{a}$, straightly from 2 to 0. This in like way diminishes the estimation of $\vec{A}$. To keep up a key district from neighboring stagnation, sporadic estimations of more massive than 1 are utilized to oblige the wolf far from the prey. This change pays astonishing identity to the examination shape. Utilizing versatile estimations of a and subsequently $\vec{A}$, which is portrayed by no absence of insurance on the planet diminishing the estimations of from 2 to 0, ensures an accreditation among examination and manhandle. This change is fit since half of the emphasess depend upon examination when $|A| \cdot 1$, while the straggling remains of the cycles is given for mishandle when $|A| < 1$. This change is one of these estimation qualities. To whole up, estimations of

$|A| < 1$ oblige the intrigue stars to move towards the prey while estimations of $|A| > 1$ oblige them to bend from it. In this check, each wolf holds an approach of N focuses that moving out of N parties. Each inside is a D dimensional vector. In like way, each wolf is tended to by a $N \times D$ vector. A people of N wolves charmingly investigate for after for the best chart of the packs. The best chart of social gatherings is reflected by the ideal spots of inside interests. These fixations are in this way used to make packs demonstrates are traded the package with closest focus. The objective function defined as follows:

$$F = \sum_{i=1}^{N} \sum_{j=1}^{M} \left\| x_{i,j} - c_j \right\|^2 \tag{10}$$

where N is the number of nodes in the cluster, M represents the number of clusters, the i-th node belongs to the j-th cluster, and c_j is the center of the cluster. For each interest head pays huge character to a method of M centers and it gives a sign on how fit this master. The fit-test compass for after expert is the one related with the base estimation of F. In get-together, inside obsessions are spread to their relating parties. The standard sensibility for undertaking is performed by scarcest bundle to center. Inside obsessions are exchanged to packs make just in light of scarcest division to center; infeasible social events might be blended. The one possible approach is to fight the Euclidean bits between each inside point and the entire obsession is figured. The obsessions are scattered to the social affair in light of humblest division until the minute that the moment that cutoff control is come to. At this stage, the remaining non-clustered customers are left of the non-amassed customers will discharge necessities if allotted to any bundle. For each non-amassed customer, we figure the measure of cutoff encroachment if the customer is doled out to every party. Each non-stuffed customer is then moved to the get-together having past what clear would think about conceivable encroachment.

4.1.2 CH Selection Using New Constraints

After the cluster formation, BS collects the constraints from each node such as received signal strength, cooperation rate, and vacant rate. Then, BS computes the quality for every node, which used to fine the CH in the cluster. The sensed information's are forward to the BS via the elected CH nodes that are avoids unwanted link failure. Additionally, the higher quality nodes not easily affected by network attacks. The detailed function of new constraints as follows:

The received signal strength (R_0) is controlled by the division and transmission tremendousness, if inside point transmits data with hugeness $E(n, d)$, the middle fixations got hail quality, with the unit of D, can be passed on as takes after:

$$R_0 = \frac{E(n, d)}{4\pi D_i^2} + T_{a, a_1/a_2} \tag{11}$$

where $E(n, d)$ addresses the importance usage of a center point, which is diverging from square of section $\left(D^2\right)$ when the spread division (D) not as much as the edge void $\left(D_0\right)$, else it is with respect to $\left(D^2\right)$.

$$E(n, d) = \begin{cases} n \times E_{elec} + n \times \varepsilon_{fs} \times D^2; & if\ D < D_0 \\ n \times E_{elec} + n \times \varepsilon_{mp} \times D^4; & if\ D \geq D_0 \end{cases} \tag{12}$$

The distance and relative speed determine the speed accurately according to the current sampled signal strength, sample points are selected which meet constrain $\Delta t_1 = \Delta t_2 = \Delta t$,

but the sample domain may have no such points. Different reference points are used to approximate nodes' actual received signal strength. The distance parameters are D_{i1}, D_{i2} and D_{i3} obtained from Eq. (4), and the modified distance is computed from the cosines laws as follows:

$$D_{i1}^2 = D_{i2}^2 + a_1 a_2^2 - 2D_{i2} \cdot a_1 a_2 \cdot \cos(\alpha) \tag{13}$$

$$D_{i3}^2 = D_{i2}^2 + a_1 a_2^2 - 2D_{i2} \cdot a_1 a_2 \cdot \cos(\beta) \tag{14}$$

The present position of center point a, is and can move to a_1 and a_2 in two reference thinks respectively. Consider $\cos(\alpha) = -\cos(\beta)$ and simply above condition to choose speed (v) as takes after:

$$2a_1 a_2^2 = D_{i1}^2 + D_{i3}^2 - 2D_{i2}^2 \tag{15}$$

$$v = \sqrt{\frac{\left(D_{i1}^2 + D_{i3}^2 - 2D_{i2}^2\right)}{2\Delta t}} \tag{16}$$

The change term for versatile concentration point from current position a to the moved position a_1 or a_2 is passed on as the division $T_{a,a_1/a_2}$ secluded within point's speed and it can get by sign law as takes after:

$$T_{a,a_1/a_2} = \frac{R \cdot \sin\vartheta}{\sin\beta \cdot v} \tag{17}$$

Use Eqs. (8) into (9) and compute R_0 as,

$$T_{a,a_1/a_2} = \frac{\Delta t \cdot R \cdot \sin\vartheta}{\sin\beta \cdot \sqrt{\frac{\left(D_{i1}^2 + D_{i3}^2 - 2D_{i2}^2\right)}{2}}} \tag{18}$$

The cooperation rate (R_1) of an inside its neighbors set is brisk enlisted from an impression of each middle point which has a place with the neighbors set of the inside point. The cooperation rate, at time between time , is gotten the hang of utilizing a weighted customary of the attestation rating factors gave by focus fixations having a place with the neighbors set of the middle. Likewise, to fulfill a certain examination of focus point practices, keep up a key section from mixed up zone in light of affiliation breaks, and certification that the fixations which are changed non-strong due to their obliged assets are not rejected from the structure, with a thought of immaterial effect on the evaluation of the last intrigue respect. The condition that enrichments finding the joint exertion rate of focus point (i) at time interim (t) and in light of a structure operation (F) as takes after:

$$R_1(i, t, F) = \sum \left(x_1(t) + x_2(t)\right) \tag{19}$$

The vacant rate (R_2) is used to compute the store of sensor center, which is gotten from investigating center point stack, basic obsession point, and enormity of focus premiums. Here, the each for the most part enchanting concentration can adaptively observe the occasion of stop up and after that exhortation the parent center obsessions to lessen the package transport rate as demonstrated by the blockage level. The vacant rate of each center is figured as takes after:

$$R_2 = v_i = \frac{\sum_{i=1}^{N} PI\left(P_i\right) - PI\left(P_i\right)}{\sum_{i=1}^{N} PI\left(P_i\right)} \tag{20}$$

where the bare rate of the node i is v_i and $V = \left\{v_i,\ 1 \le i \le m\right\}$ and $PI\left(P_i\right)$ is the node importance index, which computes a quantitative indicator. It can be defined by

$$PI\left(P_i\right) = \sum_{n_i \in L_{ij}^m} C\left(n_i\right) \tag{21}$$

where $C\left(n_i\right)$ looks out for the straightforwardness degree takes after how closed inside point is to its neighbors. Here, we use an expanding probability to address the transparency degree. It can be gotten by

$$C\left(n_i\right) = \left|\sigma_{ij}\left(n_k\right)\right| \tag{22}$$

where $\sigma_{ij}\left(n_k\right)$ represents the edge number from n_i to n_k on node L_{ij}. The Eqs. (11), (19), and (20) used to compute the quality of each node. The maximum quality owned node selected as CH in the cluster. In this paper, the Rosenbrock function used to compute the quality $\left(F_q\right)$ of sensor nodes as follows:

$$F_q = \sum_{R=0}^{3} \left[100\left(x_{R+1} - x_R^2\right) + \left(x_R - 1\right)^2\right] \tag{23}$$

Then, select the CH by

$$CH = \max\left\{F_q\right\} \tag{24}$$

The sensed environmental information's forwarded only via the CH node to reach the BS, and it forward to the data handling system.

4.2 Data Handling Using ID-3 Based Decision Making Algorithm

The gathered environment factors are effectively handled here to compute the critical situation in network. For every second, the system updates the results in terms of warning levels 1, 2, 3, and 4.

The level 1 traces the standard safe condition; level 2 portrays the general mixes caused by human progress; level 3 says the rich slide action due to surrendered rainfalls; and level 4 delineates the wide insecurity (risk level). Iterative Dichotomiser 3 (ID-3) tally is the information depiction estimation. In this paper, we utilize ID-3 for essential affiliation reason. The probability of the ID-3 is to disperse dataset into a picked number of subsets that are practically identical to the measure of above delineated levels. Each level has one of the subsets as an information subset; the ID-3 tally is then connected with all subsets in the interim. Each datum subset is inspected against the related level. The figuring produces two yields are one yield is a diagram of cases, I1 that really has a place with the related level, and the second yield is an approach of occasions, I2 that does not have a place with the related level. I2 is then moved to another level as another data dataset, and an in every way that really matters unclear structure is rehashed until all occasions that have a place with I2 are checked on against all levels. At last, an ensuing association believing is associated with the subsets I1 for each level, which passed in each steps. Let see the yield of estimation is a strategy of levels depicted as takes after:

$$L = \{l_1, l_2, l_3, l_4\} \tag{25}$$

where l_1, l_2, l_3, l_4 represents the defined warning levels. Assume that the input test data (T) for this decision making algorithm. The data set consists of gathered environment factors are

$$T = \{t_1, t_2, t_3, t_4, t_5\} \tag{26}$$

where t_1, t_2, t_3, t_4, t_5 is the testing factors rainfall, horizontal/vertical angle strata, displacement of strata, and pore-water pressure. Test data (T) is decomposed into several subsets as follows:

$$T(s_i) = T(s_1) \cup T(s_2) \cup T(s_3) \cdots \cup T(s_n) \tag{27}$$

where s_i is the test sets for verify the system model with a group of input factors.

The defined levels and a determined test data when applying the ID-3 algorithm, the functional model of each constraint is depends on the time varying function T as follows:

$$\forall v, \text{ constriant } (x_v) \tag{28}$$

where x_y is a standard occasion on the off chance that it has a place with the picked levels. The yield of ID-3 check will be an approach of sets (x_y, L); where L is between [1, 4], the level 1 looks out for the necessities are standard, level 2 watches out for the standard strategies caused by human progress, level 3 passes on advancement saw due to surrendered rainfalls, and level 4 is the last risk one. The yield of the ID-3 test information can also be described as follows:

$$T_{output} = T(l_1) \cup T(l_2) \cup T(l_3) \cup T(l_4) \tag{29}$$

where $T(l_1)$ represents the normal environmental factors denoted as level-1, $T(l_2)$ represents the pair of variations in small and denotes as level-2, $T(l_3)$ represents the pair of variations in defining vectors and denotes as level-3. $T(l_4)$ represents the pair of variations with the all determined network belongs to level-4. The test data can be defined as follows:

$$T(l_1) = \{\langle x_v, 1\rangle | \langle x_v, 1\rangle \in T_{output}\} \tag{30}$$

$$T(l_2) = \{\langle x_v, 2\rangle | \langle x_v, 2\rangle \in T_{output}\} \tag{31}$$

$$T(l_3) = \{\langle x_v, 3\rangle | \langle x_v, 3\rangle \in T_{output}\} \tag{32}$$

$$T(l_4) = \{\langle x_v, 4\rangle | \langle x_v, 4\rangle \in T_{output}\} \tag{33}$$

The classification of each testing factor x_v, whether it is a level 1, 2, 3, or 4, performed using a threshold rule. Here, we follow the threshold value of sensor nodes as per in [34] and forward the reply as warning messages in terms of one punctuation mark for Level-1, two punctuation mark for Level-2, three punctuation mark for Level-3, four punctuation mark for Level-4 with the warning mail to the authorized person. The working function of LLM algorithm is given in Algorithm 1.

Algorithm 1: Lossless landslide monitoring (LLM) system	
Input: Number of populations, control variables, and Population size **Output:** Set of clusters, CH, and level detection	
1.	Initialize the position of node.
2.	for each search agent
3.	Calculate the distance between every node and all centers.
4.	while the node not assigned
5.	Assign node to it is nearest center
6.	end while
7.	end for
8.	for i =1 to n
9.	for j = 1 to k
10.	R_0 (P_i, C_j) = Compute (Received signal strength between node i and j)
11.	R_1 (P_i, C_j) = Compute (Correlation rate between node i and j)
12.	R_2 (P_i, C_j) = Compute (Vacant rate between node i and j)
13.	Calculate quality (q) of node using Rosenbrock function (23).
14.	end for
15.	end for
16.	CH=max (q)
17.	Define the set of input test data T, and element of test set t_1, t_2, t_3, t_4, t_5
18.	for each (N, x_v)
19.	apply ID-3 using equations (30)-(33)
20.	Level= T_{output}
Return: Cluster, CH, and Level	

Table 1 Simulation parameters

Parameter	Value
Network size	1000 × 1000
Number of nodes	50, 100, 150, 200, and 250
Number of attacks	2, 4, 6, 8, and 10
Traffic source	CBR
Radio range	50 m
Radio mode	First order
Deployment type	Random model
Data rate of node	512 bits/s
Data packet size	64 bytes
Simulation time	1000 s

Table 2 Simulation scenarios

Scenarios	Number of nodes	Number of attack	Attack name/count
1	50, 100, 150, 200, 250	–	–
2	100	2, 4, 6, 8, 10	
		2	DoS-1, Blockhole-1
		4	Block hole-2
		6	Wormhole-2
		8	DoS-2, Block hole-2,
		10	Grayhole-2
			DoS-2, Block hole-2, Wormhole-2, Grayhole-2
			Block hole-4,
			Wormhole-3, Grayhole-3

5 Simulation Results

The proposed LLM structure joins two phases, the data gathering stage repeated in Network Simulator (NS-2) instrument and data controlling method made in Net Beans IDE 8.2. We consider the five particular sensors are set up in an inside point. The sensor revolves are passed around in a framework with a size of 1000×1000 m^2. The measure of center obsessions in the given structure is changed by 50, 100, 150, 200, and 250. The radio level of sensor center point is 50 m with the key deal with radio model. The BS is created in the left side corner of the sensor field. The data rate of each inside point is 512 bits/s. The concealed centrality level of each inside point is 10 J. The data package size of each inside is 64 bytes. The reenacted movement is constant bit rate (CBR). The reenactment parameters and states of proposed LLM structure is given in Tables 1 and 2. The essential testing circumstance we move the measure of center obsessions by 20, 40, 60, 80, and 100. In second, we disengage the measure of ambushes by 2, 4, 6, 8, and 10 with settled number of center obsessions as 100. The total redirection will take the season of 1000 s. The execution of proposed LAR custom is separated and the present traditions in terms of delivery ratio, energy consumption, routing overhead, and throughput.

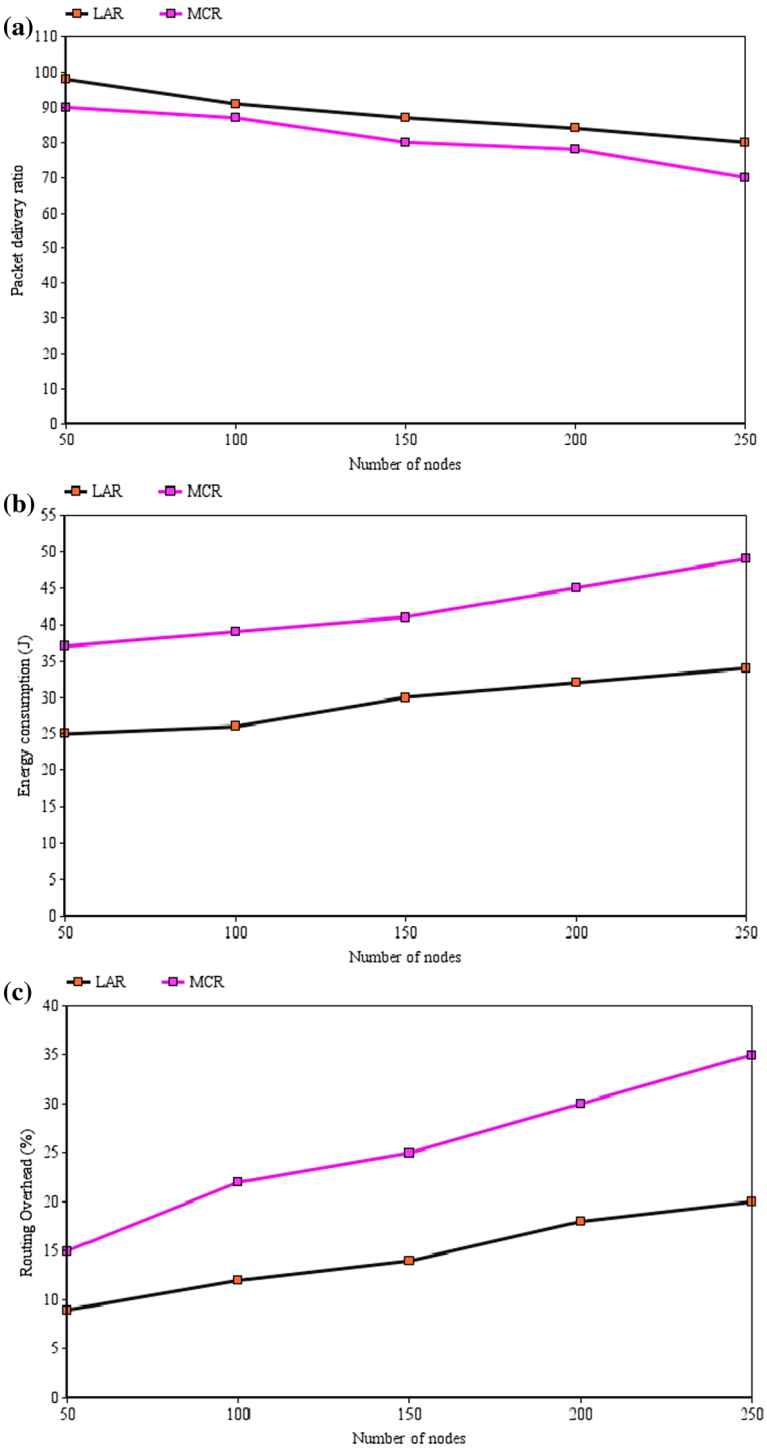


Fig. 2 Performance analysis with varying the number of sensors **a** delivery ratio, **b** energy consumption, **c** routing overhead, and **d** throughput

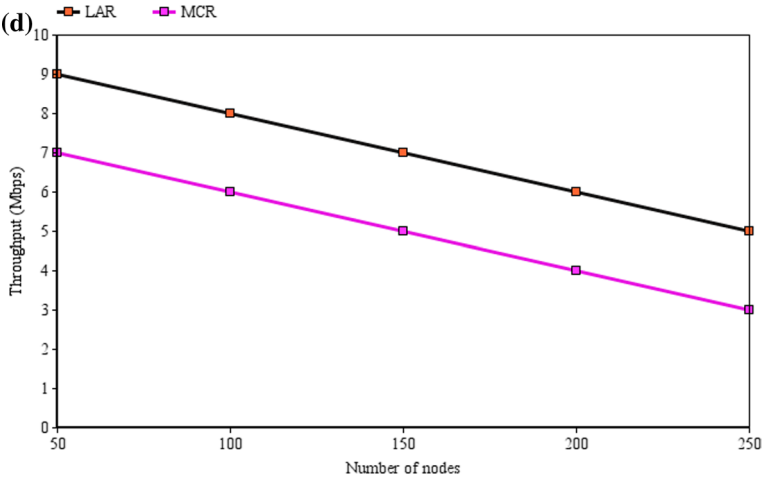


Fig. 2 (continued)

5.1 Varying Number of Sensor Nodes

In this condition, we enlist execution estimations with settled structure study as 1000×1000 m^2 area. We are moving the measure of nodes as 50, 100, 150, 200, and 250. Figure 2a demonstrates the delivery ratio of proposed LAR custom and existing MCR sorting out [35]. The plot plainly charts the delivery ratio of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the system topology. Figure 2b demonstrates the energy consumption of proposed LAR custom and existing MCR masterminding [35]. The plot verifiably depicts the energy consumption of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the structure topology. Figure 2c shows the routing overhead of proposed LAR convention and existing MCR dealing with [35]. The plot undeniably depicts the routing overhead of the proposed LAR custom is superior to anything existing convention for various number of sensors working in the structure topology. Figure 2d displays the Throughput of proposed LAR custom and existing MCR controlling [35]. The plot unmistakably portrays the Throughput of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the structure topology.

5.2 Varying Number of Attacks

In this condition, we process execution estimations with fixed network size as 1000×1000 m^2 zone. Figure 3a demonstrates the delivery ratio of proposed LAR custom and existing MCR orchestrating [35]. The plot certainly charts the delivery ratio of the proposed LAR custom is superior to anything existing convention for various number of sensors working in the structure topology. Figure 3b demonstrates the energy consumption of proposed LAR custom and existing MCR masterminding [35]. The plot certainly portrays the energy consumption of the proposed LAR custom is superior to anything existing convention for various number of sensors working in the structure topology. Figure 3c shows the routing overhead of proposed LAR convention and existing MCR designing [35]. The plot unquestionably diagrams the routing overhead of the proposed LAR custom

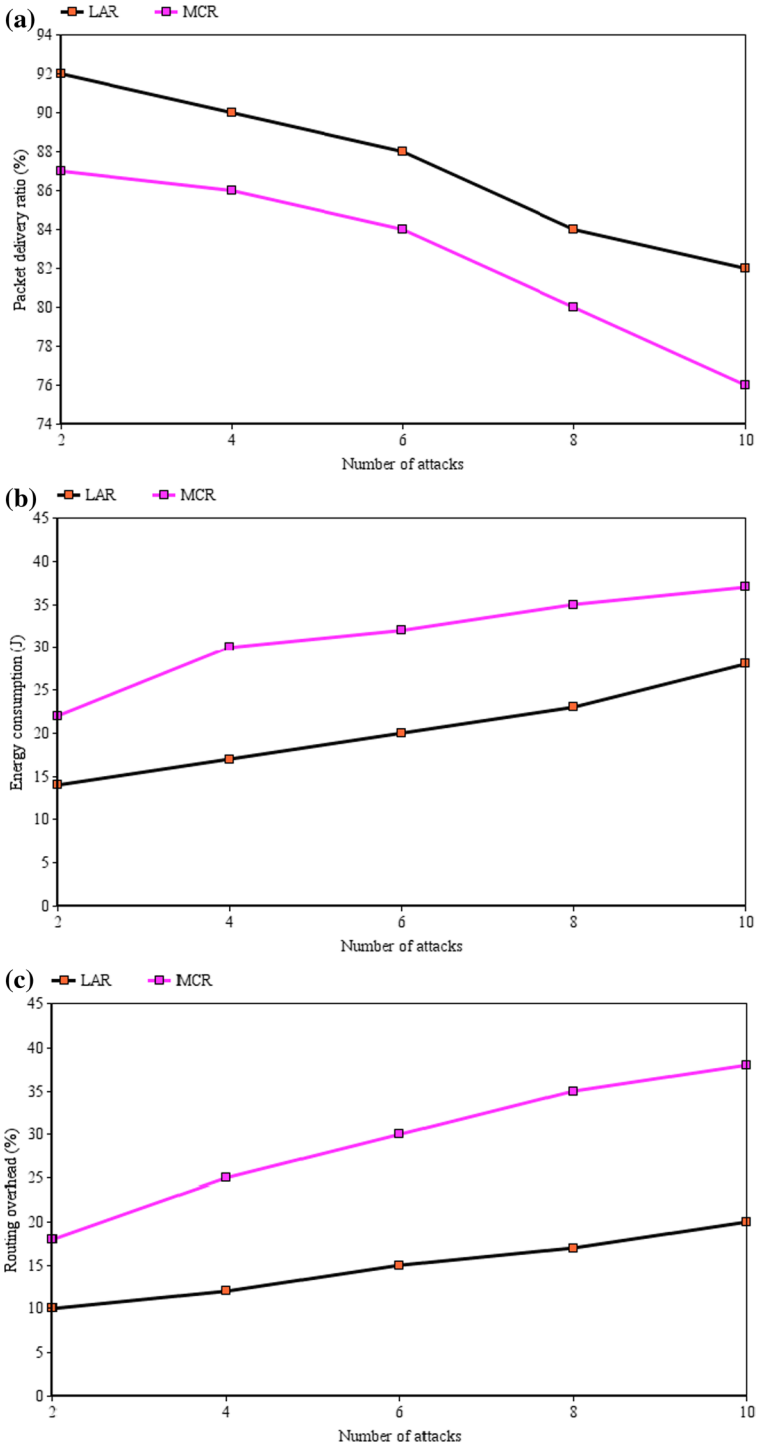


Fig. 3 Performance analysis with varying the number of attacks **a** delivery ratio, **b** energy consumption, **c** routing overhead, and **d** throughput

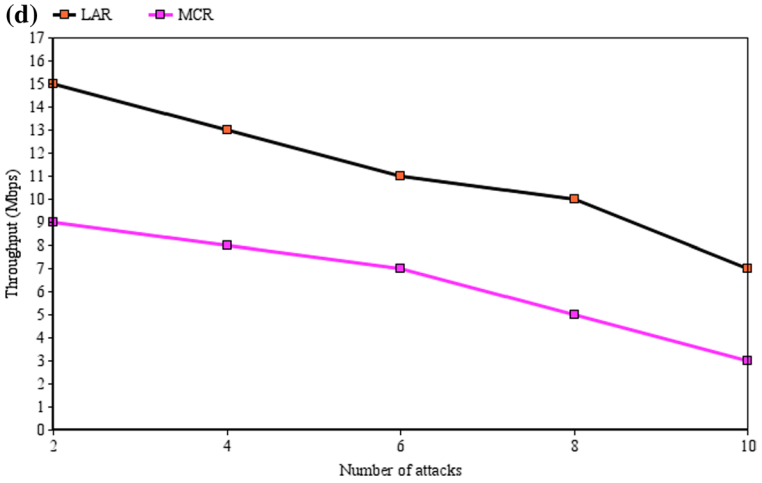


Fig. 3 (continued)

Table 3 Test data of a single sensor node

Time (s)	Rain gauge (mm)	Tilt meter (degree)	Inclinometer (degree)	Crack meter (mm)	Piezometer (kg/cm^2)
11:54:00	9.5	−0.3102	−0.10709	5.451275	0.2770603
11:54:10	9.8	−0.31094	−0.10644	5.430,952	0.2710104
11:54:20	9.5	−0.31145	−0.10452	5.483812	0.2725643
11:54:30	9.8	−0.3122	−0.10608	5.452247	0.2766139
11:54:40	9.5	−0.31023	−0.10529	5.492191	0.2799158
11:54:50	9.2	−0.31099	−0.10877	5.436885	0.2713724
11:55:00	9.4	−0.31241	−0.10708	5.447316	0.2753404

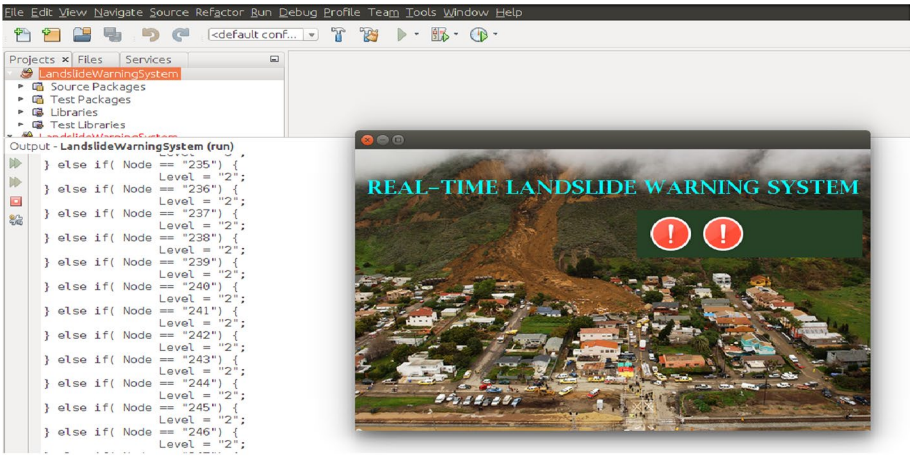
is superior to anything existing convention for various number of sensors working in the structure topology. Figure 3d demonstrates the Throughput of proposed LAR custom and existing MCR planning [35]. The plot clearly delineates the Throughput of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the system topology.

5.3 Result of Data Handling Phase

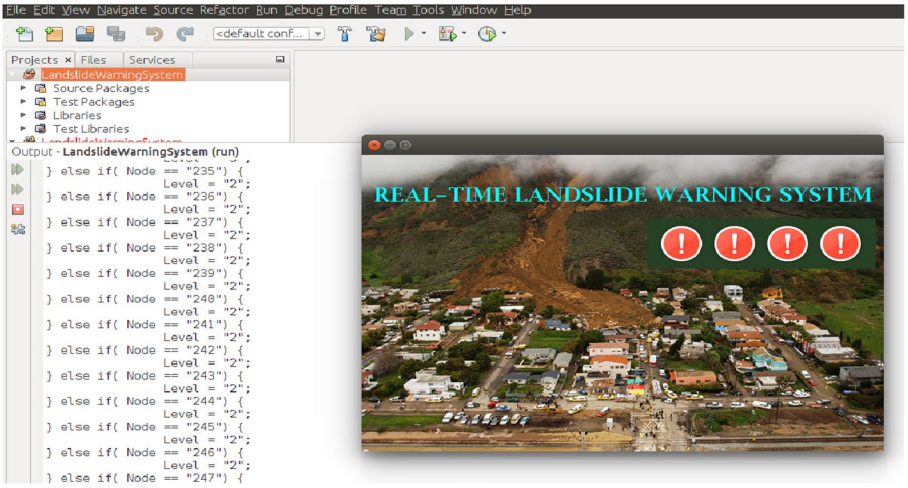
Initially data were received at an interval of 10 s and subsequently it changed to a minute to reduce the storage capacity. Rainfall, vertical angel, horizontal angel, slope displacement and pore pressure have gathered by rain gauge, tilt meter, in-place inclinometer, crack meter, and piezometer, respectively. Example test data of a single sensor node with 11:54:00 to 11:55:00 is given in Table 3. The proposed LLM system detects the landslide for test data from Table 1 and produces the result as given in Table 4. The proposed LLM system forward the messages in terms of one punctuation mark for Level-1, two

Table 4 Landslide detection for test data form Table 3

Time (s)	Rain gauge (mm)	Tilt meter (degree)	Inclinometer (degree)	Crack meter (mm)	Piezometer (kg/cm^2)	Levels
11:54:00	9.5	−0.3102	−0.10709	5.451275	0.2770603	3
11:54:10	9.8	−0.31094	−0.10644	5.430952	0.2710104	2
11:54:20	9.5	−0.31145	−0.10452	5.483812	0.2725643	2
11:54:30	9.8	−0.3122	−0.10608	5.452247	0.2766139	3
11:54:40	9.5	−0.31023	−0.10529	5.492191	0.2799158	3
11:54:50	9.2	−0.31099	−0.10877	5.436885	0.2713724	2
11:55:00	9.4	−0.31241	−0.10708	5.447316	0.2753404	2

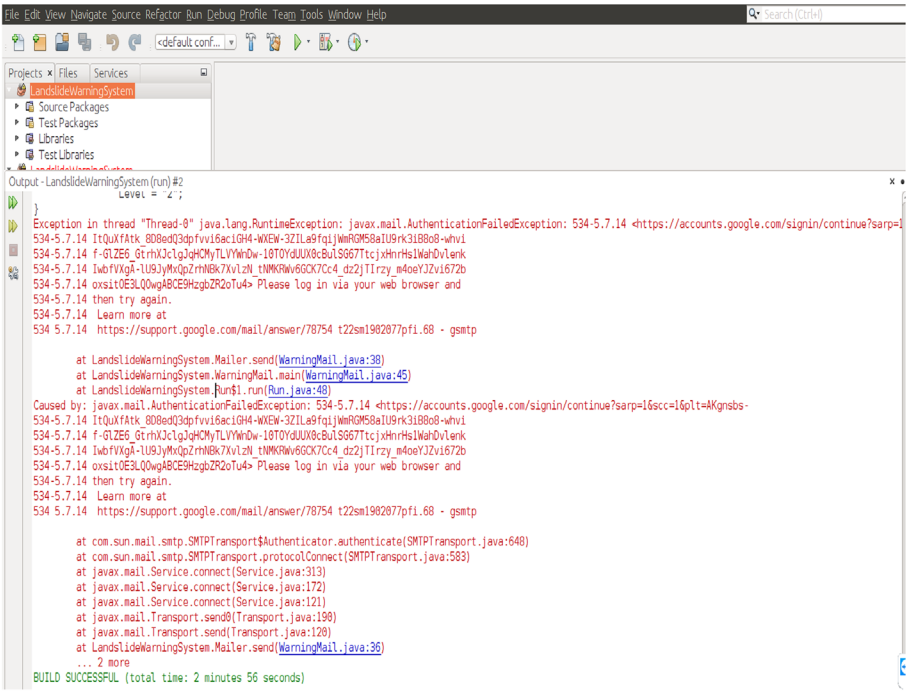


(a)

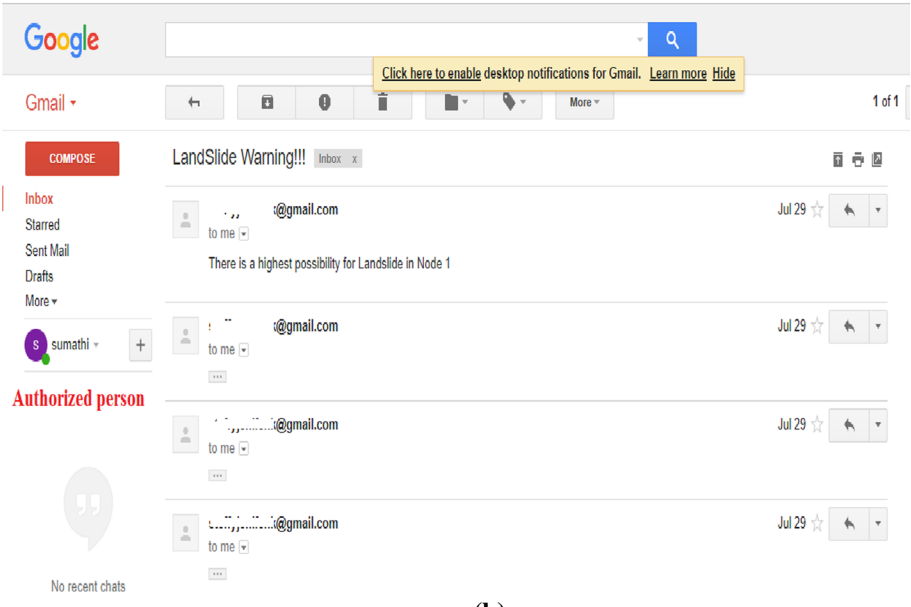


(b)

Fig. 4 Screenshots of warning signal **a** Level-2 detected **b** Level-4 detected



(a)



(b)

Fig. 5 Warning mail **a** mail forward from sender **b** mail received at receiver

punctuation mark for Level-2, three punctuation mark for Level-3, four punctuation mark for Level-4 with the warning mail to the authorized person. The screenshot of warning signals are taken from Net Beans IDE 8.2 and shown in Fig. 4.

Due to increase in pore water pressure, the landmass starts displacing from its original location and in turn triggers the landslide. When other triggering factor i.e. displacement of masses/inclination of natural slopes reaches or exceeds the threshold of crack meter, threshold of Tilt meter or in-place inclinometer, respectively along with threshold of rain gauge and piezometer, the system shows a red punctuation symbol representing a greater chance of occurrence of landslide. During this level, local people to be alerted about the occurrence of landslide by alert emails to concerned authorities. The resultant Net Beans IDE 8.2 screenshots of warning mail transmission form sender and the received by receiver is shown in Fig. 5.

6 Conclusion

In this paper, we have proposed a lossless landslide monitoring (LLM) system using efficient data gathering and handling process. The modified gray wolf optimization algorithm used to form the clusters and the new constraints used to compute the cluster head (CH) node, which provides the link aware routing (LAR). The Iterative Dichotomize-3 (ID-3) based decision making algorithm used to predict the landslides in gathered information's. For the simulation setup, five different sensors such as rain gauge incline meter, crack meter, tilt meter, and piezo meter are embedded with each node. The simulation result shows our proposed LLM system performs very better than existing system. In future, we enhance our data gathering phase by optimization algorithm to enhance the quality of data collection to ensure the landslide monitoring system.

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M. S. Sumathi obtained her Bachelor's degree in Electronics and Communication, in 2006 and Then she obtained her Master's degree in VLSI & EMBEDDED SYSTEMS, in 2009, both from Visvesvaraya Technological University, India. Currently, she is a Assistant professor at Department of Telecommunication Engineering, BMS Institute of Technology, Bangalore. Her specializations include embedded systems, wireless sensor networks, and robotics. Her current research interests are wireless sensor networks, data mining and fuzzy logic.

Dr. Gowda Sheshadri Anitha obtained her Bachelor's degree in Electrical & Electronics, in 1983 and Then she obtained her Master's degree in power system, in 1988, both from Bangalore University, India, and the Ph.D. degree from Avinashilingam Deemed University in 2010. She is currently an Associate Professor in the Department of Electrical and Electronics, RVCE, Bangalore. His research interests are in Renewable Energy, wireless sensor networks, fuzzy logic, and Structured Nano Materials Dr. G. S. Anitha Appointed as REVIEWER by IEEE forum in IEEE Intelligent Transportation Systems Society Conference Management System to be held at Vienna June 2011. Appointed as Session chair in the "INTERNATIONAL CONFERENCE ON ELECTRONICS AND COMMUNICATION ENGINEERING "held at Bangalore on 7th April 2013. Appointed as REVIEWER for IEEE International Conference on "Emerging Trends in Communication, Control, Signal Processing and Computing Applications" (C2SPCA) on 10th and 11th October 2013 at Oxford College of Engineering Bommanahalli, Bangalore Appointed as Technical Programme committee member for IEEE (ID :32069) International conferences on Advances in Electronics, computers and communications(ICAECC), on 10th–11th October 2014 Bangalore, India at Reva Institute of Technology and Management.

Evanesco-An Ultrasonic Repeller using UAV

Raghunandan G H[1], Ninaada M S[2], Keerthana R[3]

[1,2,3]*Department of Electronics and Telecommunication Engineering,*
[1,2,3]*BMS Institute of Technology and Management, Bengaluru, India.*

Abstract **-** *Ultrasonic Repeller has an up growing demand in today's world. The main function of this Repeller is to dispel the unwanted creatures in the environment. This ultrasonic Repeller is mounted on UAV. The main component used is 555 timers. Using a simple circuit and required basic components, we can tune the 555 timers to produce the desired frequency. Since this Repeller produces multiple frequencies, it is difficult for the species to adjust to this disturbing ultrasonic sound. The directionality of the ultrasonic sound is maintained. This prototype consists of transmitter and a piezoelectric transducer. It has emerged has a boon for farmers to use in agricultural fields. It can be used an alternative to scarecrows. Since animals and bird's species are detrimental, causing nuisance repellers come to need. In this paper, we propose method to address these factors. This UAV based Repeller will be emerging more efficient than existing one.*

Keywords: *Piezo electric transducers, autonomous UAV, acoustic ultrasound, power amplifiers.*

I. INTRODUCTION

A man with nature is precious. As a matter of advancement research is all along continues. We intend to take a piece of task to uphold for the purpose of both wellbeing. India stands second largest in the world after the United States for having 159.7 million hectares of arable land. Farmers depend on agriculture for their profit in farm areas like banana, jackfruit, coconut, sugarcane etc. Unfortunately, they are destroyed mainly by monkeys and other species which causes huge losses to the them. It is estimated that around 30 to 40% of crops are destroyed annually due to attacks by wild animals in India. According to the research animals namely elephant, boars, deers are the most common perpetrators of the destruction. In some districts of Odisha and Kerala, 60 percent of the crops are destroyed by elephants, claims for which are not payable by insurance companies. In Karnataka, farmers have lost many crops which account to 5 crores in 2010 because of monkeys. The state government forest department states that about 800 farmers have given up cultivation due to menace created mainly due to monkeys and other animals, bird's species in Karkalla district near Mangalore in 2012. Birds and animal repellers are of two types namely electromagnet and ultrasonic. In our project we are discussing only about ultrasonic's. Meaning of ultrasonic: Ultrasound is an acoustic sound having frequency more than 20 kHz or having frequency more than the audible range of humans and requires a material medium for its propagation. This ultrasound can be exposed in environment in two different types namely-

A. Airborne ultrasound.
B. Liquid borne ultrasound.

A. Airborne ultrasound: The most adversely affected organ in airborne ultrasound is the ear. The consequences caused by this type of ultrasound includes fatigue, nausea, imbalance of blood sugar level, tinnitus, causes irritation, headache. Further there are wide applications in industrial field namely cleaning, emulsifying, welding and flaw detection etc.

B. Liquid borne ultrasound: This have vast application in research and medical field like diagnosis, dentistry, therapy and surgery. The biological background of the animal species is as follows. Humans cannot hear ultrasound because their eardrums cannot vibrate as fast as animals like dogs, pigs, bats, and other lower animals like rabbits, deer. Insects detect sound by sensilla which is located on antennae or genitalia. Some insects like grasshoppers, moths, butterflies detect sounds by tympanal organs. Kansas State University which researched ultrasound confirmed that ultrasound sound benefits by repelling the animal, bird, insects and causes reduction in reproduction and mating. In 2002, Genesis laboratory came up with documentary studies and lent an informative hand about how rodents react to ultrasound. Scientist Dr. Philip Whit ford lab experiments proved that birds express severe distress in the presence of ultrasound frequencies. His studies showed reduced bird population in fields. Many birds like turkey, gills, pigeons find the ultrasound irritating and they get repelled. The reactance of birds, animals, insects depend on frequency, intensity of the ultrasound frequency. This prototype model is built in such way that, it is functioning with multi frequency modulated sound. The device produces frequency which changes very few seconds, with a frequency range of 20khz to 50khz. Due to this the animals and bird species are not adjusted to the acoustic sound environment. The acoustic sound radiations are highly concentrated to place. Neither this protype kills the animal and bird species which are causing menace in agricultural fields nor causes disturbance or side effects to human beings as the audible range for human beings is 20hz to 20khz. These nerve-

crushing sounds directly penetrate into animals and birds brain and nervous systems causing discomfort, and make them feel uneasy and act abnormal, such as to become frantic jumping, stampeding and leads to voluntary repulsion against ultrasonic wave areas and making it impossible to stay in such high radiated areas. This paper explains about the prototype model in detail and even throws light on the importance of ultrasonic repellers. In section 2, a brief overview is explained about the existing system models, working principle and the drawbacks faced by the systems. As mentioned above the the proposed system and range of components is explained in section 3. In section 4, the framework is evaluated based on stimulation and implementation of components and their working principle. The future scope and demands are discussed in section 5, along with further upgradation and improvisation of the project.

II. EXISTING SYSTEMS

With reference to the model [1], the ultrasonic device comprises of the power unit - Battery or AC power of 12-volt DC, and then the pulse generator unit which varied the emitted frequency continuously. The frequency which is ≤ 150 Hz is generated through 555 Timer IC and then sent to the CD4017 decade counter for the frequency division and then NPN and PNP transistor are used for the signal amplification. IC CA3130 (Audio Amplifier) was used to amplify this frequency and for transmission to the free space speaker was used.

The accuracy and working of the device had few limitations due to climatic conditions. The distance travelled by ultrasound was found to be different on sunny, rainy, dull days. Climatic conditions played a vital role in rating the performance of the Repeller. The other physical conditions like temperature, humidity also affected the radiation of the ultrasound. The sound travelled fast in moist air when compared to dry air and in mornings due to lower temperature. The project work [2] explains that the ultrasound was detected by the area of 21mm to 37mm. The author used an astable multivibrator, 555 timer which generates frequency and it can be varied by steps of 5 using IC, counter, a D type flip flop. Amplification was done using npn and pnp transistors. Variable resistors of 100K value was used to control the frequency output. The device was tested on mouse. The device sound waves were active for 5 metres from the device and later got deactivated. And caused hearing impediment due to incorrect amplification. In this project [3] an electronic oscillator was used to produce frequency. The function of an electronic oscillator is to repetitively generate electrical signal of a specific frequency. This Electronic pest control device comprised of the oscillator, a small transistor amplifier and additional circuits like tripping circuits, sonic circuit, preamplifier, 555 timer, frequency selection circuit for varying frequency and other additional components making recent designs more effective. Electronic pest control devices emitted ultrasound which goes beyond the threshold sound hearing capacity of targeted pests. During the testing it was observed that it was difficult to disperse feeding birds (difficult to break the chain). When ultrasound was broadcast over wide open spaces the sound lost their intensity rapidly with distance.

Author [4] used fluorescent lamp at night. These lamps were placed near trees, bushes and the lamp drew many insects towards it in the dark. Then the ultrasonic Repeller was activated and it repelled most of the insects. Some of the insect moved away at certain constant frequency but other species of insect didn't move as repelling frequency was found different for different species of arthropods. He found the accuracy of the device as 75%. Location of crops was required, which was an extra work and thereby the author concluded the ultrasonic range for detection is better than the location of crops if the device is kept it the boundary. This Author also talks about a circuit of an electronic pest repellent [5]. The device was effective over 16 meters from the Repeller. The device consisted of an equipment which produced fog, smokes along with the circuit which produced frequency of 35- 50 kHz. The circuit consisted of a decade counter (CD4017) which had ten outputs. From this output variable frequency was produced and each pin was high one after the other. 555 timers were used, and its output was fed as the clock signal input to decade counter, in order to produce desirable frequency. These smoke and fumes affected adversely human beings, animals, birds, insects. And making it a non eco friendly device and thereby got rejected due to its harmful property. It became too expensive to be inculcated in the day to day living of the farmers.

This prototype model [6] used a transducer for amplification. This transducer can produce 2.5W power and a frequency up to 80 kHz. A speaker of resistance 8ohm is used which is tested experimentally till it produces the required frequency, that is 100kHz.Atmega 16 is a low power AVR,8- bit microcontroller which will produce varied patterns of frequencies as required in the experiment. LM 7805 is a 3 terminal voltage regulator which is connected in series. This has a wide range of applications as it is made with several diced output voltages. A 4×4 standard keypad is used which acts as an input to the Atmega 16. However, the frequency generated, and polling cannot be used at the same time as both are continuous processes. Sonic pest device [7] is a prototype which can be used in two ways. Firstly, it can be either inserted to an outlet. Secondly it can be plugged to a power-driven battery. This sonic device can vary the monotonous acoustic communication of the targeted pests. Alternatively, this can be achieved by creating confusion or fear in them. The sound that is produced by this device working under ultra or infrasonic range is not audible to humans

and hence will not drive away humans also, this achieving the basic motto of the prototype. Several studies and experiments have been performed by experts and researchers in entomology of Kansas state university on these commercially available devices. Out of them, 3 devices were tested and marketed for controlling pests. Unfortunately, none of the 3 devices were successful in repelling ants in the fields as well as in laboratory trial.

III. PROPOSED SYSTEM

The working of the ultrasonic repellent is given by the below block diagram. There are three stages frequency generation, amplification, transducer output.

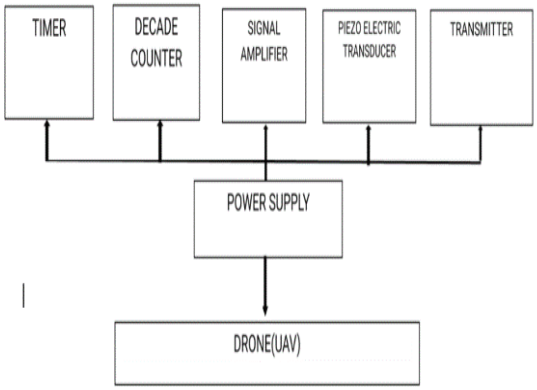

Fig 1-Overview of the circuit diagram

Frequency generator**:** The frequency generation consists of two 555timer IC and decade counter. Refer figure 1. The timer produces time delays and oscillations. IC used in the framework is 8 pin model. 555timer can operate with voltage ranging between +5V to +18V. A voltage of 9V is given to the system model. The e timer is operating on astable mode. An astable multivibrator does not have any stable state, it keeps changing from low to high and high to low. Astable multivibrator does not require an external trigger circuit to change the state of output. The 555timer produces an output frequency of 50khz using resistors of value 4.5kohms and 18kohms respectively and capacitor of 680pF. This output from pin 3 of the 555 timer is fed to the decade counter. And frequency can be continuously varied in the range of 40khz to 50khz. The output from the 555timer is clocked as an input to decade counter. When the clock starts its count the logic 1 output of the counter advances from Q0- Q1 and so on till Q9. Ten resistors ranging from r4 to r1 is placed at the output of Q0 to Q9. The output from resistors is fed to the second IC 555 timer, as shown in the figure(implementation). The second timer also operates as an astable vibrator.

Amplifier: The output from the 555 timer IC is given to the two transistors through the resistor of value 1kohm in order to maintain the potential difference. The primary uses of transistor is to amplify signals. Refer figure1 and figure2. The transistors used are NPN and PNP. The transistors are of opposite type and thereby conduct for opposite cycles of the input from the timer. The PNP and NPN transistors conduct for negative and positive half cycle respectively. Thereby both the transistors produce full wave output across the load. Thus, the weak input signal is amplified at output. The sound wave is amplified by this process.

Transducer output: Transducer is a device that converts one form of energy to other. The transducer made of quartz plate is influenced by piezoelectric effect due to the subjected electric field. Refer figure 1. The piezo effect causes the transducer to undergo alternate expansion and contractions at the electric field frequency. When the field frequency is made to coincide with the natural frequency of the crystal, it resonates producing sound waves. The intensity of the sound wave can be determined by the formula $I= P/4\pi r^2$, where P is the power of the sound wave and r is the distance travelled by the sound wave. The circuit arrangement consists of four piezo speakers placed at an angle of 90° to produce 360° coverage and the sound wave is dispersed evenly. The use of transducers ensures that the acoustic wave possesses directionality and not spread out during radiation and attenuation is avoided. The entire setup is placed on the drone. Since the drone is in complete motion and the circuit produces multiple frequencies the animals and birds do not become habitual to the acoustic environment. The animals, birds, insects get repelled automatically.

Table 1: Upper limit frequencies of bird and animals

Animal and Bird Species	**Upper Limit Frequency in KHz**
1. Dog	45-67
2. Cat	45-52
3. Sheep	30-100
4. Rabbit	42-67
5. Mouse	91-1000
6. Pig	50-54
7. Raccoon	40-100
8. Elephant	25-56
9. Turkey	6.6-25
10. Sparrow	11.5-32
11. Pigeon	4-26
12. Monkey	8-45

IV. IMPLEMENTATION

As discussed in the proposed system, various electronic components are implemented to produce the desired frequency. The components used are resistors, capacitors, decade counter, piezoelectric transducer and 555 timers.

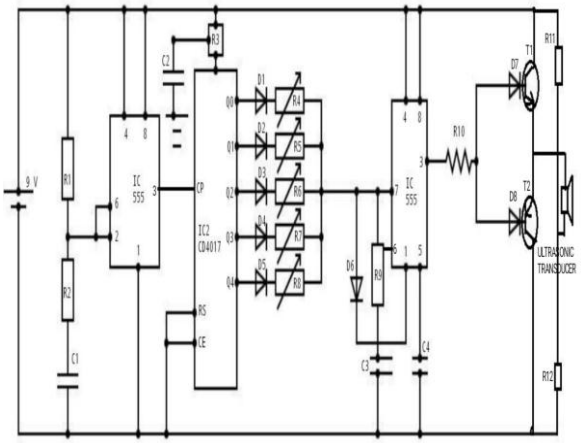

Fig 2- Circuit diagram

Fig 3-Evanesco Implemented model

A 555 timer is an integrated circuit which can be used as flip flop as it provides time delay. This astable multivibrator IC produces frequency when supplied with Vcc input of required voltage. The next major component used is decade counter. It is a circuit whose input signal is a clock signal and has a 4-bit binary output. The basic purpose of using decade counter is it will divide the given frequency. The repellant framework amplifier plays a very significant role. Its significance is explained as below. The power-driven amplifiers amplify the sound wave to larger extent and works for half cycle each. In other words, it increases the power of the signal. The frequency varies from 20 kHz to 100 kHz in an ultrasonic amplifier. A transistor can also be used as an amplifier by raising the strength of a weak signal. This can be achieved when transistors are in common emitter mode. Similarly, piezoelectric transducer is used to convert some charges, or parameters like pressure, stress etc into electrical energy. The square wave produced by the timer IC is converted into an equivalent amplified electrical signal with the usage of piezoelectric transducers. Due to the production of such oscillations in a short span of time it may also produce ultrasound of frequencies up to 20MHz which can be used for various medical purposes. Figure 2 is an autonomous drone which includes a camera module and a GPS module. The autonomous drone is configured to move to a location and/or a direction based on a command received by the tracking module. They operated autonomously onboard computers. The technology that is involved in constructing an autonomous drone includes obstacle avoidance, UAV dynamics and control. Camera module is configured for providing images and a real time video stream to the base station and the GPS module is configured to send the location of the drone to the base station. The video recording and images obtained from UAV can be used for analyzing and monitoring the activity of animal species. The entire circuit is placed on the drone. The is in complete motion ensuring the animals, birds, insects are repelled due to the high frequency acoustic radiations.

V. CONCLUSION

The ultrasonic repellent framework has various applications as mentioned earlier. The novel solution to the exponentially growing problem of animal and bird species destroying the farm fields can be solved by this prototype model. The multiple oscillations producing multiple frequency with varied intensity which is implemented on an autonomous UAV which stands better than the existing systems. The application is further improved by using power amplifiers and thereby achieving the requirements. The computerized controlled drone alerts the user. There is a growing demand and scope for this gadget due to the up growing menace caused by animals and birds. The efficiency of this device can improve by constructing a UAV which can adapt to extreme weather conditions.

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Facial Recognition using Machine Learning Algorithms on Raspberry Pi

Seema Singh
Professor and Head,
Dept of Electronics and Telecommunication Engineering,
BMS Institute of Technology and Management,
Bangalore, Karnataka
seemasingh@bmsit.in

Ramya R
Dept of Electronics and Communication Engineering,
BMS Institute of Technology and Management,
Bangalore, Karnataka
ramya.ravi2104@gmail.com

Sushma V
Dept of Electronics and Communication Engineering, BMS Institute of Technology and Management, Bangalore, Karnataka
vsushma2307@gmail.com

Roshini SR
Dept of Electronics and Communication Engineering, BMS Institute of Technology and Management, Bangalore, Karnataka
roshinirishab@gmail.com

Pavithra R
Dept of Electronics and Communication Engineering, BMS Institute of Technology and Management, Bangalore, Karnataka
rpavithra2797@gmail.com

***Abstract* – Facial recognition is a non-invasive method of biometric authentication and useful for numerous applications. The real time implementation of the algorithm with adequate accuracy is required, with hardware timing into consideration. This paper deals with the implementation of machine learning algorithm for real time facial image recognition. Two dominant methods out of many facial recognition methods are discussed, simulated and implemented using Raspberry Pi. A rigorous comparative analysis is presented considering various limitations which may be the case required for innumerable application which utilize facial recognition. The drawbacks and different use cases of each method is highlighted. The facial recognition software uses algorithms to compare a digital image captured through a camera, to the stored face print so as to authenticate a person's identity. The Haar-Cascade method was one of the first methods developed for facial recognition. The HOG (Histogram of Oriented Gradients) method has worked very effectively for object recognition and thus suitable for facial recognition also. Both the methods are compared with Eigen feature-based face recognition algorithm. Various important features are experimented like speed of operation, lighting condition, frontal face profile, side profiles, distance of image, size of image etc. The facial recognition model is implemented to detect and recognize faces in real-time by means of Raspberry Pi and Pi camera for the user defined database in addition to the available databases.**

Keywords– Facial recognition, Haar Cascade, HOG, Comparison, Raspberry Pi

I. INTRODUCTION

Face is the most authentic biometric method to identify people. Face recognition is widely used in numerous applications of security like criminal detection, airport, face tracking, forensic etc. The advantage that face recognition offers over other biometric characters like palm print, finger print, iris etc., is that it is non-invasive. It can work even without the user's knowledge and can also be useful for security-based applications and other statistics-based applications.

Face biometrics is most promising but challenging area of research. Various limitations imposed for a face recognition system are variation in illumination, variation in pose, variation in expression, the age factor, occlusion etc. Different methods are proposed in literature which works well to overcome different limitations.

Face biometrics involves three basic steps, first being training the system with labelled images, secondly, classifying them into labelled classes and thirdly, storing them in the database. When a test image of known or unknown person is presented to the system, it is compared with the existing database and then classified.

There are many algorithms that can be used to achieve this. Two methods, namely HOG and the Haar-Cascade method have been considered, implemented and compared in terms of reliability, accuracy and speed.

Haar method is implemented on Raspberry Pi using Pi-camera as the real time image capturing device. The challenges with respect to implementation of HOG method on the same target is presented in the paper. Implementation is shown with user defined database and the results are discussed with real time images which overcomes all the above-mentioned challenges of facial recognition.

II. RELATED WORK

Many researchers have attempted for facial recognition, keeping the speed of operation as the key factor. The viola jones object detection framework [1] was able to detect faces with minimum computation time and high detection rates. A boosted cascade of simple features approach was used for rapid object detection. Freund et al [3] introduced the new intermediate image representation called integral image which allows very fast feature evaluation. Feature selection process through Adaboost to form classifiers and combining the classifiers to form the cascaded structure to increase the speed of detection by focusing more in regions which is more likely to contain a face was used. Facial detection becomes

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challenging when it has to detect faces in unconstrained images subjected to different face orientations and illuminations. The facial detection for faces subjected to orientations from +90 to -90 degree using HOG descriptor is proposed in [4]. Dalal et al [5] produced excellent results for pedestrian detection using HOG and also showed detection performance is better than Haar wavelet-based detector. Chang et al [6] proposed the use HOG descriptors for facial recognition and it achieved almost the same recognition rate with lesser computation time than the Gabor descriptor and better accuracy than the LBP (Local binary pattern) descriptor. The process of facial recognition consists of three main steps: detection and normalization which is done roughly, feature extraction and precise normalization, finally identify the faces with the available database. In most of the applications it is required that all the steps are carried out in a small fraction of time, thus there is a need to separate each subtask. It becomes difficult to recognize the faces from the 2D images which are converted from the 3D images as it reduces the efficiency. However, most of the steps involved in the recognition process can be combined depending on the application according to which the required feature extraction techniques can be used. Zhao et al [11] compared the performance of different recognition algorithms. As it is clearly evident from the literature, the cascade method of Haar and HOG are explored by the researchers to a great extent. However, the important factor of its implementation in target hardware needs to be studied. The performance of the algorithms in the target hardware majorly decides its usage in any application. This work aims to implement both HOG and Haar algorithm for user created database in Raspberry Pi. This helps to analyse the performance of these algorithms for any application which requires a portable device for facial recognition.

III. METHODOLOGY

A. Haar Model

Haar-Cascade is one of the machine learning algorithms used widely to detect faces in an image. Haar is predominantly a texture based detection algorithm. It distinguishes the lighter and darker regions of the face. The first step of the algorithm is to collect haar-features. It considers adjacent rectangular region at a specific location of the detection window and sums up the pixel values of the darker region and this value is subtracted from the pixel sum of the lighter region. Such as the eye region is darker when compared to the Nose Bridge and upper cheek region in all faces. It is one of the strong two-feature classifiers.

The value of a two-rectangle feature is the subtraction of the sum of pixels of one rectangular region from the other. The regions are similar in dimensions and are horizontally adjacent to each other. It may be either horizontal or vertical as shown in Figure 1. When it comes to a three-rectangle feature the computation is done by calculating the sum of pixels within two outside rectangles subtracted from the sum of pixels in the centre rectangle. And, in a four-rectangle feature the value is computed by taking the difference between diagonal pairs of rectangles [1].

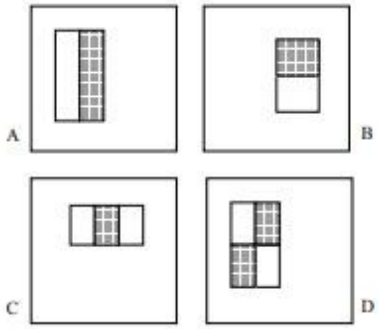

Fig 1. (A) and (B) Two-rectangle features, (C) Three-rectangle feature, (D) Four-rectangle feature.

For the faster computation of the rectangular features, intermediate representation of an image called integral image is used, the integral image of any particular location, for example x, y contains the sum of pixel values to the left and above the location of x, y.

$$ii(x, y) = \Sigma\, i(x', y') x' \leq x, y' \leq y$$

ii(x,y) is the integral image of the original image i(x',y') [1]

Majority of the extracted features are irrelevant and the best features need to be selected for further processing. There will be 180000 features associated with each sub window amongst which the best features are selected by Adaboost training [1]. Boosting is a technique which builds strong classifier by considering the weighted average of the decision made by weak learners [2]. These relevant features form the classifier. Then the classifiers are cascaded to achieve increased detection performance by reducing the false rate.

The overall detection process forms a degenerate decision tree, which is known as "cascade". The first classifier's positive result triggers the evaluation of the second classifier, both of which have been configured to obtain high detection rates. Second classifier's positive result triggers a third classifier, and so on. Instant rejection of the sub-windows [1] happens in case of negative result at any point. Thus, it does early rejection of the non-face regions in an image. This method has been explored well by the researcher. The hardware implementation and validation is done using Raspberry Pi to reinforce the same.

B. HOG Model

Histogram is the optical representation of distribution of the data; it shows sample amount of data and the number of repeated times of those data values. An image histogram acts as a pictorial representation of the tonal distribution in the image which is in its digital form. As it is the graphical representation, it plots the number of pixels for each tonal value in the digital image. Tonal distribution is the relative darkness or lightness of an area that varies from bright white of a light source to dark region.

An image gradient is a change in the direction in intensity in an image. The calculated image gradients can be used for

extracting information from the images. Those gradient images are developed from the original image generally with the help of filters by the usage of convolution like Sobel filter. Each pixel value of a gradient image calculates the intensity value change of that same pixel value in the original image, in a given direction.

Calculation of gradient in image needs to be carried out. The gradient is the vector (g_x, g_y), where an image is a discrete function of (x, y).

The direction of gradient is given by,

$$\Theta = \tan^{-1}\{g_x/g_y\}$$

And the magnitude is given by,

$$G = \sqrt{(g_{x2} + g_{y2})}$$

The edges or borders present in an image are obtained by the derivatives, which show the quick transitions from one hue to another of a color. The derivative of a matrix is calculated by an operator called the Laplacian. One needs to calculate first two derivatives, called derivatives of Sobel, each of which takes into account the gradient variations in a certain direction, one horizontal and other vertical.

Calculation of histogram of Oriented Gradients is done using following steps:

Step 1: Pre-processing

In the pre-processing step, the bounding section of the object is extracted. In this case, images with the human faces are considered. If images of only individual faces are considered, then pre-processing is assumed to be done by default.

Step 2: Developing the gradient image

To develop a HOG descriptor, horizontal and vertical gradients are measured first and the result obtained is used to measure the magnitude and direction of the gradient image.

The image in figure 2 shows the gradient,

Fig 2. Left: Magnitude of x-gradient. Center: Magnitude of y-gradient. Right: Magnitude of the resultant gradient.

The x-gradient highlights on vertical values and y-gradient highlights on horizontal values. The magnitude of gradient highlights wherever there is intense or sharp change in the intensity. None of them gets highlighted when the region is smooth i.e. when there is no sharp change in the intensity.

For images that have colour in them, the gradient values are calculated for the three channels i.e. Red, Green and Blue. The magnitude of gradient at a pixel is the highest value of the magnitude amongst the three channels, and the angle is the angle corresponding to the highest gradient.

Step 3: Developing Histogram of Gradients in 8□8 cells.

Here, the image gets a division of 8x8 cells and a histogram of gradients is developed for those divided in 8x8 cells of the image. An 8x8 image patch contains 8x8x3 = 192-pixel values. The gradient of this patch contains 2 values (magnitude and direction) per pixel which adds up to 8x8x2 = 128 numbers. Hence those 128 numbers are viewed using 9-bin histogram. That 9-bin histogram can be used to store as a row of 9 numbers. Figure 3 shows an 8x8 patch in the image and its gradients.

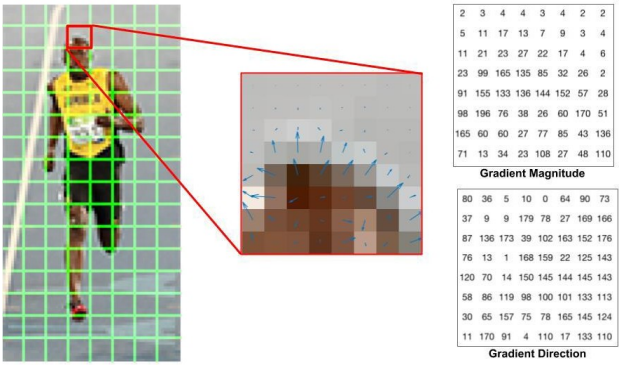

Fig 3. Center: The RGB patch and gradients represented using arrows. Right: The gradients in the same patch represented as numbers.

The next step is to create a histogram of gradients in these 8x8 cells. The histogram contains 9 bins corresponding to angles 0, 20, 40… 160.

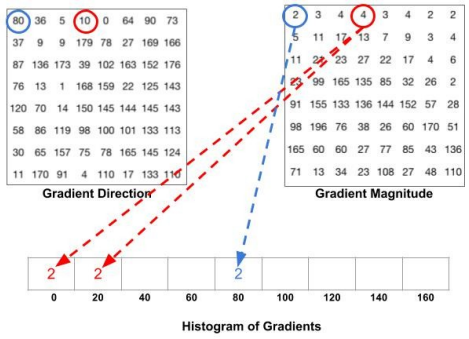

Figure 3 illustrates the process. It shows the magnitude and direction of the gradient of the same 8×8 patch which

was shown in Figure 2. A bin is selected based on the direction, and the vote (the value that goes into the bin) is selected based on the magnitude.

For example, focus on the pixel encircled in blue colour is focused first. It has an angle (direction) of 80 degrees and magnitude of 2. So it adds 2 to the 5th bin. The gradient at the pixel encircled using red colour has an angle of 10 degrees and magnitude of 4. Since 10 degrees is half way between 0 and 20, the vote by the pixel splits evenly into the two bins. If the angle is greater than 160 degrees, it is between 160 and 180, and the angle wraps around making 0 and 180 equivalents.

The contributions of all the pixels in the 8×8 cells are added up to create the 9-bin histogram. For the patch of figure 3, the block normalization is shown in Figure 4.

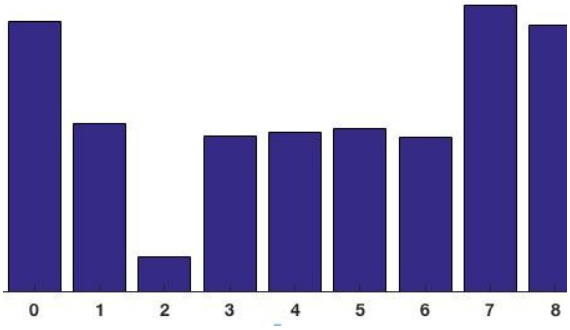

Fig 4. 16x16 Block Normalization

Step 4- 16x16 Block Normalization

Gradients of an image are sensitive to overall lighting. If the image is made darker by dividing all pixel values by 2, the gradient magnitude will change by half, and therefore the histogram values will change by half. Ideally, descriptor needs to be independent of lighting variations. The histogram is normalized so that they are unaffected by lighting variations due to camera changes.

For the image, normalization is done over a bigger sized block of 16×16. A 16×16 block has 4 histograms which can be concatenated to form a 36 x 1 element vector and it is normalized just the way a 3×1 vector is normalized. The window is then moved by 8 pixels and a normalized 36×1 vector is calculated over this window and the process is repeated over the entire image.

Step 5: Calculation of the HOG feature vector

The complete image patch, the 36×1 vector are concatenated into one giant vector. This forms the final feature vector. Each 16×16 block is represented by a 36×1 vector. After concatenation of all into one giant vector, a 36×105 = 3780-dimensional feature vector is obtained.

IV. IMPLEMENTATION

HOG and Haar algorithm is implemented to compare its reliability, accuracy and speed. The Haar method was implemented on the Raspberry Pi 3 Model B+ with 1.4GHz Cortex A53 with 1GB RAM. There is a considerable lag in the real-time output. However, it works real-time on a traditional laptop CPU giving instant efficient output.

HOG method was also tried on the Raspberry Pi but it was seen to be too computationally intensive and crashed multiple times. Hence HOG was implemented on a system with Intel i5 processor and the real-time video, though choppy was enough to check accuracy and reliability.

V. RESULTS

This implementation of the HOG method on a system with i5 processor which has support of the Nvidia Geforce Graphic Processing Unit (GPU) was carried out. Figure 5 shows the training on the user defined database using HOG algorithm. Figure 6 shows the result where the algorithm is able to identify human faces correctly in a group of images also.

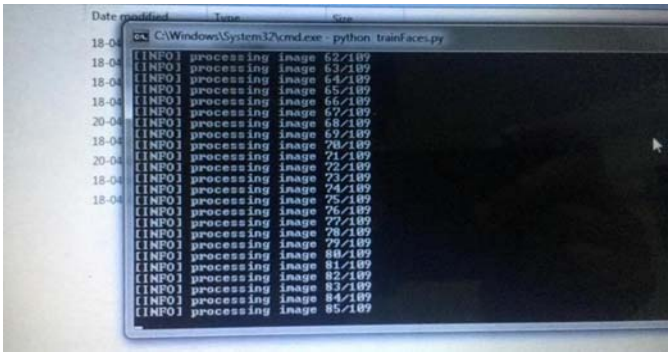

Fig 5. Training using the HOG algorithm

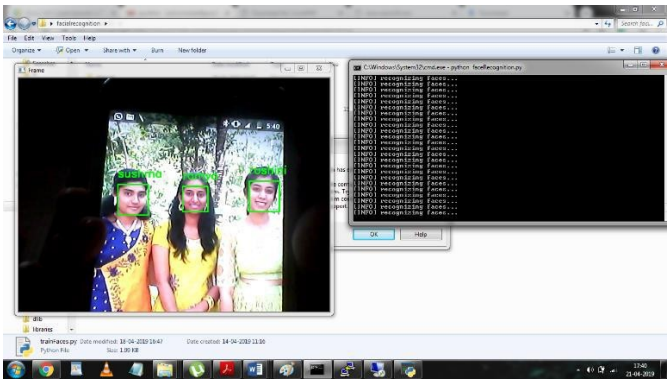

Fig 6.Correct labels assigned for the faces identified in the group images by a model trained using HOG method.

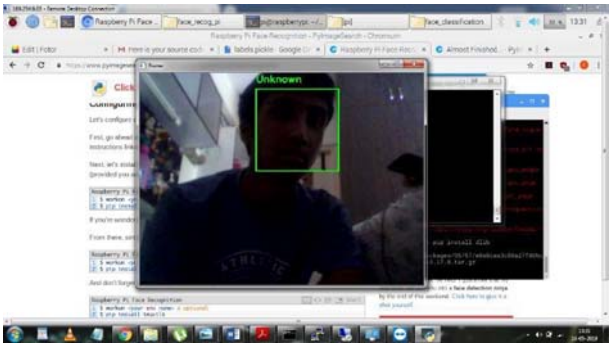

Fig 7. This method also gives the label UNKNOWN for a person whose images have not been pre-trained

It is important that the algorithm gives an unknown label for the face which is not trained with. One of such case is shown in Figure 7. HOG method works efficiently by detecting edges and therefore was 98% accurate for profile faces, specifically. However, generalized accuracy is quite lower than this.

The Haar cascade algorithm is trained on Raspberry Pi 3 Model B+ with a 64-Bit quad processor and the raspberry pi camera is used to capture the faces real time for the recognition process. The training procedure on Raspberry Pi is shown in Figure 8. The algorithm is capable of recognizing celebrity facial images (shown in Figure 9) in addition to the real time images (from video) captured through interfaced camera. Haar method was found to be better in the cases where lighting was differentiated with shade. It is efficient to recognize frontal faces. It is because the frontal image has bridge of the nose and cheek bones which cast shadows on the rest of the face leading to difference in shading. Haar method lacks efficiency in terms of detecting edges.

The accuracy of Haar method is limited in comparison to the HOG method. Haar cascade provides accuracy of about 50 percent whereas in case of HOG method the accuracy can be increased up to 80 percent for a versatile set of images.

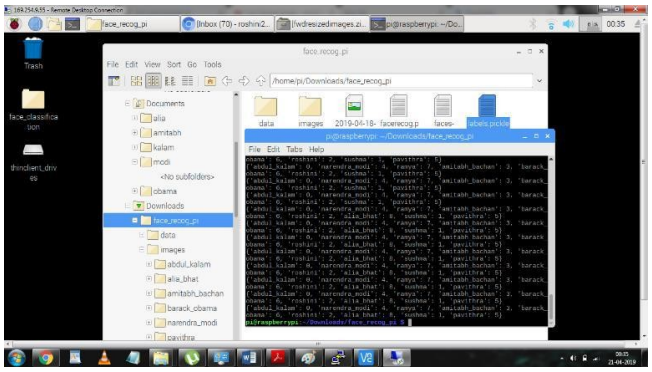

Fig 8. The training process of the Haar cascade method on raspberry pi is shown.

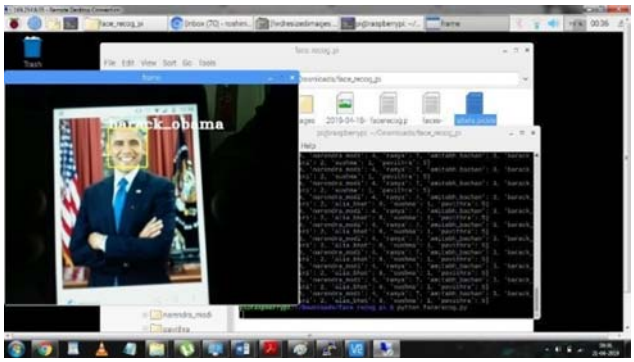

Fig 9. Raspberry pi detection of Barrack Obama using Haar method

VI. Conclusion

Face recognition is one of the biometric which authenticates the identity of the person non-invasively. Two algorithms of face recognition that is Harr cascade classifier and HOG method was discussed, simulated and implemented for the user defined database. Intensive comparative analysis was carried out to find the advantages and drawbacks of each method for different orientation, lighting condition of faces. Haar features were better at differentiating light from shade but not orientation of edges. Therefore, Haar is better suited to detect frontal faces. A frontal image of the face has the bridge of the nose and cheek bones which casts shadows on the rest of the face leading to difference in shading. HOG method, on the other hand, performs well with detecting edges and hence better suited to detect shapes. Therefore, profile faces can be detected with better accuracy using this method. The outline of features such as the nose and chin need to be taken into consideration for this type of recognition process. Haar features (and other wavelets) are "texture features" as opposed to HOG. They are good at detecting similar texture but lack orientation information. HOG provides more orientation details.

The main advantages that the Haar method provides is that it works almost real time on our traditional CPUs due to its simple architecture and it also detects faces at different scales. This scaling can be controlled and tuned according to the specific requirements. As we scale down, the computational intensity increases. But some of the limitations of this method includes the fact that it performs poorly for non-frontal and occluded faces. Furthermore, the number of false predictions is numerous that is it can provide accuracy of up to 50% whereas HOG accuracy could be up to 80%.

HOG method offers advantages like being able to detect multiple faces in group images, being non sensitive to uniform change in luminosity and being a light weight model. But it has its own limitations. Though it can handle more occlusion than the Haar method, it cannot detect faces that are small or too far away. Although it is better than Haar for non-frontal faces, it still doesn't perform well enough for extremely non-frontal faces and side profiles.

HOG offers better accuracy compared to Haar with a considerably smaller sized dataset for training. But Haar is more compatible with Raspberry-pi than HOG, because HOG requires more computation which is not supported by Raspberry Pi. Hence HOG method was implemented on laptop with Nvidia Geforce GPU support. Both methods have different characteristics and therefore may be chosen accordingly for specific applications.

Further work may be carried out in line with bigger/versatile database. The target hardware may also be explored with higher performance. Integration of both algorithms can give a robust solution for facial recognition problem.

ACKNOWLEDGMENT

The authors would like to thank the management of BMS Institute of Technology and Management for their continuous support and encouragement.

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A Compact multiband patch antenna for 5G applications using rectangular slotted DGS

[1]Banuprakash. R
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
r.bhanuprakash@bmsit.in

[2]Lekhya Sindura. N
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
sindurahoney.n@gmail.com

[3]Madhushree. M
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
madhushreem862@gmail.com

[4]Chethana. C
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
chethana.c98@gmail.com

[5]Mahima. R.D
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
mahimarajendra1@gmail.com

Abstract— The main purpose of the dealt design was to realize the frequencies used for the upcoming 5G technology. The dual band antenna of 10 x 10 x 1.6 mm3 size producing the frequencies 10.5 GHz and 26.9GHz with a S11 of -25.98 decibel and -26.07 decibel correspondingly. The dielectric material used is FR4 epoxy having 4.4 as its permittivity. It has a quadrilateral slot in the ground to achieve better bandwidth. The VSWR obtained for the generated frequencies is 1.1057 and 1.1046. The examination of return loss, radiation pattern and gain were finished utilizing High Frequency Structured Simulation instrument.

Keywords—5G, HFSS, Defective Ground Structure

I. INTRODUCTION

The interest for wireless communication frameworks is like never before. This necessity is the main impetus towards the fast-innovative work in the fields of data and correspondence advancements worldwide that drives the exploration network towards the improvement of up and coming year of remote communication [1] [9].

There has been a tremendous development in wireless sector over the years from 1G to 5G [19]. The 4th Generation remote correspondence frameworks began around the world. Be that as it may, the issues and difficulties of range shortage and force utilization despite everything persevere even with the nearness of 4G frameworks. Along these lines the requirement for 5G remote framework came for example so as to measure the quarries and the prerequisite of high information rate and versatility. Hence determining the difficulties, the examination on 5th era remote frameworks is started by 20-20 [2].

Millimetre wave (mm Wave) recurrence range around 26.5GHz, 28.5 GHz and 32.5 GHz is used for 5th-age remote advances. The equivalent bands are K_u 12-18 GHz, K 18-27GHz and K_a till 40 GHz. The 5G innovations incorporate all sort of pioneering highlights which will make it generally ground-breaking and in immense interest in distant future [17]. 5G interchanges may take the remote signs to a higher recurrence scope of 30 GHz to 300 GHz, and will decrease the frequency from centimetre to millimetre. As a result of which an immense amount of data transmission may take place and will trade off the worries of remote traffic blockage, yet it will likewise result a few difficulties to the planner [16]. A microstrip is a transmission line which comprises of a dielectric substance sandwiched by two directing strips can be created utilizing printed board circuit innovation, and is utilized to transmit electro-magnetic signals. It's a leading strip isolated and a ground plane with dielectric coat in the middle of called as the substrate. The radiofrequency and microwave items made utilizing micro-strip line, for example, receiving wires, couplers and channels and so forth is more affordable, light and small [15]. The microstrip reception apparatus likewise named as "printed radio wires" is for the most part utilized at the microwave recurrence. It's a low-profile reception apparatus, simple to manufacture and agreeable on bended surface. A dense dielectric substrate has a less dielectric consistent that is attractive for acceptable execution, bigger data transfer capacity, better radiation and better radio wire effectiveness [3].

To meet the needs of 5G, encourages higher limit, more prominent information rate, additional availability, propelled dependability, and additional lower inactivity, new ideas and configuration approaches for receiving wireless communication are in incredible need: future fifth era remote correspondence systems will no doubt utilize high recurrence band [4].

Because of more prominent capability of the geometry circular microstrip radio wires are considered for different electrical applications, with little low-profile reception apparatus. Responsive stacking is accomplished by drawing space on an originating component and by increasing the resonance [5] [14].

5G versatile correspondence frameworks to permit widespread transmission speed by utilizing various millimetre-wave ranging from 10-100 GHz. [6] [10].

It is fascinating to examine connections between a versatile terminal radio wire and human hand and head. Initial examination proposes that a reverberation

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recurrence of the receiving wire tunes down when utilized by an individual. Large measure of intensity loses because interaction of human body, this results in variation of radiation. [7].

5G correspondence innovation has presented higher solicitations to the base station recieving wire just as an open door for the business update. For the organizations which are occupied with the innovative work of base station recieving wires, the 5G innovation realizes new chances to going into a major market, yet additionally numerous innovation challenges. This would be the first run through of millimeter-wave innovation huge application in the versatile correspondence framework, which would consequently advance the millimeter-wave radio wire advances [8]. A antenna with dualband frequency and compact size is in much demand [11].

Defective ground structure (DGS) are amongst the usually utilized strategies towards energize extra resonances inside the reception apparatus structure. Defective grounds are typically spaces expurgated inside the ground plane or once a while in patch to fix or modify the current circulation by making resonance openings on the surface [12].

Mobile communications have experienced a solid advancement in the course of the most recent decades, being these days across the board in a large portion of the world social orders, utilized by an ever increasing number of uses and administrations [13]. Fifth era guarantees additional preferences and advantages to the biosphere, will make a basic contrast over 4G [18].

By and large, the equal circuit of a DGS comprises of an equal tuned circuit in arrangement with the transmission line to which it is coupled. The assortments of connected territory shapes have a similar job and similar attributes of scaling down of size, stop band, slow wave impact and high impedance. And furthermore they all have a similar equal circuit. Be that as it may, we change the sort of DGS just to improve the circuit execution of every antenna [20].

The equivalent admittance of the parallel resonance is given by Equation (1):

$$Y = 1/R + j2\pi (Cf – 1/4\pi2Lf)\text{--------} \quad (1)$$

Since Z = 1/Y, then the equivalent impedance is given by

$$Z = 1/\ 1\ R + j2\pi (Cf – 1/4\pi2Lf) \quad (2)$$

In order to compute the equivalent circuit parameters (R, L, and C), we use the following expressions

$$S_{21} = \frac{1}{1+\frac{1}{2}ZZ_0^{-1}} \quad (3)$$

$$S_{21} = \frac{2Z_0}{2Z_0+[\frac{1}{R}+j2\pi(Cf-\frac{1}{4\pi^2Lf})]^{-1}} \quad (4)$$

Supposing that R Z_0, we obtain:

$$S_{21} = \frac{2Z_0}{2Z_0+j2\pi(Cf-\frac{1}{4\pi^2Lf)]^{-1}}} \quad (5)$$

At −3 dB corresponding to the cutoff frequency fc we have:

$$|S_{21}| = \frac{2Z_0}{\sqrt{4Z_0^2+(\frac{\omega_c}{C(\omega_0^2-\omega_C^2))^2}}} \quad (6)$$

where ω_c is the cutoff angular frequency and ω_0 is the resonance angular frequency.

Using Equations (5) and (6), we conclude the capacitance and the inductance of the equivalent circuit:

$$X=\frac{\omega_C}{2Z_0(\omega_0^2-\omega_C^2)} \quad (7)$$

$$L=\frac{2Z_0(\omega_0^2-\omega_C^2)}{\omega_C\omega_0^2} \quad (8)$$

Resistance R in the equivalent circuit is best fitted around the resonance frequency. In this case, the equivalent impedance Z_e = R and then we have:

$$S_{21}|_{\omega=\omega_0} = \left|\frac{2Z_0}{2Z_0+Z_e}\right| = \frac{2Z_0}{2Z_0+R} \quad (9)$$

$$\text{Τηεν} \qquad P=\frac{2Z_0(1-S_{21|\omega=\omega_0}}{S_{21|\omega=\omega_0}} \quad (10)$$

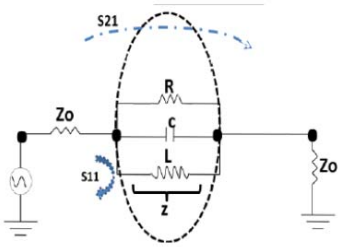

Fig. 1. Equivalent circuit of DGS

II. Formulae Used For Construction

A. Width (W)

$$\omega = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (11)$$

B. Calculation of Effective length (L)

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \quad (12)$$

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$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1 + 12\frac{h}{w}]^{\frac{-1}{2}} \qquad (13)$$

III. Antenna Structure

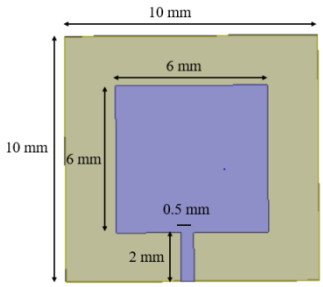

Fig. 2. Top view of the antenna

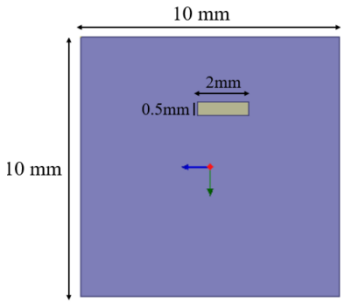

Fig. 3. Base of the antenna

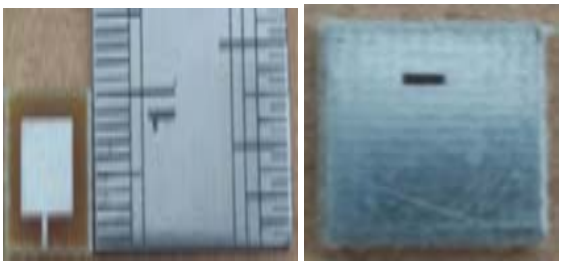

Fig. 4. Fabricated antenna

IV. Results

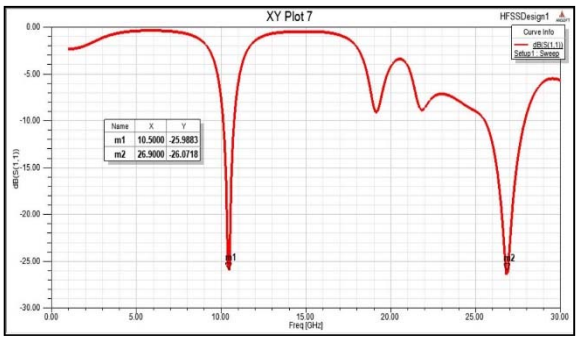

Fig. 5. Return loss in dB

The frequencies 10.5 GHz and 26.9 GHz are produced with return loss of -25.98 and -26.07 respectively in the above figure.

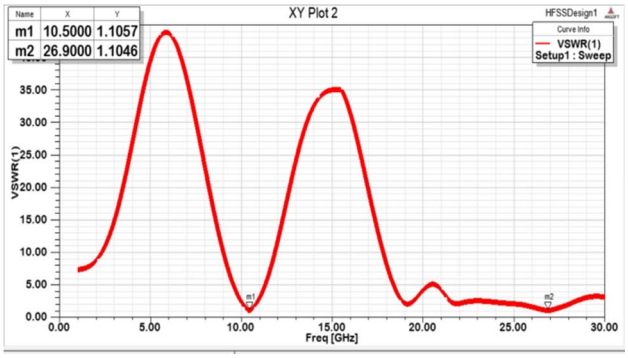

Fig. 6. Voltage Standing Wave ratio

The overhead figure shows the VSWR for obtained frequencies is 1.10 for both.

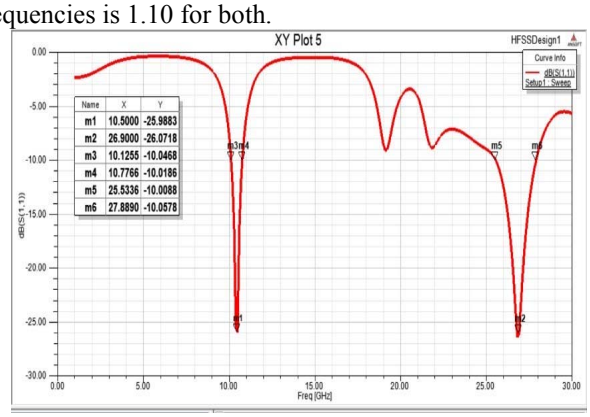

Fig. 7. Band Width

Bandwidth obtained for 10.5GHz is 652 MHz and for 26.9 it is 2400 MHz

V. Gain:

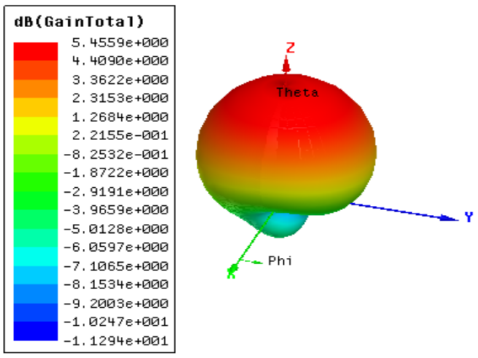

Fig. 8. For 10.5GHz gain is 5.45 dB

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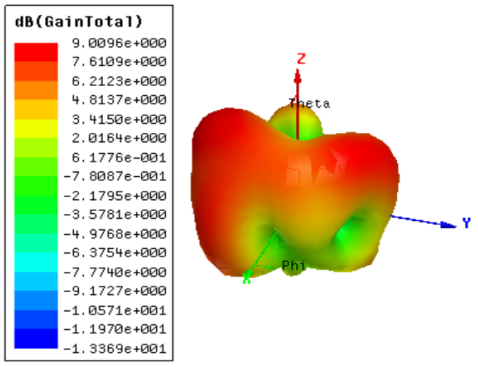

Fig. 9. For 26.9 GHz gain is 9.00 dB

VI. Radiation Patterns:

A. E-Plane:

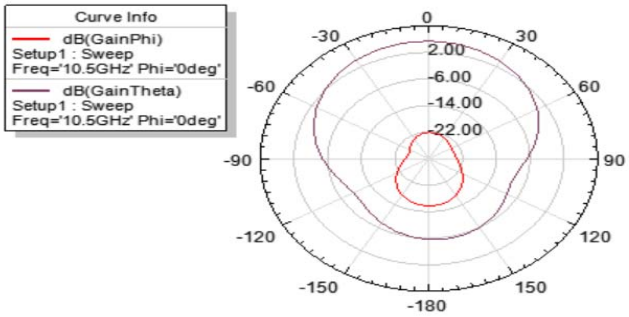

Fig. 10. For 10.5 GHz

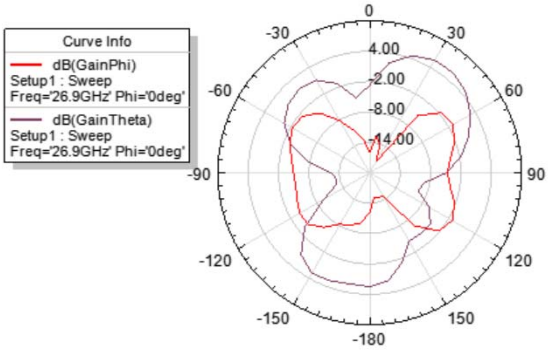

Fig. 11. For 26.9 GHz

B. H-plane:

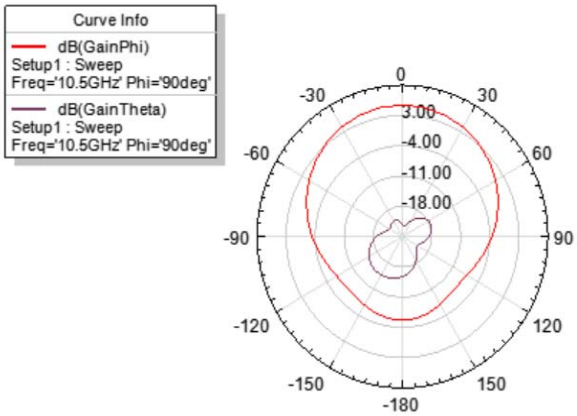

Fig. 12. For 10.5 GHz

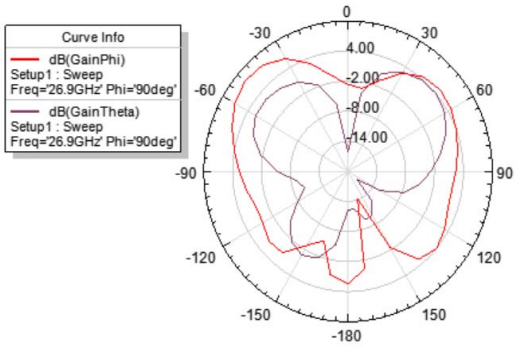

Fig. 13. For 26.9 GHz

VII. Current Distributions:

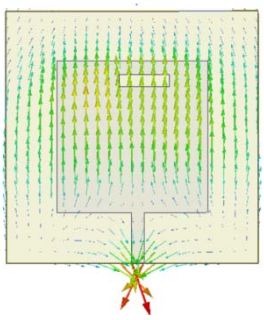

Fig. 14. For 10.5GHz

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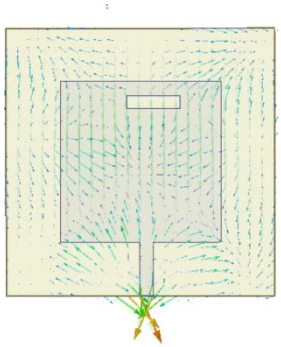

Fig. 15. For 26.9GHz

VIII. PARAMETRIC ANALYSIS

The antenna was initially designed has produced frequencies of 10.3 GHz, 19.1 GHz, 21.7 GHz and 26.5 GHz with return loss -22.20, -11.26, -10.14 and -26.55 respectively. The obtained return loss is for two frequencies is more. To reduce the same a rectangular slot was made in the ground plane. Primarily, the slot was made of dimensions 5x1.5 mm^2 and acquired 10.2, 22.5,27.8 GHz bands with return loss of -16dB, -13dB, and -25dB. To improvise performance of the radiating device the slot size has been reduced to 4mmx1mm. The S_{11} obtained was -25.9086 dB for 27.1GHz and -25.3142 dB 10. 3GHz.The slot size again varied to 2x0.5 mm^2 to improvise the bandwidth and impedance. The final results obtained are shown in Table 1.

TABLE I. FINAL RESULTS OBTAINED

Sl. no	Frequency in GHz	S_{11} dB	VSWR	Z	Gain dB	Bandwidth MHz
1	10.5	-25.98	1.10	47.11	5.455	652
2	26.9	-26.07	1.10	45.28	9.009	2400

As compared with the literature the proposed antennas have produced good return loss with increased bandwidth.

TABLE II. INTERMEDIATE RESULT TABLE

Sl.no	Frequency in GHz	S_{11} dB	VSWR	Z	Gain dB	Bandwidth MHz
Without slot	10.3	-22.20	1.16	44.97	4.86	649
	19.1	-11.26	1.75	87.73	4.97	347
	21.7	-10.14	1.90	45.60	4.93	180
	26.5	-26.55	1.09	85.16	5.83	2419
DGS with Slot 5 x 0.5mm^2	10.2	-16.56	1.34	66.36	4.89	570
	22.5	-13.90	1.50	73.77	5.20	1144
	27.8	-25.49	1.11	55.12	4.90	2284
slot with 4 x 0.5mm^2	10.3	-25.31	1.11	55.14	5.22	652

TABLE III. COMPARISON TABLE

Reference	Antenna volume (mm^3)	Frequency (GHz)	S_{11} dB	Bandwidth In MHz
[1]	160	30.5 41.5	-16 -18	1500 1500
[2]	176	27.17 - 28.15	-26	450 2200
[3]	640	26.8 -29	-18.27	400
[13]	595.68	26.83- 28.43	-16.81	1600
[14]	640	10.15	-18.27	400
[15]	1413	18	-33.59	1220
[16]	6650.15	17	<-10	2000
[17]	4000	24.8	-19.5	1318
Proposed antenna	160	10.5 26.9	-25.98 -26.07	652 2400

IX. CONCLUSION

The antenna was designed with an aim to achieve 5G applications with good gain for a miniaturized patch antenna with the help of the slot made on the ground plane. The impedance matching, bandwidth and increase in gain have been obtained by making a slot in the ground plane. The frequencies generated are 10.5GHz and 26.9GHz with corresponding gain 5.45 dB and 9.0 dB. The rectangular DGS is preferred over other shapes because there will be reflections from the edges which will help us to get better results within minimum back scattering. Applications in specific of 5G domain for 10.5 GHz is Airborne and naval Radars, Amateur Radio, Terrestrial communications and networking and commercial wireless LAN and for 26.9 GHz is Heterojunction Bipolar Transistors and inter-sat.

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Microstrip Array Antenna for 24GHz Automotive RADAR

Banuprakash. R
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
r.bhanuprakash@bmsit.in

H. Ganapathy Hebbar
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
hghebbar@bmsit.in

N. Janani
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
jananinatarajan56@gmail.com

Neha. R
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
neharamesh907@gmail.com

Raghav. K.K
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
raghavkk@outlook.com

Sudha. M
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
muppalasudha@gmail.com

***Abstract*— Automotive RADARs are used to distinguish the speed and scope of targets that is near the vehicle. A 24GHz array antenna is widely used for automotive applications. A 1 x 4 patch array antenna for automotive RADAR is presented in this article. The antenna dimension is 30 x 60 x 1.6mm^3. The antenna produces a frequency of 24GHz. FR4-epoxy is the substrate used which bears a permittivity of 4.4. The proposed antenna has reflection co-efficient of -23.81dB and a gain of 9.7dB. This antenna delivers a VSWR of 1.38 in the working frequency.**

***Keywords*— RADAR, array, automotive, 24GHz**

I. INTRODUCTION

Radio Detection and Ranging (RADAR) might be a framework which uses radio waves to identify different articles like individuals, airplanes, vehicles, boats and rockets. The Least difficult type of a radar framework comprises of a radio transmitter and a beneficiary. The Transmitter emanates electromagnetic waves with a particular frequency which are Reflected or dispersed of articles and afterward gathered by the collector. Receiving wires can be coupled together to shape a cluster which can be utilized to improve the directional addition. The stage and adequacy can be regulated with the goal that the Course of the subsequent shaft can be controlled [1].

By the advancement of societal budget and the consistent development of individuals' expectation for everyday comforts, car is turning out to be increasingly more famous as the primary methods for transportation, and the ensuing increment of traffic risky components and the expansion of car crashes have invigorated the quick advancement of car radar industry.

As per the hypothesis of radio wire exhibit, the half power beam width can be essentially decided when the number and separating of sub arrays and the level of side lobe are given. Here, with the situation that the quantity of sub arrays is specified and without grinding flap is createion, the HPBW is additionally limited by expanding the sub array separating[18].

Radar are frequently utilized for movement identification, situating, restriction, and imaging applications. The mm-wave car radar might be a key procedure of the propelled driver help frameworks. The safety and convenience are highly achievable by automotive RADAR working at 24 and 77GHz respectively. The low recurrence band radar is typically for short range radar applications, for example, vulnerable side recognition and impact evasion. The high recurrence band radar has more extensive data transmission and is dedicated to the applications of long range radar. For example, versatile voyage control [2].

For the sensors at 24 GHz the probable applications have been increased. Regardless, the huge cost remains indisputably the most huge limit counter to a quick outline of such structures into the great volume, lower class vehicle promote. For example, cruise control with autonomous approach up until this point, with the aim of achieving the lengthy acknowledgment ranges essential, a section of designers are focussed on the 77 GHz band and suggests restrictive expenses[3].

The paper portrays an ongoing exertion to configuration, fabricate, and test a 77 GHz radar to be utilized for "wise" journey control of vehicles. An examination of prerequisites is given, plan exchange offs are represented, and principle highlights of models in assembling are definite [15].

In superior remote correspondence business and government protection applications low-profile radio wires could likewise be beneficial. [4-6]

Furthermore, microstrip receiving wires can be utilized for smaller size and minimal as well as are extremely mainstream in clusters [7-8].

The radio wire has estimation limit of around 800 mm3. It works at 2.9 GHz and 6.3 GHz. It has conveyed commendable expansion of 2.065 dB at 2.9 GHz, 3.45 dB for 6.3 GHz. The gathering mechanical assembly is arranged using High Frequency Structure Simulator programming [14].

The CP reception apparatuses are exceptionally powerful in battling with multi-way obstruction, in light of the fact that reflected CP sign will bring about an inversion of polarization. Round enraptured receiving wires are once in a while utilized exclusively, because of low addition. To be specific, the radio wire exhibits with round polarization are considerably much more of the time applied, which are regularly acknowledged so the quantity of components for every one of the two tomahawks is the equivalent. [19].

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Microstrip bunches are adaptable and are used to incorporate a fundamental model that can't be cultivated with a singular part. In like manner, they're wont to analyse the light outflow structure, improve the directivity and execute different limits. Microstrip receiving wire has been broadly

utilized in the radar, correspondence and route fields, as a consequence of low profile, light weight, effortlessness in production and coordination. The exploration in the car hostile to impact radar is a well-known heading in remote and household markets. Clearly the customary enemy of impact radar that reception apparatus has fixed pillars is appropriate for the inexorably mind boggling traffic condition. With the dynamic improvement of staged cluster innovation, increasingly more vehicle makers start utilizing this innovation to the car hostile to impact radar. The radio wire as the front of a radar framework will legitimately influence the exhibition of the framework. Along these lines, the reception apparatus with enormous addition, low side-flap in addition to tight pillar width is fundamental for staged cluster hostile to crash radar framework[9].

A 16-component staged exhibit recipient has been created for cutting edge W-band car radars. The reception apparatus brings about a directivity 29.3 decibel and 28 decibel at 77 - 81 GHz accordingly [16].

Taking into account that the Wi-Fi recurrence ranges at 2.4- and 5.8-GHz are loaded with administrations and that they can't assign extensive-band signals, new, unlicensed microwave and millimeter-wave bunches are getting taken a gander at. Beside a few prospects, 24 and the 60 GHz have as of late been proposed by a few creators of industry and the scholarly community. [20]

In any case, the standing-wave arrangement took care of fix cluster can't get the formed pillar design or other awry examples due to the in-stage excitation, which constrains its application. The boundary excitation in a journeying wave game plan dealt with fix display gathering mechanical assembly (TSPAA) can be adjusted simultaneously, along these lines giving the probability to procure a discretionary radiation structure [17].

Independent driving is turning into a reality-yet minimal effort 79 GHz radar reception apparatus innovation is as yet flawed.

By diminishing the non-straight shared impedance between the transmission line and the transmitting parts, the radio wire's data transmission is elevated and the accepting wire gain is extended[21].

II. ANTENNA FORMULAE

Width (W) –

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

Calculation of Effective length (L)-

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \quad (2)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (3)$$

III. ANTENNA GEOMETRY:

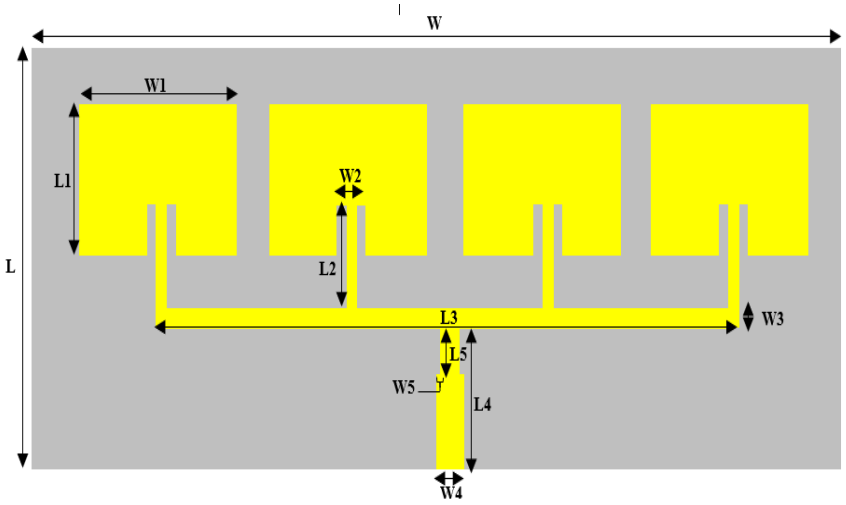

Fig. 1. Front View

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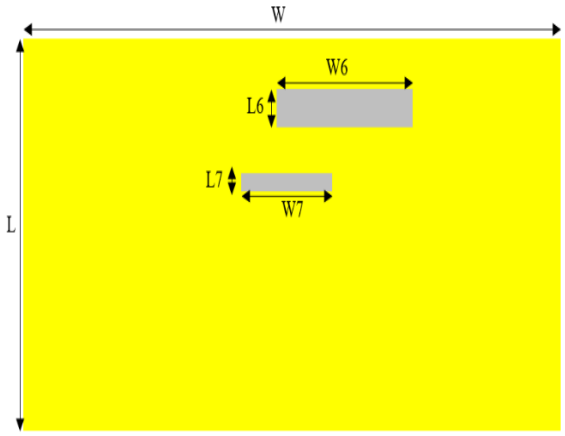


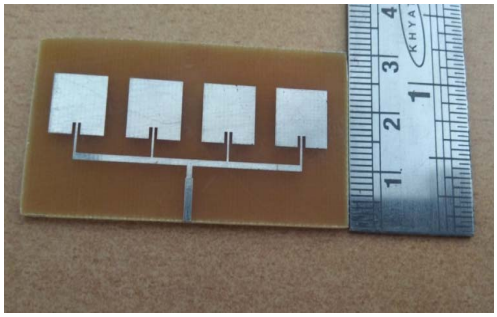
Fig. 2. Back View

The measurements of the design are listed below

TABLE I.

Dimension of the antenna			
Length	**Dimension(mm)**	**width**	**Dimension(mm)**
L	30	W	60
L1	10	W1	10
L2	4.95	W2	0.35
L3	42	W3	1.05
L4	10	W4	1.41
L5	2	W5	0.21
L6	1.6	W6	12
L7	0.45	W7	7.5

IV. FABRICATED ANTENNA



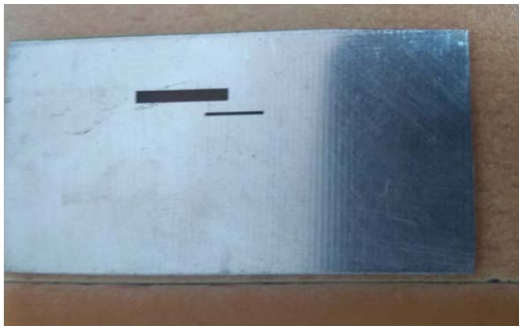


Fig. 3. Fabricated antenna

V. RESULTS

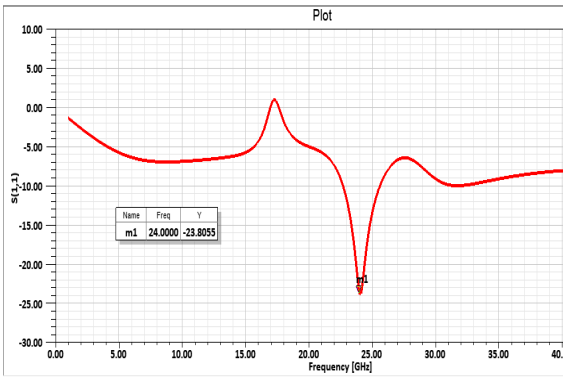


Fig. 4. Plot of S_{11} vs Frequency

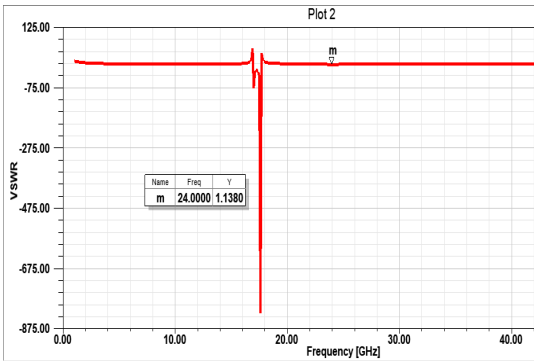


Fig. 5. Plot for VSWR

The plots shows the Simulated result of S_{11} and the VSWR plot for the antenna that is designed.

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A. STEPS:

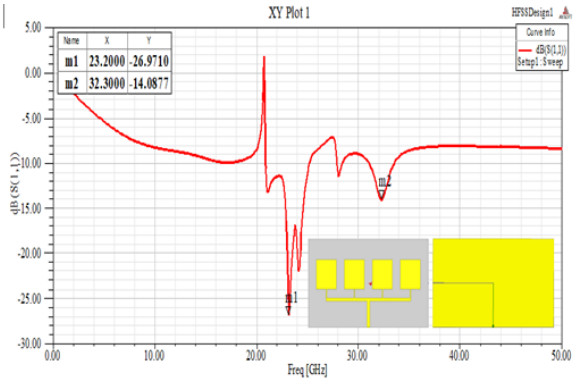

Fig. 6. Return loss vs Frequency with microstrip feed

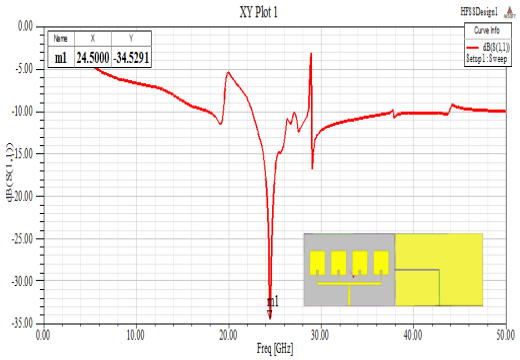

Fig. 8. S_{11} vs Frequency by narrowing the feed

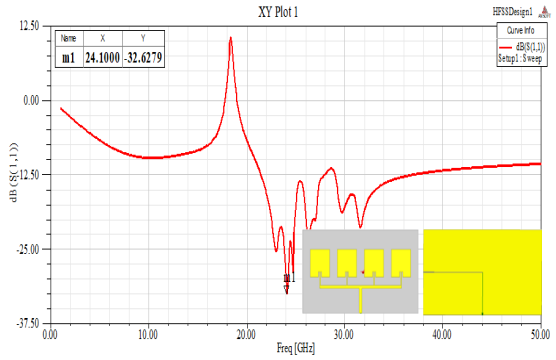

Fig. 7. S_{11} vs Frequency with inset feed

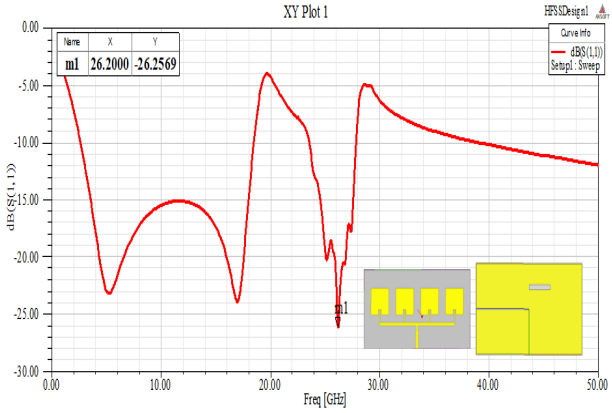

Fig. 9. S_{11} vs Frequency with DGS

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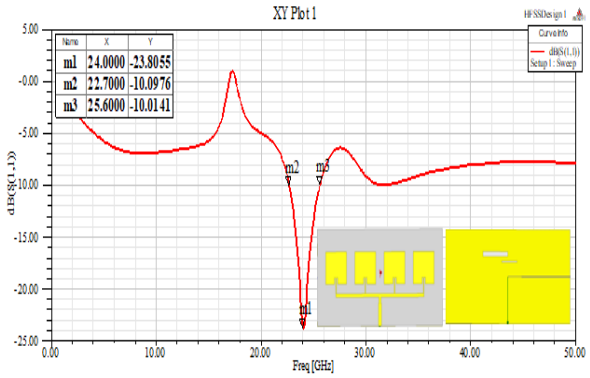

Fig. 10. S_{11} vs Frequency with DGS

The above-mentioned steps have given the return loss of -23.81dB and hence giving the operating frequency of 24GHz. Initially a 1x4 array antenna with microstrip feed is able to generate 23.2GHz and 32.3GHz with a S_{11} of -23.97dB and -14.08dB respectively. In order to obtain 24GHz an inset feed is implemented in the design after which the frequency obtained is 24.1GHz with a very good return loss. A slot dimension of 1.6x12mm^2 is inserted to provide a defected ground structure. The frequency thus obtained is 23.6GHz with a S_{11} of -28.99 and the gain obtained is less. In order to obtain the accurate result another slot of dimension 7.5x0.45mm is put in the DGS and the obtained frequency is 24GHz and S_{11} obtained is -23.81dB. The results obtained gives the impedance bandwidth as 22.7 GHz – 25.6GHz which is 2.9GHz.

TABLE II. INTERMEDIATE STEPS

SL No	*Steps*	*Frequency (GHz)*	*S_{11} (dB)*
1	Array antenna using Microstrip feed	23.2 32.3	-26.97 -14.09
2	Antenna using inset feed	24.1 31.6	-32.623 -21.24
3	By narrowing the feed at distance 3.9mm and feed width is 1.2mm	24.5	-34.53
4	By inserting two slots in the DGS. Slot dimensions: 1.6x12mm^2 0.45x7.499mm^2	 26.2 24	 -26.26 -23.81

B. GAIN

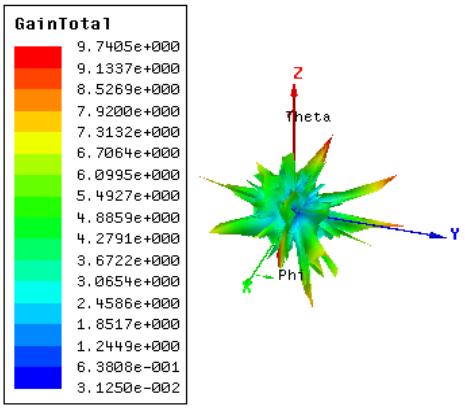

Fig. 11. Gain plot for 24GHz

This figure reveals that the designed antenna produces a gain of about 9.74dB at 24GHz.

C. RADIATION PATTERN

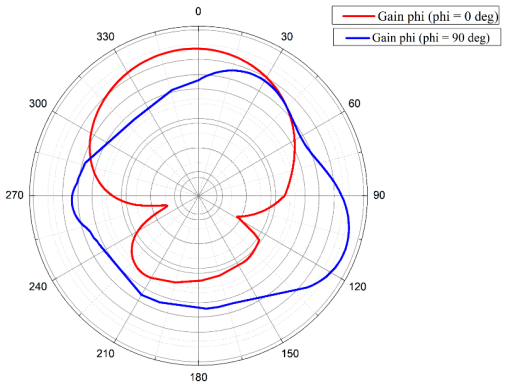

Fig. 12. Co-polarization

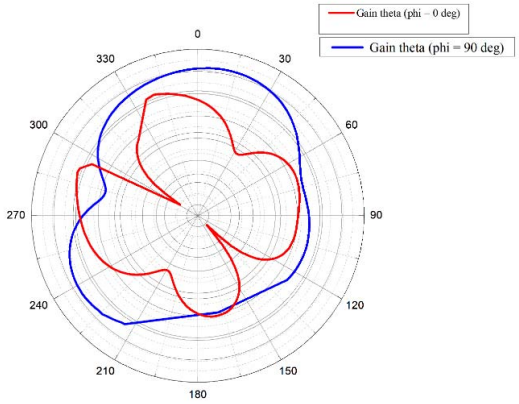

Fig. 13. Cross-polarization

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TABLE III. COMPARISON TABLE

Reference	Antenna dimension(mm^3)	Freq(GHz)	S_{11}(dB)
[10]	104x25x1.6	24	-15
[11]	146x18x1.6	24.5	-13
[12]	32x32x1.6	24	-20.1
[13]	32x32x0.787	19	-11
[15]	100x110x 1.6	77	-25.68
[20]	20x 25 x 1.6	24	-29
Proposed	30x60x1.6	24	-23.80

VI. CONCLUSION

A Microstrip array antenna at 24 GHz is structures on FR4-epoxy which is a dielectric material with $\varepsilon_r = 4.4$. 1 x 4 array antenna was designed and fabricated for automotive RADAR application using HFSS tool. The planned dimension of the design is 2880 mm^3. The result shows that bandwidth of the antenna is from 22.7GHz to 25.6GHz, the highest gain is 9.74 dB having a VSWR value of 1.38. Thus compactness is achieved with improved performance of the array antenna at 24GHz.

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A Compact Reconfigurable UWB Antenna For Short-Range Wireless Applications

Prathiba.N
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
prathiba.yashas@bmsit,in

Banuprakash. R
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
r.bhanuprakash@bmsit.in

Vivek
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
1by16te054@bmsit.in

Hemanth G
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
1by16te016@bmsit.in

Bharathkumar. S
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
1by16te010@bmsit.in

MD Yasin Faisal
Telecommunication Engineering
BMS Institute of Technology and Management
Bangalore, India
1by16te040@bmsit.in

***Abstract*- Ultra wide-band [UWB] deals with microwave occupying a very large spectral bandwidth. UWB antennas are used for short-range communications with lower power consumption. The structure and improvement have been completed utilizing the commercial software ANSYS HFSS version 13. An antenna of 30x30x1.6mm^3 dimensions is designed on FR4 dielectric medium with permittivity 4.4 and attained 11.47GHz bandwidth. In this paper, the technique of Re-configurability is applied to the antenna by inserting PIN diode. This helps us to notch the frequencies from 5.23 to 11.2 GHz.**

Key Words-UWB, Slots, Re-configurability, PIN diode.

I. INTRODUCTION

With rapid development in wireless communications, fast data transfer rates, low power consumption systems are gaining a high demand. A UWB System, however, has the above specifications to satisfy the growing needs of the wireless communication field. As of late, increasingly more examination has been completed to give straightforward and minimal UWB antennas. Different states of monopole receiving patch designs are likewise structured among which circular configuration is imported in the plan. [1]

Ultra-Wideband (UWB) alludes to the signal that either has an enormous relative transfer speed (BW) or a huge total data transmission speed. The large bandwidth (BW) obtained helps us communicate among short ranges with a higher data transfer rate. The greater part of the UWB monopole patch structures examined as of now is non-planar and because of their jutted structure, they can't be incorporated with integrated circuits.[2]

A great deal of UWB antenna structures have been proposed and explored based on the type of the feed line, for example, microstrip feed and coplanar waveguide feed. Notwithstanding, the UWB correspondence frameworks spread such a wide data transfer capacity, that covers with existing thin band communication applications, like WiFi, Bluetooth, WiMAX and so on[3][11].

However, there are a larger number of difficulties in planning an ultra-wide band structure in contrast to a restricted band one. In particular, a sensible ultra-wide band accepting structure should be prepared for working over a ultra-wide information transmission as appropriated by the FCC (Federal communication commission), that is, 3.1 to 10.6 GHz [11]. Simultaneously, it is necessary to achieve proper radiation properties for the total bandwidth. Similarly the structure should be traditionalist in size and unobtrusive to construction for client device applications. UWB radio wires that create band-reject capacities have been examined and effectively executed by utilizing a different method. [4].

Along with UWB applications, the antenna is also reconfigurable. Re-configurable antennas alter the antenna geometry and conduct to amplify the antenna execution in light of changes in their encompassing conditions. [12].

Intervention reduction in a two-manner radio framework is the normal reason why many existing remote frameworks utilize two distinctive concurrent recurrence bands. A fixed reception apparatus is adjusted by a slot inclusion at a specific area to change one full mode more than the other and accomplish a double band activity. Re-configurability can be joined by various methods. The procedure that most of the designs follow is the electronic reconfigurability method. Electronic reconfigurability is generally accomplished by consolidating switches PIN diodes specifically. [5][6][12]

The reconfiguration of a patch structure is accomplished by altering the transmitted fields of the antenna's compelling aperture [8]. It relies upon a deliberate reworking of the patch's current distribution. This redistribution of properties brings about an adjustment in the functionalities. Such a difference in capacities allows

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clients to propose reconfigurable antennas for different types of wireless communication.

The composition on UWB reconfigurability practices various reception contraptions and a short time later switch between various arrangement using MEMS(Micro electro-mechanical system), PIN diodes and immaculate switches. [9]. The perfect exchanging plan has likewise been executed utilizing the stepper engine which turns particular patches into the various arrangement. Change of resounding frequency, radiation pattern, and polarization is conceivable utilizing reconfigurable structures that utilize the electrical exchanging mechanism.[12]

In this paper, we will discuss a microstrip antenna designed for UWB performance with an etched ground plane to obtain defective ground structure and reconfigurability. The antenna is a monopole structure designed on a dielectric medium with a circular patch and slots carved on the ground structure. The proposed antenna delivers a bandwidth of 11.47GHz. The PIN diodes are embedded in the etched spaces with which the antenna operation can be designed as liked.

II. ANTENNA FORMULAE

Width (W) -

$$w = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Effective length (L)-

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\,\frac{h}{w}\right]^{-\frac{1}{2}}$$

III. ANTENNA GEOMETRY

The plan of the proposed UWB structure is shown in the Figure1. and Figure2. A circular patch placed on the substrate with a thickness of 1.6. The rear view of the arrangement houses the ground plane with slots made on them as shown in Figure 2.

TABLE.1: ANTENNA MEASUREMENTS

L= 30mm	W= 30mm
Lg= 7.5mm	W_f= 2mm
L_1= 2.5mm	W_1= 10.5mm
L_2= 1.2mm	W_2= 17.5mm
L_3= 2.5mm	W_3= 1mm
W_4= 10mm	W5= 1mm
R=10mm	
S1, S2, S3= 0.5x0.5mm^2	

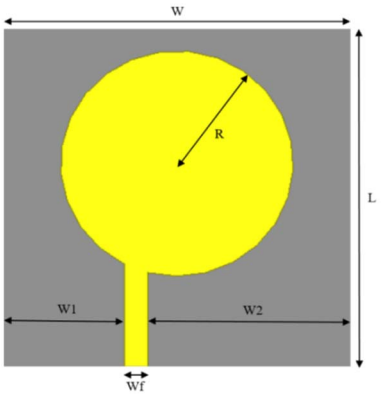

Fig.1 : Top view

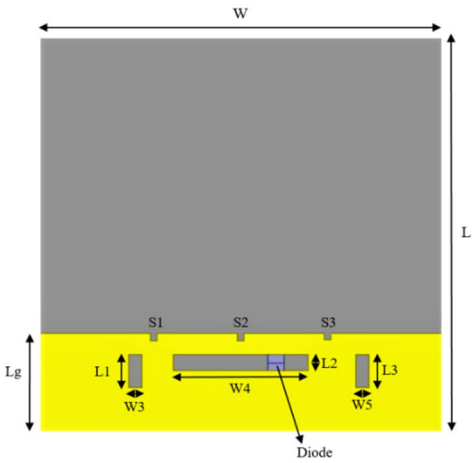

Fig. 2: Rear view

Re-Configurability is attained by inserting PIN diodes which is an electronic reconfiguration technique. At the point when the diodes are on the ON express the diode carries on as a short out and in OFF state it acts as an open circuit. In our design the antenna covers higher operating frequency bands during ON state of the diode.

The BAP6503 PIN diode is utilized in the plan to get the configurable structure. The forward biased proportionate circuit comprises inductance L= 0.45nH and resistance R_S =3.5Ω is appeared in Figure 3(a). In the reverve bias condition the inductance l=0.45nH is coupled to a parallel combination of resistance R_P=3.5kΩ and capacitance of C_T=0.008pF as appeared in Figure 3(b).

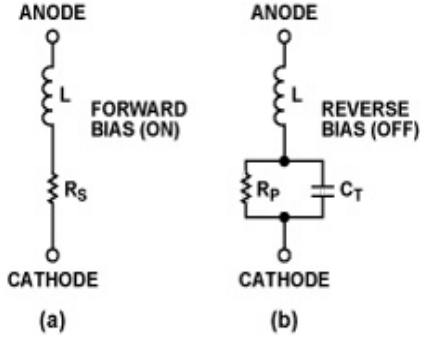

Fig.3. Diode equivalent circuit

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IV. RESULTS AND DISCUSSION

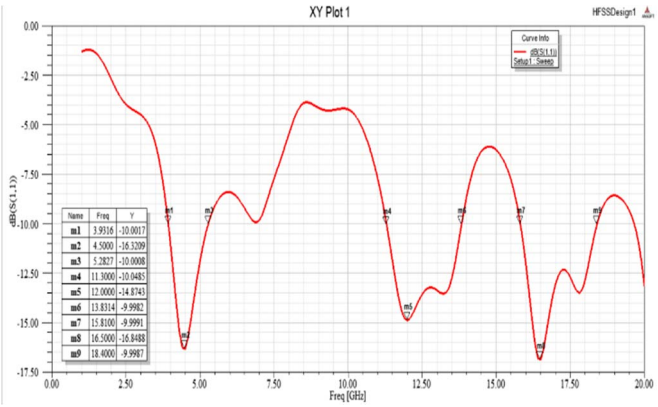


Fig. 3. Return loss - Diode OFF

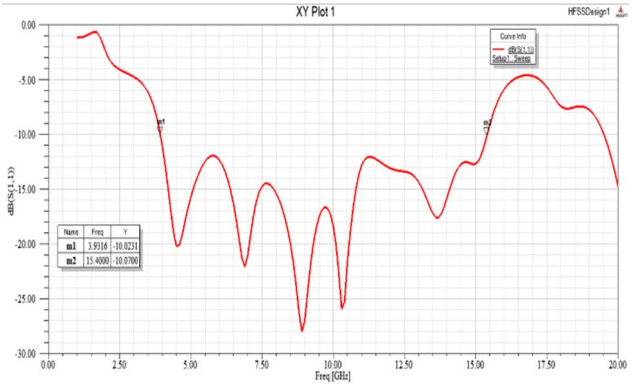


Fig.4. S_{11}- Diode ON

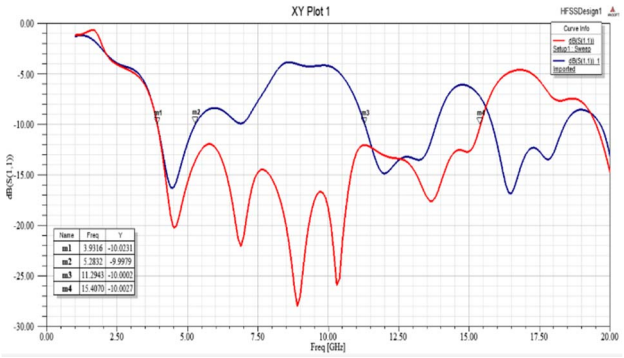


Fig.5. Notching Effect

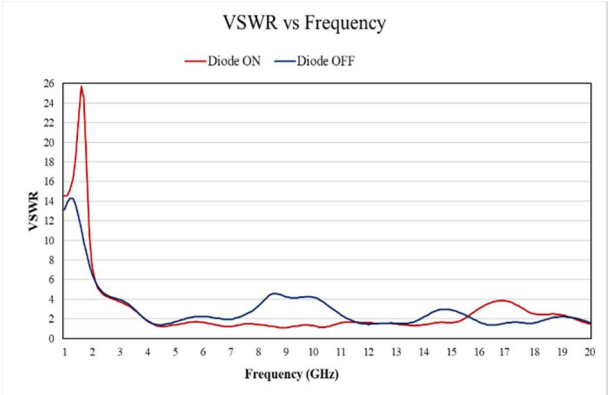


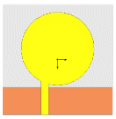
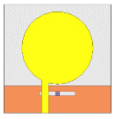
Fig.6. Plot for VSWR

Parametric Analysis:

When the diode is turned ON, the antenna works as an ultra wide-band antenna bearing a bandwidth of 11.47GHz over the frequency range of 3.93-15.4GHz. Over this range, the VSWR value is less than 2. When the diode is turned OFF the antenna works as a multiband antenna of 4.5GHz, 12GHz, and 16.5 GHz with S_{11}=-16.32dB , S_{11}=-14.87dB, S_{11}=16.87dB respectively.

Initially, a circular patch of radius 10mm is created. A 7 x 30mm^2 ground plane is placed on the other side of dielectric. A bandwidth of 3.04 GHz is achieved. To amplify the bandwidth the feed of width 2mm is moved 3.5mm to the left which yielded a bandwidth of 5.66 GHz. When the diode is turned ON a bandwidth increased to 6.88GHz.

TABLE.2: STEPS INVOLVED IN DESIGNING

Step	Design Changes	Bandwidth
1	10mm circular patch and ground plane of 7*30mm^2 with 2mm feed in the middle. 	3.04 GHz with a centre frequency of 6. 4GHz
2	Feed moved 3.5mm to the left. 	5.66 GHz
3	1.2*10mm^2 slot is made in the ground plane and inserted BAP6503 pin diode. 	6.88 GHz (Diode ON)
4	L1*W3, L3*W5, S1, S2, S3 slots are made, diode position is moved 2mm to the left to enhance the bandwidth when the diode is ON (Figure 2)	11.47 GHz (Diode ON)

To increase the bandwidth furthermore when the diode is ON, L1*W3, L3*W5, S1, S2, S3 slots are made on the ground structure with dimensions as mentioned in Table 1 and the diode position is moved 2mm to the left. The bandwidth increased to 11.47 GHz with operating frequency covering 3.93 to 15.4 GHz. The reconfigurability effect took place when the diode is turned OFF by notching the operating band from 5.28 to 11.3 GHz. When the diode is switched OFF the antenna worked as a multiband antenna with 4.5 GHz, 12GHz and

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16.5 GHz as the centre frequencies with corresponding S_{11} values of -16.32dB, -14.87dB, and -16.84dB respectively.

Gain:

Diode ON:

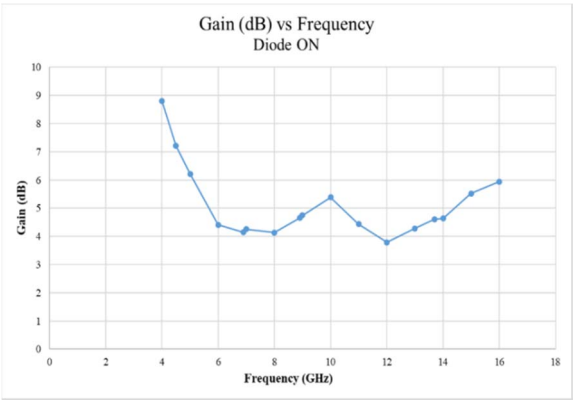

Fig.7. Gain vs Frequency Diode on

The gain is well above 4dB for the entire bandwidth of 11.48GHz when the diode is switched ON.

Diode OFF:

Gain is calculated for 4.5 GHz, 12 GHz, and 16.5 GHz.

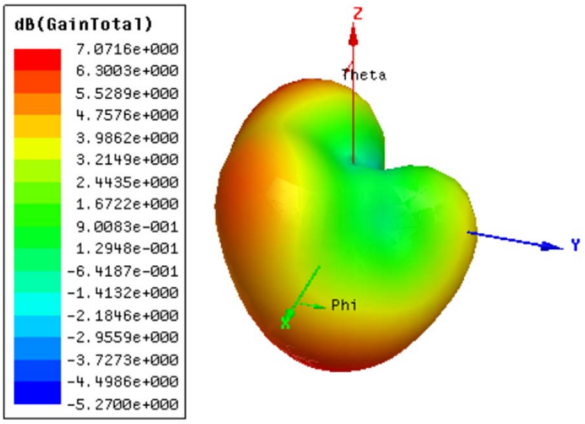

Fig.8. At 4.5GHz

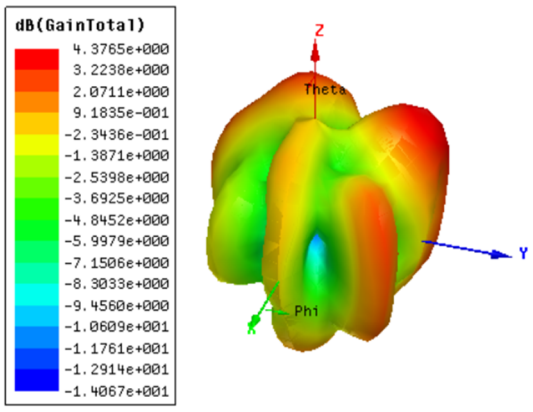

Fig.9. At 12GHz

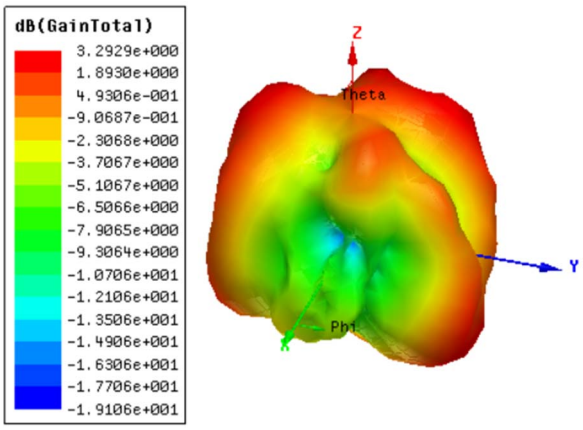

Fig.10. At 16.5 GHz

Gain at 4.5 GHz is 7.071dB, at 12 GHz is 4.376dB, and at 16.5 GHz is 3.29dB when the diode switched OFF.

V. RADIATION PATTERNS

Diode ON:

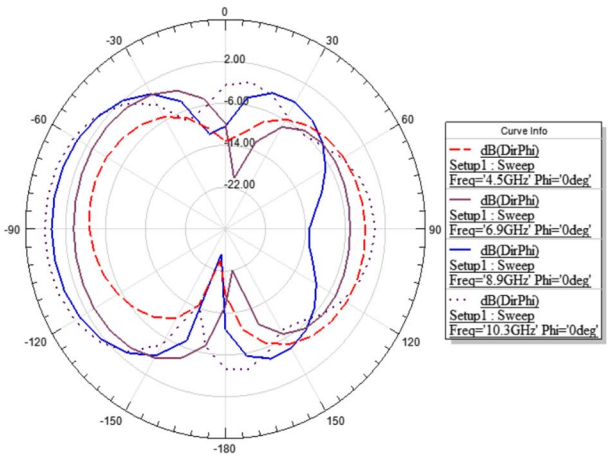

Fig.11. Co-polarization plot of E-plane when the diode is ON

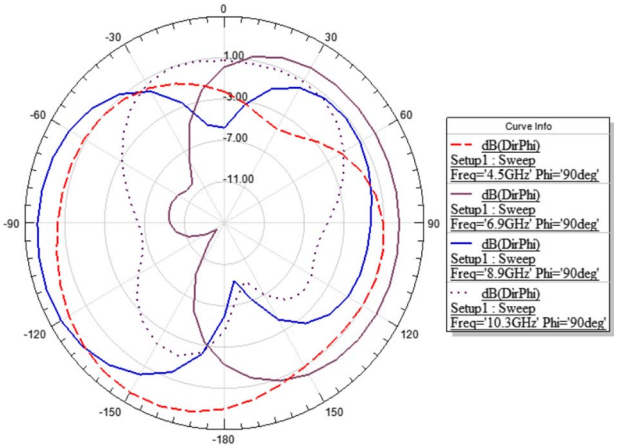

Fig.12. Co-polarization plot of H-plane when the diode is ON

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Diode OFF:

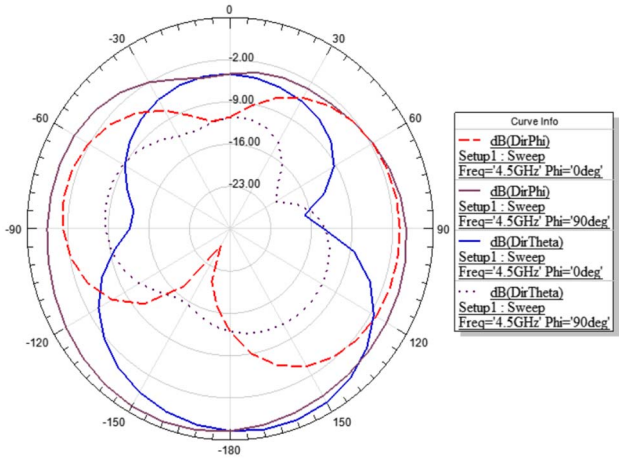

Fig.13. Radiation pattern for 4.5GHz when the diode is OFF

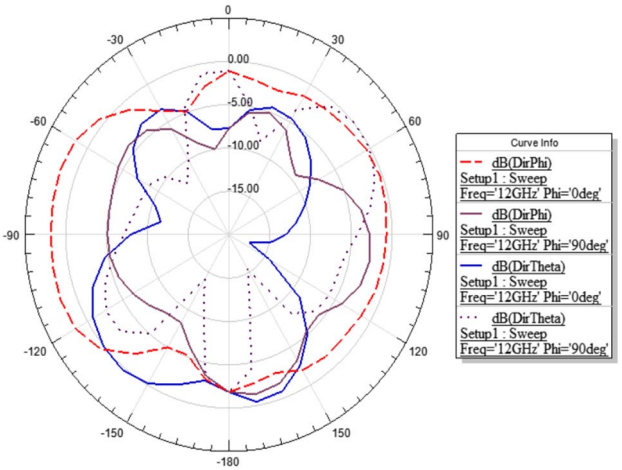

Fig.14. Radiation pattern for 12 GHz when the diode is OFF

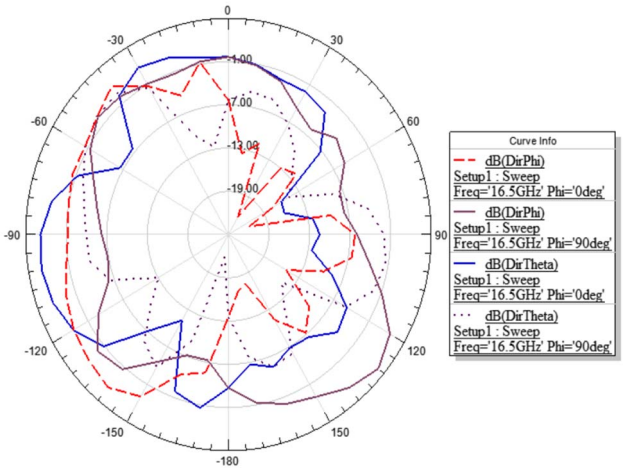

Fig.15. Radiation pattern for 16.5 GHz when the diode is OFF

VI. CONCLUSION

This paper presents a novel conservative UWB structure of size 30 x 30 x 1.6mm3 with band notch features planned of the FR4 substrate. The proposed receiving antenna can cover the UWB range from 3.93 to 15.4 GHz with re-configuration capacities. The notching effect is incorporated using the BAP6503 PIN diode placed in the ground plane. With the help of this diode, the frequency range from 5.28 to 11.3 GHz can be notched by switching the diode OFF. Thus compactness is achieved with the concept of reconfigurability and improved performance.

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Design and Performance Improvement of CNTFET Based Content Addressable Memory (CAM) Cells

Raju Hajare, Mallikarjunagowda C. P, Deekshitha, Madhuri. J, Ananya

Abstract: ***The scaling down of transistors is of paramount importance to make ICs and devices more portable and efficient. As it is the most basic component of every electronic device, there is need of finding better and innovative methods of transistor characterization. CNTFET has shown the promise and is best suited for today's faster digital processing units and Memory devices. Here Carbon Nano Tube (CNT) is characterized for its electrical property and then designed a XOR based CAM cell using CNTFET. Both delay and power analysis for the designed CAM is done.***

Keywords: Carbon Nano Tube FET (CNTFET), Content Addressable Memory (CAM) Cell, SRAM, MOSFET.

I. INTRODUCTION

The electronic devices and systems with their compactness in size, light weight, low power consumption, high performance and rich in functionalities are in great demand. For the last 4 decades, both academia and industries have pushed the downscaling of Metal-Oxide Semiconductor Field Effect Transistor (MOSFET) to achieve these demands. But the downscaling of MOSFET can be achieved only up 45nm node size as it faces severe Short Channel Effects (SCEs) below the 45nm size. So it is very important to look for an alternative device structures for replacing the present MOSFETs [1]. The newer silicon device structures such as multiple gate MOSFETs and FinFETs and others solve the SCEs to some extent. There is one more novel device made of Carbon Nano Tube called CNTFET meets most of the today's IC industries. Among all, top gated CNTFETs have attracted more attention of device scientists as it is giving better performance with respect to switching element in ICs. The improvement in performance is due its scalable dimensions and adoption of suitable geometry [8]. The ballistic carrier transport nature of CNTs with high carrier mobility achievement in semiconductor devices makes CNTFET a promising candidate for the future fast processing digital systems and faster memory chips. At the same time this device has advantages of compatibility with existing CMOS fabrication process [12]. But CNTFET is still in research phase due to its reliability issues.

Revised Manuscript Received on October 20, 2019.

***** Correspondence Author

Raju Hajare*, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Bangalore-64 , India. Email: rajuhajare@bmsit.in

Mallikarjunagowda.C.P, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Bangalore-64, India.

Email: cpmallikarjunagowda@bmsit.in

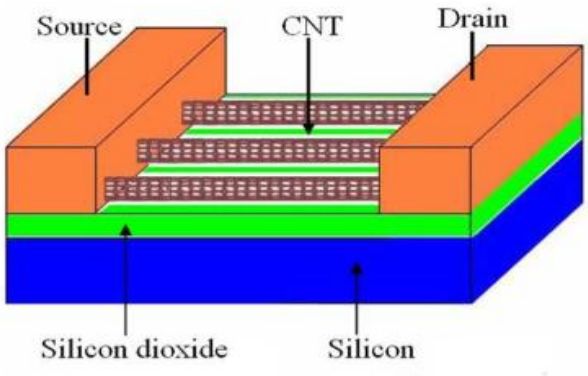


Figure 1: Structure of CNTFET [2].

II. PROPOSED CNTFET-BASED SRAM DESIGN:

Figure 2 shows a CNTFET-based 6T SRAM cell. Here the Static Random Access Memory (SRAM) cell comprising of simple CNTFET latch is shown. It has two cross coupled inverters along with two access transistors. Once Word Line(WL) is asserted the data write operation can be achieved by applying the proper values to bit lines called BL and BL'. After memory write operation, SRAM cell comes to standby mode while the WL is set to 0, and the memory cell stores the data until next working period. The simulation time taken is short for CNTFET based SRAM, with an average CPU time of circa 1 second. The power consumption of the device is obtained by calculating the output current of the SRAM cell. With small supply voltages at terminals of the transistors, the SRAM can be estimated to be power efficient.

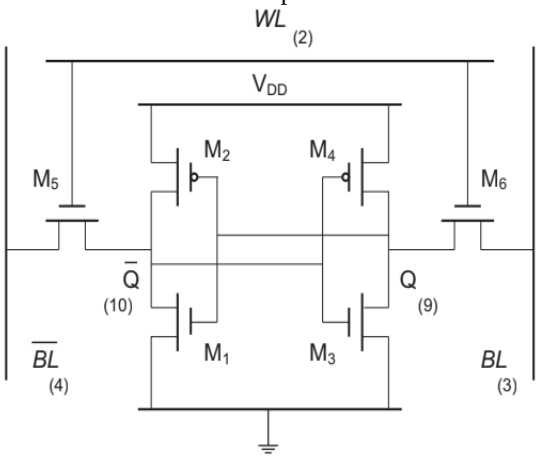


Figure 2: SRAM cell [2].

Write operation:The write cycle begins by applying the value to be written to the bit lines. If '0' is to be written, then we would apply '0' to the bit lines, i.e. setting BL to 1 and BL' to 0

A. Write Operation

The write cycle begins by applying the value to be written to the bit lines. If we wish to write a 0, we would apply a 0 to the bit lines, i.e. setting BL to 1and BL' to 0. This is similar to applying a reset pulse to an SR-latch, which causes the flip flop to change state. A '1' is written by inverting the values of the bit lines. WL is then asserted and the value that is to be stored is latched in. This works because the bit line input-drivers are designed to be much stronger than the relatively weak transistors in the cell itself so they can easily override the previous state of the cross-coupled inverters. In practice, access NMOS transistors M 5 and M 6 have to be stronger than either bottom NMOS (M 1 , M 3) or top PMOS (M 2 , M 4) transistors. This is easily obtained as PMOS transistors are much weaker than NMOS when same sized. Consequently, when one transistor pair (e.g. M 5 and M 6) is only slightly overridden by the write process, the opposite transistors pair (M 7 and M 8) gate voltage is also changed. This means that the transistors can be easier overridden, and so on.

B. Read Operation:

Reading only requires asserting the word line WL and reading the cell state by a single access transistor and bit line. However, bit lines are relatively long and have large parasitic capacitance. To speed up reading, a more complex process is used in practice. The read cycle is started by pre-charging both bit lines BL and BL', to high (logic 1) voltage. Then asserting the word line WL enables both the access transistors M 3 and M 4, which causes one bit line (BL) voltage to slightly drop. Then the BL and BL' lines will have a small voltage difference between them. A sense amplifier will sense which line has the higher voltage and thus determine whether there was 1 or 0 stored.The higher the sensitivity of the sense amplifier, the faster the read operation. As the NMOS is more powerful, the pull-down is easier. Therefore, bit lines are traditionally pre-charged to high voltage.

III. RESULTS AND DISCUSSIONS

When SRAM cell is evaluated for current characteristics, the following simulated waveforms are obtained.

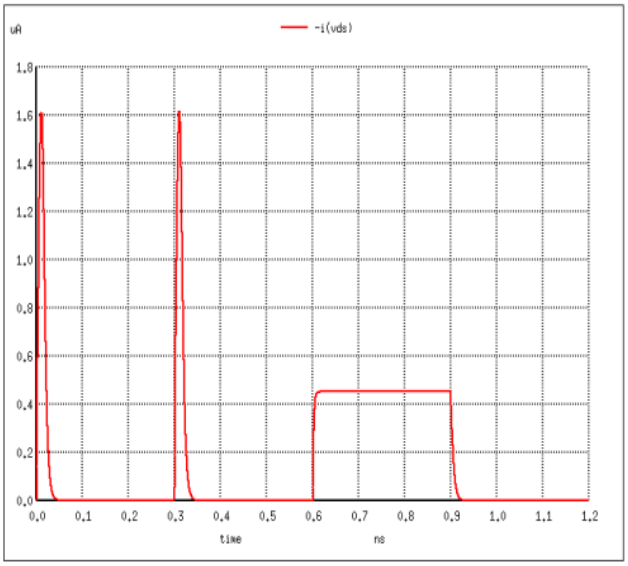


Figure 3: The operation current characteristics of the SRAM cell.

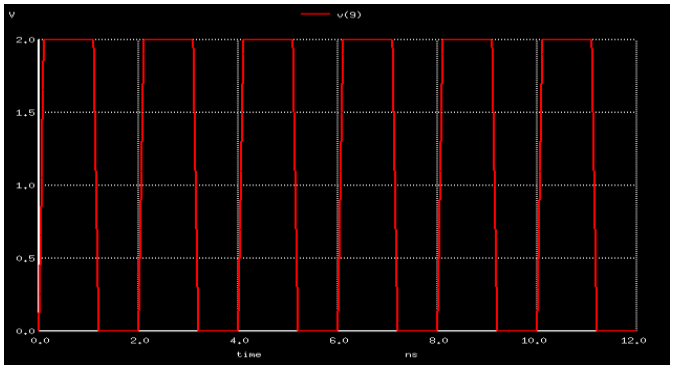
Figure 3 illustrates that the drain current of the transistors within the memory cell is less than 1.6µA. Power consumption of the SRAM cell can be estimated using Eq. 1

Psc = ½ Vdd Ipeak Tt fn – 1

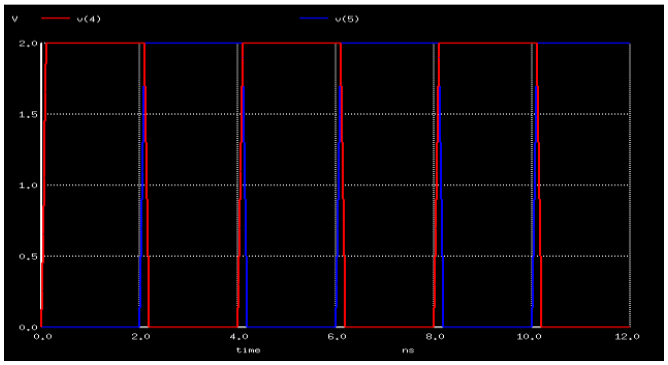
Where 'Vdd' is the drain voltage taken as 0.5V for the SRAM simulation 'f' is the frequency of operation (3.33GHz), 'Tt' represents the transition time of the input(0.1ns), 'Ipeak' is the maximum saturation current of the CNT transistor in SRAM cell(1.6µA), and 'n' is the number of transistors(6 transistors) used in the SRAM Cell.

With parameters that are derived from the simulation, the power consumption Psc can be estimated to be circa 0.8µW for the SRAM cell as per equation-1, which dissipates small energy around 2.4x10-16J per switch for the CNT based SRAM cell.

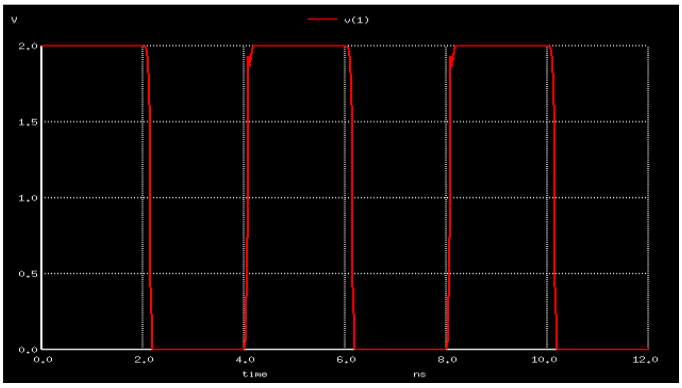
3.1 Sram Waveforms



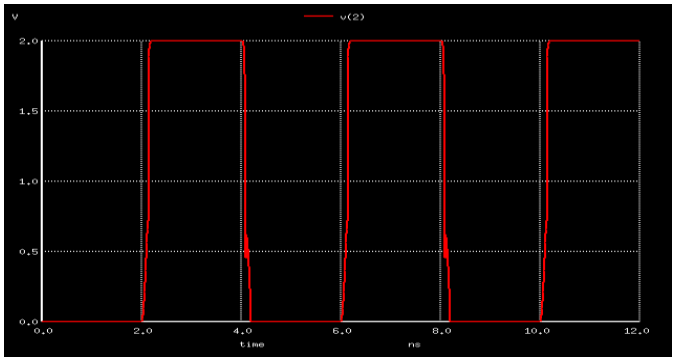
[a]



[b]



[c]

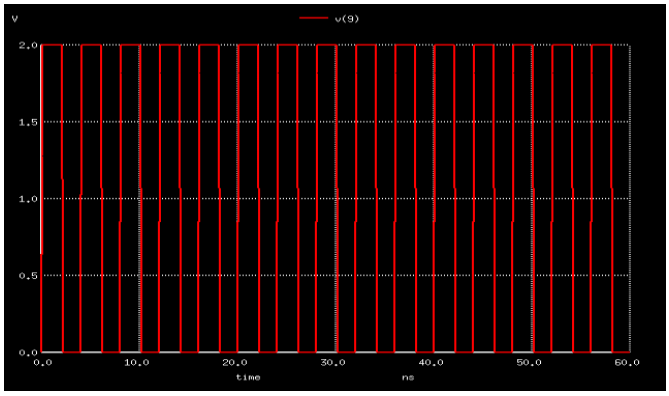


[d]

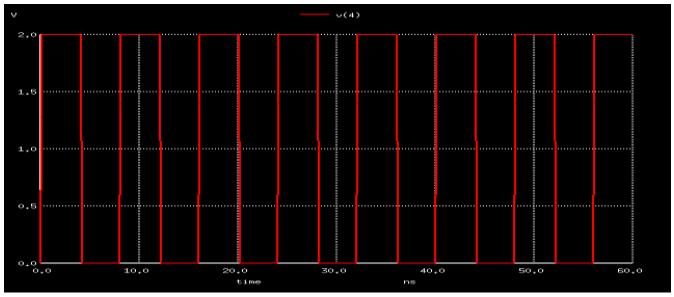
Figure 3.1: Read and write operations in SRAM.

[a] Word Length (WL) [b] BL and BL' [c] Output at point Q [d] Output at point Q'.

3.2. Cam Waveforms :



[a]



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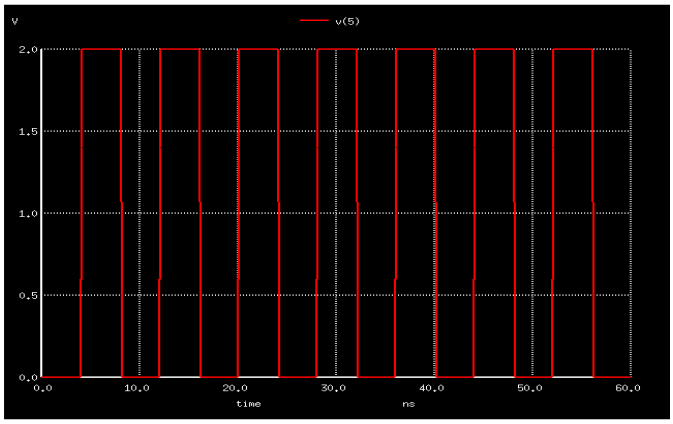
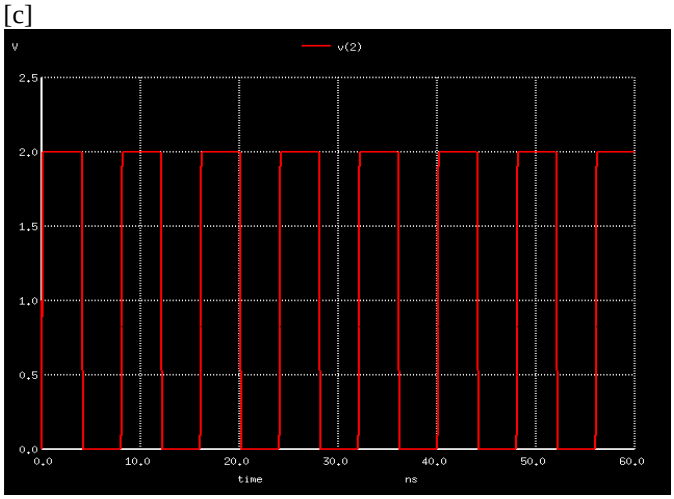


[c]



[d]

Figure 3.2: Read and write operations in CAM.

[a] Word Length (WL) [b] BL and BL' [c] Output at point Q [d] Output at point Q'.

3.3. Cascaded Inverter Based Cam Waveforms:

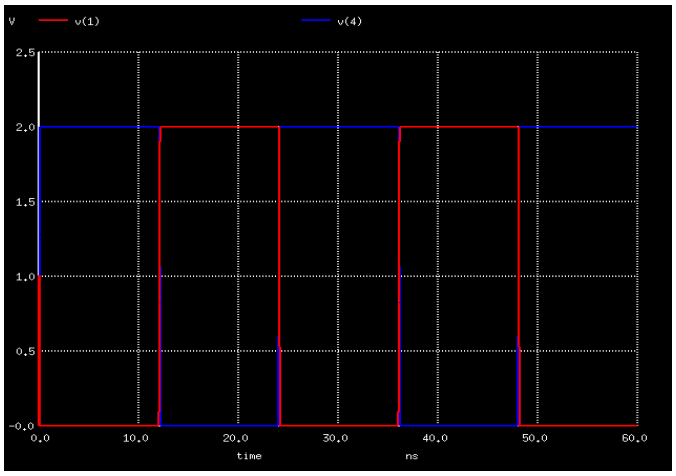


Figure 3.3: [a] Delay in 2 inverter based CAM cell

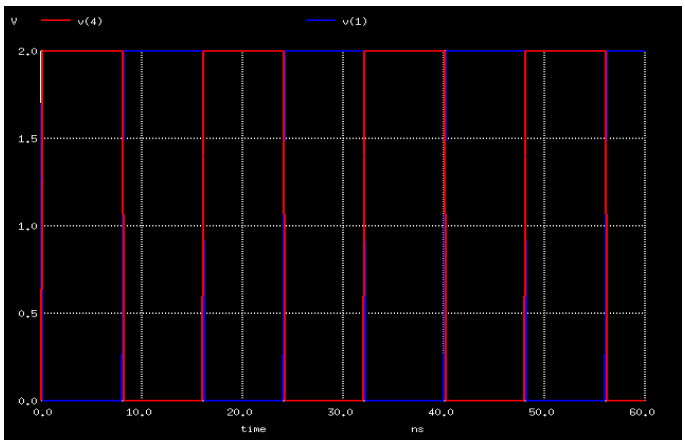


Figure 3.3: [b] Delay in 6 inverter based CAM cell.

Table 1: Delay in 2 inverter and 6 inverter based CAM cell

Operation	2 Inverter based CAM	6 Inverter based CAM
Read	321ps	62.5ps
Write	156ps	78ps

From Figure 3.3 and Table 1, it is observed that the delay is reduced by a significant amount when 6 inverters are used to latch the data instead of 2 inverters. The delay during the read operation for 2 inverter and 6 inverter based CAM cell is 312 picoseconds and 62.5 picoseconds respectively. During the write operation the delay is 156 picoseconds for 2 inverter based CAM and 78 picoseconds for 6 inverter based CAM. The pictorial graph giving comparison for inverter 2 and 6 inverter based CAM Cell is as shown in fig-8.

Figure 3.4: Pictorial comparison of Delay in 2 inverter and 6 inverter based CAM cell

Due to the inverse relation between current and time, the delay time can be reduced by increasing the current flowing through the circuit. 6 inverters drive more current than 2 inverters and thus its delay time is lesser.

IV. APPLICATIONS

CAM cells are used in Computer network devices. The MAC address table is implemented with a binary CAM, so as to find destination port very quickly when MAC table is looked into in network switching when it receives a data frame from one of its ports. It reduces the switch latency.
There are CAMs also known as ternary CAM used in network routers, which make the look up process very efficient.
The other applications of CAM also include
Artificial Neural Networks
Database engines
Data compression hardware
Intrusion prevention system

IVa . Advantages

The advantages of CAM system are:
Data storage and retrieval capabilities which simplify common data manipulations like searching, matching, sorting, cross referencing and updating.
Programming simplifications based on the placement of data in a memory.
Interconnections between components are simplified, reducing propagation delays.
Loss of any cell or malfunction doesn't affect the program, since it has periodic structure.

IVb . Disadvantages

Floating point arithmetic operations are not efficient, since it is necessary to sequentially normalize cell contents.
Cost of refrigeration for crytron devices may be considered as a disadvantage.
New software developments are required for use of CAM cell.

V. CONCLUSION

Here Content Addressable Memory designs using CNTFET is carried out to improve upon the performance in terms of read and write operation. Circuit Simulation results confirm that the CAM cells perform function accurately during read, write and search operations. It is also observed that the proposed CAM cells achieve significant improvement in terms of search speed due to reduced match line capacitance and number of transistors with respect to the CNTFET based conventional cells. Hence, the observed results reveal that the proposed CAM cells are capable of enhancing the performance of memory systems

ACKNOWLEDGEMENTS

Author thanks the management of BMSIT&M for the infrastructure facility for carrying out the work.

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AUTHORS PROFILE

Raju Hajare received B.E degree in Electronics and Communication Engineering from Mysore University, India. He did his M.Tech in the field of Power Electronics from Visvesvaraya Technological University, India. He has been awarded with Ph.D. from VTU, Belagavi for his research Thesis on nano devices modeling and characterization. He is currently working as an Associate Professor in Electronics and Telecommunication Department of BMS Institute of Technology, Bangalore. He has won two best papers awards in international conferences and participated as member of panel of Judges in Southern India Science Fairs 2017, 2018 and 2019 for evaluating Electronics projects. His areas of interest are Semiconductor Devices, Nano electronics and NEMS. He has Published research papers in Scopus indexed international Journals and presented papers at different international Conferences. He has dozens of papers in IEEE conference Proceedings to his credit.

Mallikarjuna Gowda.C.P received BE, in Electronics and Communication Engineering from Gulbarga University, India. He did his M.E. in the field of Communication Engineering from Jadavpur University, Kolkata. Currently Pursuing Ph.D in the area of Cognitive Radio Networks from Visvesvaraya Technological University, India. He is currently working as an Associate Professor in the department of Electronics and Telecommunication Engineering at BMS Institute of Technology and Management, Bengaluru. His areas of interest are wireless communication, Cognitive radio networks. He has published research papers in peer reviewed international Journals andpresented papers at different National and international Conferences, He reviewed research papers for IEEE Access Journal and IEEE Sponsored International conferences. Life member of Indian Society for Technical Education (ISTE), Solar Energy Society for India(SESI)

International Journal of Reconfigurable and Embedded Systems (IJRES)
Vol. 9, No. 2, July 2020, pp. 125~132
ISSN: 2089-4864, DOI: 10.11591/ijres.v9.i2.pp125-132

Design and development of combat robot for military applications

Raju Hajare, Mallikarjuna Gowda C. P.
Department of Electronics and Telecommunication Engineering, Visvesvaraya Technological University, India

Article Info

Article history:

Received Sep 16, 2019
Revised Feb 06, 2020
Accepted Feb 20, 2020

Keywords:

µvision Keil
Max232
Mobile robot

ABSTRACT

In this paper we have developed a combat robot which will assist our commandos to fight against terrorism. With additional weaponry system it can perform other tasks also. Our preliminary aim in this project is to design a combat robot which can be used to handle the unmanned situations like terror attack inside the building where the firing is heavy and the entry of commandos may be difficult. In such situations the combat robot with spy camera, which is controlled through the control room can be sent into the terrorist occupied area. The robot constantly sends the visuals captured through spy camera to the control room. Based on the visuals received from the robot the control room operator can give directions to the robot. This kind of spy robot can also be used in star hotels, shopping malls, jewelry show rooms.

Corresponding Author:

Raju Hajare,
Department of Electronics and Telecomcommunication Engineering,
Visvesvaraya Technological University
BMS Institute of Technology, Bangalore- 64, India.
Email: rajuhajare@bmsit.in

1. INTRODUCTION

A robot is a programmable multifunctional manipulator designed to perform variety *of tasks.* Robots are needed for a variety of tasks and have wide applications in an ever-increasing number of fields including medicine, manufacturing, space and underwater exploration as well as safety and rescue operations. Examples are space or underwater exploration, moving in confined and restrained spaces such as narrow pipes and passageways as needed in earthquake rescue tasks and moving objects that are too small or too big for humans to handle.

Some tasks require performance beyond human capabilities such as a higher degree of repetitive precision, high-speed motion, or high levels of strength. In addition to this, there are some tasks which are dangerous for humans. Work in dangerous environments such as volcano craters, space and underwater exploration missions, chemical spill clean-up, nuclear waste disposal, explosive material manipulation, and tasks that require prolonged exposure to cold, heat, pressure, lack of air, or other conditions harmful to humans. Authours Pete Miles & Tom Carroll *et al* [1], explains the science and technology behind robots, and show you what materials you need to build and program a robot for home, star hotels and jewellary shops, etc, applications.

Mobile robots have many different uses in industry and become a very important branch of Robotics. They are viewed as an important improvement in automated transportation systems. It is likely that, once the technology is sufficiently advanced to ensure safe and reliable operation, automobiles, trucks, trains, airplanes, and possibly ships will be built with the ability to move autonomously. Recent developments and integration of various research areas such as the satellite based Global Positioning System (GPS), wireless

communication systems, sensor fusion techniques, intelligent highway systems, computer networking, computer vision, sensing, and machine cognition and intelligence systems will eventually combine to produce reliable autonomous transportation systems [2-3]. Wireless communication is a pre-requisite to the economic growth and comfort, quality of the life. It is an amazing field of research which keeps on evolving day by day. Mobile robots have the capability to move around in their environment [4-6].

2. DESCRIPTIONS OF MAJOR COMPONENTS IN COMBAT ROBOT

2.1. Transmitter section

The transmitter block shown in Figure 1 consists of PC, Microcontroller, Zigbee transmitter, LCD display, RF receiver of the camera and power supply unit. RS 232 is a voltage converter used for making communication between the master and slave compatible. The receiver of the camera is connected to PC using TV tuner card and the surrounding areas of the robot can be viewed. The controls of the robot are transmitted using Zigbee and is connected to microcontroller through IC MAX232 which is used to convert RS232 voltage levels into TTL voltage level and vice versa. There is an LCD display which is used to display "Zigbee transmitter" and other status information. The power supply unit consists of bridge rectifier and voltage regulator which gives +5V and +12Vsupply.

2.2. Receiver section

The information received from transmitter using Zigbee receiver is given to microcontroller through IC MAX232 which is used to convert RS232 voltage levels into TTL voltage level and vice versa.RS 232 is a voltage converter used for making communication between the master and slave compatible .A wireless camera is mounted on the stepper motor so that it can rotate to see around. There is a LCD display which is used to display "Zigbee receiver" and other status information.

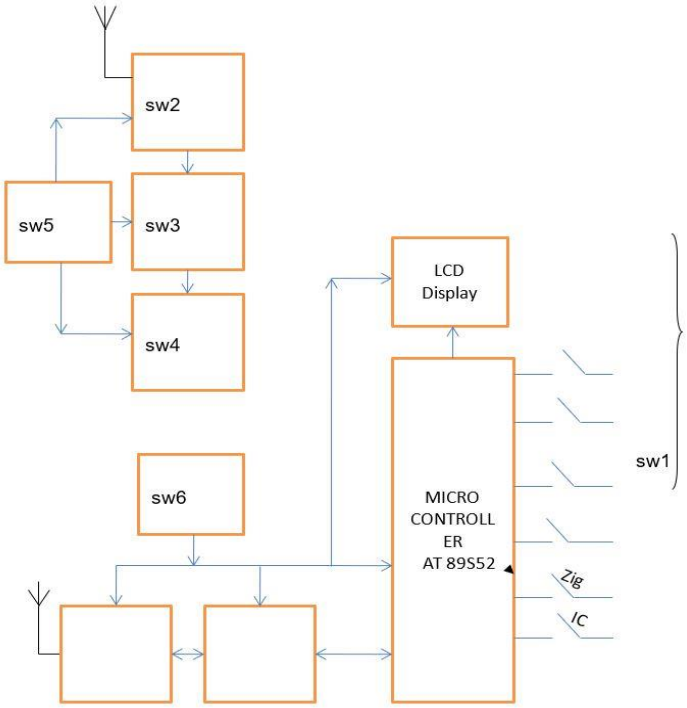

Figure 1. Block diagram of transmitter section

Stepper motor is connected to microcontroller, and will rotate continuously. Two DC motors are used, one is for the forward and backward movement, the other one is used to move left and right. The IC ULN2803 is used as driver IC, since stepper motor and DC motor requires large drive current which is not provided by the microcontroller. Therefore, ULN2803 is used to provide large drive current. The power supply unit consists of bridge rectifier and voltage regulator which gives +5V and +12Vsupply. Figure 2 shows the block diagram of receiver section.

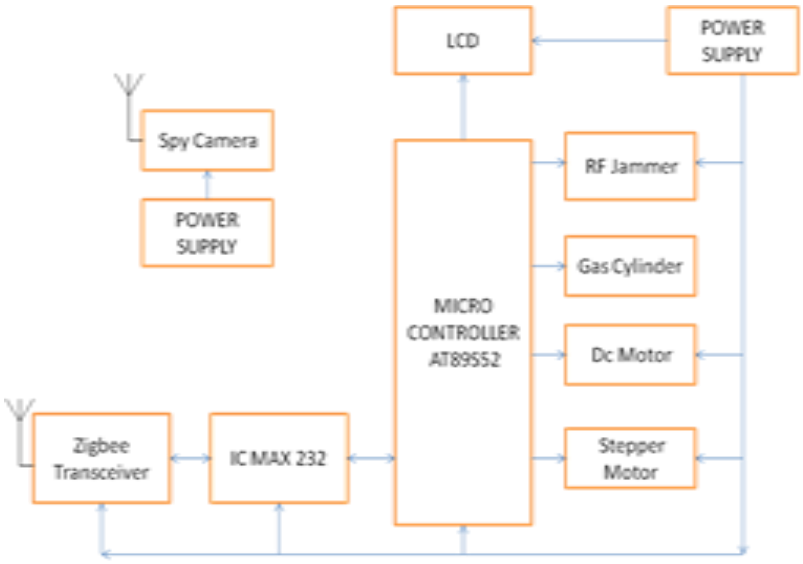

Figure 2. Block diagram of receiver section

3. HARDWARE DESIGN DETAILS

3.1. Micro controller AT89S52

The AT89S52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications [7].

3.2. DC motor

The DC motor commonly consists of axle, armature or rotor, commutator, stator, field magnets and brushes. It is placed in an external magnetic field generated by a permanent magnet. The stator is the stationary part of the motor which includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotates with respect to the stator. The rotor consists of windings, the windings being electrically connected to the commutator. When current is supplied to brushes, the polarities of the energized winding and the stator magnet(s) are misaligned, and the rotor will rotate until it is almost aligned with the stator's field magnets. As the rotor reaches alignment, the brushes move to the next commutator contacts, and energize the next winding as shown in Figure 3.

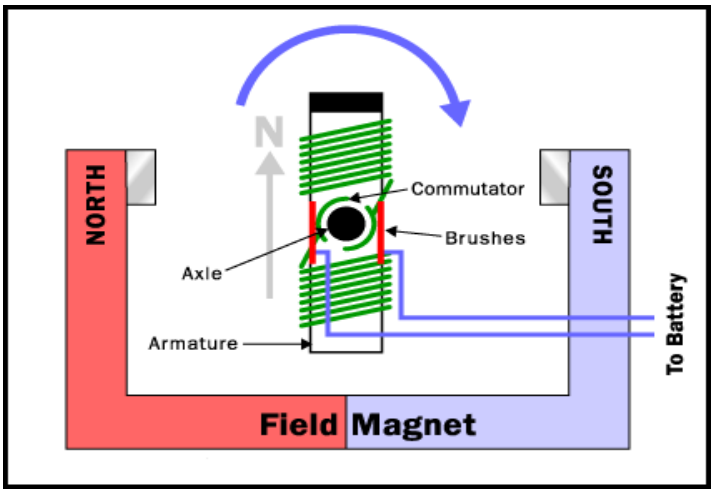

Figure 3. DC motor working principal

3.3. Stepper motor

A Stepper motor is another widely used device that translates electrical pulses into mechanical movement. It moves in steps compared to DC motor which moves continuously. Stepper motors consist of a permanent magnet rotating shaft, called the rotor, and electromagnets on the stationary portion that surrounds the motor, called the stator. Figure 4 illustrates one complete rotation of a stepper motor.

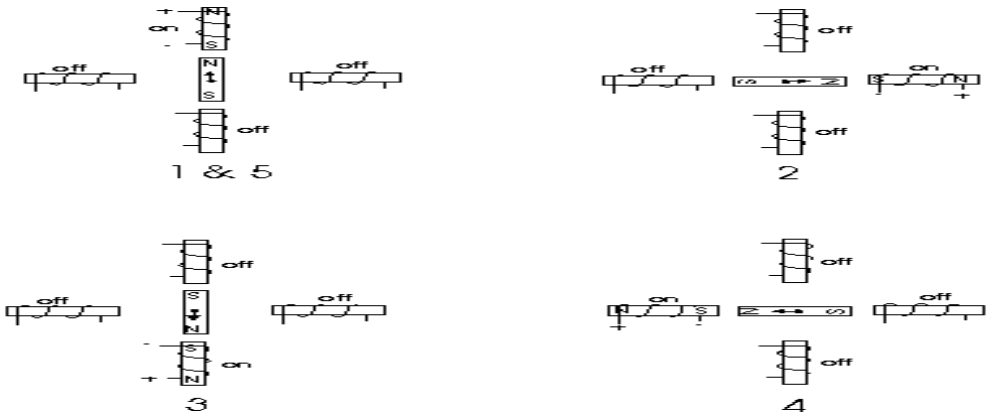

Figure 4. Stepper motor working principal

3.4. Relay coil

Relay is an electromagnetically operated switch. It consists of a coil which is obtained by wounding the wire and an electro-magnetic switch. When a current is passed through the wire which is wound in form of a coil an electro-magnetic field is developed this acts as a temporary magnet.

a. When relay is on:

When 12V (from voltage regulator) & -12V (from o/p of ULN2803) is applied to the coil. Magnetic field is setup around the coil and it acts as temporary magnet. The switch is pulled towards normally open & electric signal is obtained.

b. When relay is off:

When -12 v(from o/p of ULN2803) is not applied to the coil .Magnetic field is not setup around the coil and it doesn't acts as temporary magnet .The switch is pulled towards normally closed & no electric signal is obtained.

3.5. Wireless A/V camera and receiver

Wireless A/V camera captures the video and audio in its surroundings and transmits it to the free space after modulation. It has its own built in circuitry for capturing video/audio and transmission after modulation. The camera contains a visible lens for video capture, a power supply chord and an antenna for transmission. It also has a mount for very easy attachment. The receiver is a manual modulated which receives the broadcasted A/V signals from camera through its antenna and extracts the original signals if tuned properly.

3.6. TV tuner card

TV tuner card is a completion part of the camera and receiver unit so that views where the robot car is can be seen on computer's monitor. Tuner card needs to be mounted on main board of computer and related software program needs to be installed to computer.

3.7. Zigbee transceiver

Zigbee is the name of a specification for a suite of high-level communication protocols based on the IEEE 802.15.4 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio [8]. The technology is intended to be simpler and cheaper than other WPANs, such as Bluetooth.

3.8. RF jammer

Jamming station is used for jamming the terrorist communication. Jammers block cell phone use by sending out radio waves along the same frequencies that cellular phones use. This causes enough interference with the communication between cell phones and towers to render the phones unusable.

3.9. Gas cylinder

The gas cylinder consists of chemicals. The gas cylinder will be opened by robot on receiving commands from control room through zigbee. The terrorist goes to unconscious condition then the commandos can surround the area and capture the terrorist. Normally chemical gases like Chloroform, Carbon monoxide or Methane can be used.

4. SOFTWARE DESIGN

A simpler way of understanding any source code is by going through the flowchart or the algorithm of the code. This chapter explains the project with the help of a pseudo code. i.e. flowchart.

4.1. Transmitter side flow chart

Figure 5 shows the flow chart of transmitter section.

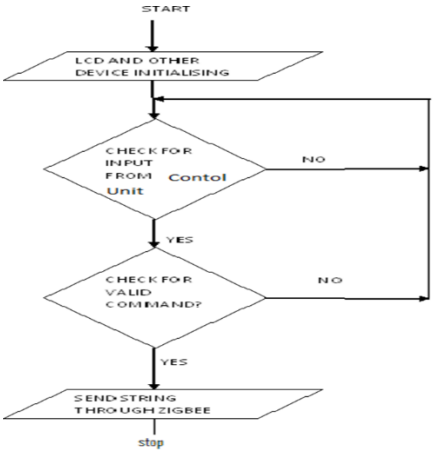

Figure 5. Flow chart of transmitter section

4.2. Receiver side flow chart:

Figure 6 illustrates the flow chart of receiver section.

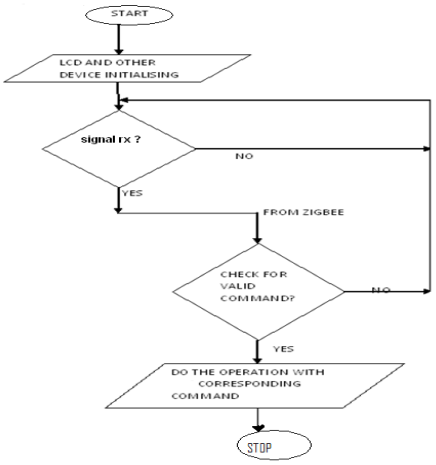

Figure 6. Flow chart of receiver section

4.3. Serial communication flow chart

Figure 7 presents the flow chart for serial communication.

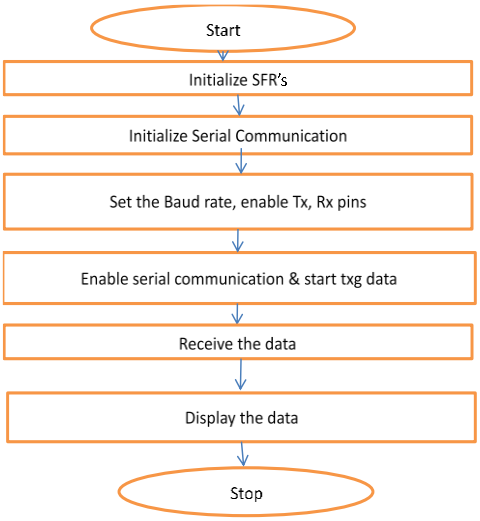

Figure 7. Flow chart for serial communication

4.4. µVision Keil

µVision Keil provides IDE for 8051 programming [8-11] and is very easy to use. When starting a new project, simply select the microcontroller you use from the Device Database and the µVision IDE sets all Compiler, Assembler, Linker, and Memory options. Its device database is large which supports many ICs of the 8051 family. A HEX file can be created with the help of Keil which is required for burning onto chip. It has a powerful debugging tool which detects most of the errors in the program, working with µVision Keil illustrated in Figure 8.

4.5. µVision IDE

The µVision IDE combines project management, a rich-featured editor with interactive error correction, option setup, make facility, and on-line help. Use µVision to create your source files and organize them into a project that defines your target application.

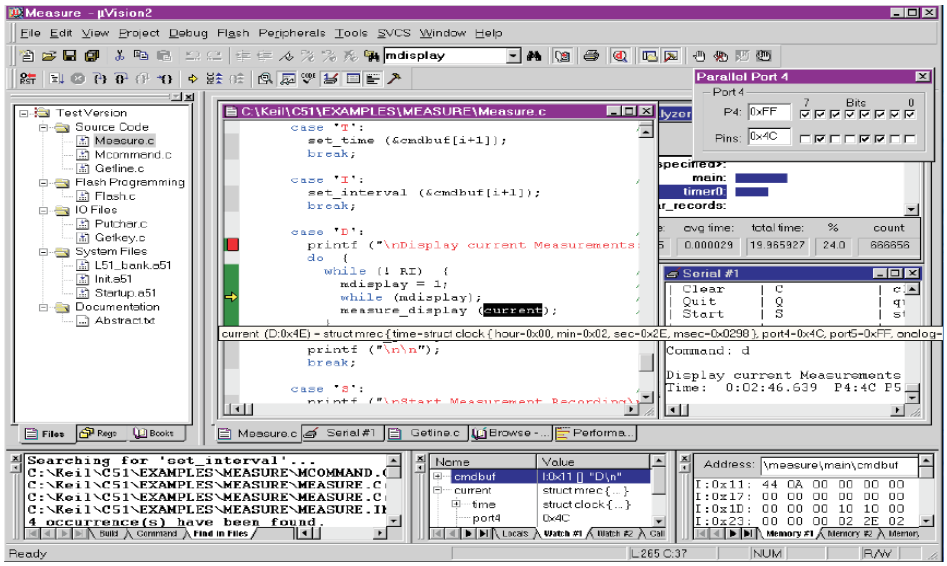

Figure 8. Working with µVision Keil

µVision automatically compiles, assembles, and links your embedded application and provides a single focal point for your development efforts.

4.6. Compiler & macro assembler

Source files are created by the µVision IDE and are passed to the C Compiler or Macro Assembler. The compiler and assembler process source files and create re locatable object files.
The Keil µVision development tools. µVision contains many useful sample programs and detailed information on how to create applications using these tool chains.

5. RESULTS AND DISCUSSIONS

5.1. Experimental set-up of combat robot

Once the circuit is rig up and power is applied through power supplies, both transmitter and receiver LCD screen is switched on. If “d1 on” switch is pressed in the transmitter the robot moves forward on receiving the commands through zigbee and when “d1 off” switch is pressed it stops. Similarly, when other switches are pressed corresponding movements are initiated. The d3 switch is used to control the gas cylinder. When “d3 on” is pressed the gas is released and on pressing “d3 off” switch its stops releasing gas Jamming station continuously jams the signal within its range and wireless camera continuously sends visuals to control, experimental set-up of our combat robot illustrated in Figure 9.

Figure 9. Experimental set-up of our combat robot

6. FUTURE SCOPE OF THE PROJECT

In order to protect ourselves better at all times, many of greatest technological achievements were used initially in military context. Through image processing technique even decision making can be made by robot. The robot can be further added with the feature like obstacle detector to avoid obstacles in the path of the robot.The robot can be controlled using the GSM, so that we can get unlimited range of control. Other weapons systems like guns, flame thrower; bomb diffusion kit etc can be installed. Use of differential steering with gradual change in wheel speed control.

To fully realize similar capabilities to today’s manned systems, semiautonomous combat robots must be developed that demonstrate increasingly tactical human like behaviors in route planning and execution, obstacle avoidance, and mission performance. Additionally, new technologies must be investigated to improve mobility of combat robot’s platforms in unstructured environments including complex terrain and urban settings using novel locomotion means and intelligent control systems.

7. CONCLUSION

The two objectives of our project were to design and implement a RF jammer and a gas cylinder on our combat robot. RF Jammer is implemented by using FM modulation. Our Model can block only one fm signal in the range of 89MHz-108MHz. By activating one switch in the control room i.e transmitter section, the opening of lid for gas release from gas cylinder can be controlled & by pressing another switch the lid closes. we presented a zigbee controlled autonomous robot which can be used for military applications. This model could have also been implemented using Bluetooth or Global System for Mobile Communication

(GSM) but the lower range problem in Bluetooth and expensive nature of GSM and high delay forced us to use zigbee which is relatively cheaper and has better range than Bluetooth. In this model apart from wireless control of robot we have also equipped robot with two more functions like jamming station and gas cylinder. This robot when implemented with advanced features and technology can save the valuable lives of commandos and can be one of the effective anti terror strategy for countries like India which is a victim of terror from neighboring countries.

Comparing Zigbee technology with the present Bluetooth technology it is evident that Zigbee can have a safe future in this effervescent world of technology. The demonstration was taken into account for three pairs of relays only. With the slight modification it can also be used for lot many other different modules also. The project proved to be in expensive to construct to the application that it can provide. This kind of spy robot can be used in star hotels, shopping malls, jewelry show rooms.

ACKNOWLEDGEMENTS

Author acknowledges the BMSIT for its infrastructure facility for carrying out the work and Mr. Tausif for contribution.

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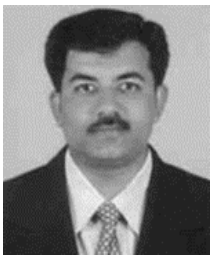
BIOGRAPHIES OF AUTHORS



Raju Hajare received B.E degree in Electronics and Communication Engineering from Mysore University, India. He did his M.Tech in the field of Power Electronics from Visvesvaraya Technological University, India. He has been awarded with Ph.D. from VTU, Belagavi for his research Thesis on nano devices modeling and characterization. He is currently working as an Associate Professor in Electronics and Telecommunication Department of BMS Institute of Technology, Bangalore. He has won two best papers awards in international conferences and participated as member of panel of Judges in Southern India Science Fairs 2017, 2018 and 2019 for evaluating Electronics projects. His areas of interest are Semiconductor Devices, Nano electronics and NEMS. He has Published research papers in Scopus indexed international Journals and presented papers at different international Conferences. He has dozens of papers in IEEE conference Proceedings to his credit.

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Design and Development of Internet of Things Based Smart Ration Dispensing System

C P Mallikarjuna Gowda, Raju Hajare, Shubha V Jois, Pavana, Srinivas M

Abstract – In this paper, we proposed a smart IOT based automated Public ration dispensing system that overcomes the major challenges present in the existing Public Distribution System (PDS) which are irregular measurement of goods, erroneous entries in the stock register of centres containing incorrect stock information of the commodities that are delivered to the consumers, this results in inaccurate distribution of the goods to the beneficiary. We overcome those drawbacks by incorporating smart measuring automated electronic device which authenticate user, measures the goods accurately, updates it in data base periodically about the availability of goods, and thereby digitizing the dispense tracking, which improves the transparency of the PDS.

Keywords- Automation, Digitization, Database management, Authentication.

I. INTRODUCTION

Public distribution system (PDS) is one of the most prominent provisioning systems in this nation. This PDS is recognized by the Government of India subordinate Ministry of Consumer Affairs, Food and Public Distribution. The fair price shops are mainly used to distribute the goods at a cost lower than that of the market rates or at absolutely no cost. The Indian food security system was established by the Government of India under the Ministry of Consumer Affairs, Food and Public Distribution to ration out food items, non-food items and other commodities to the economically weaker sections of the Indian population. This scheme was first initiated in February 1944, around the time of the Second World War, and was launched properly in the current form in June 1947. Major commodities distributed include staple food grains, such as wheat, rice, sugar and vegetable oils etc. through a network of fair price shops (also known as ration shops) established in several states across the country. Earlier there was a provision to distribute fuels such as kerosene which was used by rural and some urban households but now it has stopped. When it comes to the magnitude, coverage and the budget/expenditure it is considered to be very massive and important. However, it can be seen and has been observed that the food grains supplied at ration shops are of inferior quality or do not satisfy the needs of the community. The average level of consumption of PDS seeds in India is only 1 kg per person per month. The PDS has been heavily mocked for its urban bias and its failure to serve the economically deprived parts of community with any proper effect. The targeted PDS is costly and gives rise to a lot of room for corruption and other illegal practices in the process of extricating from the poor to serve the needs of the less needy. The Fair Price shops in India are presently known to distribute a wide variety of items ranging from rice grains, wheat, vegetable oil to other commodities like soap, laundry detergent etc. The ration distribution system is revamped and made automated by the usage of an embedded system technology. This automated ration system replaces the conventional ration card system which was completely manual by the use of a biometric scanner as in [2]. The finger print module is placed in the system in order to check the correct user access and then authentication of the user takes place. Once the user has been authenticated and checked to be true with the pre-existing database we can move on to the next step of dispensing ration. There is an attached weighing system so that accurate weighing of the ration dispensing takes place to prevent any spillage or wastage which is made possible by the use of load cells as in [4-5]. There is also an online database that is maintained as mentioned earlier to ease the process of record keeping and to prevent anyone tampering with it along with a provision to receive an acknowledgement for the ration delivery timings and notifications [6]. Information and the fingerprint impression of the eligible user from a particular family are stored securely in the database whose access is only available to the government or the organization maintaining the process of record keeping. Once the appropriate and authentic information is updated it is obtained by automated ration system concerning the existing subsidies for after the information is read the ration is dispensed according to what that user is entitled to on the database information. This also depends heavily on the availability of the product in the inventory at any given time. After every transaction made by the beneficiary, the main database is updated and he/she will be sent a SMS (Short Message Service) specifying the quantity of whatever ration has been dispensed to him/her [8]. The present PDS works in a multiple level where the responsibilities are shared between centre and state. The task of procuring food grains at minimal cost is the responsibilities of the centre.

Revised Manuscript Received on February 25, 2020.

***** Correspondence Author

C P Mallikarjuna Gowda, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Visvesvaraya Technological University, Bengaluru, India. Email: cpmallikarjunagowda@bmsit.in

Raju Hajare, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Visvesvaraya Technological University, Bengaluru, India. Email: rajuhajare@bmsit.in

Shubha V Jois, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Visvesvaraya Technological University, Bengaluru, India.

Pavana, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Visvesvaraya Technological University, Bengaluru, India.

Srinivas M, Department of Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Visvesvaraya Technological University, Bengaluru, India.

Allocation of the grains to each state is also another task carried out by the centre. Finally, the state government is responsible for carrying out the field work and surveys to identify the households eligible for ration.

The process runs as follows with the grains transported by the centre to every state's central depot and after that they are delivered to the fair price shops. Finally, FPS being the end point rations out the commodities. In the existing system, tasks like ration dispensation, Ration Card entry, product weighing and delivery of the product are carried out manually by someone who is physically present at the shop like an employee of the FPS. However, the present system has diverse drawbacks involved. Some of the irregularities include replacing actual products dispensed by the government with meagre quality products. We also see that a lot of the food grains are diverted by the FPS owners to the open markets for more profits. False entries in the stock registers that FPS agent needs to maintain are also made.

The paper is organised in the following sequence: Related works are investigated in Section II. Section III comprises of problem statement and objectives. In Section IV, we propose our method, followed by the results in section VI and conclusion of our work in Section VII. Finally, section VIII consists of future scope followed by references.

Motivation:

The current system in the PDS incorporates manual work that creates numerous problems for the government as well as the customers. Therefore, a new approach is required. The key things which played major role in taking up this project are as follows:

1. A technological advancement in electronics and digital payment age.
2. Importance given to the automatic and smart system approach in India.
3. Time factor, i.e. shops not being opened and long queues. Both contributing to slow transaction and paper trail of record keeping.
4. The deceitful dealers who sell subsidized product to unregistered ration card holders and thereby making money out of it.

II. RELATED WORKS

The NITI Aayog Development Monitoring and Evaluation Office annually publishes a report [1] for statistical purposes as well as serves as a reference for the budget needs for future and projected success failure of existing yojanas of the government. For the measurement of liquid, the models proposed by M. Pallikonda Rajesekaran, et al., [2] is considered in this paper. The liquid flow rate is calculated by the procedure given in paper [3] proposed by Vishnu R. Kale et al. Shubham Mahesh Wari et al., [4] proposed RFID cards for authentication and OTP for security of user which is incorporated in our proposed system. An OTP is sent to user with the help of GSM (SIM900C). The database is managed using MSSQL DBMS. ARM7 microcontroller i.e. LPC2148 (works on 32-bit ARM instruction set), which is low power and supports inherently GSM module and other serial port attachments without the need of any extra analogue parts. In this paper we have used a notification system using GSM module (SIM900C) rather than just OTP and biometric sensor (Fingerprint module) is used for security purposes [5-6]. The model explained in [6] by Sana A. Qader Perampall, et al is used as reference to the project for smart automation of commodities. Technological advancement for the present infrastructure is the major need in all the reports and surveys which are referred to in these papers and the cause of malnourishment, poverty, existing corruption all can be bypassed using automation. They also depict a smart automated system which includes usage of stepper & DC motors to cut down inaccuracies and user authentication tools i.e. fingerprint sensor and GSM module to prevent fraud activity. The utilization of RFID for authentication procedure and GSM module for notification is given in [7-9] for various applications. The paper [8] by R. Ramani and AKLA focuses the use of RFID and GSM module in the ration dispensing system. The RFID authentication is replaced with Biometric authentication like finger print in the proposed system [10-15] by Swathi R, AKLA.

III. PROBLEM STATEMENT AND OBJECTIVES

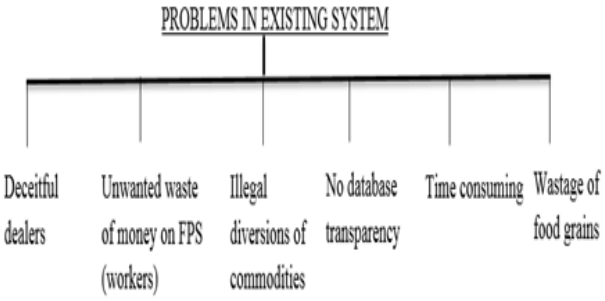

Fig.1 Problems in current PDS

The present functioning Public distribution system has various limitations. One of the major drawbacks is that the entitled person will not receive the entire sanctioned number of commodities. This situation occurs due to the diversion of the commodities by the Fair Price Shop (FPS) owner and middleman to open market for more profit due to this there will be a shortage in the quantity of the commodities. So, the needy will not receive the exact quantity. The classical method involves customer to tell the person handling the ration shop outlet, the amount of the commodity he/she needs and the type too. The person working then measures the commodity and gives it to the customer. Database opacity is the added problem.

The objectives of our work are:

1. Design and analyse the accuracy of material to dispense, real-time database management and alerts to FPS and client using GSM module.
2. To incorporate a biometric identification module (fingerprint sensor) in the system for verification and transparency.
3. Notification to the user and the FPS owner about the amount dispensed, accurate human interface using keypad for input and LCD display for output.

IV. PRESENT WORK

The model starts by the fingerprint authentication by using the biometric module. The user scans the finger with the fingerprint sensor and if the id is present, then the program proceeds with the password matched. If the password or fingerprint is not a match, then the program relays back to the initial position of scanning the fingerprint.

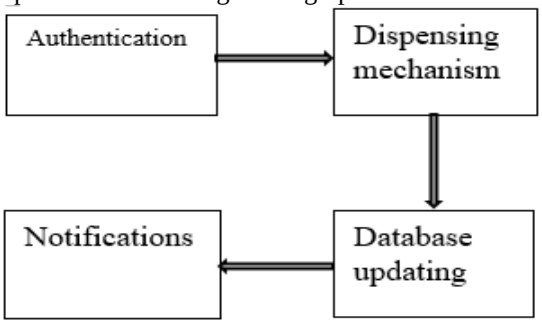

Fig.2 Flow of control block diagram

Then the control is given to the dispensing mechanism where the user is asked to select the type of the material wheat or rice, which is entered through the keyboard. Further the quantity is asked 80/100/120gms.After selection of quantity the dispensing mechanism using stepper motor and delivery tunnel begins. The ration material is collected in the plastic bowl attached to the load cell and DC motor. When the load is matched, the feedback shuts down the stepper motor and DC motor rotates to the side by an angle of 90 degrees to empty the plastic bowl into the consumer utensil. A webpage is developed to digitalize the transactions and for ease of access to details regarding the commodities allocated to the user. The user will be required to authenticate his identity using the username and password provided. After the authentication process the user can have access to the updated data of the system.

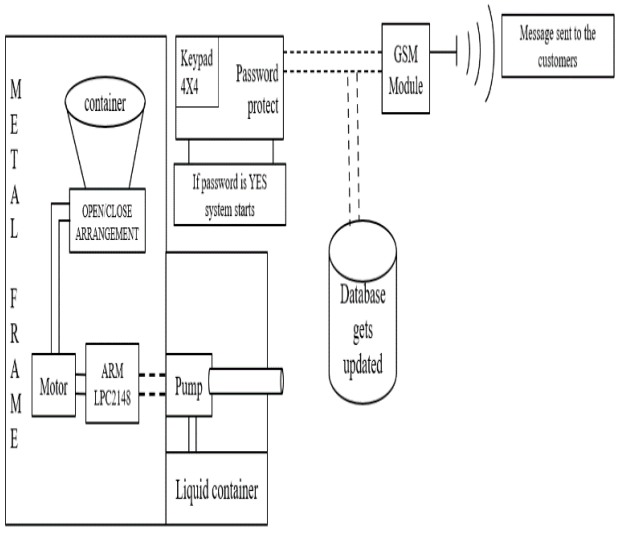

Fig.3 System Block diagram

The webpage has a database updation page consisting of the balance and distribution details of the commodities. The page is constantly updated in real time as transactions occur to show the balance quantity. Another page to maintain the ID number, names, email, phone and place of residence of the list of individuals. A verification SMS is sent to the user with the help of GSM module attached. Giving information about the amount dispensed. The flowchart depicting the system working is shown below:

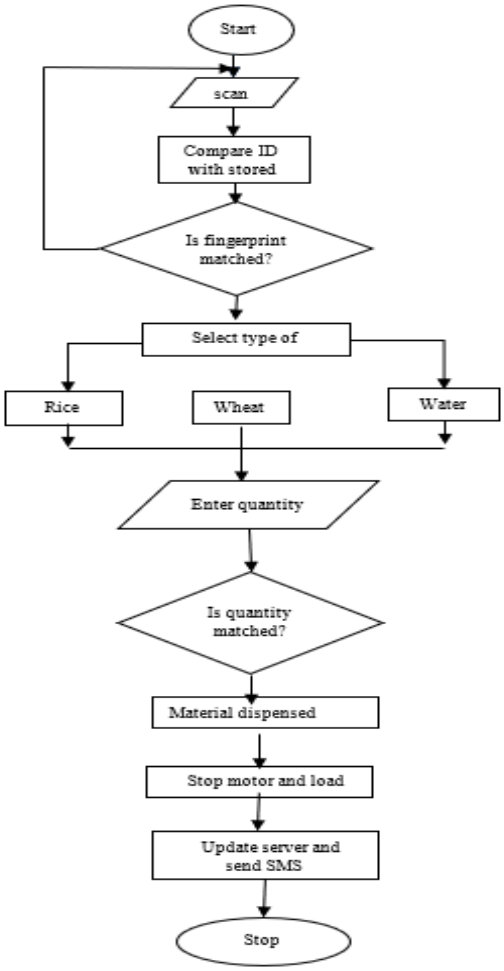

Fig.4 Flowchart of system working

The design is made up of two funnel-shaped valves for wheat and rice which leads to the dispensing unit which has a plastic bowl for the collection of ration materials. The plastic cup then tilts to a tray for the customer to collect the chosen materials. The circuit interfacing consists of ARM LPC2148, GSM module, fingerprint sensor, MAX232 UART, LCD display and Load cell with DC motor attached. GPIO pins P0.0 to P0.15 are used for LCD display (data lines) TX, RX lines of fingerprint sensor, load cell and read/write pins of each are connected to the TX/RX of the ARM microcontroller. The load cell is attached to the DC motor which after feedback from it rotates back and forth 90 degrees with a delay of 50ms.

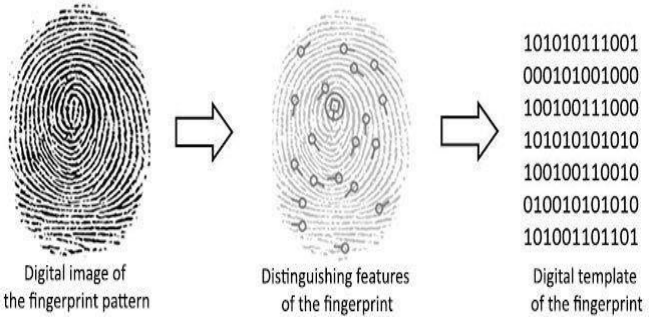

Fig. 5 Working of Fingerprint sensor

The digital image of the fingerprint pattern is captured and the image is known as a live scan which is then digitally processed. The distinguishing features are extracted and a fingerprint biometric template is created. This biometric template is stored and will be used for matching later. The module is capable of 1: N matching. The image is buffered and compared to all the stored fingerprints individually. The binary template is processed in the fingerprint module itself and a positive or negative feedback is sent to the microcontroller.

Algorithm For The Fingerprint Sensor:

Step 1: Load drivers from UART
Step 2: Create function FINGER_ENROL
Step 3: Initialise UART buffer
Step4: LCD = "PLACE YOUR FINGER"
Step 5: Send to UART buffer
Step6: LCD = "PLACE YOUR FINGER FOR CONFIRMATION"
Step7: Send to UART buffer, match=1
Step8: LCD="YOU ARE REGISTERED, THANK YOU"
Step 9: SEL0 for microcontroller.
Step10: Repeat process with flashing program again for more users.

Algorithm For Stepper Motor:

Step 1: Create 4 functions step_clock, step_clock1, step_anticlock, step_anticlock1
Step 2: Initialize all function components (4 for each)
Step 3: Loop for the case of load_cell_limit reached
Step4: while load_cell=0, set step_clock and step_anticlock for one positions in each
Step5: Delay 50ms after each step
Step6: Next, while load_cell=0, set step_clock1 and step_anticlock1 for one positions in each.
Step7: Delay 50ms after each step
Step8: when load_cell=1, execute step_clock and step_clock1for 50ms Step 9: STOP
Step10: Delay 50ms
Step11: wait for load_cell=0
Step12: REPEAT

V. RESULTS

The project prototyped is aimed to design and implement an automatic ration distribution system. According to the prototype designed, on an average a person takes about four minutes to take his/her ration. In our system, we provide wheat and rice in three different weight categories (80g, 100g, 120g). So, in average fifteen users can get their ration in an hour from the developed prototype. In real time implementation, the total working hours of a normal ration distribution center is about seven hours. Approximately 1kg of wheat and 1kg of rice can be distributed by the system in eight minutes. So, the system can serve to approximately 52 people in a day. Time taken by each consumer is taken as 4 minutes (for each wheat and grain), if the ration shop is open for 7 hours in a day, then, 60min/(time for each)= consumers in an hour i.e. 60/(4+4) = 7 people. The quantity of dispensed material is calculated with every trial and average is calculated in table 5.2 which results in the accuracy of the prototype, calculated as an average (87+82+79+78)/4 = 81.5. The average accuracy calculated is around 80-85 percent for 4 trials of weight 100gm, 80gm, 120gm. The user will be required to authenticate his identity. After the authentication process the user can have access to the updated data of the system. The list of individuals with access to receiving ration consists of a page with details of their ID no, names, email, phone and their place of residence using the username and password provided shown in.

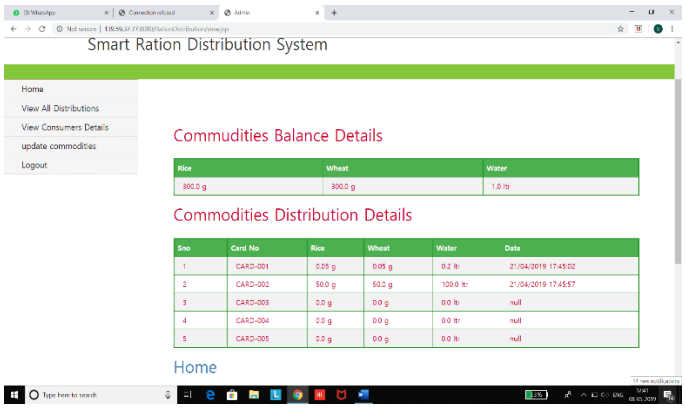

Fig.6 Database updation

The database updation page consists of the balance and distribution details for the commodities. The page is constantly updated in real time as transactions occur to show the balance quantity.

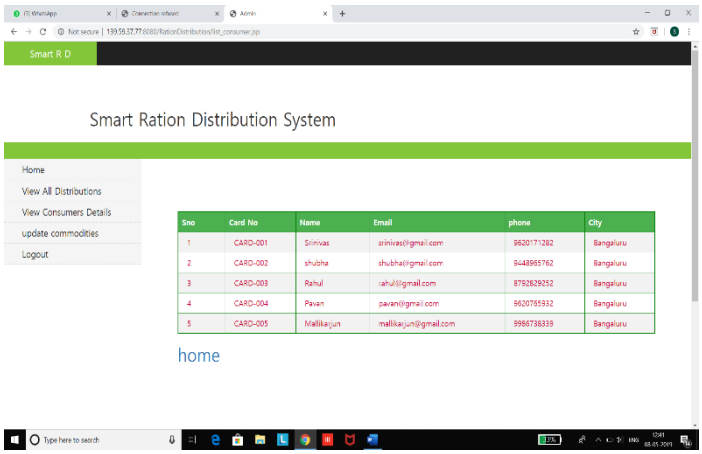

Fig.7 Ration dispensed details

VI. CONCLUSION

We have designed and developed the automation of the ration dispensing mechanism. Authentication of the user is also taken care of, which helps to avoid the ration being delivered to unintended user. Moreover, the automatic database updating and notification to consumer brings about the transparency in the entire process.

FUTURE SCOPE

There is potential for further digitalization with the inclusion of android application for the same with similar link to the government server with dynamic tracking of the amount of food grain in every FPS and with a feature of transferring grains from one shop to the other in case of high demand.

Attaching all the data received via the system in a fiscal year to the annexures of finance and budget estimation and giving back the community if monetary gain / profit is achieved in terms of discounts and coupons based on performance review of the specific FPS.

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AUTHORS PROFILE

Mallikarjuna Gowda C.P received B.E degree in Electronics and Communication Engineering from Gulbarga University, India. He did his M.E.Tel.E in the field of Communication Engineering from Jadavpur University, Kolkata. Currently Persuing Ph.D in the area of Cognitive Radio Networks from Visvesvaraya Technological University, India. He is currently working as an Associate Professor in the department of Electronics and Telecommunication Engineering at BMS Institute of Technology and Management, Bengaluru. His areas of interest are wireless communication, Cognitive radio networks. He has published research papers in peer reviewed international Journals and presented papers at different National and international Conferences, He reviewed research papers for IEEE Access Journal and IEEE Sponsored International conferences. Life member of Indian Society for Technical Education (ISTE), Solar Energy Society for India (SESI).

Raju Hajare received B.E degree in Electronics and Communication Engineering from Mysore University, India. He did his M.Tech in the field of Power Electronics from Visvesvaraya Technological University, India. He did his Ph.D in Nano electronics from Visvesvaraya Technological University, India. He is currently working as an Associate Professor in Electronics and Tele Communication Department of BMS Institute of Technology, Bangalore. His areas of interest are Nano electronics, NEMS, Power devices and Robotics. He has Published research papers in reputed peer reviewed international Journals and presented papers at different National and international Conferences.

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A Novel Method to Detect Inner Emotion States of Human using Artificial Neural Networks

Thejaswini S, K M Ravi Kumar

Abstract*: Human computer interaction is a fast growing area of research where in the physiological signals are used to identify human emotion states. Identifying emotion states can be done using various approaches. One such approach which gained interest of research is through physiological signals using EEG. In the present work, a novel approach is proposed to elicit emotion states using 3-D Video-audio stimuli. Around 66 subjects were involved during data acquisition using 32 channel Enobio device. FIR filter is used to preprocess the acquired raw EEG signals. The desired frequency bands like alpha, delta, beta and theta are extracted using 8-level DWT. The statistical features, Hurst exponential, entropy, power, energy, differential entropy of each bands are computed. Artificial Neural network is implemented using Sequential Keras model and applied on the extracted features to classify in to four classes (HVLA, HVHA, LVHA and LVLA) and eight discrete emotion states like clam, relax, happy, joy, sad, fear, tensed and bored. The performance of ANN classifier found to perform better for 4- classes than 8-classes with a classification rate of 90.835% and 74.0446% respectively. The proposed model achieved better performance rate in detecting discrete emotion states. This model can be used to build applications on health like stress / depression detection and on entertainment to build emotional DJ.

Keywords: DWT, EEG, Emotion states, ANN, Keras.

I. INTRODUCTION

The requirement and importance of emotion detection using automated methods has increased its role in human computer applications. In human life, emotion is playing a predominant role, detection of such emotion states helps to develop the intellectual BCI systems [1-2]. The emotion states can be detected using facial expressions, speech signals and physiological signals like blood pressure, activity of central nervous system, heart rate etc. There are some problems in detecting emotion states using facial expressions and speech signals. During speech and face recognition, the subject needs to speak or look in the camera direction. Moreover, the emotion states can be controlled or hidden or faked during these methods. Physiological signals can be used to avoid these problems [1,3]. The study of emotion detection using electroencephalogram signal is rapidly growing field of research nowadays. Since it is difficult to influence brain activity, measuring emotions using EEG signals is advantageous. A variety of EEG wireless devices which are portable and easy to use are available in market are helping to develop emotion recognition systems or algorithms which can be used in many applications like health care, entertainment, marketing, decision making etc. [4].

For theoretical emotion representation, various models are proposed by researchers in discrete form and in dimensional form. In the discrete model, a finite number of discrete states are defined corresponding to one of the core emotions, or a combination of them are used to represent different states of emotion. The dimensional model as shown Figure 1 spreads spatially the interpreted levels of emotion states along valence-arousal dimensions. These emotion models have been used for systematic and multilateral analyses of emotion states [5].

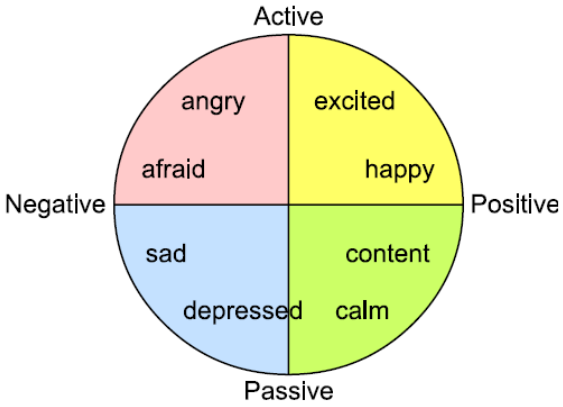

Figure1: Dimensional model [1]

The related work implemented on bench marked database: DEAP which is publicly available is discussed below. Sharma et al. [6] proposed a classification technique using non-linear Higher order statics and LSTM algorithm. Their proposed system for Valence-Arousal score attained an average accuracy of 82.01% for 4-classes and 84.68% for 2-class. Guo et al. [7] developed an emotion classification system using a hybrid of SVM and FCM classifier for valence, arousal, dominance and liking states with an average rate of 78.03%. Xing et al. [8] suggested a framework using SAE and RNN-LSTM with classification rate as 81.10 for valence and 74.38% for arousal. Pandey et al. [9] detected happy and sad emotion states happy using MLP with an average accuracy of 58.5% for frontal and theta band. Hongpei et al.

Revised Manuscript Received on March 04, 2020.
***** Correspondence Author
Thejaswini S*, Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Affiliated to VTU, Bangalore, India. Email: thejaswini79@gmail.com.
Dr. K M Ravi Kumar, Principal and Professor Department of Electronics & Communication, Engineering, S J C Institute of Technology, Affiliated to VTU, Chickballapur, India. Email: kmravikumar75@gmail.com

[10] used KNN classifier and achieved 95% in gamma band. Zamanian et al. [11] extracted Gabor and IMF along with time-domain features and using multiclass SVM as classifier, they obtained an accuracy of 93% for 3 and 7 channels. Chao et al. [12] explored deep learning framework achieving a rate of 75.92% for arousal and 76.83% for valence states. Liu et al. [13] classified the data using time and frequency domain features and obtained 70.3% and 72.6%, using SVM. Zeynab et al. [14] classified emotions using EEG signals in arousal-valence dimensions using 10 channels and frequency bands. The frequency bands were decomposed using DWT and features like entropy and energy were extracted. They have used SVM and KNN classifiers to detect the emotions. The accuracy obtained was 86.75% and 84.05% for arousal level and valence level.

Xian et al. [15] proposed SVM emotion detection system effectively using EEG by selecting only 8 channels. They calculated features in time domain, frequency domain and non-linear dynamic features and applied for SVM classifier. Among channel based classifier, channel FP1 obtained an average highest accuracy of 80.01% in arousal and 78.43% in valence states. Adrian et al. [16] implemented an algorithm for emotion recognition via EEG signals using wavelet transform and time-frequency. EEG data was acquired from 22 subjects and the channels used were FP1 and FP2 with one reference channel CZ. To stimulate discrete emotions happy and sad, they have used IAPS images. Mean, standard deviation, wavelet coefficients at db4 and sym6 features were extracted. They used ANN classifier for only two features mean and standard deviation and obtained an accuracy of 72.7% and 81.8% for happy emotion. For sad emotion frequency domain features performed better with an 72.7% accuracy.

Raja et al. [17] developed an algorithm using KNN and SVM to detect happy, scared, sad and clam emotion states. The emotions were elicited using picture (IAPS) database. Raw signals were acquired through 16 channel Emotive device. Extracted Statistical and frequency domain features were given to classifiers whose accuracy was 55% and 58% respectively. Adnan et al. [18] analyzed the music effect on human emotion states using EEG signals recorded from neurosky single channel headset for 32 audio tracks. For MLP, SVM and KNN classifier the input was extracted features of time, wavelet and frequency and obtained an accuracy of 78.11%, 75.62% and 72.8%.

From the review it is found that major work is carried out using available data base (DEAP). Some of the researchers acquired real time signals using less number of channels (2-16 channels). In both the cases signal is acquired by showing video or IAPS images. From the literature it is seen that the emotion recognition systems were limited to few discrete emotions states and some of them related these discrete states with valence-arousal model for their work. Our work focuses on developing a novel approach to elicit eight different emotion states and they are mapped across valance and arousal model.

II. METHODOLOGY

In the proposed work, a different approach using VR audio-video clips are used to elicit emotion states. The statistical and wavelet features are extracted and classified emotions into four states (HVLA, HVHALV, LVHA and LVLA) as well as 8 discrete emotion states (relax, calm, happy, excited, sad, tensed, fear, and bored) using Artificial Neural Network. The proposed methodology is shown in Figure 2.

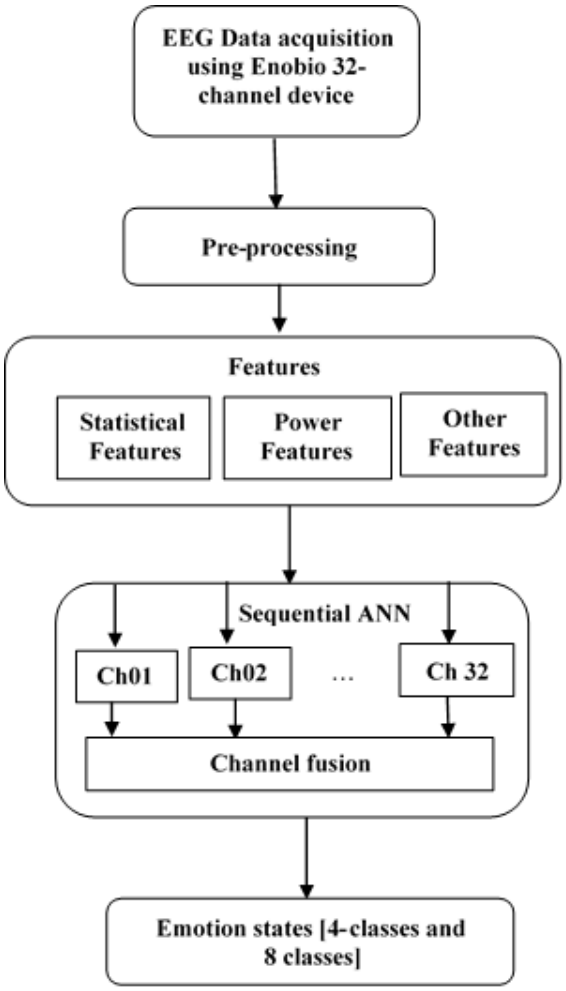

Figure 2: Proposed Methodology

A. *Experiment Set Up*

From 66 healthy subjects (36 males and 30 female) whose age is between 20 to 45 years with mean age of 35, EEG data is acquired using 32- channel Enobio device with a sampling rate 500 samples /sec. The volunteers are UG/ PG students as well as research scholars of SGGSIT, Nanded, India. For each subject, before starting the experiment, they were made familiar with the protocol which is used and are asked to fill concern form. Once the EEG Data acquisition device is worn, the subject is instructed to relax for about 60 sec.

The protocol for data acquisition is based on a little modification on the procedure which was used by available data base [19-20]. In DEAP data base [19], they had used 40 one-minute music video to elicit emotion states and have acquired data for 32 subjects. In SEED data base [20], 15 Chinese videos were used to elicit emotion for negative, neutral and positive states for 15 subjects. In the present work a novel technique is used to elicit emotion states by making the subjects to experience VR 3D-360 videos using VR virtual glasses (IRUSU PLAY VR headset). The advantageous of using VR videos is to express emotions better [21]. Eight VR videos are used to stimulate emotion states. The video clips to elicit the eight emotion states relax calm, Joy/ excited, happy, tensed, fear, sad and bored are selected. The experiment set up for real-time signal acquisition using Virtual Reality Videos is illustrated in Figure 3 and the time duration of each clip is 50 to 300 seconds depending on the emotion state. The 32 electrodes used for the data acquisition are CP2, CP1, FPZ, CP5, T7, CP6, C3, P3, C4, PZ, P4, O1, P7, FC5, P8, PO3, O2, PO4, T8, FP1, FC1, FP2, FC2, F7, FC6, F3, F4, FZ, AF3, F8, AF4, CZ. The reference electrodes used are CMS & DRL [22]. The self-assessment is done using a questionnaire session for 30sec after each emotion clip, where each subject assesses, his / her emotion state for both the experiment set up.

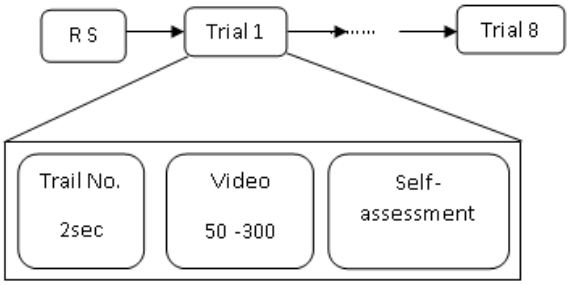

Figure 3: Protocol for data acquisition

The experiment set up and instructions are listed below. The protocol has 8 trails to elicit 8 emotion states like relax, calm, joy, excited, tensed, fear, sad and bored. After the Enobio device EEG cap is placed, the subject is asked to close eye for 1 min. This state is called Relaxation stage [RS]. Then the subject is made to experience emotion states by watching 8 audios –video clips using VR device. He /she is advised not to do body movement. Eight trails are presented and each trail includes the following:

- Base line: displays trail number.
- Audio-video clip: the subject is instructed to watch VR-videos of 3-4 min duration.
- Self-assessment: after each video clip the subject is asked to fill the self-assessment form and is informed to close his/her eyes there by relaxing themselves. [22].

The process of experiment carried out using VR device is illustrated in Figure 4.

B. Preprocessing

The raw EEG signal has some artifacts like eye blinks, muscle movement etc. The power line interface is eliminated using 50 Hzs notch filter during data acquisition only. To improve the quality of signal to noise ratio, moving average referencing technique is applied. The signal is further preprocessed using a 20th order band pass FIR filter allowing frequencies from 2 to 50 Hzs. To use zero phases, "filtfilt" command of MATLAB is used [23-24].

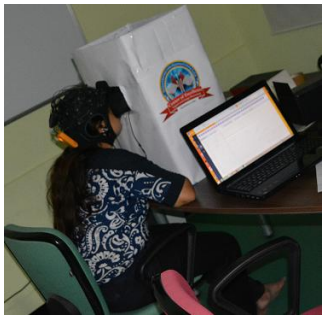

Figure 4: Data acquisition using VR device

C. Feature Extraction

For event separated preprocessed data [24], features such as time, wavelet features in time-frequency domain listed below are extracted. From the related work explored, it was observed that resolution of wavelet transforms was good compared to FFT or STFT. In the present work we have applied 8-level decomposition using DWT to extract desired frequency bands gamma (31-50Hz), beta (14-30Hz), delta (1-3Hz), theta (4-7Hz) and alpha (8-13 Hz) [24]. The wavelet features for all five bands of 32 channels are extracted are shown in Table - I. The features like differential entropy, PSD, power, average energy of all 5 bands (e_a, e_t ,e_b, e_g and e_d) are calculated.

The channel wise features listed below in Table –II are computed using MATLAB and stores separately so that each channel features are applied for channel wise classifier. The scatter plot of a few features of happy, angry sad and calm for Power of alpha band (blue), mean (red), energy of beta band (yellow) and Hurst Exponential (green) is presented in Figure 5. The features are calculated based on the formulae listed in Table –III

Table -I: 8-level decomposition using DWT

Sl No.	Decomposition Coefficients	Frequency band
1	CD5	Gamma
2	CD6	Beta
3	CD7	Alpha
4	CD8	Thetha
5	AD8	Delta

Table –II : Extracted Features

Feature Type	Feature Name
Time domain (Statistical Features)	Mean, Root mean square, Std-deviation, First & second difference, Normalized first& second difference, Skewness, Kurtosis, Variance, Mobility and Complexity (Hjorth Parameters)
Wavelet or Time-Frequency Domain features of 5 band	Band energy, Differential entropy, Power spectral density, Average band power
Other features	DASM, RASM, Hurst exponential and Permutation entropy

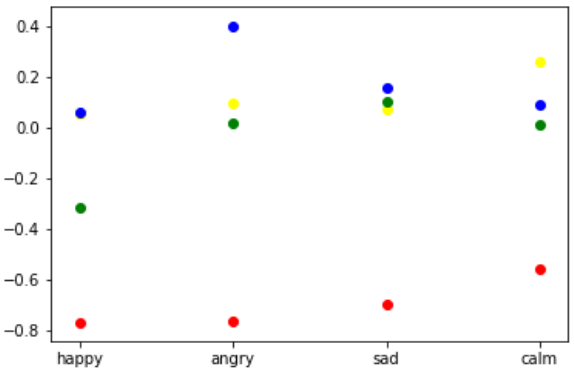

Figure 5: Scatter plot of features for a 4 emotion states of four frequency bands.

Table –III: Feature calculation [23]

Features	Formula
Mean	$\mu = \frac{1}{T}\sum_{t=1}^{T} s(t)$
Standard Deviation	$\sigma = \sqrt{\frac{1}{T}\sum_{t=1}^{T} (s(t)-\mu)^2}$
First difference	$\delta = \frac{1}{T-1}\sum_{t=1}^{T-1} \lvert s(t+1)-s(t)\rvert$
Normalized first difference	$\delta' = \frac{\delta}{\sigma}$
Second difference	$\gamma = \frac{1}{T-2}\sum_{t=1}^{T-2} \lvert s(t+2)-s(t)\rvert$
Normalized second difference	$\gamma' = \frac{\gamma}{\sigma}$
Kurtosis	$k = E(\frac{t-\mu}{\sigma})^4$
Mobility	$\sqrt{\frac{variance(\dot{s}(t))}{variance(s(t))}}$
Complexity	$\sqrt{\frac{mean(\dot{s}(t))}{mean(s(t))}}$
Differential Entropy	$G(x) = -\int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-m)^2}{2\sigma^2}} \log(\frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-m)^2}{2\sigma^2}}) dx = \frac{1}{2}\log(2\pi e\sigma^2)$

D. Classification

The extracted features are classified using basic deep learning algorithm implemented using KERAS [Sequential ANN]. The classifier is implemented to classify the extracted features into four classes (HVLA, HVHALV, LVHA and LVLA) as well as 8-discrete classes. The classifier for each channel is implemented using Keras library in python. In this paper 66 subjects each of 8 trails are used for the classification. So totally 66*8 = 528 trails are obtained from which 70% trails are used in training and 30 % for testing. So 47 *8 = 376 trails are used to train the classifiers.

Remaining 19*8 = 152 trails are used to test the trained network. The classifiers are implemented for Time-domain features, Time – frequency features and even on DASM & RASM features separately. A combined feature is also fed to the classifier. The concept of dropouts at a rate of 0.1% and cross validation of 10-fold parameter tuning is used.

The Algorithm involved in building ANN is as indicted below.

Step 1: Importing the feature vector
Step 2: Splitting the 70% feature vector as training set and Remaining as testing set using train_test_split command
Step 3: Feature scaling using Standard scaler
Step 4: Building an ANN using sequential model with input layer, hidden layer and output layer
Step 5: Making prediction and evaluating the model and saving the same for further testing of untrained signals
Step 6: predicting the test results and extracting confusion Matrix
Step 7: Repeat step 1 -6 for all 32-channels
Step 8: Calculate the average prediction rate.

In this work, in order to classify sequence data, sequential classifier is used to build ANN. By importing Keras library using Tensor flow at backend 2 models are used to build ANN. One model is sequential mode which is used for initializing ANN and is done by sequence of layers using the function Sequential ( ). The other is dense model through which different layers of ANN are built. The proposed ANN architecture uses Keras sequential model and it consists of 3 layers input layer, output layer and one hidden layer. The input nodes depend on size of the feature matrix. The activation function used for input and hidden layer is “ReLU”. The size of the output nodes depends upon number of classes i.e 4 or 8. The activation function used for output layer is “softmax”. We have used 16 nodes in hidden layers.

III. RESULT AND DISCUSSION

In the present work, signals acquired from 66 subjects are used for analysis. Totally, from 66 * 8 = 528 trails, 70% is used for training the model and remaining 30% to test the trained model. The 4 emotion states are classified along 2-dimensional models as HVLA, HVHALV, LVHA and LVLA and eight discrete emotion states such as relax, calm, joy, excited, tensed, fear, sad and bored.

The extracted 14 time-domain features, 20 time-frequency domain features and total of 34 complete features are applied to ANN classifier. Ten-fold cross validation and drop out of 0.1% is carried out. A separate classifier is developed for each channel and at the end channel fusion is carried out. The accuracy of the classifier is computed based on the average accuracy rate of all the channels. The percentage of prediction rate for 4 class by the models are 90.835%, 87.1% and 70.14% for all features, wavelet features and time domain features respectively.

Similarly, for 8- classes, the classifier accuracy is 74.044%, 68.61% and 48.67% respectively and is depicted in Table- IV and Figure 6.

Further channel reduction is applied for observing the behavior of channels on emotion states. Channels are reduced based on pre-frontal, parietal, temporal and occipital electrodes. For channel reduction from 32 to 20 channels FP1, C3, FP2, FOZ, F3, CZ, F4, FZ, F7, F8, T7, P4, T8, C4, P3, O2, P7, P8, PZ and O1 channels are selected. Further 8 channels such as FP1, FP2, FPZ, P3, P4, PZ, T7 and T8 are analyzed. This was followed in reducing further to 5 channels such as FP1, FP2, P3, P4, and PZ. The classification rate for channel reduction is tabulated in Table-V and plotted in Figure 7.

It is observed from the channels performance that, the emotions are reflected mostly in frontal electrodes of alpha and beta band. The performance of five channels is illustrated in Figure 8.

As channel reduction is done the classification accuracy also increases for 4 classes but however for 8 classes it is observed that use of 20 channels gives a better performance.

Table -IV: Performance of ANN classifier

Features .	4-Classes	8- Emotion states
Combined Time and wavelet features	90.835%	74.0446%
Wavelet Features	87.1%	68.61%
Statistical Features	70.14%	48.67%

Figure 6: Prediction rate of ANN based on features

Table -V: Performance of ANN classifier after channel reduction

No. of channels selected	4-Classes	8- Emotion states
32 channels	90.835	74.045
20 channels	89.813	89.815
8 channels	93.57	77.62
5 channels	93.048	76.48

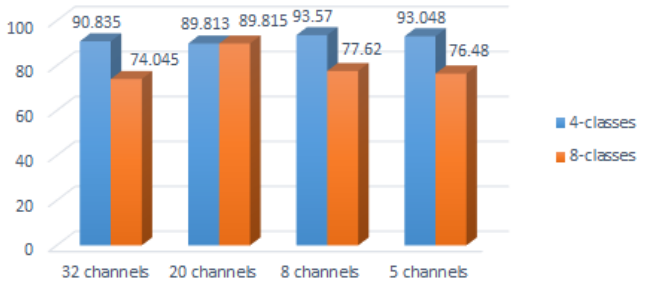

Figure 7: Performance of ANN classifier based of no. of channels selected

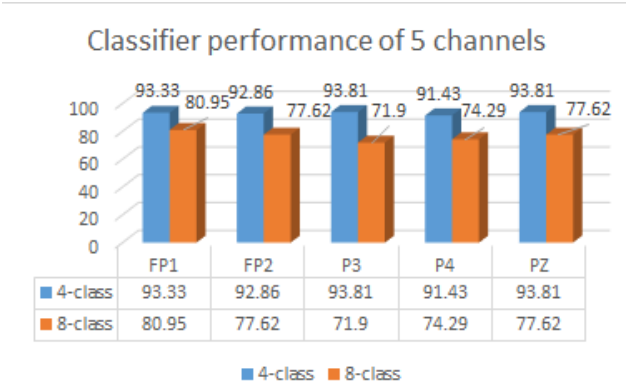

Figure 8: Classification rate for five channels

IV. CONCLUSION

In this paper protocol for data acquiring is done using a novel technique to elicit emotion states using VR device. For 66 volunteer subjects, EEG signals were recorded through 32 channels of 500 Hz sampling rate. A Deep Learning Neural network based on sequential Keras model is developed to detect 4-classes of two dimensional states and 8- discrete emotion states form the acquired data.

The statistical and Time- frequency domain using DWT features, entropy features are used for ANN classifier. The accuracy for proposed system is 90.835% and 74.0446% for 4 class and 8 class respectively. Channel reduction method is incorporated and observed that for discrete emotion states more number of channels are required for better prediction results.

Future more deep learning algorithms for time series data can be explored. This trained model is performing better for the acquired data. The model can be tested on online available data there by developing a robust model and can be tested on various others classifiers for better classification rate. The model can be used to build for different applications.

ACKNOWLEDGMENT

The Authors would like to thank, Dr. Manesh B Kokare, Dean Research and Development Associate Professor and PI of Center of Excellence in Signal and Image Processing and Dr. D D Doye, Professor, Department of Electronics and Telecommunication SGGS Institute of Engineering and Technology, Vishnupuri, Nanded, Maharastra, India, for permitting to acquire EEG data as well sharing the same.

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AUTHORS PROFILE

Mrs. Thejaswini S, is working as Assistant Professor, Department of Electronics and Telecommunication Engineering, B M S Institute of Technology and Management, Bengaluru, Karnataka, India. She has completed her BE in E&CE and M. Tech in digital Communication and Networking. she is pursuing her Ph.D. in the area of Brain computer interface. Her area of interest is BCI, Machine Learning & signal Processing. She has a teaching experience of 18 years thejaswini79@gmail.com

Dr. K M Ravikumar, is working as Principal and Professor Department of Electronics & Communication, Engineering, S J C Institute of Technology, Chickballapur, Karnataka, India. He has obtained his Ph.D. in the area of Digital signal processing. He a has around 22 years of teaching experience and more than 10 years of research experience in the fields of speech processing, Brain Computer Interface, Image processing domains. He has more than 20 publications in peer reviewed Journals and more than 15 papers in International Conferences. Some of his achievements Are Special Officer, VTU-Regional, Expert Committee Member for National Board of Accreditation (NBA), New Delhi, Reviewer: Elsevier Editorial Systems, Member LIC (Local Inquiry Committee), VTU, Belgaum. He has received various awards and few are Bharat Vidya Shiromani Award, Best Engineering College Principal of the year- 2016, Rashtriya Vidya Gaurav Gold Medal Award etc. kmravikumar75@gmail.com

Key Management Schemes for Distributed and Centralised WSNs: A Survey

Siddiq Iqbal [#1], Sushmitha K R [#2], Vaishnavi P S [#3], Rashmi Dhananjaya Shastri [#4], Shivangi Jain [#5]

Department of Electronics & Telecommunication Engineering, BMS Institute of Technology and Management, Bengaluru, India.

Abstract— **If the nodes in a network can transmit the information collected from an area via wireless medium is called Wireless Sensor Network. It is made of base stations and numerous nodes. Different varieties of sensors are used in a network, based on the requirement. Since the transferring of data happens in an open environment there are chances of hacking the data. Hence, security plays a very important role. We discuss about different schemes proposed in the area of key management. Key management is the technique which provides security to the data. The paper also discusses about the advantages of using key management such as conservation of energy, reduction in computation time etc. The paper also talks about different schemes in key management which can be used based on the network. There are schemes which talk about generation of different types keys to provide security.**

Keywords— **WSN, key management, key pre- distribution, attacks, key size.**

I. INTRODUCTION

Wireless sensor network contains enormous number of minute nodes which have energy constraints and computational complexities. There are many fields where WSN has wide applications for example in military, medical, home appliance management etc. Providing security is among the key goals in WSN. Especially, in the field of military WSN security is very important because confidential data will be transmitted through wireless links. There are many methods through which the information in the data packets can be stolen. WSN has both embedded systems and distributed systems in it. Security plays an important role because data packets are transmitted in air. Security is provided to the information by encrypting the data. But lot of complications are involved in encrypting the data in wireless medium. There are many ways in which the data packets can be encrypted. One among many techniques is key-management. Further, in key management there are two types they are static and dynamic key management. Here, keys are distributed to nodes in static key management. A few keys are pre distributed in sensor nodes in dynamic key management. The paper discusses about the different methods used to provide security to the information.

A. Fast-Hierarchical Key-Management Scheme with Transitory Master Key for WSN [1].

In this paper, problems involved in symmetric encryption is represented using symmetric keys. One of the important approaches in key management is transitory master key(MK). During initialization pair-wise keys are created using a global secret, which is gets removed in the working phase. A key negotiation routine is presented. The proposed scheme mainly concentrates on reducing the time taken during initialization, accordingly the master key is compromised. This is attained by dividing the initialization phase into hierarchical sub phases with more security. Adding of a new node can be done after the first deployment and key establishment can also be done, the time taken for this is same as initial deployment. LEAP+ is the main scheme which is dependent on transitory MK. Hierarchical method with transitory MK(HSTMK), is a latest key-management method built using Mk. This is mainly designed for static WSNs, where a node can be added without having the deployment knowledge. The effective operation of handshake routine, that is further divided into different phases is the freshness in the scheme. The count of packets exchanged in each phase is decreased which in turn reduces the count of collisions and lets a low key setup time. The security given by HSTMK is more than LEAP+, which is its major advantage. The security of network is upgraded in the matter of vulnerability to clone attacks. Disadvantages is that it suitable only for static node.

B. Micro Key Management System for WSNs(μKMS) [2].

There are two ways in key management, centralizing a trusted key management and distributed key management system which is difficult work. The advantages of existing schemes are optimizing of key numbers, re-keying frequency of the encryption system of the keys distributed. In this paper μKMS for WSN is proposed. A method which embeds the re-keying technique messages on an undeveloped coding space of swapped zigbee packets is applied by μKMS. μKMS is very tough in opposition of the replay attack, it assures the integrity of private-key exchanged although the intruder changes the data in the packets during transmission. The exchanged keys are hidden using this method. The un-exploited coding space with no communication overhead is also used. This works on energy saving issues, specifically in WSN.

C. SENSOR Lock: A Lightweight Key Management Scheme for WSN [3].

The stored Cryptographic keys are given security. A technique customized to sensor networks called SENSNOR Lock is introduced. The main purpose is to illustrate the usefulness of SENSNOR Lock for symmetric distribution of keys, by using which the problem of stored key exposure is resolved. The network's security against the interference of sensor nodes has been increased with this method. MicaZ and TlosB which are off-the-shelf sensors can be deployed using this method. The goal of this method is to extend and correct the key exposure problem faced in key management. Even after the information stored in sensor flash and memory content of MN are known the scheme guarantees the security of the keys used in the system. The time taken for processing the overhead is in terms of nanoseconds and microseconds. The proposed scheme doesn't support multi-hop key distribution.

D. An Efficient Key-Management Scheme for WSN [4].

Due to vulnerability of WSN the need to advance the secure key management scheme has been increased. Talks about key management scheme called MAKM. It depends mainly on congruency nature of modular arithmetic. All the nodes will have a key seed stored in it. A unique key which is shared is calculated by using the key seed and cluster head and a group key. Storage space of the key is reduced. This method has better storing capacity and is strong in case of node capture attack compared to other key-pool-based methods. MAKM is used to lower time delay and utilization of energy for key formation in large scale. One disadvantage in the proposed method is that RAM storage space used to store key seeds is more compared other schemes.

E. Energy-Efficient Distributed Deterministic KM for WSN (EDDK) [5].

A distributed deterministic key management method which is energy efficient has been proposed for resource repressed wireless sensor networks. EDDK is chiefly used to create and sustain the pairwise keys and keys given to clusters which are local. To efficiently manage the updating and storage of keys the neighbour table has been created. Elliptic-curve digital signature algorithm is used in EDDK so that mobile and fresh nodes can join or re-join a sensor network securely. EDDK has high flexibility. There are many advantages in EDDK that is, it has very less overhead with reference to calculation, communication and memory required. Pairwise keys are completely decentralized. The non-compromised pairwise keys are not affected by the compromised sensor nodes.

F. Tree-Based Protocol for KM in WSN [6].

The problems related to security faced by wireless sensor network is addressed in the paper. Most of the solutions to solve security problems use symmetric cryptosystem. A key management method which uses symmetric cryptography is adjusted to the certain properties of WSN. The proposed scheme has many advantages such as limited memory consumption, guarantees scalability, and protects against the hardest attack. Parameters such as memory problem, communication problem key connectivity, toughness against node capture were considered to assess the performance of the method. Spanning tree is constructed quickly and cheaply to refresh the shared key with less costs. The solution is scalable and uses little memory.

G. A KM Scheme Using Deployment-Knowledge for WSN [7].

Along with challenges related to security there is another problem in WSN that is bootstrapping secure communication among nodes. There are several schemes but they do not satisfy all the needs. desired

connectivity is attained by using more memory and they cannot even offer toughness against node capture attacks. This method talks about key management using deployment knowledge. Here, the selected area is split into grids which are hexagonal in shape, further nodes are split into groups whose number is same as that of grids, here every group is placed into an isolated grid. The count of groups from where a node's neighbours arrive are reduced by deployment knowledge. The method is better than the existing schemes in many ways, connectivity is more with less memory needed and low transmission range. It's tough against node capture attacks is high. Pairwise keys can be generated by using information stored in neighbour nodes. Geometric random graph is used to study network connectivity.

H. Secured WSN Using Improved KM [8].

Sensors used in Wireless Sensor Network have many disadvantages for-example low energy, less storage capacity and low computation. Key management scheme is used to give robust security in WSN. Two ways of keys are used in key-management they are symmetric and asymmetric. In the proposed scheme, key-management using symmetric keys has been presented. Keys are generated in every node using pseudo-random generator, these keys are given to the base station which are dependent on initial key which is distributed and CBC RC5 to achieve confidentiality, integrity and authentication. Communication is not used to create the keys because there is not mediation between the nodes, this is an advantage. Provides high resistance, high scalability and less storage space. The proposed scheme is better than already existing scheme such as SPIN. The disadvantage of this scheme is that it can be used only in homogeneous network.

I. Improved-Blom KM Scheme for Wireless Sensor Network [9].

This paper mainly tries to overcome the problems faced in creating pairwise links which are secure between resources constrained sensor nodes. The main issue addressed in this paper are scalability, high memory requirements and calculation overhead for designing pairwise key agreement. In this paper, there are three phases to provide greater support for scalability, and to provide full network connectivity, they are Key pre-distribution phase, pairwise key establishment. This scheme provides pairwise key establishment within the range where nodes can communicate with less calculational overhead and effective usage of energy as compared to other schemes. However, in this scheme work has to be done on how the security can be maintained when a fresh node is added or the existing node is deleted.

J. Key-Recoverability in Wireless Sensor Networks [10].

There exist many methods for the identification of unhealthy nodes. After the compromised node has been discovered investigation has not been done to regain the secure communication. This capacity allows to know the functionality level which is retrieved after a successful attack and removal of the compromised secret material. For the first time they have discussed about recoverability property and formulas have been provided for the computation. Simulation results are used to validate the formulae. The advanced key management schemes for WSN has been explored to check their capacity to regain the communications securely after the material that is secret is owned by some nodes has been reserved.

K. Location-Based KM Strong Against Insider- Threats in WSN [11].

Secure communication is the main problem in wireless sensor network. Security is achieved when sensor nodes share secret keys with neighbouring nodes and these keys should be updated every now and then to defeat insider threats of corrupted nodes. To achieve security during communication a location based key management has been proposed. There exist many schemes in location based key management, in this paper position dependent key management is used. To overcome the problem of communication interference in LDK a key editing method that includes grid based location information has been used. Key update and revocation process is added to withstand inside attackers. If the least number of keys common which are needed for key formation is more this method can increase connectivity. There is another advantage using this method is that whenever there is an unhealthy node holding insider threats, every sensor node can be given rekey except for the corrupted node. Hexagonal deployment of anchor nodes is used to reduce network cost. The proposed method LDK+ is the improved version of LDK. This method doesn't just talk about key establishment and key revocation it also deals about packet drop attack and other insider attack.

L. Effective-KM in Dynamic WSN [12].

WSN network is used in many areas such as military to sense and track, to monitor patient's status, hence security plays a key role. To achieve security, a method is proposed where there is no certificate effective key-management protocol (CL EKM) is used to communicate with security in dynamic wireless sensor networks distinguished by node movement. Another benefit in using CL-EKM is that it guarantees secrecy during encryption and decryption and gives effective updates of key whenever a node leaves or enters the cluster. Also assists for the effective revocation of key for unhealthy node and reduces the effect of a compromised node on the communication links security. The proposed method is tough against node compromise, impersonation attacks, cloning and also protects confidentiality of data and integrity. The scheme also supports communication when the node quits or joins a cluster.

M. A Highly Scalable-Key Pre Distribution Scheme for WSN [13].

Problem faced while developing a key-management is the network extensibility, because of the limitations in resources. To permit extensive deployment of the network the method used must assist a huge number of nodes. To provide good secure connectivity coverage a unital design theory is used. High key sharing probability is not assured by the unital design. Hence, to provide great network scalability and better key sharing chance, the scheme uses an enhanced unital dependent key pre distribution protocol. The simulations were done and compared with the existing methods the outcome indicates that the proposal increases the scalability of the network and provides good connectivity coverage which is secure and an altogether improved performance. This scheme provides a large scale WSN with a less key-storage overhead and good network resilience. A solution parameter was discussed and proposed enough values which gives a very good trade-off between network extensibility and secure connectivity.

N. An Efficient-KM Scheme for Secure Data Access Control in Wireless Broadcast Services [14].

As security is a very important aspect in the communication symmetric key dependent encryption is made use of so that only authenticated user can use the information. An effective key management method called KTR has been proposed. There are many advantages such as it assists all subscription activities in wireless broadcast services, for all the subscribed activities the user needs to carry only one set of keys and it allows to minimize the rekey cost. About 45% of communication overhead is saved and about 50% of decryption cost is reduced. KTR is scalable, efficient and secure key management. By using KTR the user needs to hold only fewer keys because various programs share a single tree. An oval distributed key management is proposed to decrease rekey cost. To other LKH-based approach also this scheme can be used.

O. Location-Aware Combinatorial KM Scheme for Clustered Sensor Networks [15].

WSNs and their physical environment face lot of problems such as they become highly unguarded to node capture and many attacks. Managing encrypted keys in large scale clustered WSNs is important. Hence a new distributed key-management scheme built on Exclusion Basis Systems has been suggested. The proposed method is named as SHELL because it is scalable, hierarchical, effective, location aware and less weight. One of the advantages in the proposed scheme is that SHELL assists rekeying. Hence it increases security of the network and lastingness in opposition to node capture. The memory and energy usage is reduced by compromising in the number of keys and rekeying messages, SHELL shares key management service among multiple nodes. A new set of rules for key-assignment that decreases the chances of the network being captured through the collusion of unhealthy nodes has been introduced. Should work on reducing the involvement of common node in key-management and should extend SHELL to take care of more dynamic network topologies.

P. An Attack Model-Based Highly Secure KM Scheme for WSN [16].

The inherent characteristics and ignored working of wireless sensor network have let them to easily get prone to many attacks. An effective disruptive cellular model of WSN has been included to decrease the node capture impact. The adversarial model incorporated in the WSN exploits some vulnerabilities in the system like high node density, location where sink nodes are placed, neighbour influence feature to calculate the compromise chance of every cell. The length hash chain is also defined for every cell. The length of hash for every cell has different re-key intermission to make the system strong in opposition to node capture. The method has Proved to be more effective than existing schemes in increasing the WSN security. One of the aspects to be considered during the forming of key management is the attacking behaviour. The proposed scheme presents highly secure key-management method for cellular model of

networks. To design an attack model, the placement of the sink is taken into consideration. This helps to efficiently deal the node capture attacks. At the end of the hash chain the pool of keys of the cells which are more susceptible to attacks are placed. One of the advantages is that the rekeying overhead is reduced. The work has to be done to design alternate ways to compute neighbour impact on different types of cell.

Q. An Efficient KM Scheme for Hierarchical-WSN [17].

Talks about lightweight performance of the framework of public key called cluster-based public-infrastructure(CBPKI). Architecture of the network and characteristics of sensors are taken into account to implement this. It is important for the base station to have security and authenticity as CBPKI depends on it and it performs set of handshakes to set-up session-keys between the base-station and sensors in the system to ensure data confidentiality and integrity. Encryption keys which are symmetric are established between network sensors and the base station using set of handshakes. Using these session keys confidentiality of the data in the network and integrity of the data by using message authenticated code is guaranteed. CBPKI is resistant to many attacks. The power consumption and network overhead are low.

R. A Chinese-Remainder Theorem Based KM Algorithm for Hierarchical WSN [18].

To achieve energy efficiency, sensors with different capacities form a hierarchy. Key management is majorly used to provide security in these networks. Which includes key pre distribution, discovery of the key that is shared, key revocation and refreshing. A new method for hierarchical WSN, dependent on Chinese-Remainder theorem has been suggested. The key is established with less computation, storage, communication expense at every node. It is very scalable and resistant to many attacks. The proposed scheme can be implemented in cluster like environment. Work should be done to combine the CRT dependent method with distributed architecture in a hybrid method.

S. Energy-Efficient KM Scheme for WSN [19].

Due to the disadvantages existing in the present techniques such as high energy and computational overhead the paper has suggested a technique which assists the creation of three types of keys for each and every node, an independent key given to the base station, a pairwise key given with neighbour node, a group-key that is given by all the nodes in the system. The involvement of base station is reduced and is very energy efficient. The keys during initialization, during the change of membership and during compromising of a key are generated using polynomial function. The advantage of this method is that it works in unspecified deployment environment. In computation, communication and storage the proposed method has very less overhead. The difficulty of the algorithm makes the of the sensor networks tough towards various attacks high.

T. An Efficient-Identity Based KM Scheme for WSN Using the Bloom-Filter [20].

The importance given to the security in WSN a scheme has proposed a well-organised identity based key-management (IBKM) method, that make use of the bloom-filter to give authentication to the communication sensor node that uses limited storage. The advantage of the proposed scheme is that it can stop many attacks effectively with good calculation and communication overhead. The session keys between the nodes are distributed by acquiring the Bloom-filter into identity-based cryptosystem. Here, certification authority is used to achieve the advantages of the node's identity authentication without complex certification by IBKM.

TABLE I
Comparison with Schemes

Paper title	Computational complexity	Memory	Energy consump	Scalability	Communication over	Approa	Technique Used	Grid type	Node	Key size	Networ	Tool used	Application	Advantages	Disadvantages	Attacks (Resistant to)	Attacks (vulnerable to)

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[1]	low	low		high	low	Asymmetric	Transitory master key (MK)	Undefined	Immobile		Centralised	Tiny OS (Motesky IV)	Military applications	Less key setup time, number of packets exchanged are less for key negotiation	Setting up initialisation phase is critical task	Node compromising attack Clone attack	Looping in the network attack Eavesdropping
[2]	low	low	low	good	low	Cluster based	µKMS	Undefined	Immobile	low	Centralised	MATLAB	real time video transmission, intruder tracking	Less overhead, communication energy consumption is low	Storage overhead increases with increase in network size	Replay attack Sybil attack Physical attack Logical attack	Selective forwarding attack
[10]		low			low	Symmetric					Any	C		Correctly describes recoverability level in WSNs			
[11]	high					Symmetric	location-dependent key management	Hexagonal	Immobile		Centralised	C++ and MATLAB		Higher connectivity, Stability Security Addresses insider attack	Does not consider mobile nodes	Outsider-Eavesdropping, Node Capture attack, Replay attack, Grayhole and On–Off Packet drop attack.	
[12]	low	high	high	Good	high	Symmetric	Certificateless EKM	Dynamic	Mobile		Centralised	Contiki OS and TI exp5438	Military applications	Effective key management procedures are defined and key revocation process for compromised nodes.	Does not take into account energy consumption	Node compromising attack, forward and backward secrecy, cloning and impersonation attack.	Direct attack Intersection attack
[13]	Low	Low	Low	High		Symmetric	Unital design theory	Dynamic	Any	Low	Any	Analytical analysis		increases the network extensibility, high secure connectivity coverage.		Key compromise	Node cloning attack

[14]	High	low		Good	Low	Symmetric	SKT(shared key tree) and KTR (key tree reuse)	Undefined	Mobile		Distributed	Analytical analysis	Broadcast services	Communication overhead, and decryption cost for each user is decrese.	Rekeying cost is high	Non-group confidentiality, collusion freedom, forward ,backward secrecy	
[15]	High	High	Low	High	High		Combinatorial formulation and EBS methodology	Undefined	Immobile		Centralised	Simulation and analytical analysis	Military applications	removes the need for large storage capacity.	Dynamic network topologies not addressed	Collusion attacks, node capture and compromise	Multihop node collusion
[16]		low				Symmetric	Random key management scheme	Undefined		Dependent on a hal gorithm	Distributed	analytical analysis		least chance of key compromise. overhead in rekeying is decreased.	Number of nodes captured is reduced but no completely avoided	Node capture attack	
[17]	less	less		better	less	hybrid	DES	Undefined			Centralised	MICA from CrossBow, tiny OS				Node compromise attack	Brute force attack
[18]	low	low		good		symmetric	Chinese Reminder Theorom	Undefined			Centralised	Simulation and analytical analysis	Military applications	less computation, storage and communication cost. high scalability	Does not account for distributed networks	Brute-Force Attack, Node-Capture Attack, Collusion Attack	Timing attack
[19]	less	less	less		less	Symmetric	Polynomial function	Undefined	Immobile		Centralised	MATLAB		Group and pairwise keys are generated using one of the polynomial function. The polynomial function is identified with the help	Complex algorithm	Node compromise attack, Reply attack	Insider attacks

													of its ID. The BS computes the individual key for each node using the unique keys and the node IDs that it has stored.			
[9]	low	low		Good		Asymmetric	Blom Key Management Scheme	Undefined	Immobile		Distributed	MATLAB		Takes less storage space, less computation time and more energy efficient	Addition and deletion of new nodes is untouched	Node capture attack	
[20]	low	low			good	Asymmetric	Bilinear computational Diffie–Hellman (BCDH) and the Bloom	Undefined	Any		Centralised			Node identity authentication without difficult certification Verification.	Bloom filter introduces false positives into the attack path	Sybil attack, hello flood attack, Man-in-the-middle attack	
[3]	low		low		good	Symmetric	Sensor LOCK			Increases as with number of nodes	Distributed	TinyOS, nesC,TOSSIM, Xubunt OS	Smartcard, financial and telecommunications	Processing overhead is very low and increase in security.		capturing and tampering attacks	
[4]	medium		low			Hybrid	modular arithmetic based key management			low	Centralised		military fields, aircrafts health monitor.	Takes less time for computation and less energy consumption		Node capture attack	
[5]	less	less			better	Symmetric	Elliptic curve digital signature		Immobile	low	Centralised	MATLAB		has a very less overhead in terms of calculation, communication, and storage.		Sybil attacks, rushing attacks, node replication attacks	

[6]				Good		Symmetric	A Spanning Tree-Based Key Management					Matlab,NS2		Scalable and uses less memory		node-compromise attack, Sybil attack, hello flood attack	
[7]		low			Good	Symmetric	Group based deployment model	Hexagonal	Immobile	low	Centralised			achieves more connectivity with a low memory requirement and short transmission range.		Node capture	
[8]		low		good		Symmetric	PRNG, CBC-RC5			low				very simple and low computation complexity. Less time and energy. high resistance to node capture, high scalability and less memory required to store the keys	This technique is implemented only on homogeneous WSN.	Node capture	

II. Conclusions

There are many schemes that propose different methods to provide security in wireless sensor network as compared in Table1. Some of the proposed schemes are discussed in this paper. Though the main goal is to provide security the difference between is the time taken for the computation and one of the main factors that needs to be addressed in the WSN security is energy consumption. Lot of work has been done to provide strong security by consuming less energy. Work is going on to reduce the computation time needed during key generation and many intermediate steps involved during the key distribution.

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A Metamaterial Inspired, Slotted Multiband Patch Antenna with Reconfigurability

Banuprakash. R, Hariprasad. S.A

Abstract*: In this letter the antenna is designed for achieving the multiband frequency configuration with the dimension of 26*26*1.6 mm3 with the use of substrate of dielectric constant of 4.4. It is capable of operating at the frequency of 3.9 GHz,5.8GHz and 6.7GHz, with a gain of 2.9dB,4.6dB,-1.5dB respectively. By using the method like DGS, Slots and SSRR structure, the design is able to generate and operate at the above mentioned frequencies. Furthermore by placing a metallic switch on the rectangular shaped slot the proposed antenna can also be used as reconfigurable antenna to produce different frequency.

***Index Terms*: Slots, DGS, Reconfigurability, HFSS.**

I. INTRODUCTION

In recent years the rapid development of the antenna has led to the increased demand of multiband microstrip antenna[6]. This has changed the approach of antenna design in completely diverse way[2]. Antenna is a passive device which converts electrical energy into Radio Frequency energy and couple it to free space for transmission. Since the antenna is an elementary device for wireless communication setup the microstrip multiband antenna has given a new manner to accomplish this objective.

The performance of an antenna depends on the design parameters like dielectric constant, height of the substrate, frequency etc. There is an immense need of packed size and light weight antenna's which can be effectively bound together in present day communication systems. The micro strip patch antenna have been broadly utilized in elite satellite and remote specialized gadgets because of their low cost, compact shape, lightweight, simplicity of creation and similarity of combination with circuit technology. However, low transmission capacity, low power handling limit, low gain and directivity are the real disadvantages of patch antenna. Therefore, the challenge in microstrip antenna design is to increase the bandwidth and gain.

To attain good gain and bandwidth, at low frequency bands in handheld and portable wireless devices antenna size plays a dynamic role. For flexibility to various situations in wireless remote sensing and radar systems, antenna with numerous working frequencies is must [2] and patch antennas can be designed by engraving a portion of metal on ground plane either in periodic or non-periodic mode called as Defective Ground Structure (DGS). A break in the current distribution created by the slots make a positive influence on input impedance to generate supplementary resonant frequencies [5].

For better compatibility and to satisfy the developing needs of different portable electric devices, many wideband, ultra wideband and multiband antennas have been designed. In any case, multiband antennas are a preferred choice over other wide band and ultra wide band antennas as they ease the effects of electromagnetic impedance and pulse distortion. [1]. Overall, multiband resonant modes can be achieved by altering patch or ground plane. This can be achieved by adding multi-diverged strips and carved slots [3].

A. Reconfigurability of the Antenna

The progression in wireless communication technologies composed with the upward need of reconfigurable property of antenna for users has motivated the demand for smaller and multi-functional wireless antennas in communication device. Reconfigurable antennas have been proposed to fix a vital issue of employing the restricted spectrum effectively on the communication applications [4]..

II. ANTENNA GEOMETRY AND RESULTS

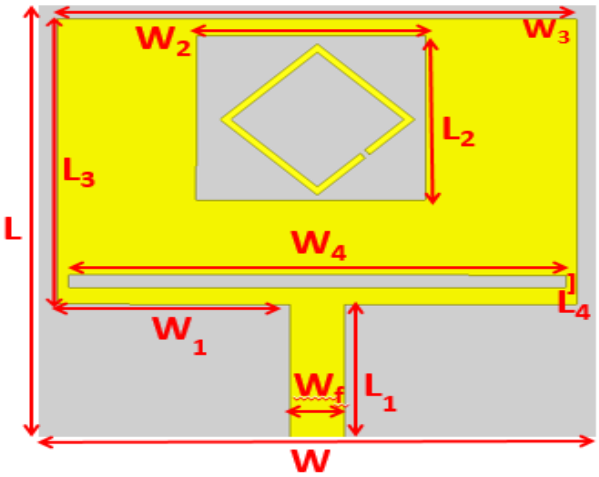


Fig1.Front View

Revised Manuscript Received on July 5, 2019

Banuprakash R, Telecommunication Engineering, BMS Institute of Technology and Management, Bangalore, India, r.bhanuprakash@bmsit.in
Hariprasad S A, Electronics and Communication Engineering, SET, Jain University, Bangalore, India.

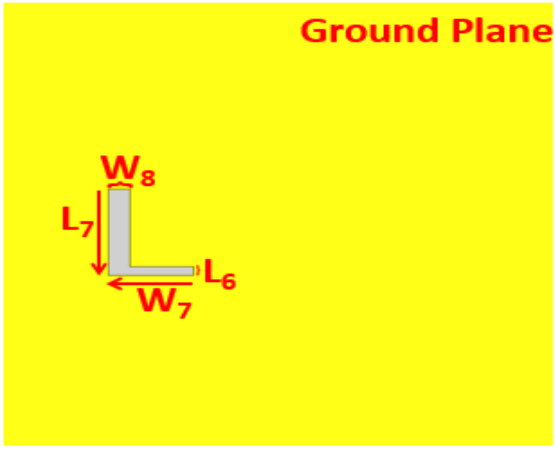


Fig.2. Back view

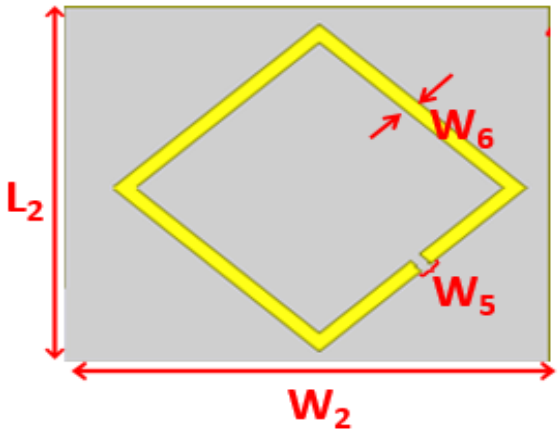
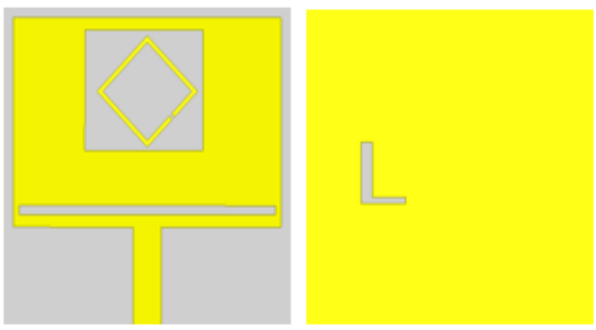


Fig. 3. SSRR structure

The measurements of the design are listed below:

W = 26 mm	L = 26 mm
W1 = 10.75 mm	L1 = 8 mm
W2 = 10.6 mm	L2 = 9.8 mm
W3 = 24 mm	L3 = 17 mm
W4 = 23 mm	L4 = 0.45 mm
W7 = 4 mm	L6 = 0.5 mm
W8 = 1 mm	L7 = 5mm

The above mentioned structure is obtained after the repeated iterations. The different steps which led to the final design and corresponding results are as follows



Patch Ground

Fig.4a) The proposed design

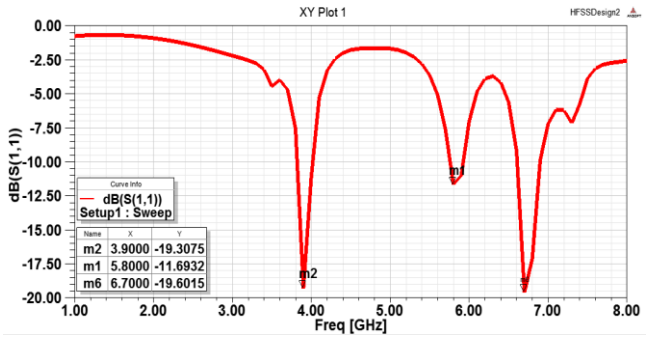


Fig. 4b). Plot of return loss for proposed antenna

And the initial designs which led to the proposed antenna are as follows

Step1:

Fig5.a) Patch Ground

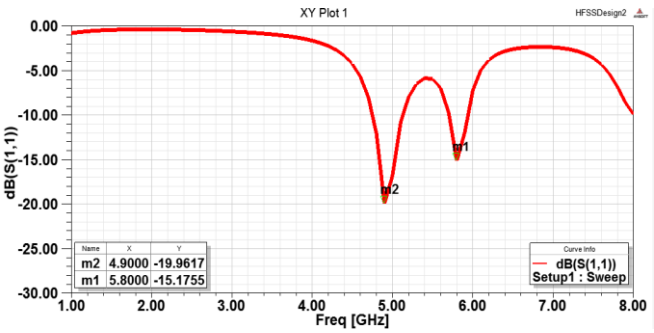
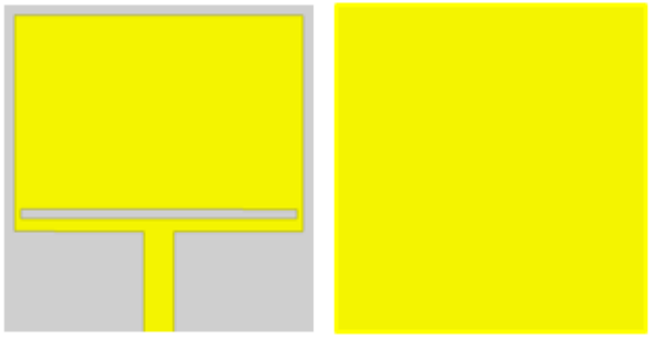


Fig.5.b) Frequency Vs Return loss

Fig.5(a,b). Initial design and the corresponding result

Step 2:



Patch Ground

Fig6.a) Design with slot

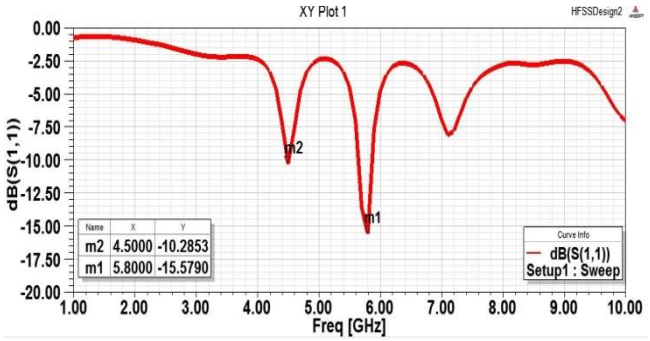
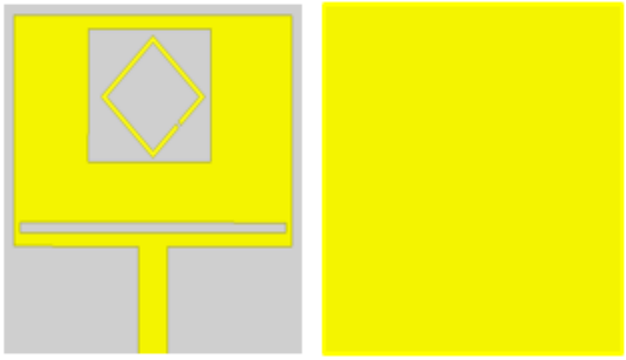


Fig.6 b) Return loss

Step 3:



Patch Ground

Fig.7 a) Patch with Square Split Ring Resonator

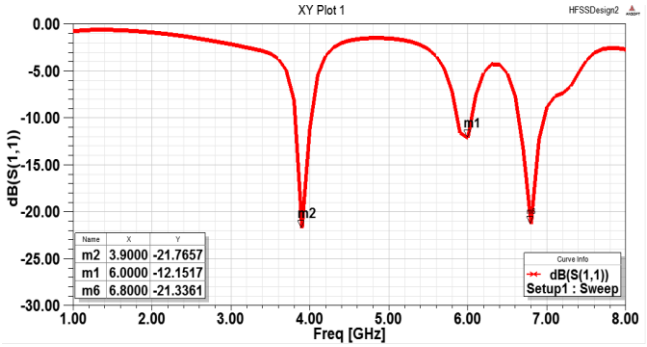


Fig.7 b) Return loss

The above mentioned steps have given the corresponding return loss values and hence giving the operating frequencies. From the above mentioned design steps and the corresponding results it shoes that initially the simple microstrip patch antenna is able to generate 4.9GHz and 5.8GHz frequencies but after the insertion of rectangular slot near the feed the antenna produced 4.5GHz and 5.8 GHz. Then to produce another frequency the use of SSRR structure is incorporated and the antenna is simulated to get the result. The antenna was then able to generate 3.9 GHz,6GHz and 6.8GHz.

To obtain a better gain an L slot is presented in ground plane hence leading to the defective ground structure (DGS). It produced the final set if frequencies of 3.9GHz, 5.8GHz and 6.7GHz with good gain.

The plot of gain for above mentioned frequencies are as follows

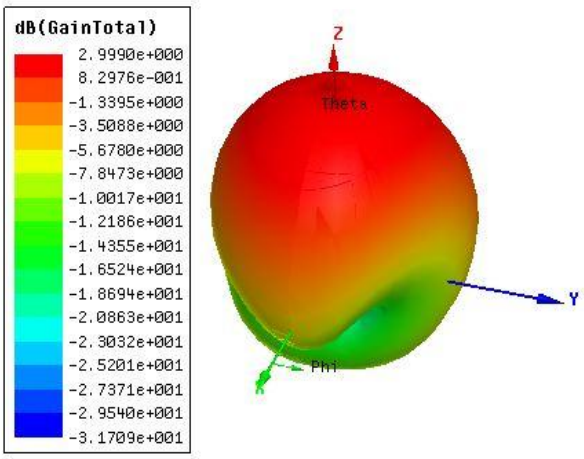


Fig.8a): For 3.9GHz

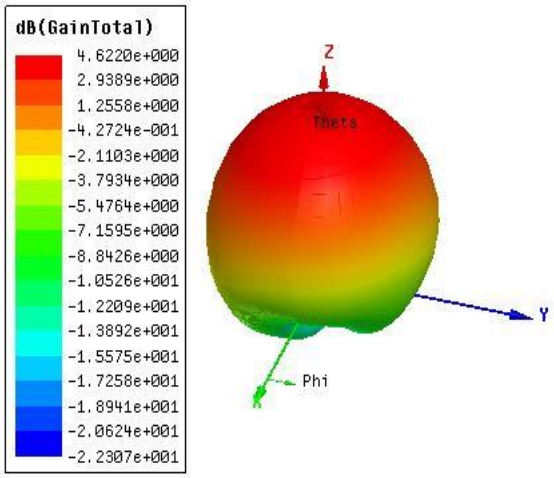


Fig. 8b): At 5.8GHz

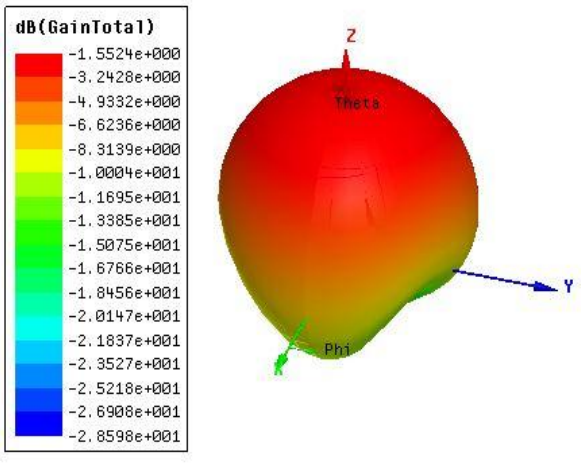


Fig. 8c): For 6.7GHz

From the above figures it is clear that the proposed antenna produces a gain of 2.99dB for 3.9GHz, 4.62dB for 5.8GHz and -1.55dB for 6.7GHz respectively.

Radiation patterns of the proposed structure :

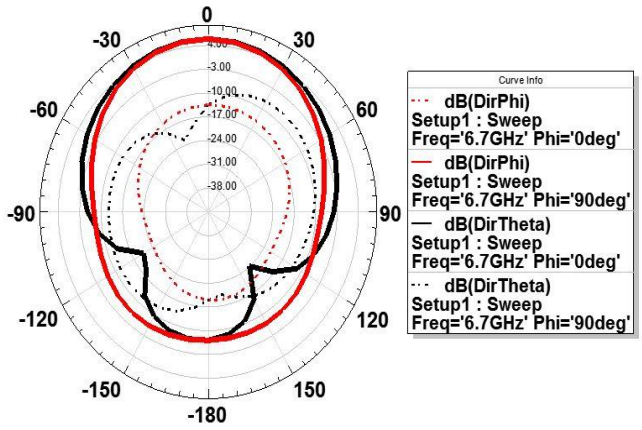


Fig.9a): For 3.9GHz

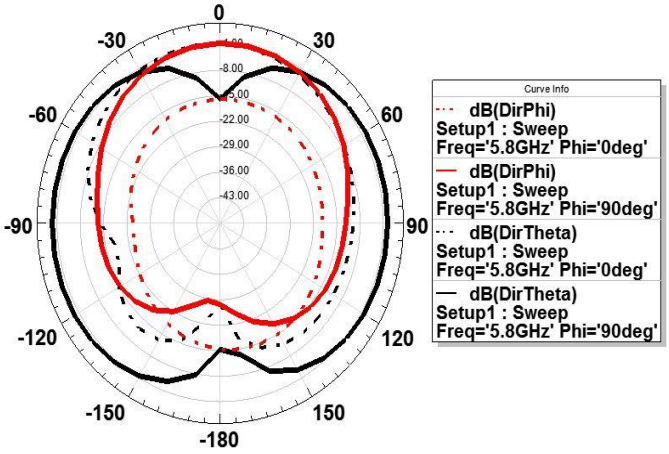


Fig.9b): For 5.8GHz

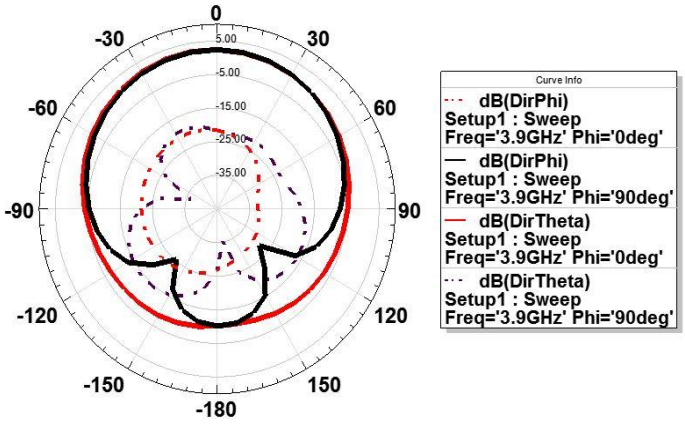


Fig.9c): For 3.9GHz

The above figures illustrate the radiation plot for the obtained frequencies.

Frequency Reconfigurability:

The antenna can be reconfigured to 6 GHz by placing a simple metal switch in the slot as shown in Fig 10.

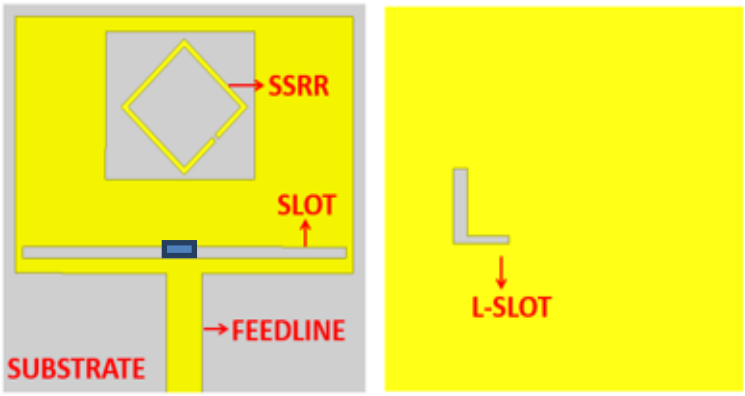


Fig.10: Antenna structure with a metal switch

The above mentioned reconfigurable antenna produces the following result

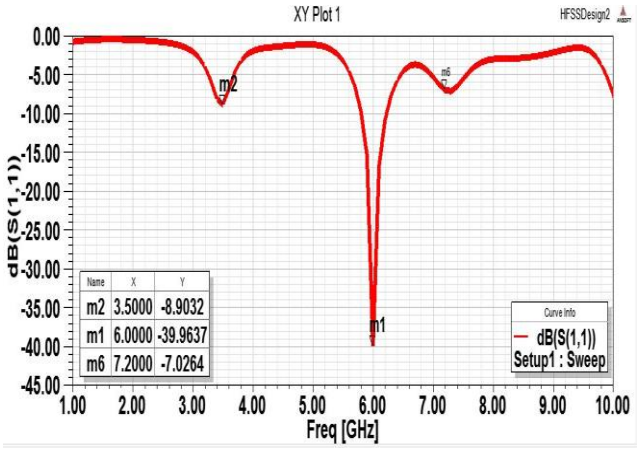


Fig.11: Return loss plot for the reconfigured antenna

Comparison table for result obtained in each step:

Step	Frequency GHz	S_{11} in dB	Applications
#1	4.9 5.8	-19.9 -15.1	• C-band • Wi-Max
#2	4.5 5.8	-10 -15	• C-band • WLAN
#3	3.9 6.0 6.8	-21 -12 -21	• Wi-Max • Lower satellite band • Satellite Television
#4 Proposed design	3.9 5.8 6.7	-19 -11 -19	• Middle Wi-Max • Upper Wi-Max • Satellite Television

Comparison of the proposed antenna:

Ref. no.	Year	Total area (mm^2)	Operating bands (GHz)	Reconfigurability
[1]	2015	50x50	2.54/3.55/ 5.7	NO
[2]	2017	40x40	3.04/3.83/4.83/ 5.76	NO
[3]	2016	38x38	2.4/3.5/5.8 1.52/1.6/1.5	NO
[5]	2015	56x44	3.1/5.52/7.3/9. 7	NO
Proposed Antenna		26x26	3.9/5.8/6.7	YES

III. CONCLUSION

The increasing demand for the antenna for multiband frequencies is increasing exponentially. In an effort to get a solution the above antenna is proposed with multiband frequency operation characteristics. The proposed antenna operates at 3.9GHz,5.8GHz and 6.7GHz with return loss of -21.7dB,-12.1dB and -21.3 dB respectively. It has produced a gain of 2.9dB,4.6dB and -1.5dB accordingly. The same antenna with the help of electric switches like metal switch can be modified to produce 6 GHz and made as a reconfigurable antenna. Hence the proposed antenna not only offers multiband frequency operation capability it also offers reconfigurability.

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AUTHORS PROFILE

Banuprakash R, presentaly working in Telecommunication Engineering, BMS Institute of Technology and Management, Bangalore, India, He is BE, MTech, and PhD. Prof. Banuprakash R were Resource Persons for the training program on RF communication at East West Institute of Technology in association with Technilab Instrument from 16th to 19th July 2018.

Hariprasad S A, I currently is Director, School of Engineering and Technology, Jain University, Bengaluru, India. His area is Embedded system

A miniaturized multiband antenna using SRR and DGS for cognitive radio applications

[1]Banuprakash R, [2]Hariprasad S A
[1]BMS Institute of Technology and Management, Bangalore
Visvesvaraya Technological University, Belagavi, India
[2]FET, Jain University, Bangalore

Abstract— **Here a triple band patch antenna is aimed at applications of cognitive radio. It has a FR4 epoxy substrate of size 26 x 26 x 1.6mm^3 with a dielectric constant 4.4. A Spit Ring Resonator Metamaterial is tested and used on the patch to generate 4.3GHz frequency. The other frequencies obtained are 6.7GHz and 7.7GHz. The S_{11} of about -11.36dB, -12.35dB and -10.34dB produced respectively for the above frequencies. The proposed antennas is successfully simulated and performed using HFSS and experimental validations are presented to demonstrate the performance of these antenna.**

Keywords—**SRR Metamaterial, Cognitive radio, Triple Band, HFSS, ZVH Vector Network Analyzer.**

I. INTRODUCTION

The multiband or broadband radio wires have stimulated high enthusiasm for ongoing years for application to multimode correspondence frameworks [6][7]. With an expanding request of remote correspondence, best thought is to plan a scaled down, less weight, truncated shape, unique receiving wire that can move data amid at least dual focuses without receiving association through any electrical director. High return loss, thin frequency bandwidth and low gain are major shortcomings of printed antenna. The projection of metamaterials was the major advancement in passive equipments [12][2]. Metamaterials are finding various applications for novel reception apparatuses. The ability to control their permittivity and penetrability makes metamaterials practical for the construction of host media [3][9].

In receiving devices left hand material (LHM) structures have utilized largely [4]. Scaling down of microstrip antenna has been endeavoured for quite a while utilizing different various strategies [1]. Complementary split-ring resonator (CSRR) acts as a shunt LC resonator energized by the balanced electric field. It transforms negative permeability to negative permittivity. Attractive coupling through the split of the external ring and capacitive coupling through the ring space are created for the coupling between patch and CSRR [8]. SRR offers better performance, gain improvement antenna miniaturization [5][11].In this letter, a basic triple-band plan of metamaterial structures referred to as CSRR. The location of metamaterial played a significant role in enhancing transmission capacity and gain [16].

Authors have proposed a metamaterial inspired monopole dual band antenna for Wi-Fi applications. A second resonance is created along with monopole resonance by metamaterial loading. The design is well suited for WLAN applications [14]. A dual resistance SRR is implanted for broadband concentration. The resonance frequency is determined by the distance from top resonator to ground plane.The absorption frequency band switching took place by proposed SGP and PIN diodes [13].

Here Split ring resonators are designed for two distinct frequencies and SRR are converged with monopole reception apparatus structured at 3GHz. This receiving wire shape appears as though a weapon club thus it is named as square shape cudgel radio wire. The said antenna gives four unique frequencies in the UWB run. Both the receiving wires can be utilized for WLAN and WiMAX applications as it covers both the frequencies. The reciprocal Split Ring Resonators are carved at ground surface to improve the Bandwidth of radio wire, and transmission capacity upgrade is accomplished at higher recurrence. The metamaterial

property of SRR is demonstrated in first segment of paper. The created recieving wires tried utilizing the vector organize analyser, the deliberate and re-enacted results are in acceptable concurrence with each other[17].

An ultra-wideband passive device with fork structured patch is proposed here. The bandwidth attained from from 3.1 to 13.2 GHz. At that point, fresh and straightforward strategies are realised to illuminate the trouble for wide band opening receiving wires to acknowledge band-indented attributes. From 5.5 to 6.1GHz and 7.9 to 8.7 GHz are dismissed, separately by the usage of split ring resonator. The antenna gives almost steady radioactivity designs, high efficiency and gain [19].

A miniaturized micro-strip antenna, with "E"SRR metamaterial is proposed in this paper. For the structure with extension of split-ring resonators, the recurrence is moved to 2.4GHz from 2.38GHz. The gain enhanced from 7.1 to 7.31dBi [18].

This letter presents, a compact printed antenna with three bands for Long term evolution / Wireless LAN / Wi-MAX applications. It comprises of ring resonator with square shape and rectangular stub which prompts 20% receiving wire scaling down without corrupting the reverberation conduct. The stub creates one band and SRR generates two bands. The arrangement has an impression dimension of $0.16\lambda_0 \times 0.18\lambda_0 \times 0.012\lambda_0$ produced 2.23GHz [21].

An assortment of antenna has been built with meatamaterials (MTMs) and metamaterial-enlivened develops to improve their presentation qualities. Models incorporate electrically little, close field thunderous parasitic (NFRP) antenna that require no coordinating system and have high radiation efficiencies. Exploratory confirmation of their anticipated conduct's has been gotten. Late improvements with this NFRP electrically little worldview will be explored. They incorporate contemplations of expanded transmission capacities, just as multiband and multifunctional extensions[20][10].

II. ANTENNA FORMULAS

Width (W):

$$w = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Calculation of Effective length (L):

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

III. ANTENNA GEOMETRY

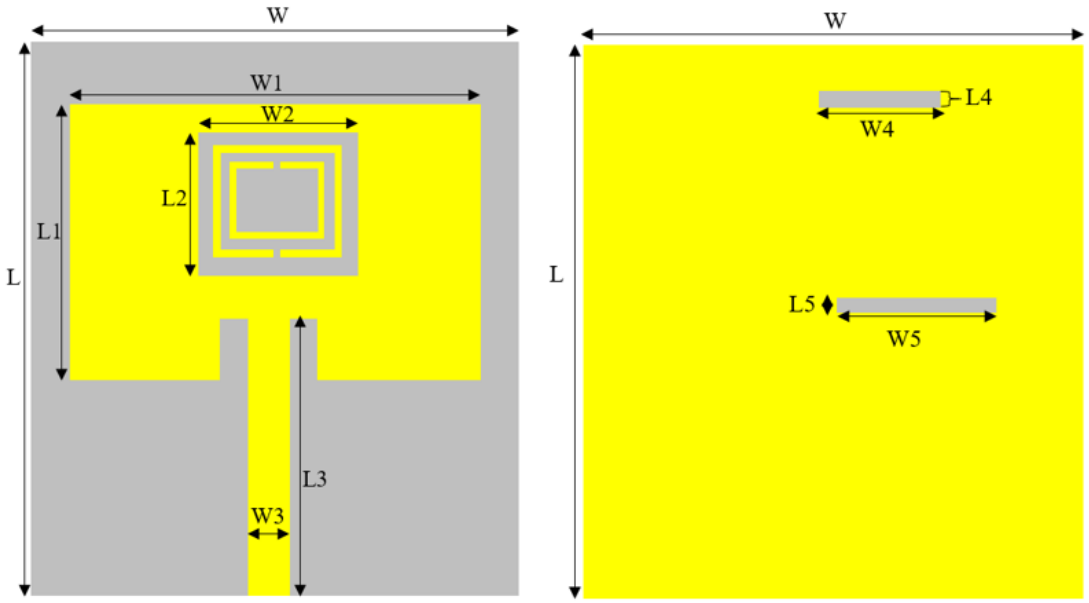

Figure1:Front and back view of antenna

TABLE I:
MEASUREMENTS OF THE DESIGN

W = 26mm	W_1 = 22mm	W_2 = 8mm	W_3 = 1.25mm	W_4 = 5.4mm	W_5 = 6mm
L = 26mm	L_1 = 14mm	L_2 = 8mm	L_3 =14mm	L_4 = 0.45mm	L_5 = 0.35mm

A. DESIGN OF METAMATERIAL:

A Split-ring resonator with rectangular shape is tested in a waveguide medium and inserted on the patch.

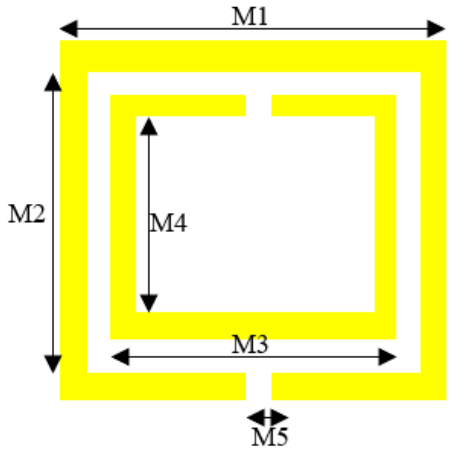

Figure. 2.Meta-material design

TABLE II :
DIMENSIONS OF METAMATERIAL

PARAMETER	M1	M2	M3	M4	M5
DIMENSION (in mm)	6	5.3	4	3.3	0.3

IV. RESULTS

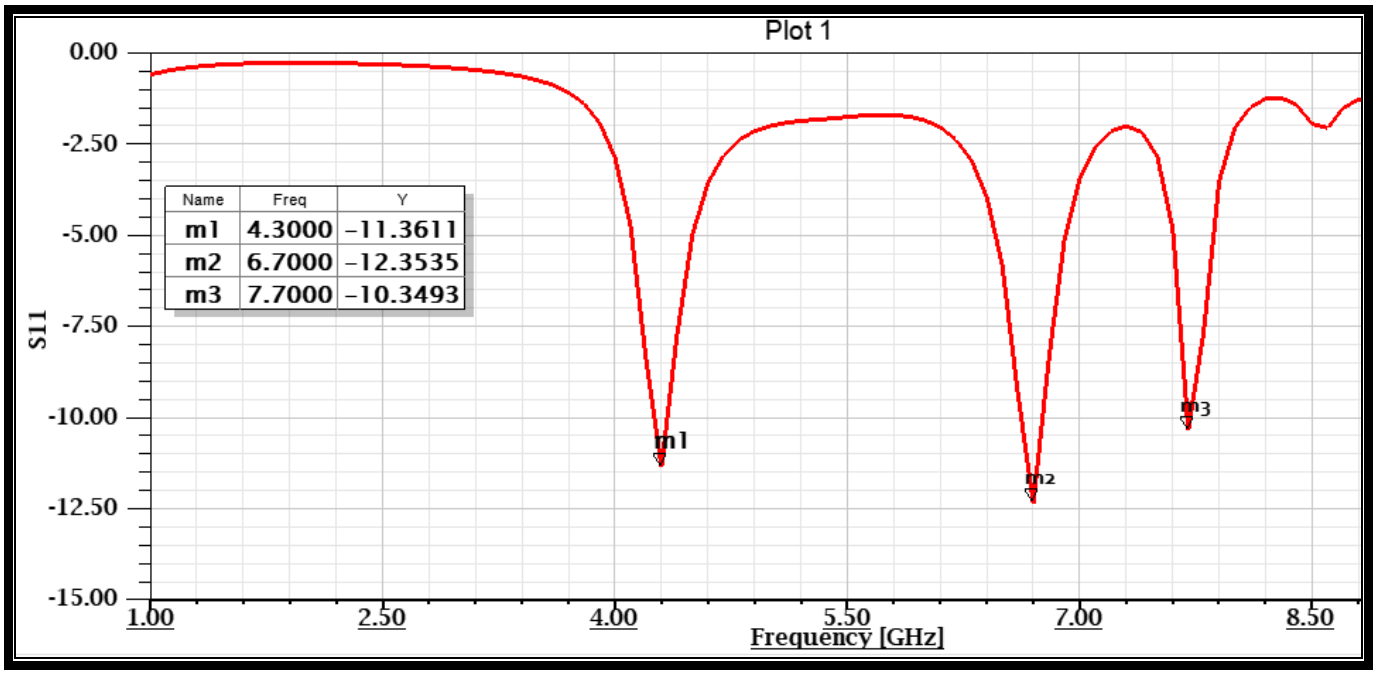

Figure.3. S_{11} vs Frequency

Triple band frequencies at 4.3GHz, 6.7GHz and 7.7GHz with return loss of -11.36dB, -12.53dB and -10.34dB respectively are obtained , of which 4.3GHz is provided by the metamaterial.

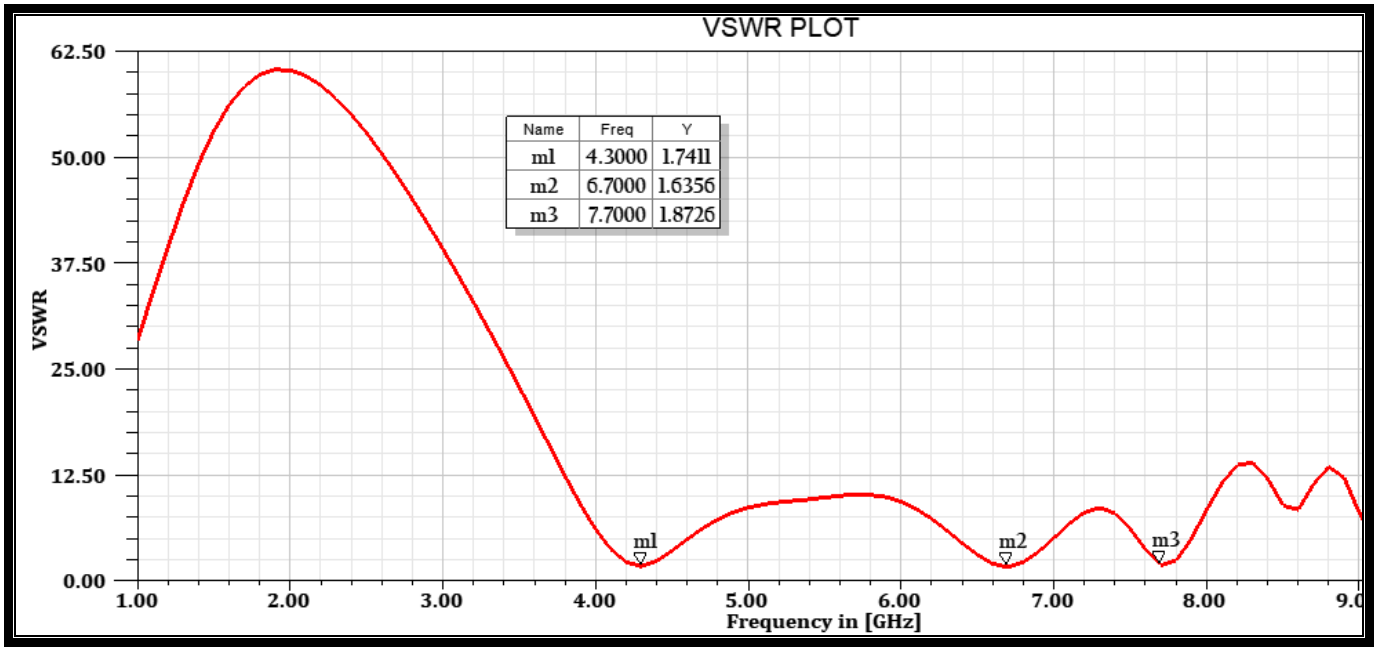

Figure.5 VSWR

The value of VSWR at the obtained frequencies is shown in the above graph. It is clearly depicted that all the values lie below 2 which makes this antenna a high performance antenna with minimum loss.

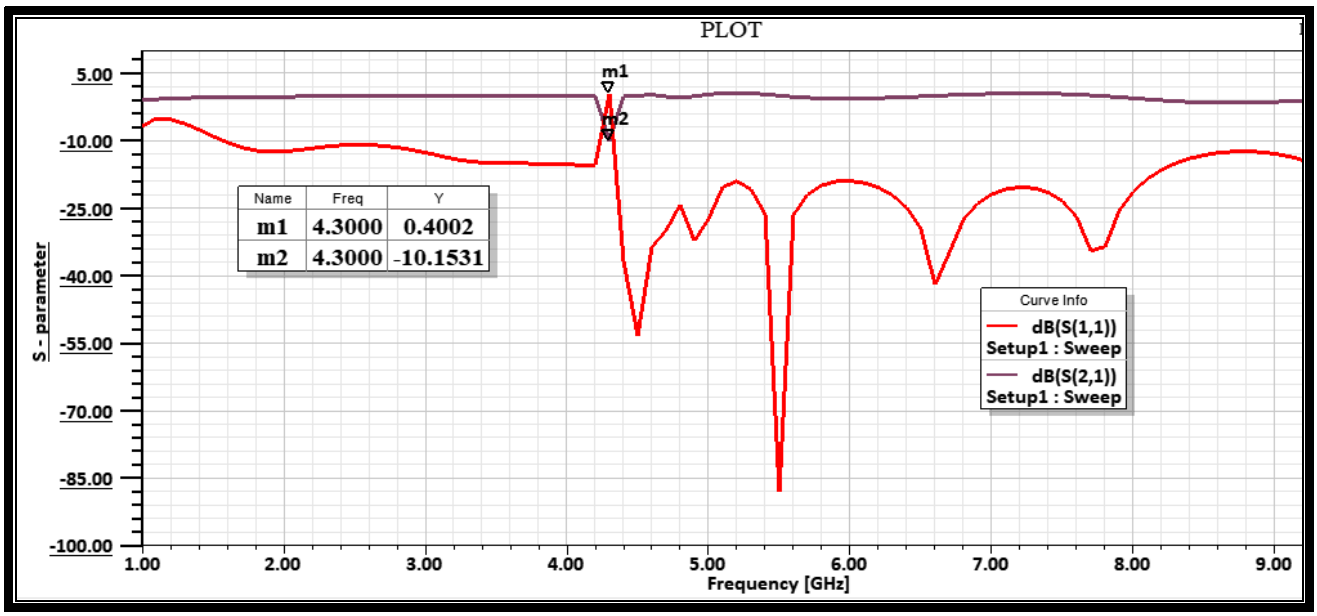

Figure.6 Metamaterial frequency

The Metamaterial has generated a frequency of 4.3GHz.

TABLE III:
INTERMEDIATE DESIGN STEPS

Sl No	STRUCTURE	FREQUENCY (GHz)	S_{11} (dB)
1	Metamaterial testing	4.3	-
2	Patch with inset feed	4.6 6.3 8.2	-15.83 -11.44 -27.63
3	The patch with metamaterial	4.3 7.5	-12.97 -10.25
4	With slots on Ground plane **0.45 x 5.4 mm^2**	6.7	-11.49
	0.35 x 6.0 mm^2	4.3 6.7 7.7	-11.36 -12.35 -10.34

From the previously mentioned steps and the comparing results it shows that at first the metamaterial when tried in a waveguide medium, it delivers a recurrence of 4.3GHz. A straightforward microstrip patch antenna with embed feed can produce 4.6GHz, 6.3GHz and 8.2GHz frequencies however after the setting the metamaterial on the fix the receiving wire creates 4.3GHz and 7.5GHz.

However, rectangular metal portion is etched at ground plane to acquire better gain and impedance matching. At first with a space of measurements 0.45 x 0.45 mm^2 in the DGS, the receiving wire gives a recurrence of 6.7GHz in particular. It is obviously observed that the metamaterial recurrence is lost. So as to get 4.3GHz which is the metamaterial frequency we decline the space measurement to 0.35 x 6.0 mm^2. Now the antenna produces triple band frequencies at 4.3GHz, 6.7GHz and 7.7GHz with enhanced gain, return loss and VSWR useful for Cognitive radio applications.

GAIN:

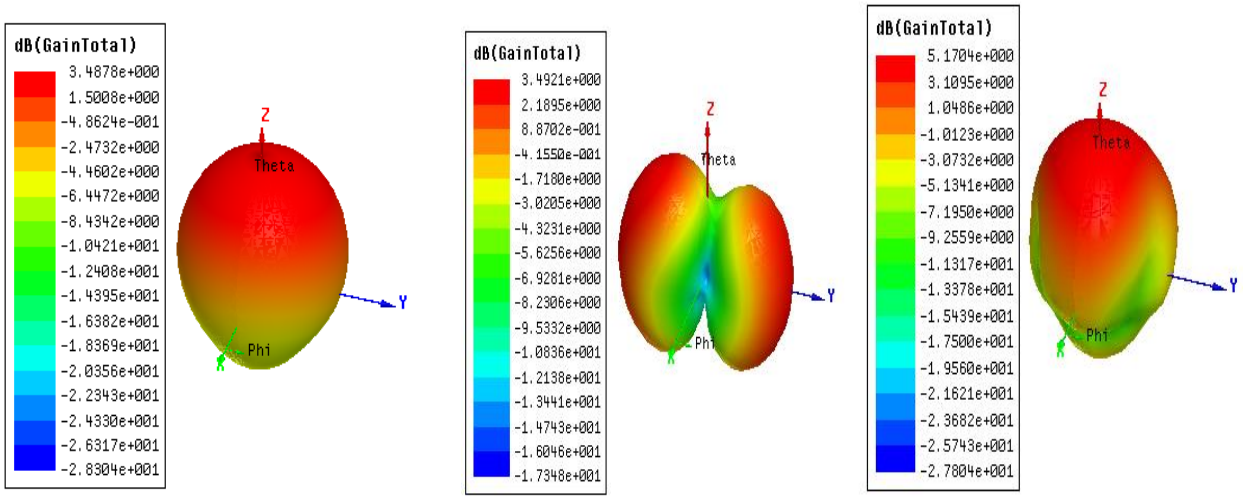

Figure.7: For 4.3GHz For 6.7GHz For 7.7GHz

From the above figure's it is clear that the presented antenna produces a gain of 3.48dB for 4.3GHz, 3.49dB for 6.7GHz, 5.17dB for 7.7GHz respectively.

RADIATION PATTERNS:

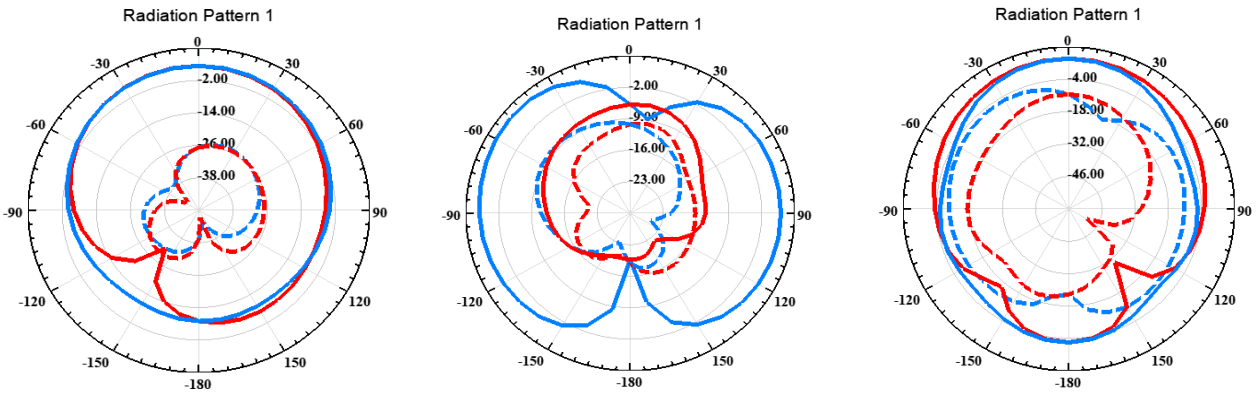

Figure.8 : 4.3GHz 6.7GHz 7.7GHz

ANTENNA PROTOTYPE:

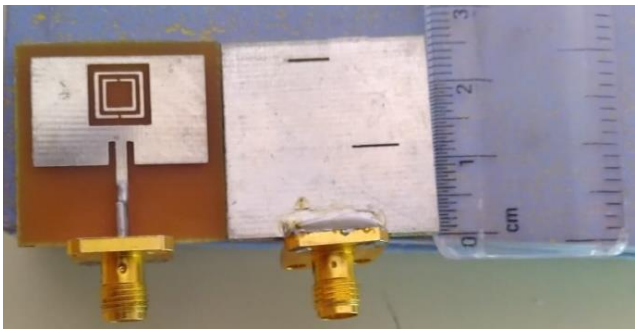

Figure.9: Prototyped Antenna

MEASURED RESULT:

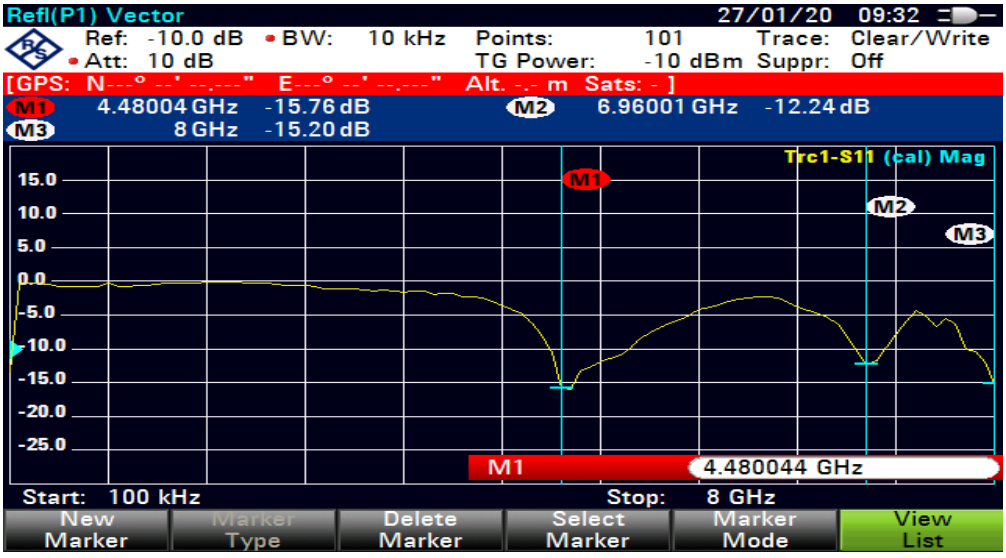

Figure.10: Measured return loss

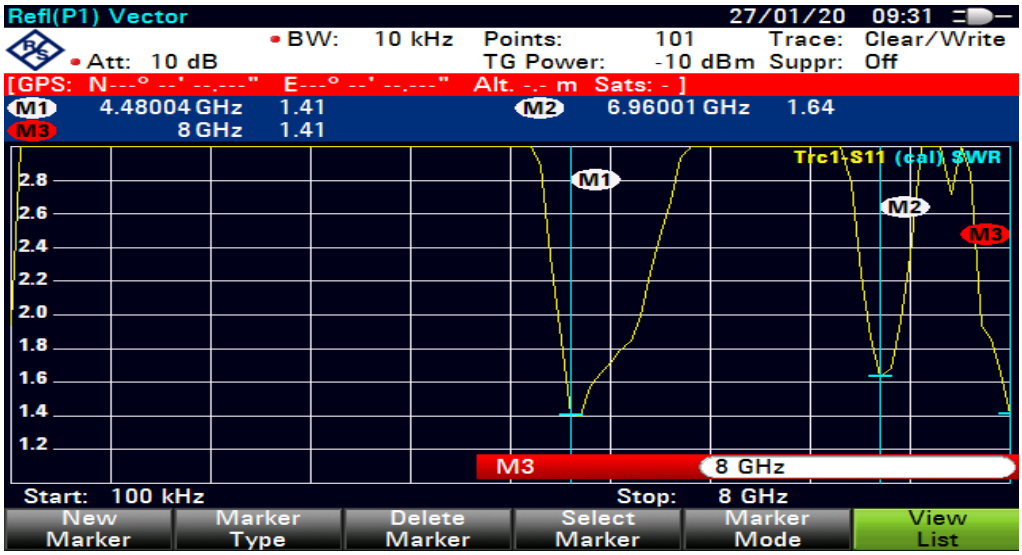

Figure.11: VSWR vs Frequency

TABLE V:
RESULTS COMAPRISON

PARAMETER	SIMULATED	MEASURED
Frequency (GHz)	4.3/6.7/7.7	4.48/6.96/8
S_{11} (dB)	-11.36/-12.53/-10.34	-15.76/-12.24/-15.20
VSWR	1.74/1.63/1.87	1.41/1.41/1.64

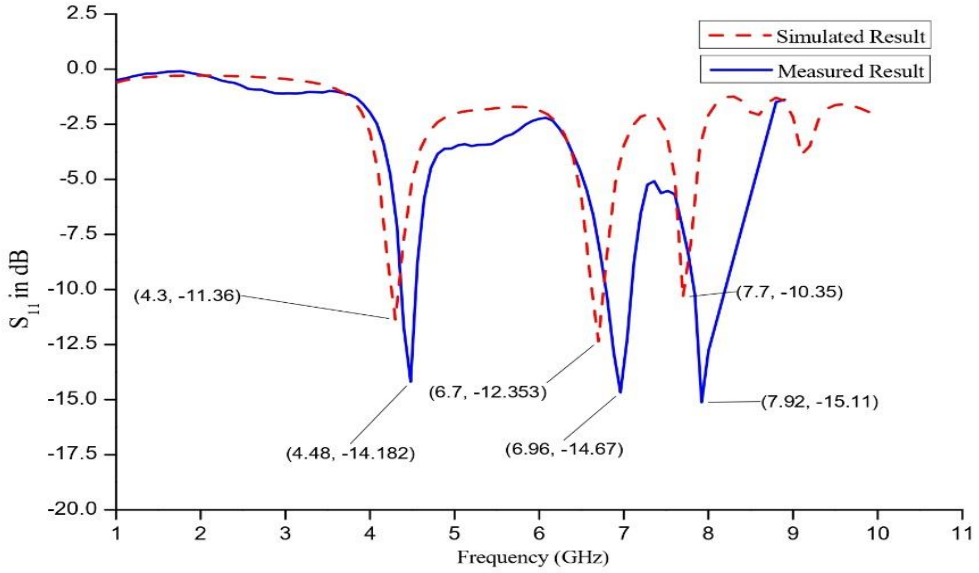

Figure.12: Measured Results vs. Simulated Results

COMPARISON TABLE:

Ref. no.	Total area (mm^3)	Operating bands (GHz)	Gain in dB
[7]	40 x 25 x 1.6	2.34/3.23	2.5/1.2
[5]	30 x 30x 1.57	2.4/5.8	5.17/7.12
[18]	100 x 100 x 1.6	2.4	7.3dB
[21]	22 x 24 x 1.6	2.23/3.65/5.13	2.22/2.31/1.98
[14]	30 x 32 x 1.6	2.46/5.5	0.71/1.53
[15]	25 x 30 x 1.6	2.4/5.2	1.4/5.1
Proposed antenna	26 x 26 x 1.6	4.3/6.7/7.7	2.48/3.49/5.17

V. CONCLUSION

A triple band microstrip patch antenna has been intended to produce the frequencies of 4.3GHz, 6.7 GHz and 7.7 GHz valuable for Cognitive radio applications. Here the SRR supported antenna to create multiband by delivering a frequency of 4.3 GHz. Inset feed is utilized to decrease the return loss. Slots are used to disturb current distributions and thus impact on converting a dual band to triple band. The incorporation of slots and Metamaterial has improved the overall performance of the antenna.

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JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

A RECONFIGURABLE MICROSTRIP ANTENNA FOR C, X AND KU BAND APPLICATIONS

Banuprakash R[1], Hariprasad S A[2], Neha R[3], N Janani[4]

[1]Assistant Professor, Department of Telecommunication Engineering BMS institute of Technology & Management, Bengaluru Visvesvaraya Technological university, Belagavi
[3,4]Students, Department of Telecommunication Engineering BMS institute of Technology & Management, Bengaluru Visvesvaraya Technological university, Belagavi
[2]Director, FET, Jain University,

Emails : [1]Bengaluru r.bhanuprakash @ bmsit.in

Received: 14 April 2020 Revised and Accepted: 8 August 2020

ABSTRACT : This work introduces a square shaped antenna with quadruple band reception with size $25x25x1.6mm^3$. The reconfigurability of frequencies is obtained by two PIN diode switches. The antenna resonates at frequencies 6.2GHz, 8.1GHz, 17.7GHz and 18.4GHz with return loss of about -10.7124dB, -18.2627dB, -22.5452dB, -25.5545dB correspondingly. FR4 with permittivity of 4.4 is the dielectric medium used here. The design and simulation has been done by using Ansoft HFSS software with substrate FR4_epoxy, which has dielectric constant 4.4

KEYWORDS: Quad band, PIN diode BAP6502, Reconfigurability

I. INTRODUCTION

A reconfigurable radio wire is a gathering contraption fit for changing its repeat and radiation behavior dynamically, in a efficient way. So as to fetch unique reaction, reconfigurable radio wires coordinate an inward system that allow the intended rearrangement of RF fluxes on the surface of the receiver and produce reversible adjustments in its characteristics. Reconfigurable passive devices diverge from keen reception apparatuses on the grounds that the reconfiguration instrument lies inside the recieving antenna, as opposed to in peripheral beam forming system. The re- configuration capacity of re-configurable reception apparatuses is utilized to expand the antenna execution in a changing situation.

II. LITERATURE SURVEY

Minimal multi-band reconfigurable radio wires have likewise been proposed which targets cell phone application with omni-directional examples[1]. The reconfigurable reception apparatus is one of significant perspective in psychological radio frameworks alongside detecting receiving wires. The recurrence reconfigurable reception apparatus is structured utilizing microstrip fix receiving wire having reconfigurable channel.[10]

Radio wires are basic segment of any remote specialized gadget. They productively move electromagnetic vitality from a transmission line into free space. As of late, interest for little reception apparatuses on remote correspondence has expanded the enthusiasm of exploration take a shot at minimized fix radio wire structure among correspondence engineers [1-3].

To help the high portability need for media transmission gadgets a small and light weight conservative fix receiving wire is one of the most appropriate applications. Microstrip fix reception apparatuses are manufactured on a dielectric substrate. These receiving wires can be inserted alongside different segments in a framework. These reception apparatuses are broadly utilized in correspondence frameworks on account of their simplicity of examination, less cost, light weight, simple to take care of and their alluring radiation characteristics.one of the significant hindrance of fix receiving wire is limited data transfer capacity and low gain.[15]

Radio wire reconfigurability has been a subject specifically noteworthy over the previous decade. Greater adaptability in reception apparatus structures not just makes it conceivable to lessen bothersome misfortunes in remote correspondence joins, however can give increasingly refined frameworks which adjust to their surroundings and client situations. [7]

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

Remote connections are dependent upon numerous wellsprings of blurring, which add to low motion toward commotion proportions, low information rates or even total loss of sign. [5]

The physical viewpoints are hard to change intensely, yet utilizing a regular fix gathering contraption with various feed centers, it is possible to electrically modify its polarisation execution. Example assorted variety reception apparatuses are utilized in different remote correspondence frameworks, for example, base station radio wires, versatile handset recieving wires and MIMO decent variety radio wires. [3,10]

The reconfiguration component can be acknowledged by utilizing twofold post twofold through (DPDT) switch8or varactor diode 9or RF switch10or pin diode or GaAs FET switch, smaller scale electromechanical switches (MEMs) or counterfeit trans-mission lines[3]. All in all, reconfigurable reception apparatuses can be arranged into 3 gatherings, either dependent on radiation example, polarization, or as recurrence reconfiguration[5].

A reconfigurable mechanism with switching operation multiband functionalities is presented. The gathering mechanical assembly works one by one at five adjoining repeat substitute bands in ultra wideband repeat band of 6 to 10.6 GHz. Initially starting with a sub band then onto the next is ready electronically with five PIN diodes. The receiving device in like manner has a vertical polarization and practically omnidirectional radiation plan, with at all of its repeat sub bands. Reformed, evaluated results are considered and are displayed to be in worthy understanding.[10]

With the brisk improvement of remote exchanges, handsets are eventually required to be lighter in weight, lower in cost, humbler in estimation, and continuously exceptional in their highlights. Besides, handsets might be required to work at various measures or for different applications [11].Recurrence gathering contraption is a superior choice other than wide band or multiband recieving wires due than their capacity to alter the working repeat band [14]. Reconfigurability is fusing frequencies into one repeat with the best expansion and transmission ability to meet a particular application [15].

ANTENNA FORMULAS

Width (W) -

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Calculation of Effective length (L)-

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

ANTENNA GEOMETRY

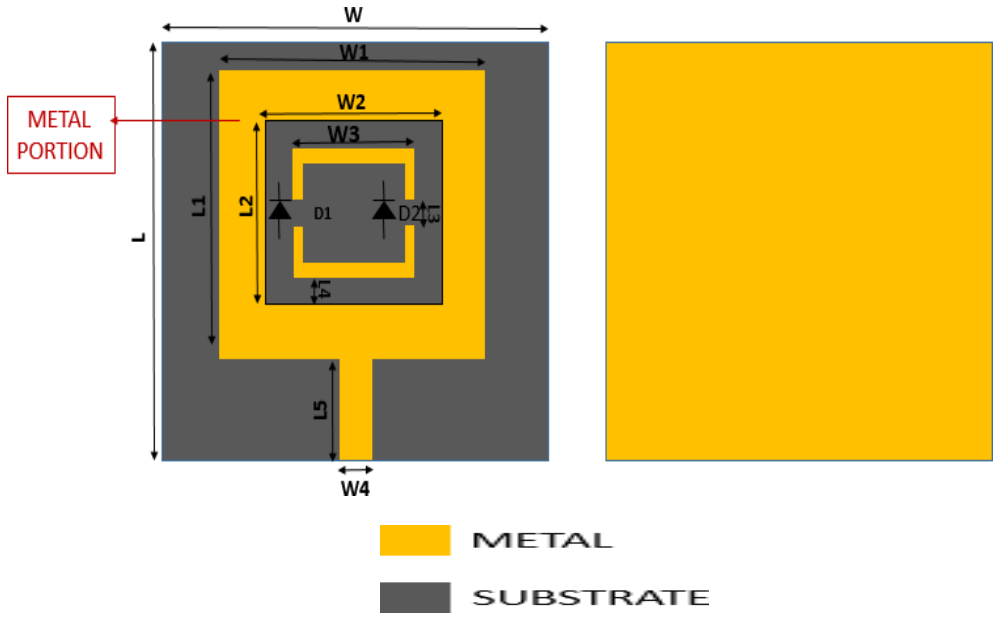

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Figure. 1: Antenna Front and Rear view Table. 1: Measurements of the Design

Sl. No.	Dimensions of the Design	Indicating Letters	Measurements (mm)
1.	Length of Substrate	L	25
2.	Span of the Substrate	W	25
3.	Extent of the outer Patch	L_1	18
4.	Distance of the outer Patch	W_1	18
5.	Extension of the inner metal	L_2	12
6.	Span of the inner metal	W_2	12
7.	Width of the innermost metal region	W_3	8
8.	Width of the feed	W_4	2
9.	Length of diode	L_3	1
10.	Space between inner and innermost patch	L_4	1
11.	Length of the feed	L_5	5.5

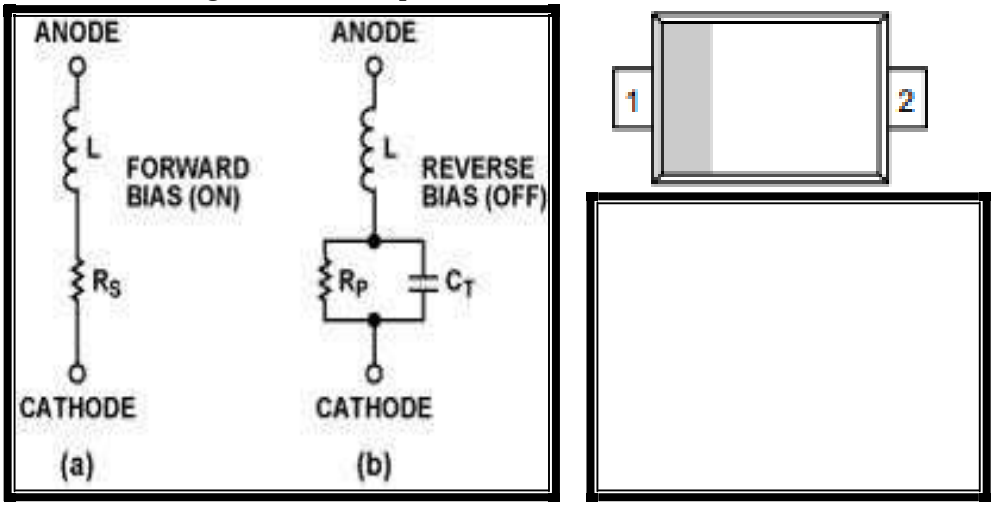
The table 1 speaks to each part of the structured radio wire. It incorporates the names given to components, their membership and measurements of each component remembered for the recieving wire. It appears the measurements utilized for planning of the recieving wire are in millimeter. It would support an individual to totally comprehend the development of the planned radio wire.

BAP65-02 PIN Diode

To maintain a strategic distance from this statement of charge at the door of a transistor, a diode is commonly utilized backward one-sided mode which can deplete out the charge without influencing the transistor hardware The diode used is BAP65-02 pin diode. Its features are

1. High voltage, current controlled
2. Less diode Capacitance
3. Low forward Obstruction
4. Very low arrangement inductance
5. RF resistor for RF switches

Figure. 2: Diode Equivalent Circuit and its outline



The BAP6502 diode is utilized in the arrangement to get configurable structure. The forward one-sided proportionate circuit involves inductance L= 0.5nH and obstruction RS
=1ω is showed up in Figure 2(a). The inductance l=0.5nH is coupled to an equal blend of obstruction RP=1 Ω and capacitance of CP=0.1μF as showed up in Figure 2(b).

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III. RESULTS

i. Without Diodes

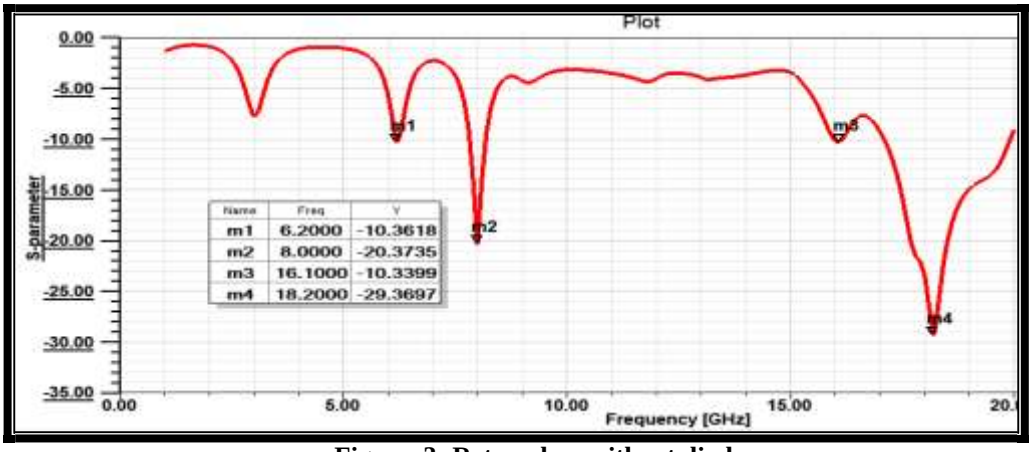

Figure. 3: Return loss without diodes

Without the use of diodes the microstrip antenna produces 4 frequencies at 6.2GHz , 8GHz , 16.1GHz and 18.2GHz respectively with a return loss of - 10.36dB, -20.37dB, -10.33dB and -29.36dB respectively.

a) Instance 00

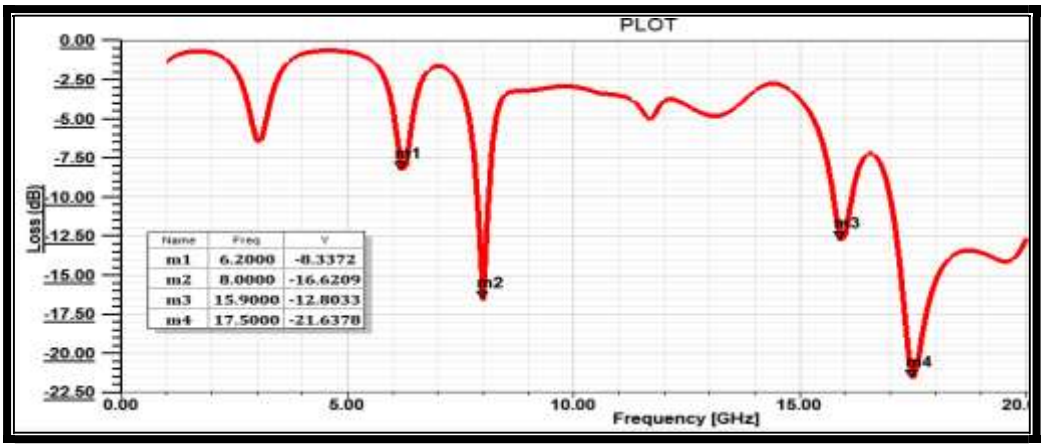

Figure .4: S11 vs Frequency

b) Instance 01

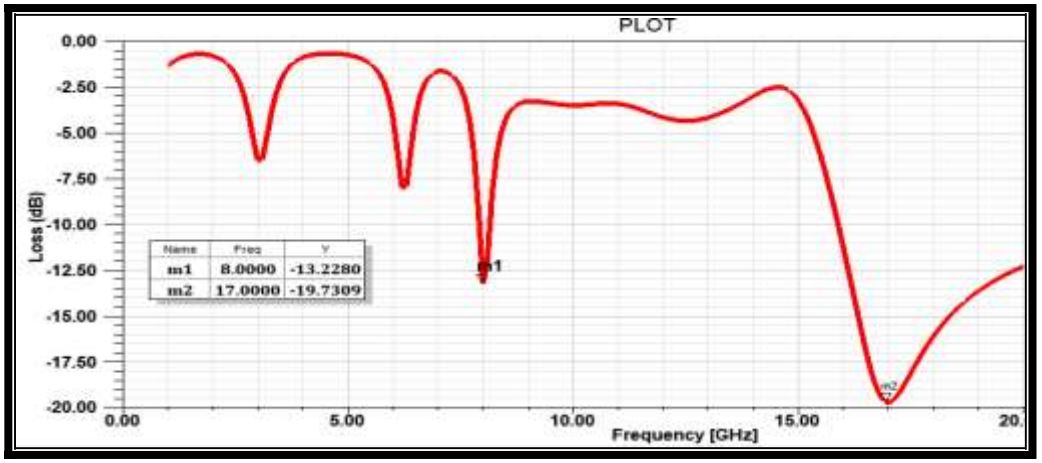

Figure 5: S (1,1) versus frequency

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c) Instance 10

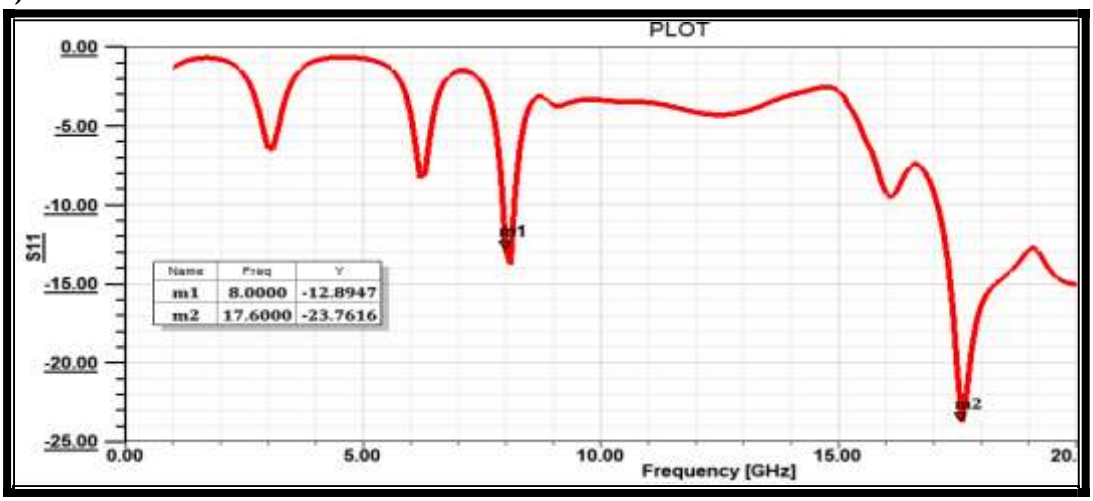


Figure 6: S parameter vs Frequency

d) Instance 11

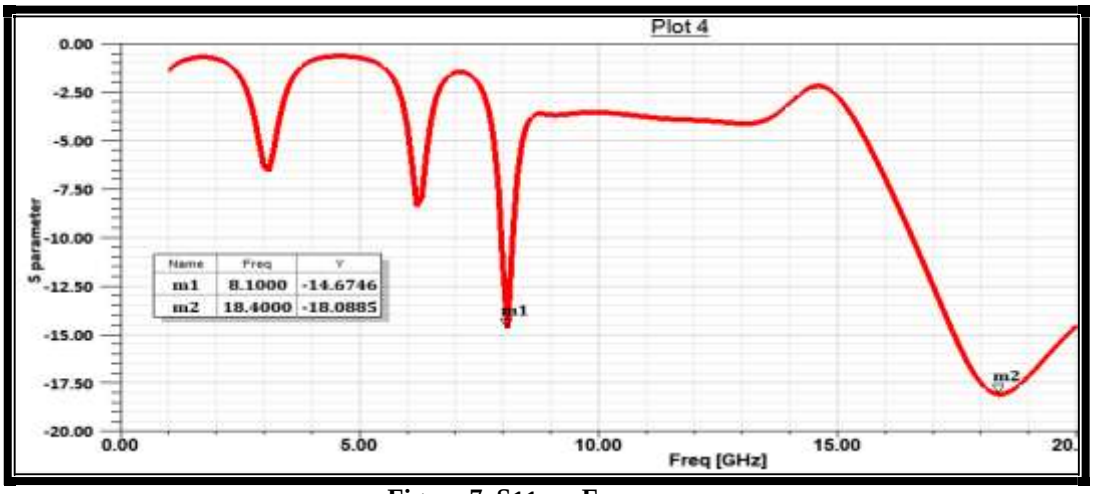
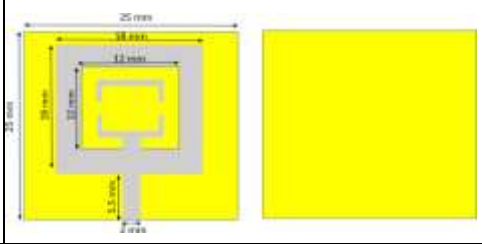
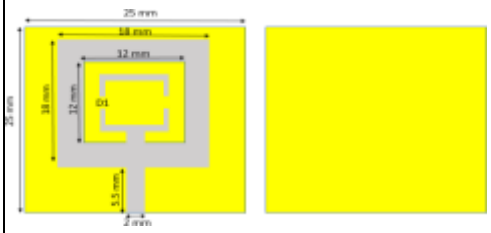
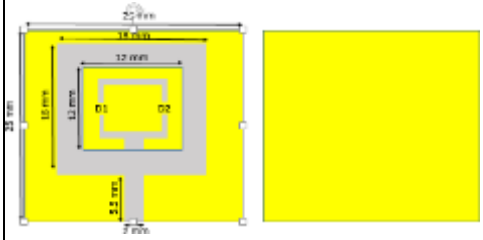
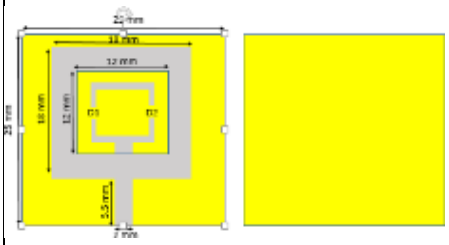
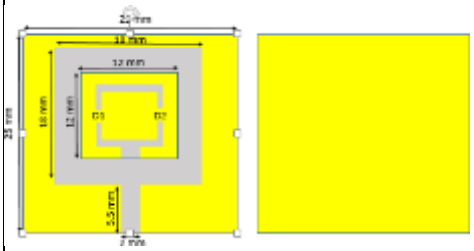
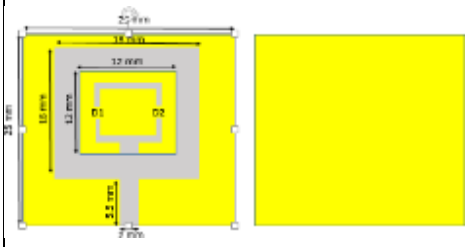


Figure 7. S11 vs Frequency

Above graphs show return loss vs frequency for 00, 01, 10, 11 cases. The recurring frequencies in all the four cases is 8.0GHz/

Table. 2: Intermediate steps

SL NO.	STEPS	FREQUENCY (GHz)	S11 (dB)	Gain (dB)
1.	Without Diodes 	6.2 8.0 16.1 18.2	-10.36 -20.37 -10.33 -29.36	-9.40 5.13 5.69 1.80
2.	With Left Diode	6.2	-10.02	-8.67

		7.9 16.1 18.1	-19.70 -10.80 -36.65	2.04 5.32 4.40
3.	With Diode D1 OFF (0) and Diode D2 OFF (0) 	8.0 15.9 17.5	-16.62 -12.80 -21.63	3.35 8.93 6.55
4.	With Diode D1 OFF (0) and Diode D2 ON (1) 	8.0 17.0	-10.56 -21.56	2.99 5.54
5.	With Diode D1 ON (1) and Diode D2 OFF (0) 	8.0 17.6	-12.89 -23.76	2.63 6.86
6.	With Diode D1 ON (1) and Diode D2 ON (1) 	8.1 17.6	-14.67 -18.08	3.33 9.02

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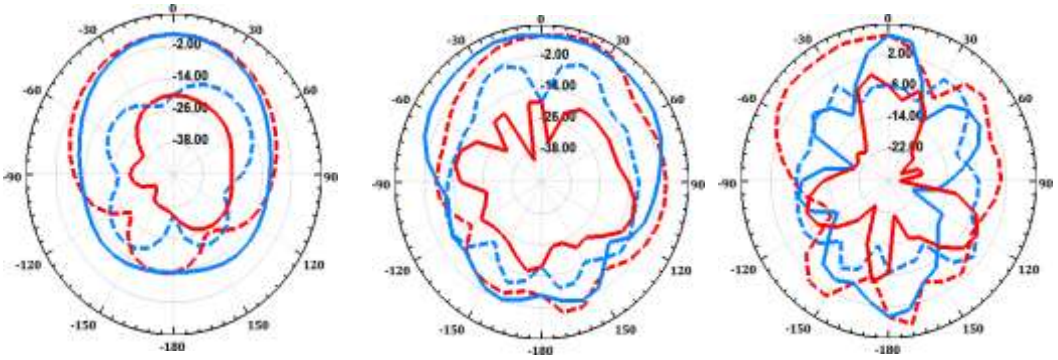
IV. RADIATION PATTERN

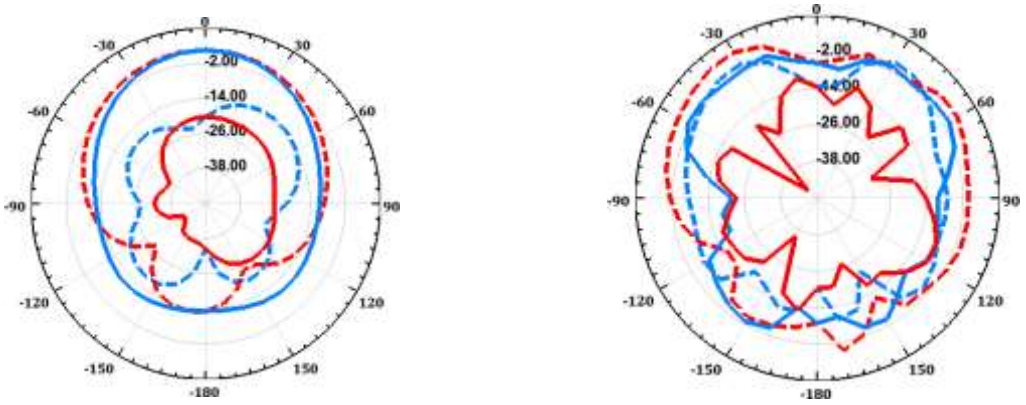
Condition 1: Diode 1 is OFF and Diode 2 is OFF

8GHz **15.9GHz** **17.5 GHz**



Condition 2: Diode 1 is OFF and Diode 2 is ON

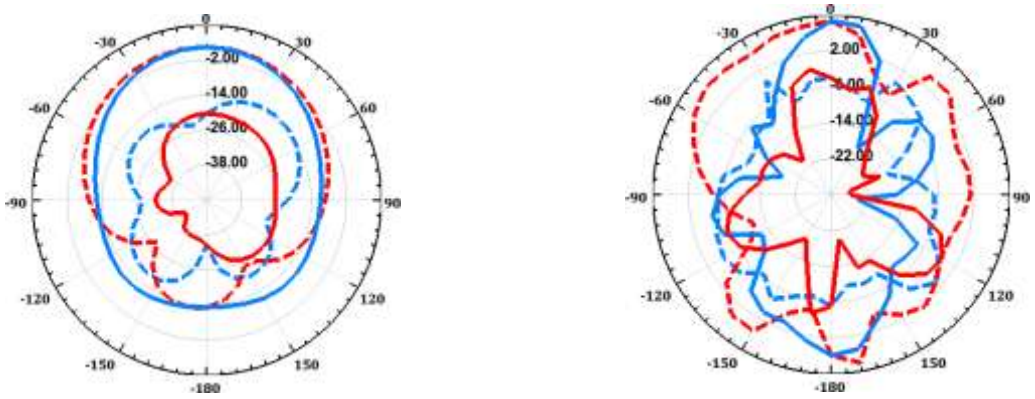
8.0 GHz **17.0GHz**



Condition 3: Diode 1 is ON and Diode 2 is OFF

GHz **17.6 GHz**

Condition 4: Diode 1 is ON and Diode 2 is ON



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GHz **17.6 GHz**

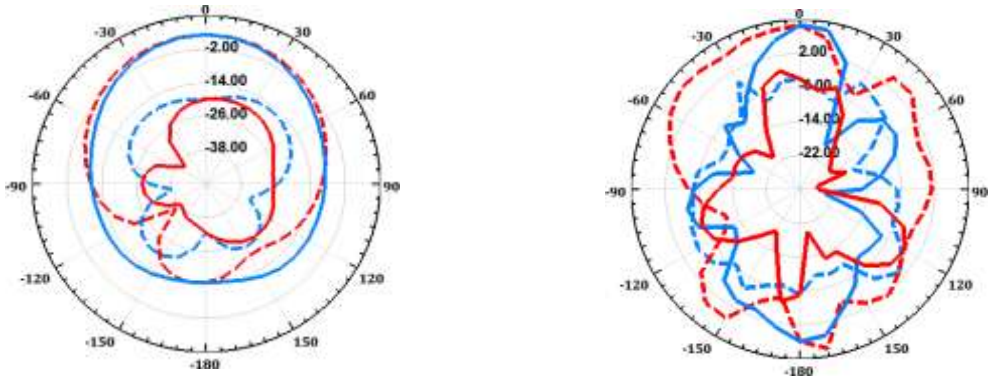


Table. 2 : Polarization

	H plane	**Copolarization**
		X- polarization
	E plane	**Copolarization**
		X- polarization

V. GAIN

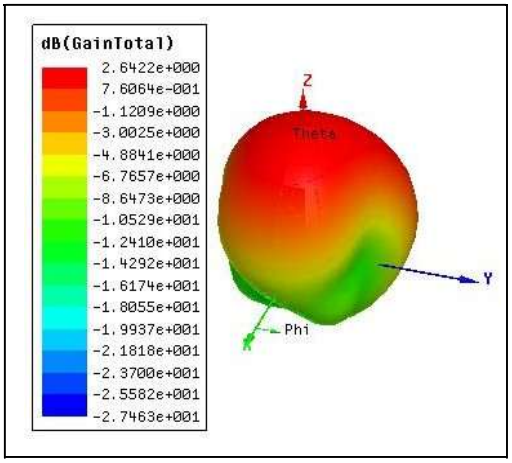


Figure 8: At 8 GHz

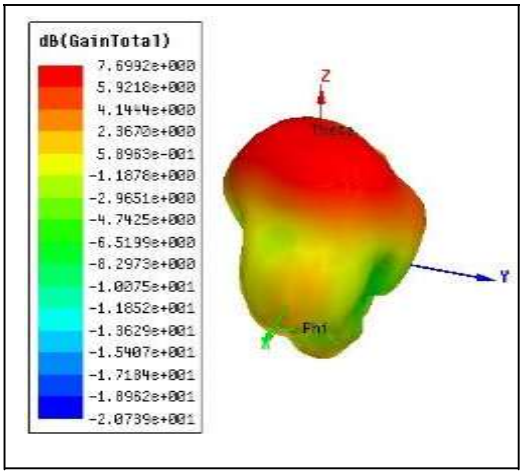
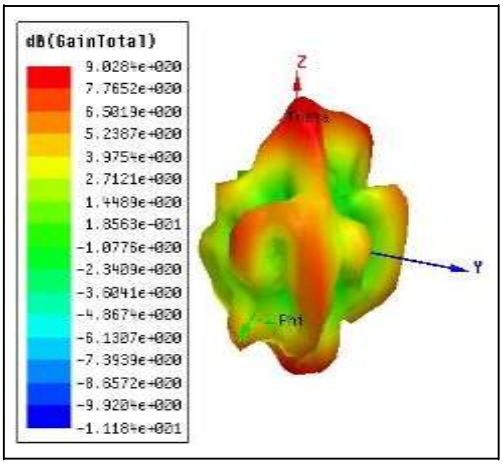


Figure 9: At 15.9 GHz



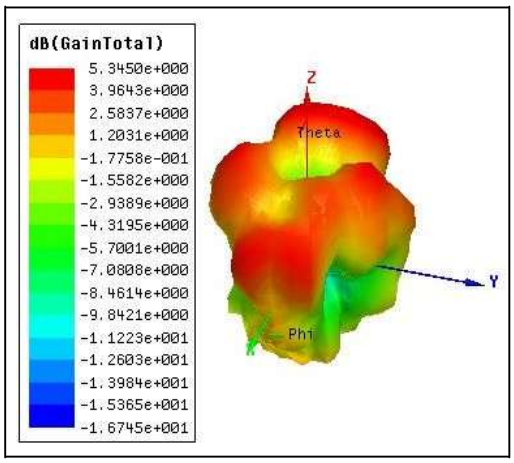


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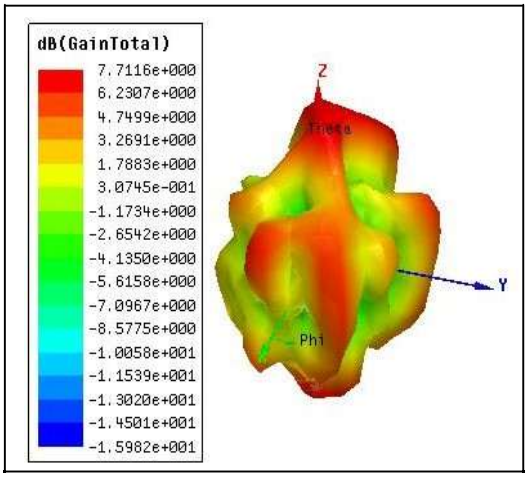
Figure 10: For 17.6 GHz

Figure 11: For 17 GHz



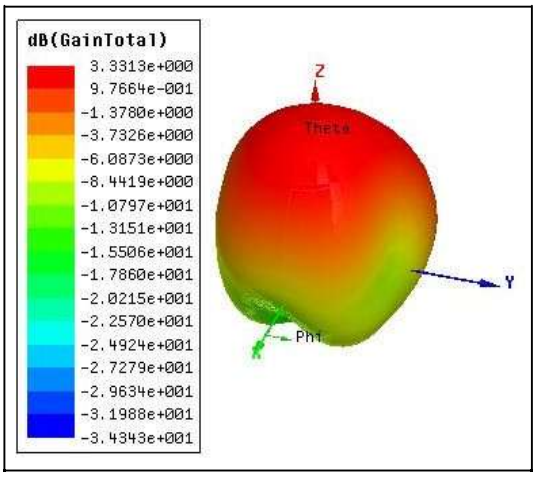


Figure 12: For 17.5GHz

Figure 13: For 8.1GHz

It is evident from the above figures that planned antenna produces gain of 0.212dB for 6.2GHz, 1.5542dB for 8 GHz, 7.8962dB for 17.4 GHz and 5.9861dB for 18.2 GHz.

Table. 3: Comparison with Literature

Ref. No.	Size (mm^3)	Frequency (GHz)	S11 (dB)	Gain (dB)
[3]	50 x 50 x 1.6	1.88 – 2.55	-10	4.54/5.16
[5]	49 x 37.8 x 1.6	3.5 – 5.97	<-10	2.47
[6]	150 x 12.5 x 1.6	11	-10	10
Proposed antenna	25 x 25 x 1.6	8/15.9/17/17.5	<-10	2.6/7.6/5.3/9.02

VI. CONCLUSION

A Quadruple band reconfigurability antenna is designed in this paper using FR4 Epoxy Substrate and the metal considered is Copper (Cu). The tool used is HFSS. The proposed frequencies are 6.2GHz, 8GHz, 17.4GHz and 18.2GHz. The designed antenna operates at C, X, Ku and K bands respectively. It tends to be utilized for RADAR applications. The diode utilized is BAP65-02. Simulation and experimental outcomes shows that the proposed design has excellent impedance matching with moderate gain performance across the frequency band of interest.

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Dual Band Compact Hexagonal Microstrip Antenna with Quadrangular Slot and I Shaped DGS

Banuprakash R, Hariprasad S A

Abstract*: *Here an hexagonal printed antenna is reported. The antenna has measurement volume of 800 mm^3. It operates at the frequencies 2.9 GHz, and 6.3 GHz with S_{11} of -10.17 dB and -14.49dB respectively. It has produced acceptable gain of 2.065dB for 2.9 GHz and 3.45dB for 6.3 GHz. The frequencies obtained are useful for aeronautical radio location and satellite applications. The antenna is designed using HFSS software and tested using ZVH vector network analyzer.

Keywords* : *Dual band, radio location, HFSS, VNA.

I. INTRODUCTION

The designers come across many challenges due to the intense progress of contemporary wireless networks and the pertinent applications [1]. Multiband antenna has become proficient in current mobile communications. Incorporating several frequencies into a movable device is done through ample significant efforts [9].

Due to its unique features printed antenna is the most prevalent in today's microwave communication . It consists of radiating metal on one side and metal groundplane on the other side, in between these two sides a dielectric medium is present. It devises the amenity of being low outline, low cost, simple structure to construct[3]. Patch antenna offers linear or circular polarization with multiple frequency operation.[6]. To acquire the required frequency, with S_{11} below -10dB , to improve the bandwidth , to improve the gain and for better radiation patterns slots can be made either on patch and on ground plane which is defective ground structure(DGS) [2][10].

Different structures of patch can introduce wider bandwidth like U shaped slot and E shaped radiating element [4]. Lower dispersion, wider bandwidth and less radiation loss can be exhibited by slot antennas than microstrip antennas. The connection of active and passive elements in series and parallel for improving the gain becomes easy if the feed is coplanar waveguide. [14].

Slots of an antenna can be of different shapes like rectangular, square, circular. A wideband response can be obtained by combination of patch resonance and the resonance created by slot.[11]. The variations of slot dimensions provide more effects on the Circular Polarization and minute impact on impedance [7].Fractal geometry can also be used to improve impedance bandwidth of printed antennas by making similar type of slots with different measurements [12][13].

The slots are not only responsible for producing the multiple frequencies by disturbing the current distribution but also improves the impedance matching of an antenna. For this a small portion of metal portion can be etched based on the distribution of current[15]. To enhance the performance of an antenna the slot dimensions play a vibrant role . The substrates with higher value of dielectric constant are vital in miniaturizing the antenna size[8].

II. ANTENNA GEOMETRY

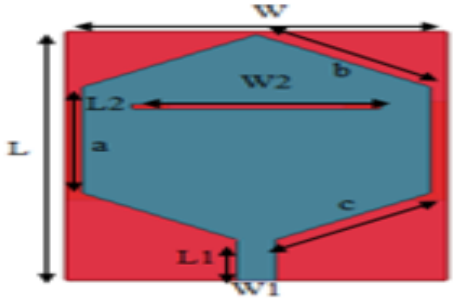


Figure1.Front View

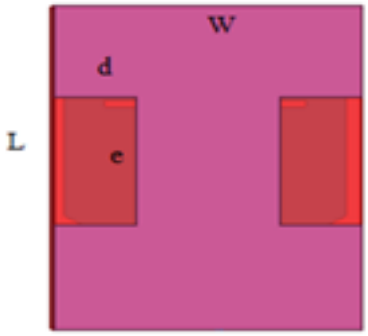


Figure2. Back view

Revised Manuscript Received on March 29, 2020.

***** Correspondence Author

Banuprakash R*, Electronics and Telecommunication Engineering, BMS Institute of Technology and Management, Bengaluru, Visvesvaraya Technological University, Belagavi, India. Email: r.bhanuprakash@bmsit.in.

Hariprasad S A, Electronics and Communication Engineering, School of Engineering and Technology , Jain University, Bengaluru, India.

L	25mm
W	20mm
L_1	4.1mm
W_1	2mm
L_2	0.5mm
W_2	13mm
a	6mm
b	5mm
c	5mm
d	5.3mm
e	10mm

Table 1: The measurements of the design

III. SIMULATED RESULTS

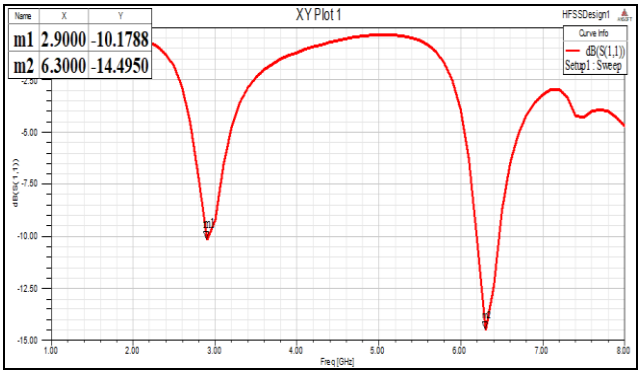


Figure3. S_{11} vs Frequency

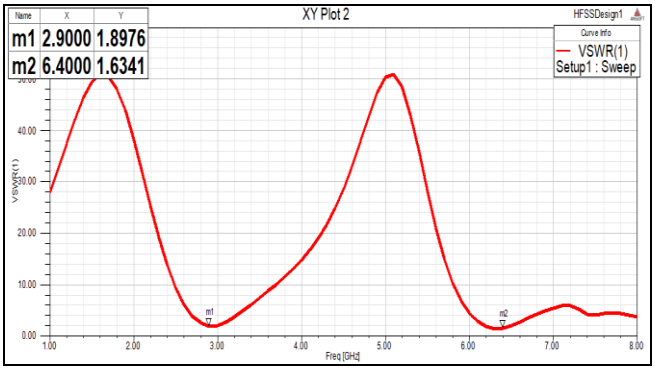


Figure4. VSWR

Parametric Analysis:

The antenna with hexagonal patch generated a frequency of 4.2GHz with a return loss of -10.45 dB. To transform it as multiband antenna a rectangular slot of 0.5x13mm^2 is made on the patch, frequency obtained was 6.3GHz. The return loss is minimized through I shaped defective ground and slot on patch with dimension of 1x13mm^2. The frequencies obtained were 2.9 and 6.3 GHz correspondingly.

Steps	Structure		Frequency (GHz)	S_{11} (dB)
1.	Hexagon patch		4.2	-10.45
2.	Patch with slot dimension	0.5x13 mm^2	6.3	-10.10
		1 x 13 mm^2	3.2 6.5	-5.81 -7.13
3.	With slot on patch and DGS		2.9 6.3	-10.17 -14.49

Table 2: Design steps

GAIN:

The plot of gain for above mentioned frequencies are as follows :

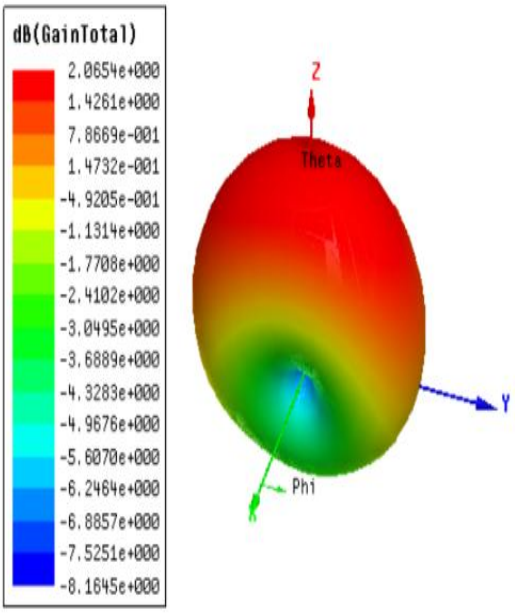


Figure.5: For 2.9GHz

IV. FABRICATED ANTENNA

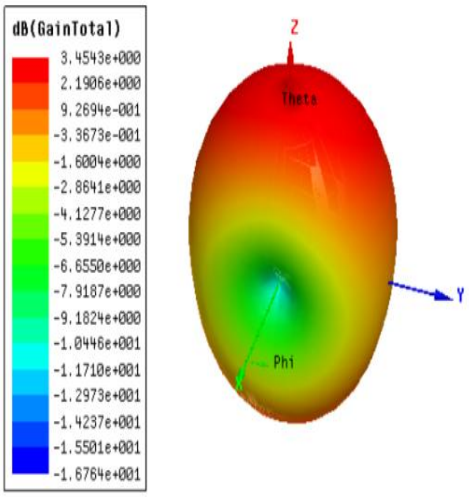


Figure.6: For 6.3GHz

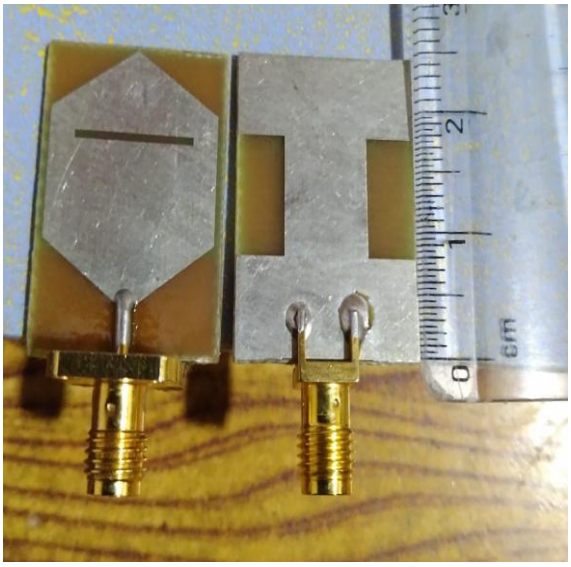


Figure7: Fabricated Antenna

V. MEASURED RESULTS

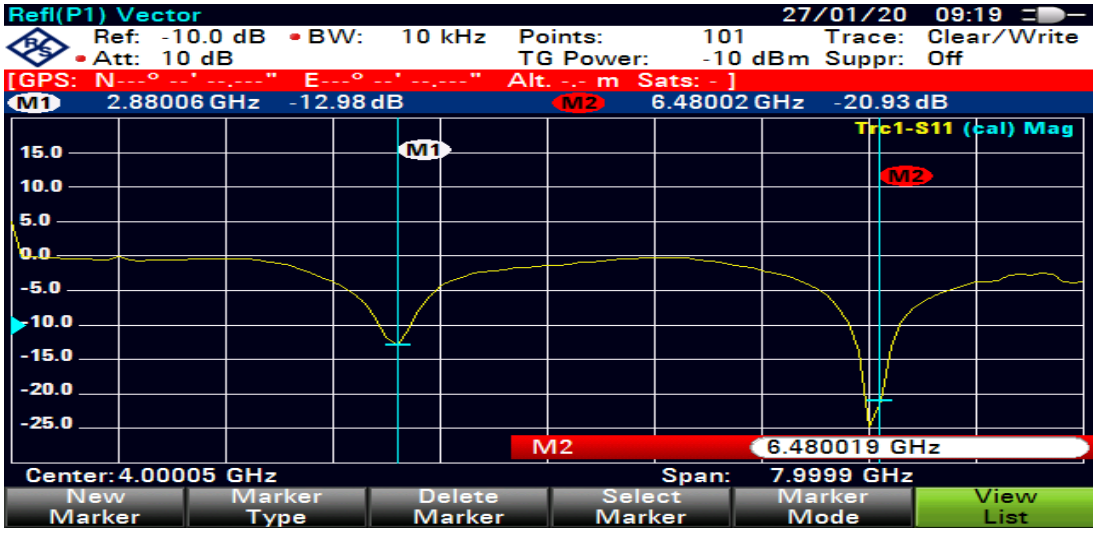


Figure 8: Measured S_{11}

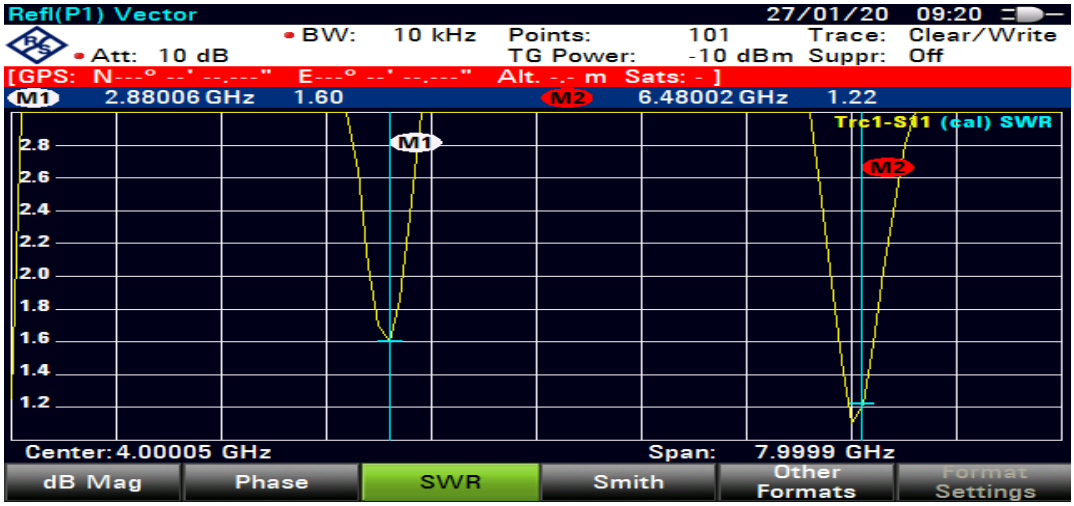
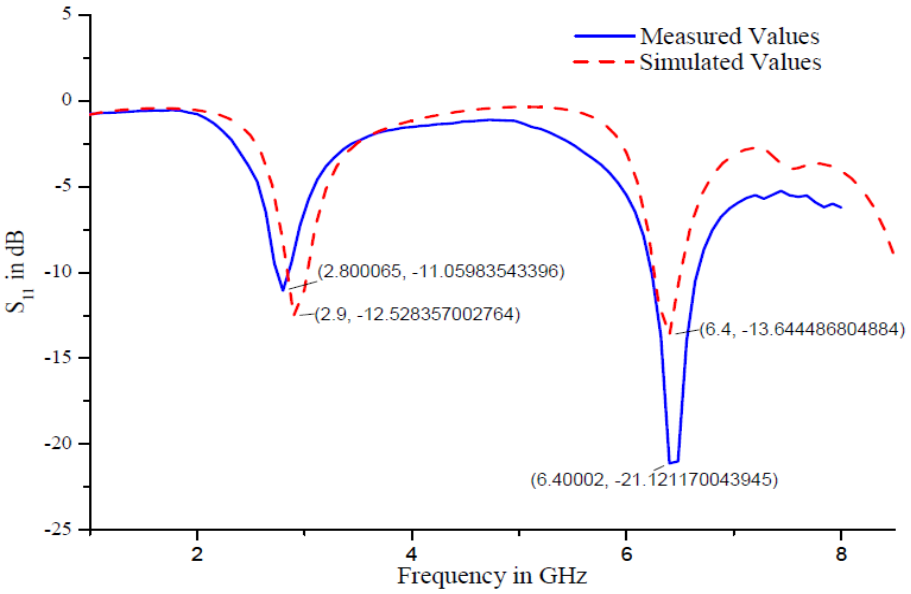


Figure 9: Measured VSWR

SIMULATED Vs MEASURED RESULTS



Parameters	Simulated		Measured	
Frequency in GHz	2.9	6.3	2.88	6.48
S_{11} in dB	-10.17	-14.45	-12.08	-20.93
VSWR	1.89	1.63	1.6	1.22

Table3: Simulated Vs Measured results

V. RADIATION PATTERNS

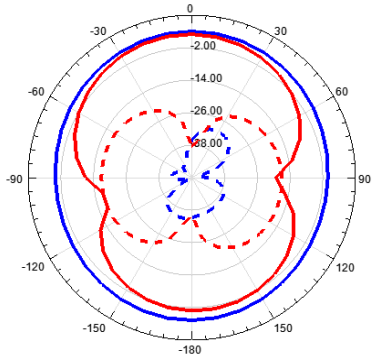


Figure 10: For 2.9GHz

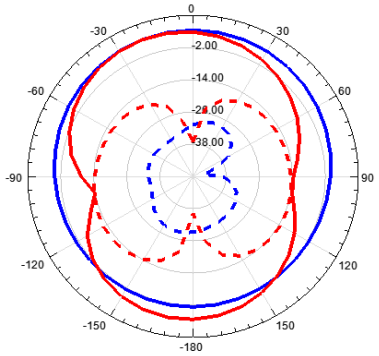


Figure 11: For 6.3GHz

COMPARISON OF PROPOSED ANTENNA

Ref. no.	Total area (mm^3)	Operating bands (GHz)
[5]	34x30x1.6	5.8
[4]	135x135x1.2	1.85/2.19/ 2.5
[2]	50x33x0.8	2.4/3.5
[3]	50x33.5x1.6	1.9 / 2.8/5.1
[1]	26x32x1.6	3.4/6.7
[15]	24x30x1.5875	2.84/ 1.54
Proposed antenna	25x20x1.6	2.9/6.3

Table4: Comparison with literature

VI. CONCLUSION

The insertion of slots produced multiband frequencies. The defective ground expands the performance of antenna by reducing standing wave ratio. The proposed antenna operates at 2.9GHz and 6.3GHz with S_{11} of -10.17dB, and -14.45 dB respectively. As the size reduces there is a challenge to produce good gain. With the help of I shaped DGS the gain obtained is acceptable for the miniaturized antenna with total volume of 800 mm^3

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AUTHORS PROFILE

Banuprakash R presently working in Electronics and Telecommunication Engineering department, BMS Institute of Technology and Management, Bangalore, India, He is BE, M.Tech, and pursuing Ph.D in the field of RF communication. He published around 15 research papers on antennas in international journals and conferences. He has got Best Paper award twice for the research papers in IEEE conferences. Guided 20 UG projects. He was Resource Person for the training program on RF communication at different institutes.

Hariprasad S A completed B.E degree in the year 1991, M.E in the year 2000, He Completed PhD degree in the year 2011 and two additional highest degrees, doctor of science degrees in the year 2013 and 2014 for the post-doctoral research work on communication and embedded systems.Working with Department of Electronics and Communication Engineering, Jain University, Bangalore. He also established industry supported labs and served as visiting professor for various reputed colleges in Bangalore. He executed funded projects tuning to 1 crore rupees for various government funding agencies. Guided 34 PG projects, 40 UG projects and guiding 8 PhD students. He has delivered expert talk in conferences and workshops in the area of embedded systems and Microwave Engineering domains. Worked as main Coordinator as well as mentor for input/output and outcome Based Education Accreditation models. Won awards for best teacher for publishing international conference paper and text book. He has published 60 research publications in both International and National Journals and presented papers in National and International conferences. He has written text book on Advance Microprocessor.

Research Challenges and QoS Provisioning MAC Protocol for Cyber Physical Systems

Saritha I. G., Rajeshwari Hegde

Abstract: ***One of the latest emerging class of systems which implants cyber features into the physical world is the Cyber Physical System (CPS), which provides a platform for interaction between physical world and virtual world. CPS promises to transform the physical world to virtual world through interaction similar to human interaction with each other. With the increasing demand of cyber physical systems in various applications, it requires wide variety of communication protocols for reliable and real time data transmission. The low- power and low – cost features of some canonical protocols lead to some short falls, reliability and timeliness. In this paper, we discuss an extensive survey on MAC protocols and Research challenges for enhancing the QoS in CPS.***

Keywords : CPS, MAC and QoS

I. INTRODUCTION

It is required to bridge the existing world to the virtual world to accompany the communications and computing with the great revolution from embedded systems to networked CPSs. Cyber physical system is a integration of networking, assessment and physical objects so that networked embedded devices sense, actuate and control the physical world [1]. Though, wireless sensor network became the significantly growing research, research in cyber physical system is moving in the direction to improve the interactions among human and object in the physical world and the virtual world [14]. The QoS linked problems in such networks could be addressed using an efficient QoS aware protocol [12]. Fig. 1 shows the interaction and dataflow between the virtual and physical. In this scenario, the physical world could be the real hospital and the virtual world could be the networked hospital. The interactions happen between these worlds through the intelligent components. The data protection and the security are the biggest challenge in the cyber physical world.

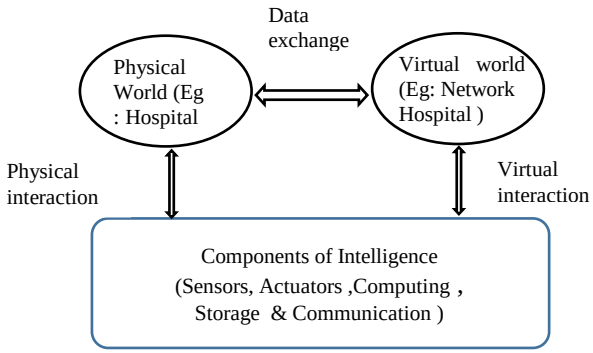

Fig1. Interactions and data flow in CPS

Revised Manuscript Received on December 05, 2019.

Mrs. Saritha I. G., Asst. Professor, Dept. of ETE ,BMSIT, Bengaluru, India.

Rajeshwari Hegde, Dept. of ETE, BMSIT, Bengaluru, India.

Relationship Between Wsn And Cps Features

1. Quality of services: CPS focuses towards high-level QoS, such as network usage, confidentiality and security of sensing data with high quality of information/intellect etc which is again very important for WSN.

2. **Network formation**: Network formation in WSN is with low mobility and field-specific which connects on Internet. However, sensor network is dynamic in nature for participation and departure.

3.**Communication pattern**: WSN incorporates query-response based collective converge communications which allows different routing capability. Some of CPS applications are like flood prevention, water-level controlled dam water gates allows both cross-domain communications and WSN

4. **Power management:** As sensors are generally deployed on unattended areas, WSN focuses on energy saving with deeper sleeping modes and more redundancy. Whereas activation of sensors have diversified modes in CPS.

5. **Network coverage:** WSN allows both connectivity and coverage for a single network. The CPS allows different levels of connectivity and coverage for diversified sensor networks.

6. **Node mobility:** The node mobility is very less in **WSN** without any control. Whereas the controllable and uncontrollable mobility achieved by CPS applications which lead to collect sensing data from mobile sensor nodes.

7. **Knowledge mining:** A WSN focuses only on data acquisition whereas CPS emphasizes more on collecting and controlling sensed data and also uses its intelligence to utilize properly.

A good optimized network protocol is a design of an efficient MAC protocol. A controlled and coordinated channel access not only reduces power utilization but also ensures high reliability. This paper is planned as below . Section II meant for the transformation from WSN to CPS. Section III highlighted with the QoS demand in CPS. Section IV deals with related work. Section V gives the Unique Features & Research challenges in CPS. Section VI deals with CPS handled QoS parameters from MAC protocols. Section VII describes the applications of CPS and is finally concluded in section VIII.

II. TRANSFORMATION FROM WSNS TO CPS

By integrating and bridging the gap between information and intelligence of cyber world to sensing and controlling of physical world,

CPS transformed from WSN to overcome the issues like formation of network, power and security. CPS features are categorized in the table 1.

Table1: CPS applications over Platforms

Applications	Cross domain Sensor Types	Heterogeneous Information flows	Intelligent systems
Healthcare systems	ECG, EEG, EMG , SPo2, Accelerometer and tilt ensors.	Zigbee/BSNs/GPRS/Bluetooth WLAN	Sensing entity, Actuator entity, Home manager , Surveillance centre , Locality Manager , Local responder.
Navigation & Rescue applications	Smoke , Temperature, Humidity, Camera sensors, Life detectors and Infrared sensors	Wifi/Zigbee/IEEE802.15.4	Fire Grid --Data acquisition --Simulation component --Agent based Command – control component --Grid Middleware component
Intelligent Transport systems	Accelerometer, Microphones, Inertial sensors and Air sensors, GPS, Ultrasonic and range sensors.	Intra vehicular communication -OBD & CAN bus Vehicle to vehicle communication -DSRC/WAVE Toll collection-Electronic toll collection Traffic- Car web	VTrack & Park net
Social Networking and Gaming Applications	Inertial sensors & Thi- chi	BSN/WSn/Wifi GPS	CenceMe 1.Conversation classifier 2.Social context 3.Mobility mode detector 4.Location classifier Am I Hot .

III. QOS DEMAND IN CPS

Need for designing a CPS QoS include

(1) Service-oriented architecture (SOA) lead to decay CPS into various small units as services with quick and scalable growth of CPS.

(2) Cross domain communications to achieve high QoS.

(3) Adaptation and allocation of resources such as Energy, CPU time, Memory and Bandwidth achieved by Minimized resource management.

(4) QoS-aware power management for minimized power requirement [14].

Minimizing resource utilization and maximizing QoS is a great challenge to upcoming CPSs which can be achieved by Cloud computing technique. Cloud computing services categorized as following types:

(1) Infrastructure as a Service assists the lower-layer for users' cloud infrastructures, Platform as a Service (PaaS), facilitated application development by virtual platforms and service APIs and Software as a Service (SaaS) aids a set of software and applications with convenient QoS [14]. Fig. 2 shows the various components of a CPS.

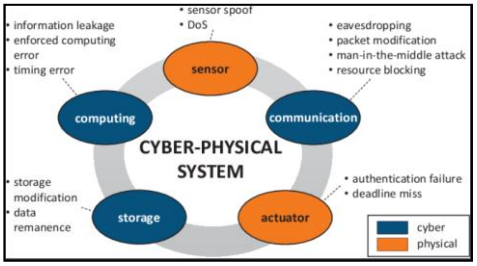

Fig2. Components of CPS

IV. RELATED WORK

Due to harsh RF environment and applications of wireless networks in CPS which impose hard real time constraints and high reliability differentiates it from the conventional embedded systems.

As MAC protocol is the key consideration for enabling CPS networks, Meng Zheng et al., [5] anticipated a novel MAC protocol to attain instantaneous priority aware polling. In [2], the authors have proposed the optimized design of efficient MAC-RA and a review on the expected challenges and features for IEEE 802.11ax. In the context of TDMA MAC protocols for CPS networks [15] deals with number of slots to allocate for retransmissions. In [11], to achieve low cost channel state estimation, the authors proposed a scheduling algorithm for wireless sensor networks [8] to investigate the scheduling of TDMA slots for retransmissions to reduce the packet drop to avoid the missing of deadlines. In [6], a new protocol for industrial wireless networks was proposed to overcome the limitations of the existing TDMA-MAC protocols.

V. UNIQUE FEATURES & RESEARCH CHALLENGES IN CPS

This section explains the unique features of CPS.

Cross domain sensor exchanges the sensed data with heterogeneous network and intelligent systems.

1. Mobile and Embedded Sensing uses dynamic high degree mobility sensors which vary sensing coverage over time for analyzing mobile data.
2. Give & take like models to encourage sharing and privacy issues.
3. CPS adopts "pay as you go "concept to serve cloud supported storage, computing and communication capability.
4. Acquired intelligence and comprehension by means of knowledge and data mining is essential for understanding temporal and spatial correlation for sensed data.
5. A rich interaction among many objects such as Sensor – sensor, sensor – actuators and actuators- user facilitates various applications through internet of things (IOT).

Following are the reviewed Research challenges and progress for better performance of CPS.

1. Networking Issues: - Tiny OS based light weighted power saving IP Network architecture, a low powered embedded devices and IPV6 datagram to carry 802.15.4 frames from LoWPAN. IPv6 based network architectures which services with Hop by Hop, Routing protocols and duty cycle . IP link based border router network architecture lead to upcoming CPSs with cross domain peer to peer communication.

2. Cross domain interface avoidance: The difficulty of communication reliability exist due to multiple devices such as Wi-Fi, Bluetooth and Zigbee**.** To solve the overlapped channels by other networks, a Pessimistic approach is used. A virtual channel approach is used to allow scheduled Zigbee networks by their Super frames. Different channels at diverse period is achieved by Dynamic approach

3. Location based services: Locations of sensor implementation is very important in CPS, as outdoor positioning tracked by GPS, there is a wide demand for indoor positioning which can be scaled up more easily by WLAN infrastructures. Inertial sensors used to facilitate indoor positioning to achieve the signal fluctuation problem.

Small embedded tags used for tracking assets and stolen vehicle.

4. **Monitoring services:** CPS services support continuous monitoring of both WSN and Cooperative models. The sensor carriers include mobile phones, vehicles and many such devices. Mobieyes is used for urban monitoring by vehicles.

5. **Security and Privacy challenges:** As sensed data in CPS are not owned by local devices, security and privacy are the two major issues. Determination of degree of privacy achieved by Utilization data collection model for more sensed data acquisition. Perturbation based techniques used for masking the original data by noise which lead to noise cancellation for accurate calculations. Since perturbation technique prone to more errors, the combination of above said two approaches implemented to overcome the same problem. A privacy based vehicular participatory sensing model implemented by linear regression to diminish modeling error and exploit reconstruction error.

VI. CPS HANDLED QOS FROM MAC PROTOCOLS

A) LPWAN MAC protocols

LPWANs are newly used for monitoring and controlling delay and bandwidth requirements to achieve reliability. Therefore LPWAN MAC protocols ensure end to end bounded delays. The channel utilization for high data rates of CPS [1] used for Long range communications of order 10's of kms.

LPWAN- MAC protocol is introduced as replacement of LoRA WAN to handle such challenges of CPS to improve bursty traffic patterns and high data rates . LPWAN MAC allows differentiated traffic patterns of data slots and transmission channels to achieve 868MHz band .

LPWA MAC meet 84% of peer to peer delays and 100% of throughput , high reliability and zero collision rate of data packets.

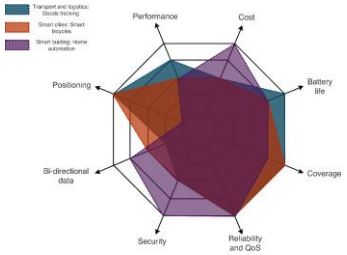

Fig 3 Features of LPWA-MAC DESIGN

i) Underlying Physical Layer: This LPWA-MAC is easily ported and deliberated to the LoRa physical layers.

ii) Channel Access Scheme: LPWA-MAC make use of central authority (the gateway) to traffic differentiation for its channel access and traffic patterns based data slots and time constrained data. Resources like data slots and transmission channels are allocated on demand, so that LPWA-MAC ensures that effective system reliability and zero data collisions .

iii) **Resource Request Discipline:** At any time if a node wanted to channel access to transmit data towards the gateway on request, the nodes need to follow the request regulation. A sole channel is reserved for both uplink demand transmissions and downlink demand approval decisions by LPWA-MAC. The gateway performs discrimination of node's traffic to a explicit channel and request based data slot. It also schedules time slots for transmission of node's data so that the node can be in the sleep mode until its slot for sending data to cut down the battery usage.

B) TDMA MAC protocol

The Industrial wireless sensor network has time constraint in data delivery which is unpredictable due to routing and collision in WSN [4]. To avoid bounded transmission delay and collision of data, TDMA MAC seemed to be very efficient. The slot assignment problem in TDMA is overcome by using simulated anneal algorithm in WSN.

In WSN, the environment status sensed and sends data periodically to sink node which forwards same data to control the centre which take right action to respond. A signal collision problem may take place since data delivery in WSN along with CSMA/CA MAC protocol will lead to raise an issue of reaching sensed data to control centre in bounded delay. To overcome this problem, TDMA MAC protocol is used to have bounded transmission delay so that in every time slot single sensor node is allowed to transmit which achieves collision free medium access using slot assignment scheme with spatial reuse and data aggregation for minimizing the time required for sensed data acquisition and longer the system operation under limited battery power to improve the energy efficiency.

SLOT ASSIGNMENT ALGORITHM

a) Topology Construction*:* The Dijkstra algorithm is used for deriving routing path from every sensor node to sink node. The sensor node sends collected data from neighbor node to sink node and again it replies back

with acknowledgement frame which includes identity of a node its MAC address and number of hops to the source node. The sensor node again sends the neighbor node table to the sink node if sensor node doesn't receive any neighbor discover frame. Once the sink node collects data from all neighboring node table sent by the sensor nodes, the topology is constructed.

b) ***TDMA Slot Assignment:*** TDMA MAC uses a frame which is necessary for assigning slots for all sensor nodes, which allocates one slot to one sensor node, when sensor node overlap each other , these sensor nodes can be allocated to identical slot to reduce frame length.

c) Adaptive MAC protocol: With the rising demands for healthcare systems, Cyber physical systems emerged as high-quality health care monitoring system over Wireless body sensor networks [7]. Communication protocols are required to achieve both reliable, real-time data transmissions with zero collision and more adaptation . IEEE 802.15.4 is a limited power and minimum cost protocols lead to achieve low reliability. Whereas IEEE 802.15.4, based Adaptive MAC protocol is a cross protocol which combines both scheduled based time triggered and contention based protocols with guaranteed time slots allocation. Fig. 4 shows the application of CPS in medical field. The physical parameters from patients are collected using different sensors and the report is sent to the doctor for diagnosis.

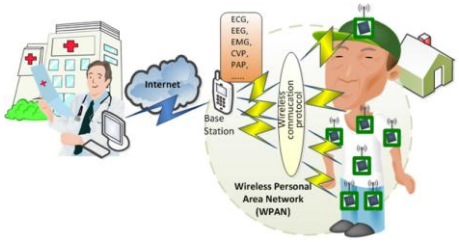

Fig 4. Application of CPS in Medical field

(a)IEEE 802.15.4 and time-triggered protocol

IEEE 802.15.4 is a typical protocol intended for both Physical layer and MAC layer of a small-rate wireless network namely PAN. The Physical layer includes 27 communication channels and acts in three different frequency bands. The MAC layer uses two different modes: beacon-enable mode which enable beacon frame, a time between two consecutive frames to transmit periodically and non beacon-enable which disables beacon frame. The superframe divides equally into sixteen time slots; it contains beacon frame, a contention access period (CAP) and a contention free period (CFP). The Contention free period is elective and contains up to seven GTSs (Guaranteed Time Slot) in every superframe is stored for the particular nodes to transmit time considerable packets.

Time-triggered protocol: This is used in scattered real-time applications which needed a high reliability and it avoids collisions. It also guarantees the data transmission with expected little latency and serviced with minimal overhead.

Superframe structure : This super frame is categorized into a number of fixed mini-slots and each one is long enough to transmit each data packet. The super frame in turn subdivided into the following three periods: (1) Contention free period consists a number of PAN coordinator allocated GTS to the particular nodes to transfer real-time data. (2) CAP is located after the CFP so that every node can send ordinary data using the slotted based CSMA/CA mechanism during the CAP. (3) The inactive period

D) Adaptive CSMA/CA

CPS provisioned QoS in Wireless sensor / actual network plays an important part in applications such as Smart grid, which uses IEEE 802.15.4 in providing multiple QoS [10]. IEEE 802.15.4 slotted CSMA/CA provide static services without providing differentiated services and self adaptability in networks which was overcome by Priority based service differentiated & Adaptive CSMA/CA algorithm to provide differentiated QoS such as Effective data rate, Average delay and Packet loss rate. In Service differentiation Mechanism, service differentiation is needed to enable devices that produce emergency data to take priority over other devices. It consists of three levels L1<L2<L3 for varying different parameters such as Contention Windows, mac Min BEs and mac Max BEs according to priority of the devices.

In Adaptive Backoff mechanisms, it can adaptively adjust BE to traffic conditions. When there is a heavy traffic, a larger BE is used while a smaller BE is used for light traffic, which leads to transmit more effective data packets with less waiting period and smaller amount of collisions. This shows that the future traffic load could be estimated by the effective data rate.

Some of the QoS parameters of CPS in IEEE802.15.4 are listed below

a. **Average delay**-It is the ratio of average time required by data packet to successful packet reception. It is used to evaluate the performance of a real time network.

$$D_{avg} = \frac{Navg}{Nsusspacket} = \sum \frac{(Total\ delay\ by\ all\ packets\ from\ start\ to\ end\ of\ reception)}{(Total\ number\ of\ packets\ successfully\ received\ by\ all\ nodes)} \quad (1)$$

b. **Effective data rate**-This parameter is used to assess link between CPS resource consumption and network dependability.

$$R_{eff\ Data} = \frac{N\ susspacket\ \ X\ LMSDU}{Tend - Tstart} \quad (2)$$

Where L_{MSDU} = MSDU length of data frames and T_{end} - T_{start} = Total time required for transmission

c. Packet Loss rate- This is the ratio of total traffic dropped by network to overall traffic which shows the degree of reliability for effective transmission in CPS.

$$R_{loss} = \frac{N\ dropped}{Ngenerated} = \frac{Traffic\ dropped\ by\ network}{Overall\ traffic} \quad (3)$$

E) **PLA MAC(Priority and Load adaptive MAC) protocol**

Priority and load adaptive MAC protocol for BSNs maintains efficiency in power consumption to improve their QoS and Transmission of data packets schedules based on their priorities. Super frame structure of PLA MAC protocol varies depending on power consumption and quantity of traffic load. BSNs are emerging CPS through improved, lowcost healthcare systems by incorporating improved sensing and actuations [9].

Data packets of PLA-MAC for BSN based on their priority and dynamic super frame structure where slots allocation in the structure vary based on the traffic load .Superframe structure consists of inactive period during low traffic load and it is active when traffic load is high with energy efficiency.

PAL MAC protocol Modifies superframe structure of IEEE 802.15.4 in BSN , traffic classification is based on delay and reliability constraints of data packets .

The different priority and back off calculated by classification and data generated by sensor nodes , where as a coordinator uses priority for allocation of slots for data packets and sensor nodes uses back off to perform priority based random back off for data packet transmission .

Traffic classifications-Data packets are categorized as follows in PAL-MAC

a)**Ordinary data packets (OPs)** measures physical characteristics such as body temperature but does not have reliability or dealy constraints .

b) **Delay driven data packets (DPs)** delivered timely without much reliability Ex: Video streaming .

c) **Relaibility driven data packets (RPs)** delivers a packet with high reliability Ex:Both respiration and ph monitoring.

d)**Critical data packets** (CPs) delivered with high relaibility and any delay deadline Ex: ECG data.

Superframe structure: The five periods of frame structure are firstly, Beacon frame allows super frame structure to start and gives basic information about coordinator and nodes to all the member. Secondly, Contention Access Period (CAP) allows allocation requests for CP, RP and OP packets in Contention free period(CFP). CFP can be very small in low traffic and is high in high traffic load, so that it occupies rest of superframe. Otherwise CFP does not use superframe which will be inactive period.

Backoff Calculation : Each node performs a random Backoff, which transmits either packet data or acknowledgement packet in CAP. Backoff is calculated based on value of traffic class. The packet data with lesser traffic have small back off value and high traffic class have large Backoff value .

Priority calculation : Priority of each packet calculated by sensor nodes $P_i = \frac{Ti}{Gi \cdot Si}$ (4)

Where P_i = Priority , T_i =Traffic class value and S_i = Size in bytes , G_i = Data generation rate.

PLA – MAC significantly improves the following QOS metric for performance evaluation

- **Average Packet delivery delay** – It is time between packet generation at sensor node and reception at sink node in definite slot of cooresponding superframe.
- **Average Packet delivery delay for delay driven packet** – Thease pasckets are to be delivered in deadline so that delay reduces .
- **Throughput** – The average rate of successful delivery of packets over a comunication channel over a unit time is measured by throughput which increases with the number of nodes.
- **Coordinator Power requirement** – The power utilized at different states such as transmit, receive, listening and sleep is different. IEEE 802.15.4 allows low power cosumption due to long inactive period. PLA MAC power consumption is low for low traffic and it increases linearly with traffic load.

VII. RESULTS AND DISCUSSIONS

1. Smart Building: The building control application of CPS can prevent logical and physical as well as external and internal attacks. The substantial integration of the building is implemented with power, transportation, first response and law enforcement.

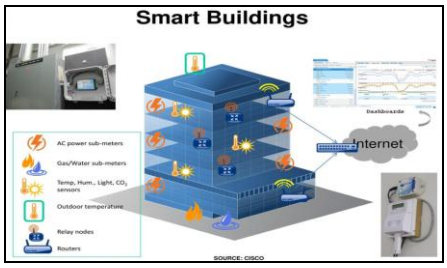

Fig5.Smart building application in CPS

2. Agriculture

Due to exponential increase in the worldwide population, there is a high risk of food shortage due to unstable climate change. As per the survey, today, more than 50% of food is wasted during production, storage and transportation. Smart agriculture system using CPS could be employed to reduce the food wastage. The use of CPS system will improve the processing of food at various stages using smart sensors and actuators for collecting and processing intelligent data from agriculture systems there by increasing the operational efficiency and reduction of pollution.

3. Cyber Defense

The CPS cyber security over a network systems play a critical role for achieving military missions and national defense requirements. The flexibility, robustness and resilience would be ensure by the software enabled CPS. To provide situational awareness to the public during disaster, the intelligent systems can alert the public well in advance using CPS enabled early warning systems, public safety systems and other such applications.

4. Smart Manufacturing

The CPS with IoT covers protocols, applications, and other domains for smart manufacturing. It is the web that not only enables machine-to-machine communication (M2M) but also hooks up the physical objects with virtual intelligence and services. The physical devices would gather the data and virtual system can process and exchange the information.

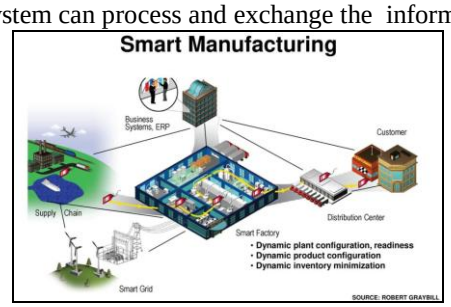

Fig 6. Smart Manufacturing application in CPS

VIII. CONCLUSION

The Cyber Physical System is a future class of research area which provides wide opportunities for the technologists to explore in many different fields. It is a multidimensional system that integrates both cyber word and the physical world, raised to have increasing interest towards privacy for control systems with differential privacy, such as data minimization by changing sampling period and homo-morphic cryptography in feedback systems. The future application of CPS in terms of energy, transportation, robotics fields and healthcare systems with wearable electronic devices or sensors. Through the approach of Cyber-physical system, the human get closer to nature which results in reduced casualties, calamities and material loss with future trend research such as creation of tools to speed up the system development process.

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AUTHORS PROFILE

Mrs. Saritha I. G. Completed B.E (TCE), from MVIT, Bangalore, M.Tech (Digital electronics and communication) from MSRIT Bengaluru, and Pursuing Ph.D (Cyber security) from Visvesvaraya University, Belagavi. she has 12 years of teaching, 3 years of research experience. At Present, working as Asst.Professor, ETE Dept.,BMSIT, Bengaluru. Member for professional bodies, ISTE & IAPURAI. Organized and attended many Workshops, FDPs and STTPs. Guided UG Projects . Published 11 Technical papers in National \ International journals \ Conference

Rajeshwari Hegde received her Bachelor of Engineering in Electronics and Communication Engineering from National Institute of Engineering, Mysore, Master of Engineering in Electronics from BMS College of Engineering, Bangalore and PhD from Bangalore University. She is presently associated with the Department of Electronics and Telecommunication Engineering of BMS College of Engineering, Bangalore, India. Her Research interests include embedded systems and Communication. She has published 120 research papers in reputed journals and conference.

International Journal of Advanced Science and Technology
Vol. 29, No. 3, (2020), pp. 11717 - 11723

Design and Implementation of Efficient Routing Algorithm for Wireless Sensor Networks

[1]Raghunandan.G.H, [2]Dr.A.Shobha Rani,

[1]*Department of Electronics and Telecommunication Engineering,*

[2]*Department of Electronics and Communication Engineering,*

[1,2]*BMS Institute of Technology and Management, Bengaluru, India*

[1]*Email: raghunandangh@bmsit.in*

Abstract

A minor node with wireless communications, computation capabilities, sensing Applications in the field of Wireless sensor network has broadened in various fields. These applications necessitate precise information gathering and also unremitting, expanded active service. Overall energy consumption is one the noteworthy impact of sensor networks in routing protocol. Appropriate Energy. Efficient routing algorithms require characteristics of networks to be inherited. Because of limited resources in WSN, increasing the lifetime of the network will always have a great interest. A large amount of the sensor node's energy is used for data transmission to base station. Consequently, the energy drains more rapidly. In this project, Agglomerative cluster based approach is used between sensor nodes, base station and gateway nodes to reduce the energy used by the cluster heads. It was proved that the efficiency of the network lifespan, residual energy of network has been improved in the in the simulation results. The performance of WSN of the proposed scheme is compared to other routing scheme and it shows improvement in the WSN.

Keywords: *WSN, cluster head, sensor node, LEACH.*

1. Introduction

Major developments in digital signal processing (DSP) which has led to growth of micro-sensors. Previously few industries use wired sensors; implementation provides deployment of sensor nodes more viable than before. Previously, there has been study regarding applications of WSN such as agricultural field, vehicle monitoring, machine monitoring, military surveillance and home automation. Many researches are undergoing considering the power constraints in WSNs by large deployment of sensors. To ensure real-time and reliable data transmission. Recently there has been exposure in the field of WSNs and their applications because they are easy to deploy and are of low cost, have flexibility. A WSN have distinctive set of resource curtailment like limited battery power, processing ability and limited communication bandwidth. Since sensors are battery-powered, energy efficiency is of vital importance in WSNs. Algorithms are used to solve the problem of power constraint without altering the standard. Local collaboration among sensors, suppression, data compression, redundant data, avoidance of direct transmission to far distant sensors are of the major factors that influence algorithm designers to device unique distributed, scalable and energy competent solution for WSNs.

In common, the sensor nodes measure environmental conditions. The sensor node extracts some useful information by processing the raw sensor signals. The output of this processed signal is transmitted the through direct communication or multi-hop

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communication with access point across other sensor nodes. In some situations, repeaters (RPs) are used for multi-hops, to support sensors installed outside the radio range. One of the components of WSN is the base stations which have more energy, computational, communication resources. Forwarding of data from wireless sensor network on to a server is done by the BS which acts as a gateway. Energy is a limited resource of WSN, and it determines the lifetime of WSNs. The computation subsystem has less energy consumption when compared to the communication subsystem. The energy required for transmitting one bit may consume as same as executing a few thousands instructions. Hence, communication must be traded for computation. In different environment, together with remote and hostile regions, in which ad-hoc communications are the key element of WSNs that is to be deployed in large numbers. Due to this reason, algorithms and protocols should concentrate on the subsequent issues:

- Lifetime maximization: Sensor nodes must be energy efficient and consumption of energy of the device should be less due to the limited energy resources. The radio power supply when not in use should shut off to conserve power of the node
- Fault tolerance and Robustness.
- Self-configuration.

2. Existing Systems

In this system [2] Network is divided into areas as per geographical locations based on clustering for Cluster Head (CH) selection and formation in WSNs. CH. The cluster head energy level reduces after several trials because of more energy consumption. The data is forwarded to base station after aggregating at cluster level. Hence, it is no more able to be a cluster head. Thus, formation of cluster takes place when CH remaining energy is below threshold goes; hence cluster reformation is not that efficient comparatively. In [3] it aims at that in the network level and sensor node level in a WSN they should minimize energy consumption. The distance between the receiver and the transmitter is estimated before available transmission, and then, the very minimum transmission power needed to transmit, to minimize the energy consumption of the sensor node, but here the neighbor status awareness is less in [4] extending the network life time of the network was done considering mobile base station. Even though it shows better performance but mobile base station is not feasible for all the situations. In [9] for transmission of data to the Base Station majority of the energy of sensor nodes is used. Thus, there is fast depletion of energy. Here agglomerative to reduce energy consumption of cluster heads a portable base station is utilized along with cluster approach. But movement of Base Station is not always feasible.

In [5] this it discusses up several technical challenges and many application possibilities which occurs when the sensor networks interconnect several nodes when wide networks are established. This wireless sensor networks communicates using multiple -hop wireless communications systems. In [6] In order to guarantee reliable multi-hop communication and to maintain the routes in the network routing protocols for wireless sensor networks are used. It provides us with an idea on routing protocols for Wireless Sensor Networks and compares their relative strengths and limitations provide better energy efficiency or increase wireless. The proposed model in [10] discusses about WSN using a gateway nodes which will further increase the number of nodes. If gateway nodes dies then there will chances of losing the data which is already aggregated for transmission to base station. Routing in WSNs [5] is generally, classified into many basis. The classification considered in this paper is based on network structure.

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3. Proposed System

The following assumptions are considered for the proposed system:

- The base station and sensor is considered to be static.
- The nodes have equivalent initial energy and are left as unattained after deployment, i.e. battery recharge is not possible. But a limitation on energy, memory and computation is not considered for Base Station. The nodes have the capability to vary the power transmission with reference to the distance.
- Using wireless radio signal strength distance can be calculated.
- Usually, energy reduction is one of the reasons for node failure.

In the recent past wireless sensor network has attracted substantial research attention as WSN's are fast growing in hierarchical-based routing algorithms, Cluster Heads are in-charge of compressing, forwarding and, gathering, data to the BS. Cluster heads plays an important role in reducing the congestion of the network. CHs are also elected based on certain criteria. Thus efficiency, network lifetime and network stability of WSN are increased. In proposed algorithm, the sensor member senses the data and sends the data to the individual Cluster Heads.

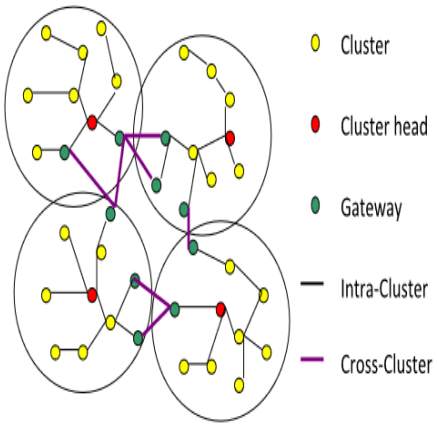

Figure 1. Clustering in WSN

Cluster Head processes this data and sends it to gateway node which in turn forwards it to the Base Station. Hence the lifespan of the CH increases which increases the network lifetime. Clustering is a process of connecting nodes using a specific topology to perform certain tasks as per the requirements. The algorithm used for wireless sensor network discovers a set of distinguished nodes to construct the appropriate topology of the network.

Next step after the deployment of the sensor nodes is grouping the sensors into cluster. In proposed algorithm, cluster formation is same as that employed in the LEACH algorithm. Once Cluster is formed considering nodes of the network, the Cluster Head (CH) is elected at the beginning of every round. The proposed technique is fixed with threshold value for the cluster head selection. Data transmission is continuously monitored with energy updating after each round. We have agglomerative based clustering approach, the distance between each single node to each of other nodes is determined and the node which is at almost equal distance with neighboring nodes is considered to be CH. Cluster Head is elected based on following set of rules:

- CH's residual energy: The CH is selected based on the maximum amount of energy it has.

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- Cluster head to the base station distance is considered. The more distance from each other the more energy required for data transmission.
- Depends on the number of nodes in the cluster that is in a cluster if there are more number of members data processing required is also more.

4. Simulation and Evaluation

The proposed system is simulated using MATLAB software. We consider 100 sq.m area and 100 nodes are distributed randomly. MATLAB Simulation is done for 1200 rounds. The proposed algorithm is compared with LEACH. Figure 2 shows sensor deployment, Identification of cluster head in each cluster and presence of base station. Figure 3 indicates transfer of data from the sensors to the cluster head, from cluster head to base station. Figure 4 shows the presence of dead sensors after around 950 iterations. Figure 5 shows the number of dead sensors present after few more iteration.

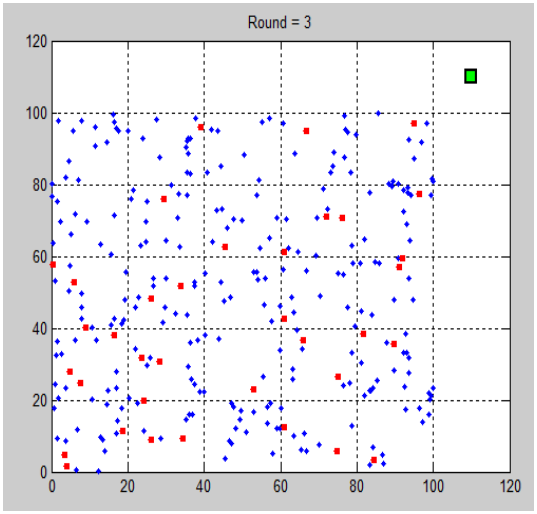

Figure 2. The Sensor Deployment and the Presence of Cluster Heads

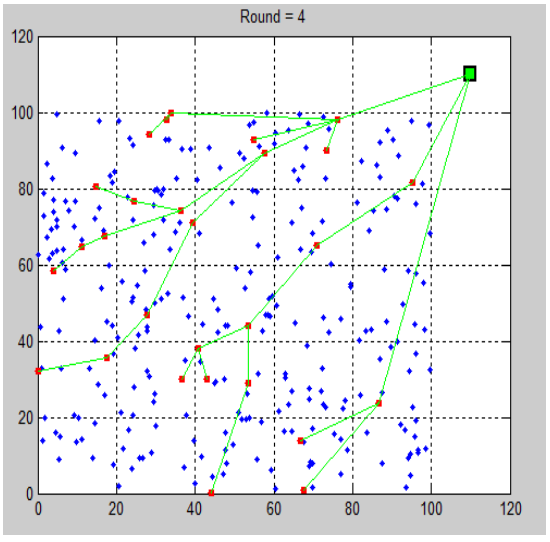

Figure 3. Communication of the Cluster of Sensors with Cluster Head and BS

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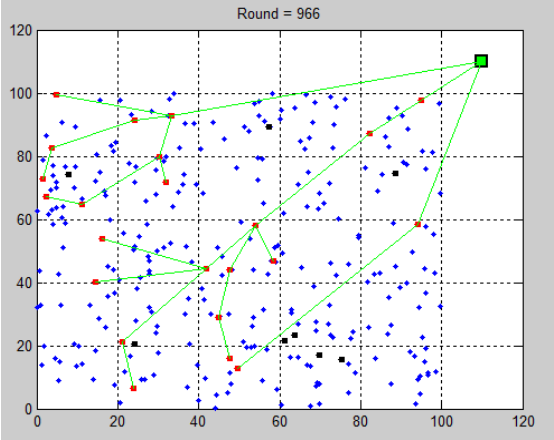

Figure 4. Presence of few dead sensors after little iteration

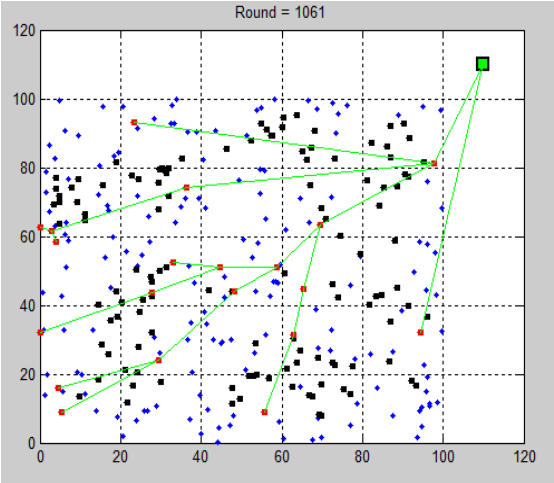

Figure 5. More Number of Dead Sensors after Further More Iteration

Here we are comparing our proposed system with leach protocol. Figure 6 indicates the presence of alive nodes after corresponding iterations. The number of dead sensors appears nearly around 1000 iteration as shown in figure 7. Hence the network lifetime is improved and the residual energy after each round provides us the information about the amount of energy consumed as in figure 8. Hence there is an improvement in the lifetime of the network of our proposed system.

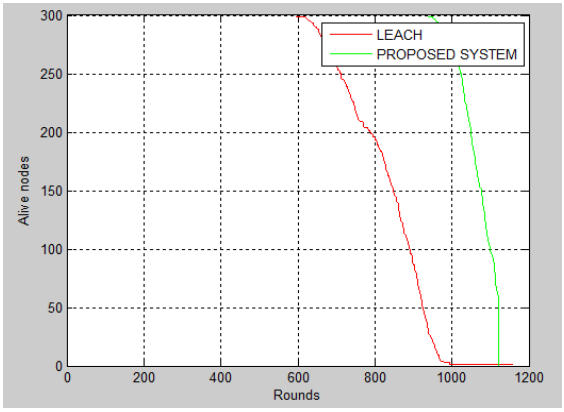

Figure 6. Number of Alive Sensor after Corresponding Rounds

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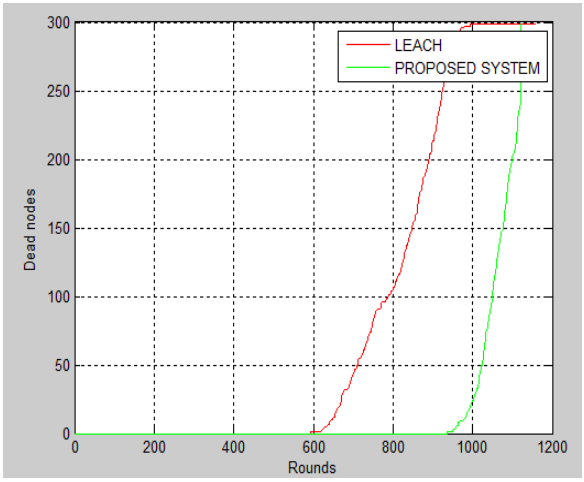

Figure 7. Graph of the Number of Dead Nodes Present After the Respective Rounds

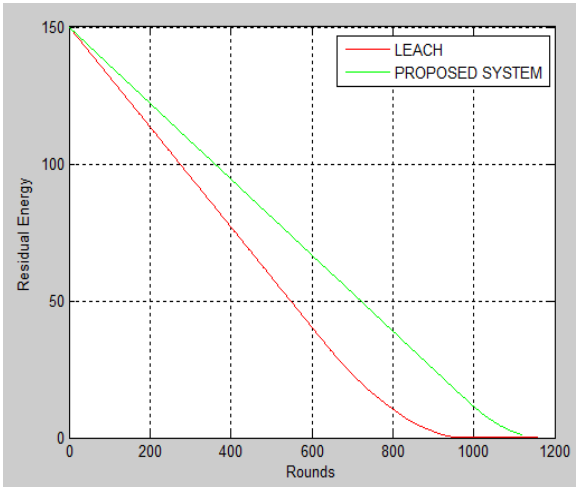

Figure 8. Residual Energy after Each Round

5. Conclusion and Future scope

In agglomerative clustering, the CH selection and power consumption is a major challenge. The energy utilization can be decreased by properly designing the cluster head selection mechanism. The selection of cluster head proposed in this paper is a new technique discussed with respect to distance from base station. The proposed system shows its performance in increasing lifetime of the network and overall performance of the network, which stay alive for the maximum amount of time. For the purpose of increase in lifetime of wireless sensors there is a need of significant research done in this field. An efficient manner is required for reducing the energy utilization by the nodes in wireless sensor networks.

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Authors

Prof.Raghunandan.G.H is presently working as Assistant Professor in Department of Electronics and Telecommunication Engineering of BMSITM, Bengaluru. Wireless Ad-Hoc and Sensor Networks, Embedded system are some of his research interest. He has authored six Textbooks and published more than 20 papers at various International conferences and journals.

Dr.A.Shobha Rani is presently working as Associate Professor in Department of Electronics and Communication of BMSITM, Bengaluru. Her areas of interest are Wireless Ad-Hoc and Sensor Networks. She has published many papers at various International conferences and journals.

ISSN: 2005-4238 IJAST

Evanesco-An Ultrasonic Repeller using UAV

Raghunandan G H[1], Ninaada M S[2], Keerthana R[3]

[1,2,3]*Department of Electronics and Telecommunication Engineering,*
[1,2,3]*BMS Institute of Technology and Management, Bengaluru, India.*

Abstract **-** *Ultrasonic Repeller has an up growing demand in today's world. The main function of this Repeller is to dispel the unwanted creatures in the environment. This ultrasonic Repeller is mounted on UAV. The main component used is 555 timers. Using a simple circuit and required basic components, we can tune the 555 timers to produce the desired frequency. Since this Repeller produces multiple frequencies, it is difficult for the species to adjust to this disturbing ultrasonic sound. The directionality of the ultrasonic sound is maintained. This prototype consists of transmitter and a piezoelectric transducer. It has emerged has a boon for farmers to use in agricultural fields. It can be used an alternative to scarecrows. Since animals and bird's species are detrimental, causing nuisance repellers come to need. In this paper, we propose method to address these factors. This UAV based Repeller will be emerging more efficient than existing one.*

Keywords: *Piezo electric transducers, autonomous UAV, acoustic ultrasound, power amplifiers.*

I. INTRODUCTION

A man with nature is precious. As a matter of advancement research is all along continues. We intend to take a piece of task to uphold for the purpose of both wellbeing. India stands second largest in the world after the United States for having 159.7 million hectares of arable land. Farmers depend on agriculture for their profit in farm areas like banana, jackfruit, coconut, sugarcane etc. Unfortunately, they are destroyed mainly by monkeys and other species which causes huge losses to the them. It is estimated that around 30 to 40% of crops are destroyed annually due to attacks by wild animals in India. According to the research animals namely elephant, boars, deers are the most common perpetrators of the destruction. In some districts of Odisha and Kerala, 60 percent of the crops are destroyed by elephants, claims for which are not payable by insurance companies. In Karnataka, farmers have lost many crops which account to 5 crores in 2010 because of monkeys. The state government forest department states that about 800 farmers have given up cultivation due to menace created mainly due to monkeys and other animals, bird's species in Karkalla district near Mangalore in 2012. Birds and animal repellers are of two types namely electromagnet and ultrasonic. In our project we are discussing only about ultrasonic's. Meaning of ultrasonic: Ultrasound is an acoustic sound having frequency more than 20 kHz or having frequency more than the audible range of humans and requires a material medium for its propagation. This ultrasound can be exposed in environment in two different types namely-

A. Airborne ultrasound.
B. Liquid borne ultrasound.

A. Airborne ultrasound: The most adversely affected organ in airborne ultrasound is the ear. The consequences caused by this type of ultrasound includes fatigue, nausea, imbalance of blood sugar level, tinnitus, causes irritation, headache. Further there are wide applications in industrial field namely cleaning, emulsifying, welding and flaw detection etc.

B. Liquid borne ultrasound: This have vast application in research and medical field like diagnosis, dentistry, therapy and surgery. The biological background of the animal species is as follows. Humans cannot hear ultrasound because their eardrums cannot vibrate as fast as animals like dogs, pigs, bats, and other lower animals like rabbits, deer. Insects detect sound by sensilla which is located on antennae or genitalia. Some insects like grasshoppers, moths, butterflies detect sounds by tympanal organs. Kansas State University which researched ultrasound confirmed that ultrasound sound benefits by repelling the animal, bird, insects and causes reduction in reproduction and mating. In 2002, Genesis laboratory came up with documentary studies and lent an informative hand about how rodents react to ultrasound. Scientist Dr. Philip Whit ford lab experiments proved that birds express severe distress in the presence of ultrasound frequencies. His studies showed reduced bird population in fields. Many birds like turkey, gills, pigeons find the ultrasound irritating and they get repelled. The reactance of birds, animals, insects depend on frequency, intensity of the ultrasound frequency. This prototype model is built in such way that, it is functioning with multi frequency modulated sound. The device produces frequency which changes very few seconds, with a frequency range of 20khz to 50khz. Due to this the animals and bird species are not adjusted to the acoustic sound environment. The acoustic sound radiations are highly concentrated to place. Neither this protype kills the animal and bird species which are causing menace in agricultural fields nor causes disturbance or side effects to human beings as the audible range for human beings is 20hz to 20khz. These nerve-

crushing sounds directly penetrate into animals and birds brain and nervous systems causing discomfort, and make them feel uneasy and act abnormal, such as to become frantic jumping, stampeding and leads to voluntary repulsion against ultrasonic wave areas and making it impossible to stay in such high radiated areas. This paper explains about the prototype model in detail and even throws light on the importance of ultrasonic repellers. In section 2, a brief overview is explained about the existing system models, working principle and the drawbacks faced by the systems. As mentioned above the the proposed system and range of components is explained in section 3. In section 4, the framework is evaluated based on stimulation and implementation of components and their working principle. The future scope and demands are discussed in section 5, along with further upgradation and improvisation of the project.

II. EXISTING SYSTEMS

With reference to the model [1], the ultrasonic device comprises of the power unit - Battery or AC power of 12-volt DC, and then the pulse generator unit which varied the emitted frequency continuously. The frequency which is ≤ 150 Hz is generated through 555 Timer IC and then sent to the CD4017 decade counter for the frequency division and then NPN and PNP transistor are used for the signal amplification. IC CA3130 (Audio Amplifier) was used to amplify this frequency and for transmission to the free space speaker was used.

The accuracy and working of the device had few limitations due to climatic conditions. The distance travelled by ultrasound was found to be different on sunny, rainy, dull days. Climatic conditions played a vital role in rating the performance of the Repeller. The other physical conditions like temperature, humidity also affected the radiation of the ultrasound. The sound travelled fast in moist air when compared to dry air and in mornings due to lower temperature. The project work [2] explains that the ultrasound was detected by the area of 21mm to 37mm. The author used an astable multivibrator, 555 timer which generates frequency and it can be varied by steps of 5 using IC, counter, a D type flip flop. Amplification was done using npn and pnp transistors. Variable resistors of 100K value was used to control the frequency output. The device was tested on mouse. The device sound waves were active for 5 metres from the device and later got deactivated. And caused hearing impediment due to incorrect amplification. In this project [3] an electronic oscillator was used to produce frequency. The function of an electronic oscillator is to repetitively generate electrical signal of a specific frequency. This Electronic pest control device comprised of the oscillator, a small transistor amplifier and additional circuits like tripping circuits, sonic circuit, preamplifier, 555 timer, frequency selection circuit for varying frequency and other additional components making recent designs more effective. Electronic pest control devices emitted ultrasound which goes beyond the threshold sound hearing capacity of targeted pests. During the testing it was observed that it was difficult to disperse feeding birds (difficult to break the chain). When ultrasound was broadcast over wide open spaces the sound lost their intensity rapidly with distance.

Author [4] used fluorescent lamp at night. These lamps were placed near trees, bushes and the lamp drew many insects towards it in the dark. Then the ultrasonic Repeller was activated and it repelled most of the insects. Some of the insect moved away at certain constant frequency but other species of insect didn't move as repelling frequency was found different for different species of arthropods. He found the accuracy of the device as 75%. Location of crops was required, which was an extra work and thereby the author concluded the ultrasonic range for detection is better than the location of crops if the device is kept it the boundary. This Author also talks about a circuit of an electronic pest repellent [5]. The device was effective over 16 meters from the Repeller. The device consisted of an equipment which produced fog, smokes along with the circuit which produced frequency of 35- 50 kHz. The circuit consisted of a decade counter (CD4017) which had ten outputs. From this output variable frequency was produced and each pin was high one after the other. 555 timers were used, and its output was fed as the clock signal input to decade counter, in order to produce desirable frequency. These smoke and fumes affected adversely human beings, animals, birds, insects. And making it a non eco friendly device and thereby got rejected due to its harmful property. It became too expensive to be inculcated in the day to day living of the farmers.

This prototype model [6] used a transducer for amplification. This transducer can produce 2.5W power and a frequency up to 80 kHz. A speaker of resistance 8ohm is used which is tested experimentally till it produces the required frequency, that is 100kHz.Atmega 16 is a low power AVR,8- bit microcontroller which will produce varied patterns of frequencies as required in the experiment. LM 7805 is a 3 terminal voltage regulator which is connected in series. This has a wide range of applications as it is made with several diced output voltages. A 4×4 standard keypad is used which acts as an input to the Atmega 16. However, the frequency generated, and polling cannot be used at the same time as both are continuous processes. Sonic pest device [7] is a prototype which can be used in two ways. Firstly, it can be either inserted to an outlet. Secondly it can be plugged to a power-driven battery. This sonic device can vary the monotonous acoustic communication of the targeted pests. Alternatively, this can be achieved by creating confusion or fear in them. The sound that is produced by this device working under ultra or infrasonic range is not audible to humans

and hence will not drive away humans also, this achieving the basic motto of the prototype. Several studies and experiments have been performed by experts and researchers in entomology of Kansas state university on these commercially available devices. Out of them, 3 devices were tested and marketed for controlling pests. Unfortunately, none of the 3 devices were successful in repelling ants in the fields as well as in laboratory trial.

III. PROPOSED SYSTEM

The working of the ultrasonic repellent is given by the below block diagram. There are three stages frequency generation, amplification, transducer output.

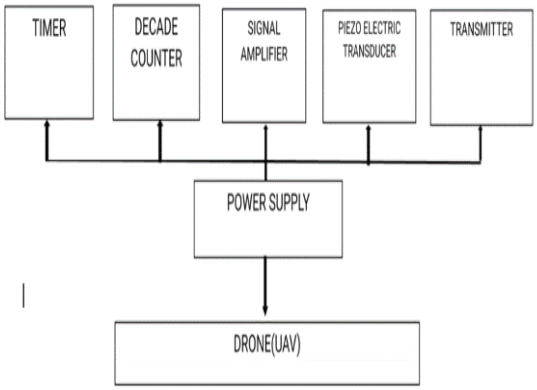

Fig 1-Overview of the circuit diagram

Frequency generator**:** The frequency generation consists of two 555timer IC and decade counter. Refer figure 1. The timer produces time delays and oscillations. IC used in the framework is 8 pin model. 555timer can operate with voltage ranging between +5V to +18V. A voltage of 9V is given to the system model. The e timer is operating on astable mode. An astable multivibrator does not have any stable state, it keeps changing from low to high and high to low. Astable multivibrator does not require an external trigger circuit to change the state of output. The 555timer produces an output frequency of 50khz using resistors of value 4.5kohms and 18kohms respectively and capacitor of 680pF. This output from pin 3 of the 555 timer is fed to the decade counter. And frequency can be continuously varied in the range of 40khz to 50khz. The output from the 555timer is clocked as an input to decade counter. When the clock starts its count the logic 1 output of the counter advances from Q0- Q1 and so on till Q9. Ten resistors ranging from r4 to r1 is placed at the output of Q0 to Q9. The output from resistors is fed to the second IC 555 timer, as shown in the figure(implementation). The second timer also operates as an astable vibrator.

Amplifier: The output from the 555 timer IC is given to the two transistors through the resistor of value 1kohm in order to maintain the potential difference. The primary uses of transistor is to amplify signals. Refer figure1 and figure2. The transistors used are NPN and PNP. The transistors are of opposite type and thereby conduct for opposite cycles of the input from the timer. The PNP and NPN transistors conduct for negative and positive half cycle respectively. Thereby both the transistors produce full wave output across the load. Thus, the weak input signal is amplified at output. The sound wave is amplified by this process.

Transducer output: Transducer is a device that converts one form of energy to other. The transducer made of quartz plate is influenced by piezoelectric effect due to the subjected electric field. Refer figure 1. The piezo effect causes the transducer to undergo alternate expansion and contractions at the electric field frequency. When the field frequency is made to coincide with the natural frequency of the crystal, it resonates producing sound waves. The intensity of the sound wave can be determined by the formula $I= P/4\pi r^2$, where P is the power of the sound wave and r is the distance travelled by the sound wave. The circuit arrangement consists of four piezo speakers placed at an angle of 90° to produce 360° coverage and the sound wave is dispersed evenly. The use of transducers ensures that the acoustic wave possesses directionality and not spread out during radiation and attenuation is avoided. The entire setup is placed on the drone. Since the drone is in complete motion and the circuit produces multiple frequencies the animals and birds do not become habitual to the acoustic environment. The animals, birds, insects get repelled automatically.

Table 1: Upper limit frequencies of bird and animals

Animal and Bird Species	**Upper Limit Frequency in KHz**
1. Dog	45-67
2. Cat	45-52
3. Sheep	30-100
4. Rabbit	42-67
5. Mouse	91-1000
6. Pig	50-54
7. Raccoon	40-100
8. Elephant	25-56
9. Turkey	6.6-25
10. Sparrow	11.5-32
11. Pigeon	4-26
12. Monkey	8-45

IV. IMPLEMENTATION

As discussed in the proposed system, various electronic components are implemented to produce the desired frequency. The components used are resistors, capacitors, decade counter, piezoelectric transducer and 555 timers.

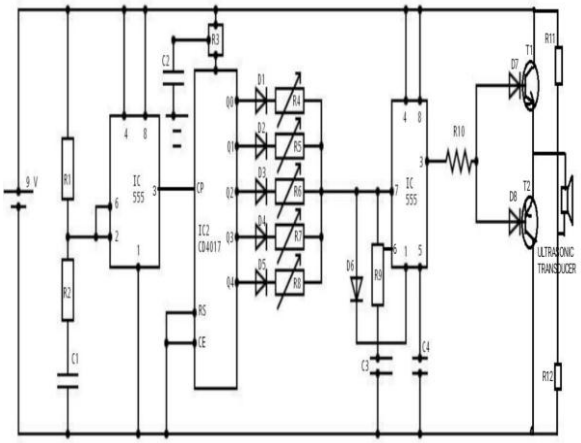

Fig 2- Circuit diagram

Fig 3-Evanesco Implemented model

A 555 timer is an integrated circuit which can be used as flip flop as it provides time delay. This astable multivibrator IC produces frequency when supplied with Vcc input of required voltage. The next major component used is decade counter. It is a circuit whose input signal is a clock signal and has a 4-bit binary output. The basic purpose of using decade counter is it will divide the given frequency. The repellant framework amplifier plays a very significant role. Its significance is explained as below. The power-driven amplifiers amplify the sound wave to larger extent and works for half cycle each. In other words, it increases the power of the signal. The frequency varies from 20 kHz to 100 kHz in an ultrasonic amplifier. A transistor can also be used as an amplifier by raising the strength of a weak signal. This can be achieved when transistors are in common emitter mode. Similarly, piezoelectric transducer is used to convert some charges, or parameters like pressure, stress etc into electrical energy. The square wave produced by the timer IC is converted into an equivalent amplified electrical signal with the usage of piezoelectric transducers. Due to the production of such oscillations in a short span of time it may also produce ultrasound of frequencies up to 20MHz which can be used for various medical purposes. Figure 2 is an autonomous drone which includes a camera module and a GPS module. The autonomous drone is configured to move to a location and/or a direction based on a command received by the tracking module. They operated autonomously onboard computers. The technology that is involved in constructing an autonomous drone includes obstacle avoidance, UAV dynamics and control. Camera module is configured for providing images and a real time video stream to the base station and the GPS module is configured to send the location of the drone to the base station. The video recording and images obtained from UAV can be used for analyzing and monitoring the activity of animal species. The entire circuit is placed on the drone. The is in complete motion ensuring the animals, birds, insects are repelled due to the high frequency acoustic radiations.

V. CONCLUSION

The ultrasonic repellent framework has various applications as mentioned earlier. The novel solution to the exponentially growing problem of animal and bird species destroying the farm fields can be solved by this prototype model. The multiple oscillations producing multiple frequency with varied intensity which is implemented on an autonomous UAV which stands better than the existing systems. The application is further improved by using power amplifiers and thereby achieving the requirements. The computerized controlled drone alerts the user. There is a growing demand and scope for this gadget due to the up growing menace caused by animals and birds. The efficiency of this device can improve by constructing a UAV which can adapt to extreme weather conditions.

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European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 08, 2020

Electroencephalogram Based Emotion Detection Using Hybrid LongShort Term Memory

Thejaswini S,[1], *Dr. K M Ravikumar ,[2]

[1]DepartmentofElectronics and Telecommunication Engineering,B M S Institute of Technology and Management,Bengaluru, Karnataka,India.
[2] Principal and Professor Department of Electronics and Communication Engineering, S J C Institute of Technology, Chickballapur, Karnataka,India

thejaswini79@gmail.com

Abstract

Emotion detection using physiological signals is an upcoming research extending applications in various domains. One important challenge in detection of inner emotion states is a good predictive rate in order to build any application. In our present work, a hybrid Long Short Term Memory (LSTM) algorithm is proposed based on channel fusion approach. Data is acquired by eliciting emotions using eight 3-D Virtual Reality (VR) videos for eight discrete emotion states. On preprocessed data, 8-level decomposition using Discrete Wavelet Transforms(DWT) is performed, wavelet features and time-domain features are extracted and fed to Hybrid LSTM. The hybrid algorithm is performing well for eight discrete emotion states (happy excited, calm, bored, fear, tensed, sad and relax), with an accuracy rate of 80.05% and 93.24 % for 4 states in categorical form (Valence- Arousal scale). Frequency domain features on various bands exhibited a good predictive rate than time domain features.

Keywords: EEG, Emotion states, LSTM, DWT, Channel reduction

1. Introduction

Human emotion states plays an important role in daily life and this has high impact on their daily routine activities [1]. To develop an emotional model which can measure human emotions states and interface these with computer is aim of affective computing which has enormously increased the applications in HCI. The inner emotions of person are subjective, it depends on feelings, experience both internals and externals of subjects [2]. There as several ways to detect and evaluate emotion states, to list a few is through speech, facial and physiological signals. The shortcomings of speech and facial approach is that subject can avoid or fake their emotion states which may give rise to wrong decision making. Analyzing using physiological signal have overwhelmed these flaws [3-4]. Detection of emotions using electroencephalogram (EEG) is rapidly growing due the fact like, no influencing of brain signals, availability of many portable devices for data acquisition. This has enabled to develop applications in medical and non- medical fields [5].

The categorical and dimensional models are used to represented emotions states. The Categorical / discrete model makes use of emotion states in discrete form namely happy, sad, anger, joy, fear etc. In dimensional model, common set of dimensions which links emotion states into two spaces-valence and arousal states and is depicted in Figure 1.

Based on 10-20 International standard electrode system, EEG signals are acquired. To stimulate emotions in subject's, video or audio stimulus is used. In this paper a hybrid LSTM algorithm is designed for real-time data acquired using VR stimuli. The main objective of our work is used to develop an efficient Deep learning algorithm to detect emotion states with respect to dimensional model (Four states) and Categorical model (eight states).

The paper is structured as sections. In section 2 related work in this area are explored. Step by step Methodology of the proposed work are briefed out in section 3. Results and discussions are described in section 4 followed by section 5 with conclusion and future scope.

2. Related Work

In [6], they developed a multi-modal attention-based BLSTM network of three layers to recognize temporal features and used DNN to classify future using AMIGOS database. They obtained an accuracy of 82.5 % for arousal and 77.8% for valance (third layer). LSTM algorithm using non-linear HOC for DEAP data was proposed [7]. They system accuracy rate of valence-arousal was 84.68% and 82.01% for 2 and 4 classes. Their system attained an accuracy for Valence-Arousal score for four classes as 82.01% and 84.68% for two-class. In [8], they proposed a channel fused dense CNN for SEED and DEAP database. They used images of Differential Entropy of 5 bands to CDCN model. The accuracies were an average of 90.63% for SEED and 92.58% DEAP datasets. For seed data base, the accuracy of different frequency bands was as follows: Delta 65.19, Theta 69.84, Alpha 72.16, Beta 80.83, and Gamma 82.63. For DEAP data base the valence and arousal accuracy rate were 92.24 & 92.92 respectively. In [9] PSD was used for pre and post 2-D and 2-D movie watching on five member groups using 20 channels device. The success of classifier rate was 73.36 % and 89.11% for PLSR and SVM using STFT. The same using DWT was 75.18% and 87.26%.

The following authors work is related to DEAP database. A [10] merged LSTM was used which consists of channel wise LSTM layer followed by dense layer for wavelet features. The classification rate of valence and arousal were 84.89% and 83.85% respectively. In [11], they used frequency band power on a combination of Stack auto encoder and LSTM frame work and got a valence accuracy as 81.10%, arousal rate as 74.38%. They proposed an R2G-STNNwhich consists of spatial and temporal neural network models for SEED data base and obtained an average accuracy of 92.9 %[12]. In [13], they used KNN classifier for different frequency bands and obtained 95% accuracy in gamma band. They showed increase in accuracy when number of channels were increased. In [14], they developed multi class SVM classifier using time domain as well as Gabor-IMF features and obtained an 93% classification rate for 7 and 3 channels. Deep learning frame work with arousal and valence performance of 75.92% and 76.83% explored [15]. In [16], they classified the data using SVM on frequency and time features with 72.6% and 70.3% accuracy rate. In [17]they, used DWT, energy and entropy features on SVM and KNN classifier with an efficiency of 86.75% for arousal and 84.05% for valance. In [18], they used 8 channels and SVM classifier on extracted features like non-linear, time and frequency domain. Their classifier performance is 74.43 % for valence and 80.01 % for arousal.

From the above review it was noted that work was carried out using different databases, used various machine learning and deep learning algorithms for classifying emotion states into basic emotion models discussed earlier with an accuracy of 75 % to 93%. Only a few work is carried out with discrete emotion states. In our proposed work, a modified LSTM network is built to classify emotions into valence- arousal and eight discrete emotion states. To elicit emotions VR video clips are used.

3. Methodology

Propose System: In the proposed work, to elicit emotion states, 3-D VR videos are used. The extracted time-frequency, Statistical features are applied for modified LSTM frame work to classify into eight (8) categorical states (calm, relax, excited, happy, tensed, fear, bored and sad) as well as four (4) dimensional states (HAHV, HALV, LAHV & LALV). The methodology proposed for our work is dissipated in Figure 2.

Protocol for Data Acquisition : The data acquisition protocol was developed based on the ground rules followed in DEAP [19] and SEED [20] databases. In the experiment set up, 66 subjects were shown eight 3-D VR videos and EEG signals are captured using Enobio- 32- channel device with 500 Hz sampling rate. Out of 66 subjects, 30 were female and 36 were male around 35 years average age. The channels used are CP2, C3, P7, FC1, CZ, CP1, P3, FC5, FC2, AF4, FPZ, C4, PO3, F7, AF3, CP5, PZ, O2, FP2, T7, P4, PO4, T8, FC6, F8, CP6, O1 P8, FP1, F3, F4, FZ [21-22].

The complete protocol is shown in Figure 3. The subject is briefed out with the complete protocol and with his/her concern the data acquisition is carried out. Once the subject wears EEG device they are asked to relax for 60 second [Relaxation state]. There after trail begins with presenting each video in the above said format. Trail number is displayed for 2 sec followed by video related to corresponding emotion state for 50 to 300 seconds. The trail ends with self-assessment.

Preprocessing: The acquired raw EEG data includes artifacts like muscle movements, blinking of eye etc. the device had inbuilt notch filter which remove 50Hs line interface noise. Further median filter, moving average referencing filter and a band pass FIR filter with 20^{th} order is implemented using MATLAB command “filtflit” [23,24].

Feature Extraction: On the preprocessed signal, 8-Level DWT decomposition is applied to extract the desired band of frequencies. The extracted features are tabulated in Table I. Total 34 features are extracted for each subjects. The features are computed using MATLAB and channel wise feature extraction is implemented using Python.

Classification: Hybrid Deep Neural Network (HDNN) classifier is applied on the extracted features. In our previous work, [22] sequential ANN was implemented and classification accuracy for 4 states is 90.835% and 8 states is74.045 %. To increase the prediction rate we developed deep learning network using LSTM with a modified frame work on the features vector. For 66 subjects we have 8 trails each and for each trail 34 features were calculated. So the feature vector 34 * 264 which implies 34 features for 264 trails.

The hybrid LSTM [HLSTM] architecture has 10 layers is shown in Figure 4 . The layers are first layer is 1X1 Sequential layer which has 34 input nodes which represents number of features applied for the HDNN. Second layer is Fully connected layer. Third layer is BILSTM with 100 hidden units. Fourth layer is ReLU layer. Fifth and eight layer is Dropout with 0.2 % drop out of nodes occurs. Sixth layer is LSTM layer, which is followed by Leaky ReLu layer and drop out layer. Ninth layer is Softmax layer followed by classification layer which is the last layer of our network.

Hybrid LSTM is implemented as per the steps given below using MATLAB.

Step 1: Reading the channel wise feature vector.
Step 2: Splitting the 70% features for training 'XTrain' and 30% for testing 'XTest'
Step 3: Reading the label and splitting into 'YTrain' and 'YTest'
Step 4: Converting the labels into required form for network using categorical function
Step 5: building layers using deep network designer in MATLAB and analyzing for proper functionality of layers
Step 5: Initializing training options of the layers using "Training Options" command
Step 6: training the network designed using the command "train Network (XTrain, YTrain, layers, options)"
Step7: The trained network is tested using "classify (net, XTest)"
Step 8: Prediction accuracy is calculated and confusion matrix is plotted.

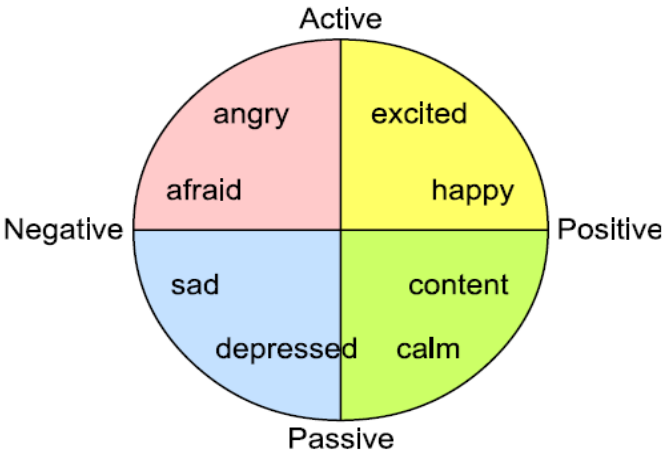

Figure 1: Dimensional model [1]

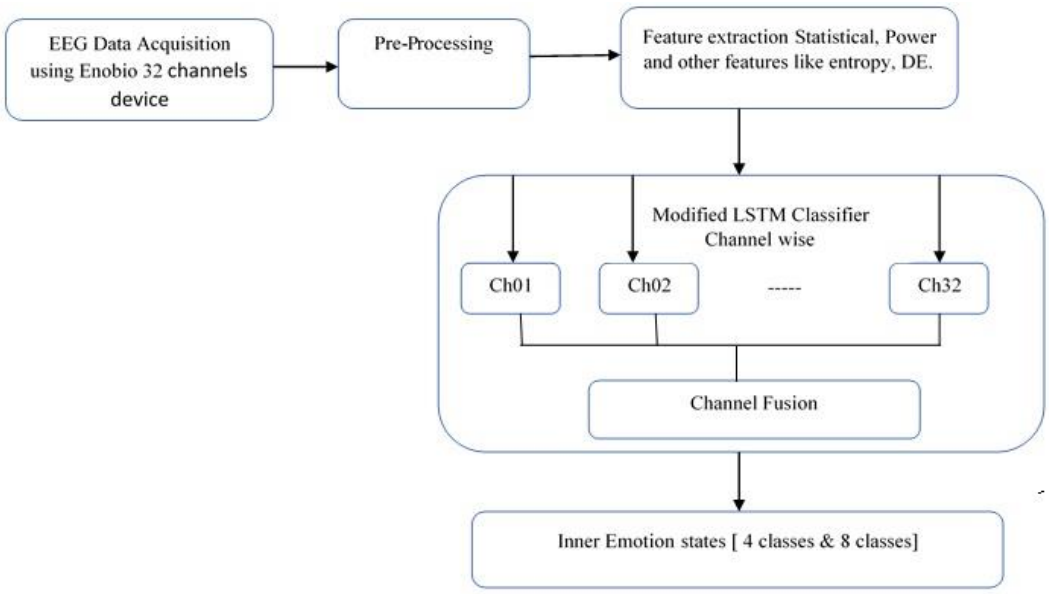

Figure 2: Methodology of proposed system

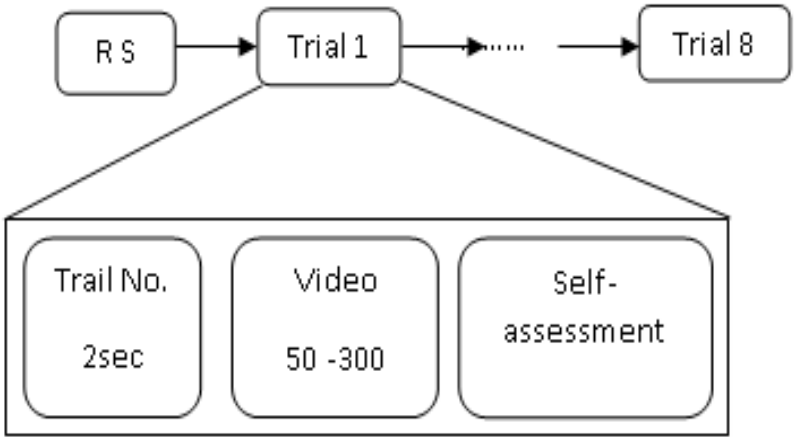

Figure 3: Protocol used for data acquisition [21, 22]

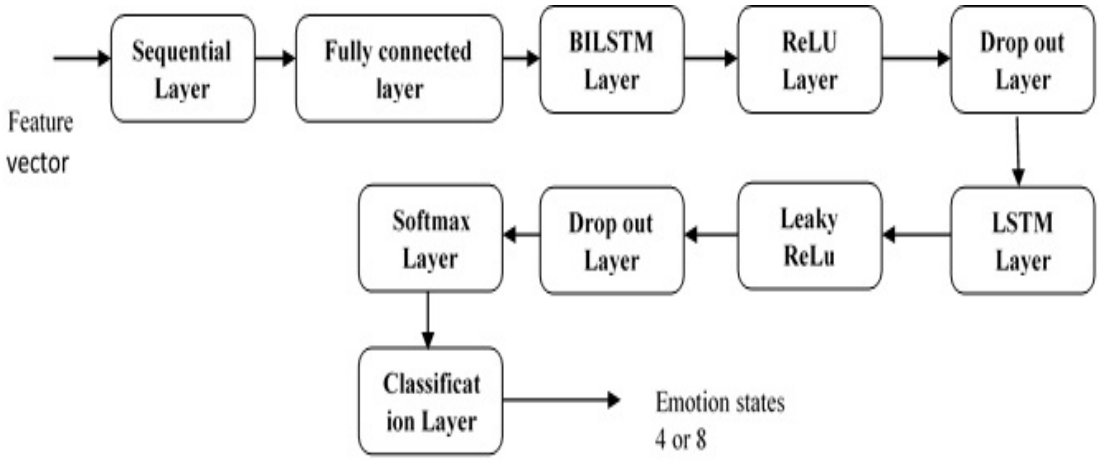

Figure 4: Hybrid LSTM Architecture

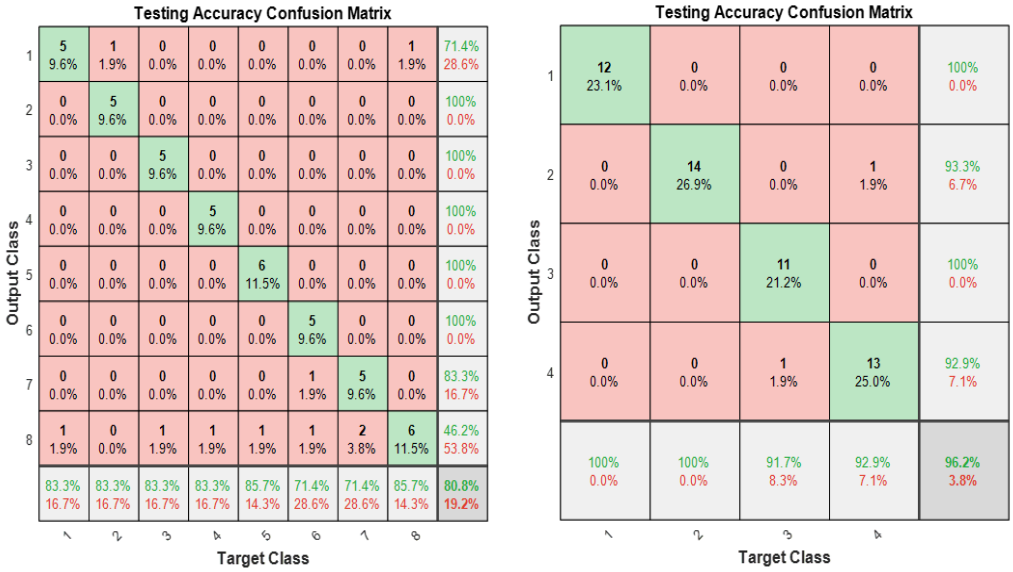

Figure 5: Confusion matrix of 4 & 8 classes of channel FP1

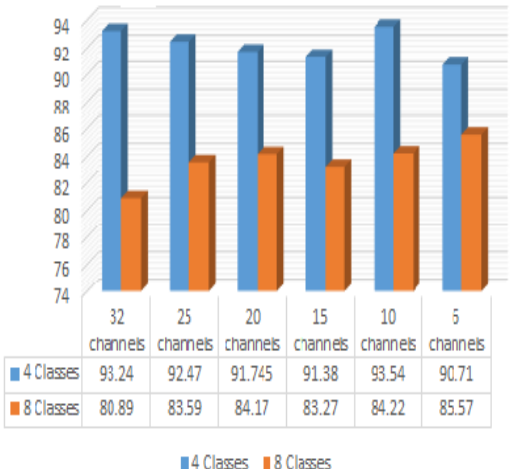

Figure 6: Performance of channel reduction

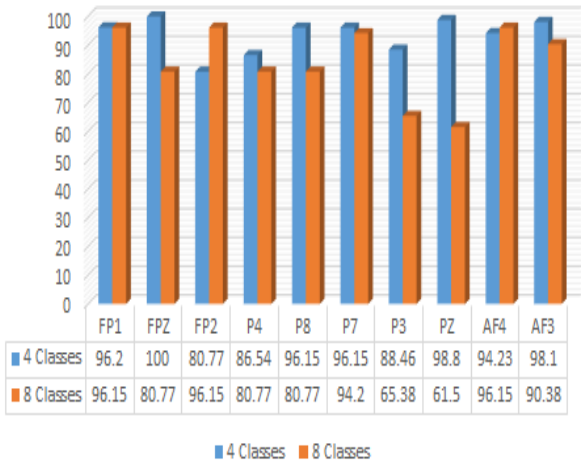

Figure 7: Classifier Accuracy of 10 Channels

Table I: Statistical and Frequency domain features [22]

Feature extracted	**List of Feature**
Statistical Features	Mobility and Complexity (Hijorth Parameters), Skewness ,Kurtosis Mean, Variance, First & second difference, Normalized
Frequency Domain features	Energy, DE, PSD, Average power
Other features	Hurst exponential and Permutation entropy

Table II: Performance of HLSTM classifier

Type of Features	**Four states**	**Eight states**
Combined features (Time and wavelet)	93.24%	80.05%
Wavelet Features	84.24%	76.85%
statistical	67.24%	53.9%

Table III: Classifier accuracy of HLSTM for channel reduction

Number of Channels selected	Four states	Eight states
32	93.24	80.89
25	92.47	83.59
20	91.745	84.17
15	91.38	83.27
10	93.54	84.22
6	90.71	85.57

4. Results and Discussion

Feature extracted form 66 subjects for eight trails are considered for analysis in the present work. Thirty-four combined features, fourteen statistical and twenty wavelet features are applied for H-LSTM network. Out of 264 samples, 70% of them i.e. 184 samples are used for training and reaming 30% i.e. 80 samples are used for testing the network. The prediction accuracy for 8 classes and 4 classes are 80.05% and 93.24% respectively and is tabulated in Table II. The confusion matrix for FP1channel is illustrated in Figure 5.

Further channel reduction is performed based on prefrontal, temporal, parietal and occipital channel to analyze the emotion states [22]. The performance analysis of channel reduction is shown in Table III and Figure 6. Ten predominant channels performance is shown in figure 6. It is observed that for four classes, when channel reduction is done, the performance is better for ten channels. To detect discrete emotions, channel reduction has shown better predication rate. From thirty-four features, differential entropy, PSD and power of 5 bands, Hurst exponential, kurtosis, skewness, 1^{st} and 2^{nd} normalized difference found to be predominant features. It was also keenly noted that HLSTM performed better for frequency domain features than time domain. Conclusion

In this paper, a hybrid LSTM [HLSTM] is proposed to detect the inner emotion states of 66 subjects whose emotions are elicited by projecting 8 3-D VR videos. The protocol is so designed that the emotions can be classified based on 2-dimensional (4 classes) and discrete model (8 classes). The time domain and frequency domain features are extracted after the removal of artifacts and applied to HLSTM network. The prediction accuracy for 4 classes is 93.24% and 80.05% for eight classes. The performance of our hybrid network is found to be better than others.

Further feature reduction can be used in order to improve the accuracy. The work can be compared with EEG signal acquired using normal video. Based on the emotions detected we can build an emotional DJ which plays the songs related to a detected state.

Acknowledgments

The Authors would like to thank, Dr. Manesh B Kokare, Dean Research and Development Associate Professor and PI of Center of Excellence in Signal and Image Processing and Dr. D D Doye, Professor, Department of Electronics and Telecommunication SGGS Institute of Engineering and Technology, Vishnupuri, Nanded, Maharastra, India, for permitting to acquire EEG data as well sharing the same.

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Trace File Analysis To Obtain Congestion Window, Throughput And PDR

Sowmyashree M S[1],Saritha I G[1],Archana Arun[1],Manasa M[1],Samhitha C S[1], Spoorthi H Shetty1

1Department of Telecommunication Engineering,BMS Institute of Technology and Management, Bangalore, Karnataka, 560064, India

sowmyashree.m.s@bmsit.in

Abstract
The use of wireless networks have led to a recognizable evolution in the area of wireless Body Area Networks (WBANs).With the help of WBAN a patient's state of health can be repeatedly monitored without affecting his day to day activities. A wide range of technologies have played a significant role in supporting WBAN applications which includes telemedicine, remote monitoring and ambient assisted living by focusing on particular quality of service requirements. In this project, the QOS parameters like delay and throughput will be improved compared to existing protocols with the help of a simulator(NS2).We will collect values from the present database and transmit it via the internet such that it will have minimum delay and throughput, so that the packet without any loss of data can be collected at the hospitals.

Keywords: Throughput; PDR; Trace-files; Congestion window; WBAN.

1. INTRODUCTION

In the field of health care rapid developments were made with the assistance of wireless body area networks WBAN. The growing demand for high quality and instant simplified services in health care have led to utilisation of information and communication technology in different ways. There are lot of factors which have impact on WBAN applications which are more evident with the new results showing health impact on quality issues, so it is very important to have a hold on problems mostly related to implementation. Proper implementation requires a good service quality for all the parameters in consideration in which the delay and the throughput play an important role. In order to improve the health technologies it is very important to scale up the QOS parameters in WBAN. To accelerate the transformation of our health care systems and to achieve affordability and quality for all in the near future QOS improvement plays a significant role. Wireless Body Area Network(WBAN) is a variant of wireless communication technologies, that connects independent nodes which can explore and detect a appropriate network to communicate and send data to a distant database server. These nodes are capable of sensing, gathering the human body signs.

We can implement the process with various simulation tools like omnet++,netsim,ns2 but we prefer ns2 for demonstration as it is a free source software. WBAN signals are mainly used in medical fields to transmit data like heart rate i.e. EC,EEG, Blood Pressure(BP),body temperature and sometimes sugar levels in the blood.By taking up this project we would like to reduce the probability of the same happening by improving the QoS of WBAN signals by using the Ns2 simulator, thereby try to improve the efficiency of the quick response care in emergency situations.

2. Related Works

Research works related to WBAN are quite large in number. Some of the works are listed as follows-This paper address the improvement of energy efficiency and service quality in a new wireless body area network architecture. This architecture is developed with dual sink nodes to reduce energy consumption and delay in this proposed work a new persistent media access control protocol is defined which can perceive the importance of perceptual data[1];Each WBAN comprises of a coordinator and multiple sensing nodes. When twhenhese nodes simultaneously transmit interference occurs. In order to avoid interference in wireless body area networks CSMA/CA is implemented at the coordinator level.The coordinator automatically adjusts its frame length to avoid interference [2];A comparison between the performance of AODV and DSDV for UDP and TCP is made and evaluation of their performance is carried out in similar simulation conditions. Here AODV performs better than DSDV and DSR[3];This research aims to solve the problem of energy consumption by a sophisticated classification scheme which categorises the data into normal, semi-urgent and urgent. this also provides a method for medical sensors that can send packets during a gateway failure[4];A mac protocol defined in this paper aims to meet the requirements and increase power consumption rate which increases rapidly as the number of nodes goes high.In order to effectively and objectively evaluate the MAC protocol it is compared with 802.15.6 protocol[5];In this paper Virtual Group formation architecture based on time instances.The way data is being transmitted from a source patient node to the destination node which is the doctor or nurse's mobile device through WLAN is one of the fastest approaches. For a particular time interval the data gets updated automatically[6].

3. METHODOLOGY

Topology :

The proposed topology consists of nodes acting as sensors along with intermediate node depending on distance and a final node acting as data base. These sensors are body sensors that are used to capture data like pulse, blood pressure, sugar and temperature. The data is captured based on requirement and the data will be transmitted to the database of the nearest hospital. This topology tries to meet real time situations as close as possible.The topology is implemented using Network Simulator (NS-2).

Queueing:

In general, class of object that has the ability to hold and perhaps mark or discard packets as they travel in a particular simulated topology is called a Queue. Here we use Drop Tail type of queueing. It is a simple queuing mechanism where routers use it to drop excess packets. In this mechanism, all packets are considered identical and given equal importance, so when the queue reaches its utmost capacity, all the new packets entering are are not taken until the queue has adequate area to allow the upcoming traffic payload. When the queue is full, the router discards all the packets hence dropping of the tail mechanism. This dropping of packets will make the sender enter into a slow-start phase, which will reduce the value of throughput and hence increasing the congestion window.

Routing Protocol:

The routing protocol can help the node find the required path and maintain the route for a certain time level until the target node has obtained the data packet from the source node. Routing protocols constitute an important part of mobile ad hoc networks. The routing protocols are available in three types which are active, passive, and mixed. The table-driven routing protocol is proactive, where every node constantly updates the table consisting of the routing information of other nodes, which helps to detect the route to the target node. In this paper, on-demand protocols are used, also known reactive routing protocols . Here, the mobile node consists only of information on the active path. According to the request of the source node to send the data packet, the reactive routing mechanism will find the path to the target node. Reactive routing includes protocols such as AdHoc on-demand multipath distance vector (AOMDV),Ad-Hoc on-demand distance vector (AODV) and dynamic source routing (DSR). Hybrid routing is a combination of both and location identification routing algorithms such as Gathering Routing Protocol (GRP) and Temporally Ordered Routing Algorithm (TORA).

DSDV Routing protocol:
Destination Sequenced Distance Vector (DSDV), basically it is a routing protocol which is based on the hop-by-hop mechanism. This protocol requires periodical update on broadcast routing at each nodes. This algorithm is based on the table-driven scheme, which is comparable to the scheme of modified Bellman-Ford routing .The network has nodes all the nodes are destined to have a routing table to keep the track of all the entries at the destination and need to have count on the hop required to achieve that particular destination. Their should be a sequence number at the entry to determine previous and old entries. Every node associated in the network periodically sends updated labels with consistently increasing even sequence numbers throughout the network to announce its position.

The latest available broadcasts consist of information regarding destination, hop count required to attain target, the details of the sequence number received with respect to destination, details with respect to the latest sequence that is specific about broadcast. The frequently selected path is basically the one which has its sequence number to be the most recent one. On the reception of this particular information by the nodes surrounded around the source node, heseneighbour nodes realize that they short of a hop with regard to transmitting one and hence try to accumulate this information in their respective DV. Each node keeps track of the following hop for each accessible target in their vector table. It is always the path having the utmost sequence number is chosen over other paths i.e. the latest path is used. On determining Y cant be reached by its neighbouring X and hence X helps to find a new path to it by a infinite method metric. The recent sequence number will help find all the new path in order to update it.

802.11 Standard:
802.11 is an IEEE protocol under the 802 protocol that specifies the LAN protocol. IEEE 802.11 defines protocols in the physical and data layers (especially the MAC layer). This protocol implements CSMA/CA. The protocol is usually used in the frequency range of 2.4GHz, 5GHz and 60GHz.Various sub-protocols are defined in 802.11, inclusive of 802.11a (that supports up to 54Mbps bandwidth when using 5GHz) and 802.11b (supports up to 11Mbps bandwidth when using 2.4GHz range), and is only supported by DSSS (direct spread spectrum sequence). This paper uses 802.11e, which is an improvement of 802.11a and 802.11b. It provides QoS functions, including data prioritization. The range it supports is the traditional 2.4GHz range. We know that the higher the frequency range, the faster the data transmission rate, thereby reducing sensitivity[9].
There are three parts in the MAC frame structure of the CSMA/CA protocol which are uplink, downlink and beacon, as seen in the figure. Beacon is responsible for synchronizing and defining the structure of the frame. The message in the beacon will consist of information of synchronization and transmission line up for all of the nodes inside the WBAN, also the transmission duration required for a particular frame is indicated by the duration field , during which the channel will be kept busy. Other nodes and coordinators set their network allocation vector(NAV) by keeping a track of the duration field in the wireless medium , which specifies for how long it should refrain from accessing the channel. The transmission information that is passed from coordinators to the receptor nodes is present in the downlink section, inclusive of both unicast as well as broadcast data. The uplink section consists of the contention access period(CAP) and the contention-free period(CFP). During CAP, nodes compete for an opportunity to transmit using a mechanism of slotted CSMA/CA. Meantime, in CFP, the coordinator manages the slot allotment for the receptor nodes i.e, the guaranteed time slots(GTS).The CSMA/CA protocol regulates the length of the frame and also changes the length accordingly, while in the downlink, coordinator puts together the CAP and CFP based upon the present characteristics of traffic.

Radio Propagation Model:

The received signal power of each data packet is predicted by the Radio propagation model which is applied in NS. At the lowest basic layer of every wireless node, there is a reception threshold. After receiving the data packet, if its signal power is lower than the reception threshold, it is considered as an error and discarded by the MAC layer. So far, NS has three types of propagation models, namely the two-ray ground reflection model, free space model 1 and the shadow model. We used a two-ray ground reflection model. There are two paths in two ray ground reflection model namely the direct path and the ground reflection path. The results show that, compared with the free space model, the model offers a more precise prediction over long distances.

Antenna type:

The antenna can be either Omni-directional or directional , we are using Omni-directional antenna as it is a WBAN application. Omni-directional antenna can transmit signals in any direction. The directivity of the antenna is given by:

$$D \approx 10\log_{10}(101.5/HPBW - 0.0072HPBW^2)dB. \quad (1)$$

where HPBW is half power beam width.

Other considerations:

Wireless PHY defines the network in the physical layer. It allows nodes to transmit and receive in the physical layer. For tracing the packets in each layer of the network we have trace options. Router trace(RTR) traces the packet in network layer, whereas Agent trace(AGT) traces the packet in transport layer, MAC trace (MAC) traces packet in Data Link layer .the nodes can be stationary or mobile in a wireless environment, if the nodes are mobile and we would want to trace their movement,movement trace will serve the purposely type LL is an abbreviation for link layer.It is accountable for flow of packets from network to mac layer and mac layer to physical layer.It is also possible to specify the queue length with the help of ifqLen command.

4. Prioritization

To guarantee QoS is fulfilled by coordinating QoS mechanisms to the network, this permits separation of various sorts of traffic. The frames that show up in the MAC layer are segregated dependent on priorities. This is done with the assistance of medium access parameters, each having a different AC value.[7].The classification mechanism differentiates different user priorities into different packets. This allows the network in identification and separation of the different types of traffic into flows or a group of flow.

802.11e uses two ways to control air-time. It uses EDCA for prioritization and using HCF for scheduling. EDCA or Enhanced Distribution Channel Access uses multiple Access Categories (AC) each of which is given a contention window (CW) specific to it. Attribution Inter-Frame Space (AIFS) and Transmit Opportunity (TxOP) supports QoS enhancement method. The time that every client holds up after every transmission is constrained by Arbitrary Inter Frame Space Number (AIFSN). Its range defaults from 2 voice-slots to 7 voice-slots. The back-off interval which is utilized when the channel is occupied is irregular and is constrained by Contention Window (CW). The default esteems for Background and Best Effort min and max CW are twice as that for video while it is four times as that of voice.By default, Background and Best Effort min and max CW are twice as long as those used for Video and four times those used for Voice. AIFSN and CW are the parameters used for scheduling the packets. AIFSN is Arbitration Inter-Frame Space Number, CW belongs to CWmaxand CWminand the AFIS for the ithpacket is calculated using:

$$AIFSi = SIFS + AIFSNi \times Timeslot \quad (2)$$

SIFS is the Short Inter-Frame Space and is defined as the spacing that is provided before the acknowledgement is transmitted.HCF or Hybrid Coordination Function is characterized as the capability for a 802.11 radio to push various frames when transmission is on the RF medium.
A Power Save (PS) is a 802.11e extension which diminishes power utilization by letting the customers or applications sleep between transmissions, accordingly, saving battery life. This convention alters PS for better by permitting better control to applications or clients while snoozing, yet at the same time requests receive data.

WBAN categorises packets as Normal, Emergency and On-demand. The data that is requested by a doctor or coordinator is called On-demand, this category usually contains diagnostic information which is launched on demand. This is additionally characterised as continuous (for surgical events) and discontinuous (for timely disclosure). Emergency packets are the packets generated by nodes on a regular basis but are unpredictable. Nodes initiate traffic as emergencies at the point when they surpass a predefined threshold. Normal packets are those packets in which traffic of data is in normal condition without time criticality or event requests. These include packets that are transmitted at regular intervals and are used in medical conditions such as neurological diseases, gastro-intestinal and cardiac disorders and detection of oncological diseases. Data in these packets are collected and processed by the coordinator. These packets are assigned a packet subtype and a user priority (UP).PS is responsible for mapping these packets to access categories of WLAN protocols, thereby mapping WBAN categories to WLAN's ACs. The mapping module maps the three WBAN groups to WLAN categories. The packet type with the highest user priority will be mapped to the highest numbered AC which is then given the highest priority. The highest UP which is 7 is given to Emergency followed by UP 6 to Normal traffic. The lowest priority between these WBAN categories is given to On-Demand packets as they correspond to normal physiological parameters. Mapping module maps UPs to their corresponding WLAN AC. Based on the UP, the ACs assigned to Emergency was AC 3 while to Normal was AC 2 and so on. Non-medical data is given the lowest priority of all and is therefore mapped to AC 0.

After mapping the packets with the mapping module, the packets have to be transmitted through the network. There are two ways to transmit information. The first method is to directly transmit every WBAN frame that arrives at the MAC layer. The second method is an indirect one in which the WBAN frames are aggregated i.e. WBAN frames are combined to a WLAN frame such that the maximum Degree of Aggregation (DoA) will be the maximum payload size defined by 802.11e. This WLAN/WBAN Bridge gathers and consolidates datagram frames from the WBAN hubs and then transfers this to the medical server. Once packets are ready to be transmitted they have to be queued and scheduled before transmitting it through the network. The scheduling system of flows has to be such that when a packet is chosen from a chosen queue the QoS is met at all times.[8]

5. Simulation and Results

The simulation was conducted using NS-2 on linux based ubuntu and the results namely throughput, end to end delay,for overall network or for a specific node is obtained and analysed. Simulation was done for 7 nodes consisting of 4 sensor nodes, intermediate nodes and the database node. Initially the parameters for wireless sensor nodes were set. After the code is written we obtain trace files for the congestion window and the trace file for the whole event. Weanalyse the trace files to obtain congestion window, PDR and throughput. The trace file format is given below-

The first column represents the event type;it can be s,r,d,f for sent, received, dropped and forwarded respectively. The time is represented in the second column .The node number is given in the third column. The fourth column indicates the AGT to specify the Transport layer(e.gtcp)packet, MAC if a packet is from the MAC layer ,or RTR to specify the route packet. Sometimes it is IFQ for drop packet. Fifth column is the global sequence number of packets(not

tcp sequence).The sixth column provide the details of the packet type(e.g. udp,tcp or ack).Seventh column represents the packet size in the form of bytes.In the eighth field, the details of Media access layer is given by square brackets with four numbers .The first hexadecimal number states the required time in seconds to send the datagrams through the wireless medium.The second one stands for the Media access identity of source node, third number is for receptor node. The fourth number,800,defines ETHERNETTYPE_IP which is a media access type. The next number of the second square bracket in the ninth column represents the Internet Protocol transmitting and receiving addresses, then the Time To Live (TTL) of the packet(In our file it is 32).The tenth column where third bracket specifies the tcp details as sequence number and acknowledgement number respectively.

The NAM window shows the simulation.Here we have 4 sensor nodes as tcp source nodes which generate the raw data.we set an actuator node as tcp/sink node .Then we may have a router node which is also given by tcp/sink node and finally the sink node.The sensor node data is added to the actuator and from the actuator the data travels to the final sink via a router node.A comparison of the values is given in the table below-

The table gives us the information about how the values of simulation vary with the time range. For our research, we have only considered the number of sending events, number of receiving events and the number of receiving events occurred when agent trace is on.

Congestion Window:
Congestion Window (cwnd) is a TCP state variable which controls the quantity of data a TCP can push into the network environment before obtaining a response is called a congestion window. In the following graph X-axis specifies time in ms and Y-axis specifies no. of MSS.MSS refers to maximum segment size. the congestion window is divided into three phases, i.e, slow start phase, congestion voidance, congestion detection. In slow start phase ,we set the size of congestion window equal to Maximum Segment Size (1 MSS).When acknowledgement is obtained the size of the congestion window size is increased by 1MSS.In this phase size of congestion window increases exponentially .In congestion avoidance phase the size of congestion window linearly increased to avoid the congestion. After obtaining every acknowledgement (ACK), the size of the congestion window is incremented by 1.In congestion detection phase ,when the loss of packets is observed, there is going to be a sharp decrease from the peak value. This may be due to time-out or by obtaining three identical ACKs.

For slow start phase,

CWND size = CWND size +MSS

(3)

For congestion avoidance phase,

CWND size = CWND size+1

(4)

Packet DeliveryRatio;
Packet Delivery Ratio is the ratio of packets or datagrams received to the total packets sent..This is determined by summing up the send and receive events from the trace file.Hence, the formula is given by:

$$\mathbf{PDR=\Sigma\ R/\Sigma\ S}$$

(5)

By this method we obtained the PDR as 98%.

Throughput; Throughput is the number of packets received successfully in unit time and it is defined in bits per second. Here we calculate the throughput by summing up send and receive

events when either the packet is AGT type or MAC type and dividing by the time. Hence formula is given by:

$$T=(\Sigma S-\Sigma R)/(\text{start time-stop time}) \quad (6)$$

The throughput obtained for this method was 370KBps.

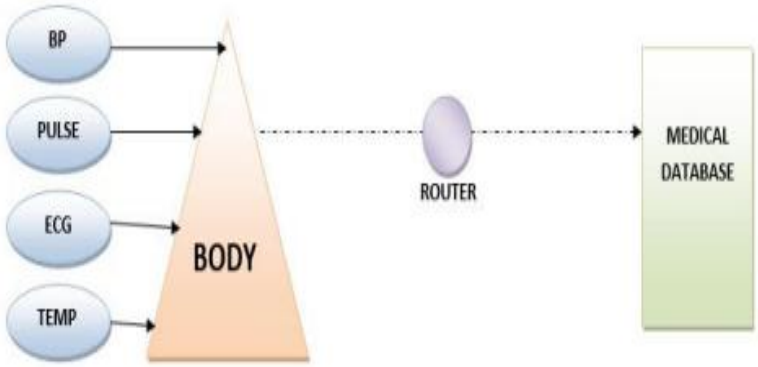

Figure 1. Block Diagram

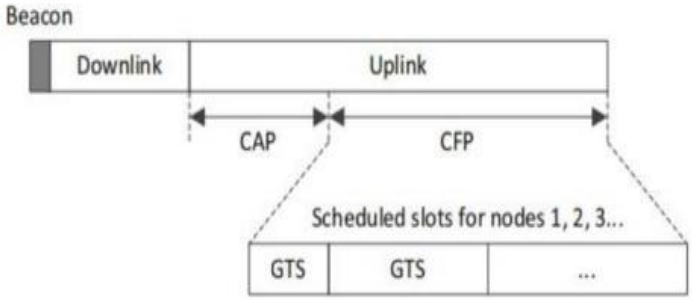

Figure 2. MAC Frame Format.

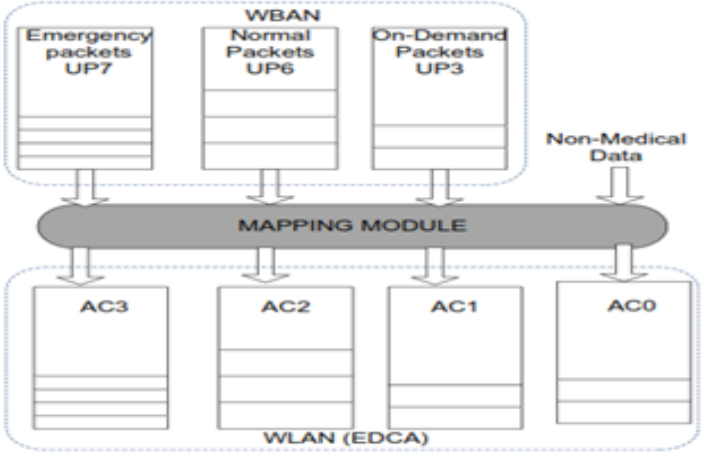

Figure 3. Prioritization in WBAN

```
s 5.068195427 _0_ RTR  --- 44 tcp 100 [0 0 0 0] ------- [0:0 4:0 32 4] [12 0] 0 0
r 5.071539488 _6_ AGT  --- 32 tcp 210 [13a 6 5 800] ------- [5:1 6:0 32 6] [4 0] 1 0
s 5.071539488 _6_ AGT  --- 45 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [4 0] 0 0
r 5.071539488 _6_ RTR  --- 45 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [4 0] 0 0
s 5.071539488 _6_ RTR  --- 45 ack 60 [0 0 0 0] ------- [6:0 5:1 32 5] [4 0] 0 0
r 5.074763541 _6_ AGT  --- 36 tcp 210 [13a 6 5 800] ------- [5:1 6:0 32 6] [5 0] 1 0
s 5.074763541 _6_ AGT  --- 46 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [5 0] 0 0
r 5.074763541  6  RTR  --- 46 ack 40 [0 0 0 0] ------- [6:0 5:1 32 0] [5 0] 0 0
```

Figure 4. Trace File Format

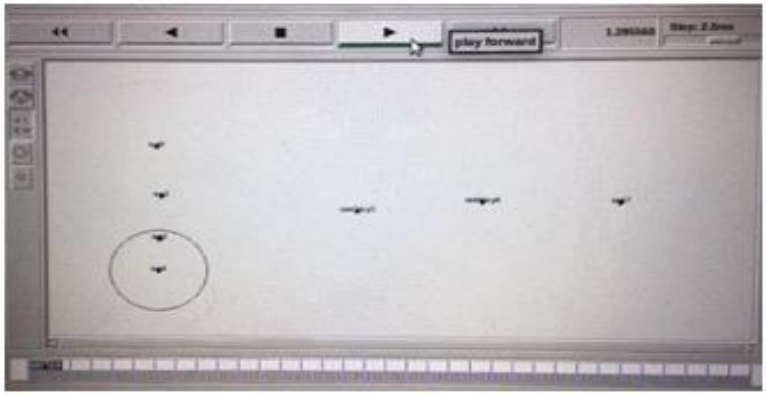

Figure 5:NAM Window

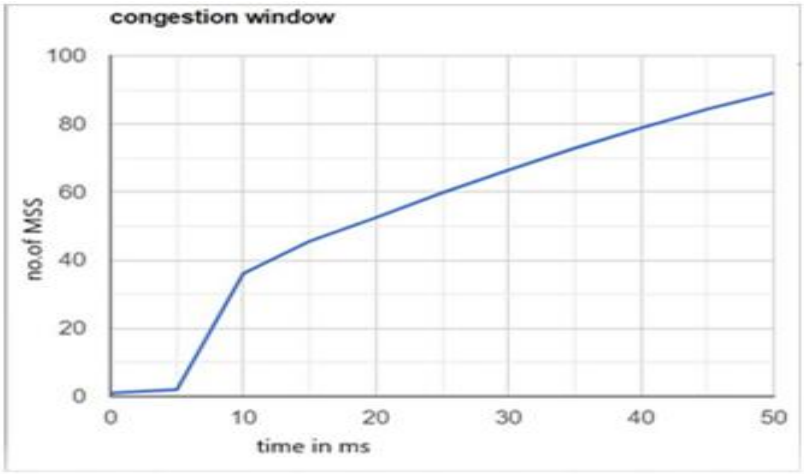

Figure 6:Graph of Congestion Window

Figure 7:Graph of PDR vs. Time

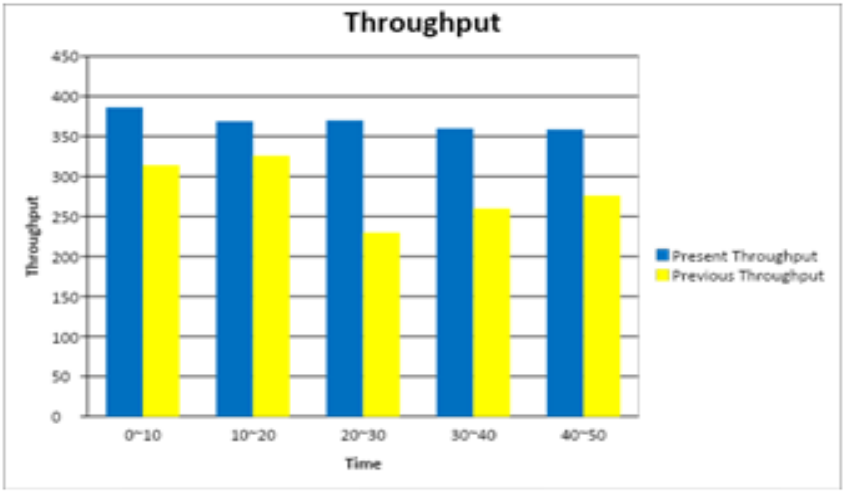

Figure 8:Graph of Throughput vs.Time.

Table I. Node configuration parameters and specifications.

Node Configuration Parameters	**Specifications**
Routing	Ad Hoc Routing DSDV
LL_type	LL
MAC_type	802_11
Queue type	DropTail
Queue length	50
PHY_type	Wireless
Channel Type	Wireless Channel

Propagation Type	Two Ray Ground
Antenna Type	Omni Antenna
Agent Trace	ON
Router Trace	ON
Maximum Packet Size	150
Number of Nodes	7
Simulation Time	50ms

Table II. Comparison of TCP packets vs. Time

Range	Time of first TCP packet	Time of last TCP packet	No. Of send events	No.of receive events	No.of receive events with agent trace
0-10	5	10.99	4788	4720	2312
11-20	11	20.99	7924	7866	3683
21-30	21	30.99	7500	7406	3698
31-40	31	40.99	7312	7206	3594
41-50	41	49.99	6575	6472	3224

7. CONCLUSION

This paper implements a WBAN with CSMA/CA using 802.11e protocol. The congestion window of the network is analysed. This paper also suggests a prioritization method that can be implemented in the network so as to achieve the QoS parameters in the network,which in this case is Throughput and Packet Delivery Ratio.The total number of sent and received packets is found using the trace file over the time interval and the corresponding Packet Delivery Ratio (PDR) and Throughput is calculated as 0.9874 and 370.993kbps respectively. Thus, concluding that the PDR and Throughput values have been improved from previous works.[15].This paper limits its research to PDR and throughput but it is possible to measure other QoS parameters like delay, bandwidth and energy with the same process.

Acknowledgement:

The authors gratefully acknowledge support from Visvesvaraya Technological University(VTU) as well as BMS Institute of Technology and Management(BMSIT&M). Secondly, the

department of telecommunication engineering(TCE) which has provided patient advice and guidance throughout the research process.

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Mitigating Losses In Landslide Detection For An Early Warning System With Wireless Sensor Networks

Sumathi M. S,[1]Shruthi J,[2]Gagana Jadhav,[3]Kritika Sharma,[4]Nischitha GV, [5]Samruddhi Patil1

1,3,4,5Department of ETE, BMS Institute of Technology and Management, Bengaluru, Karnataka, 560097, India
2Department of CSE, BMS Institute of Technology and Management, Bengaluru, Karnataka, 560097, India

[1]sumathi.m@bmsit.in

Abstract

Landslide is a catastrophic movement of the soil and rock in a downward slope. It is usually an after-effect of earthquakes, heavy rains, volcanic eruptions, or soil erosion. It might lead to injury, death, or damage of property ultimately resulting in financial loss. In order to reduce colossal destruction, it is important to detect landslides before they occur. Typically, a wireless sensor network comprises sensor nodes that are spatially dispersed over an area. The nodes can transmit data with each other wirelessly and also gather data about the variations in physical parameters such as temperature, pressure, etc. Since nodes have restricted or limited resources such as power and sense, they need to be used in an efficient manner in order to improve a network's lifetime. In this paper, we use the LEACH protocol for clustering and the AODV protocol for routing. NS-2 is a software that predicts the behaviour of computer networks to provide accurate analysis of system performance. The paper aims to evaluate performance through a network simulator for the existing system. The enhanced system shows an improvement in energy efficiency, throughput, packet delivery ratio, overhead and delay through simulation results. Additionally, features like fault tolerance, faster data processing rate, and higher transmission range have been incorporated in the system. In this paper, the enhanced WSN is designed using NS-2 tool for landslide detection.

Keywords—Landslide detection, LEACH protocol, NS-2 Simulation, WSN

1. INTRODUCTION

The violent movement of debris, rock and soil down a slope of a mountain is called a landslide. They are usually caused by earthquakes, rain, volcanoes, soil erosion and other man-made factors contributing to the instability of the rock mass. It might lead to injury, death, or damage of property ultimately resulting in financial loss. In order to reduce colossal destruction, it is important to detect landslides before they occur. [1]This paper aims to design an early warning energy-efficient Wireless Sensor Network using NS-2 simulation for landslide detection. A wireless sensor network comprises sensor nodes that are spatially dispersed over an area. Sensor nodes can transmit data with each other wirelessly and also gather data about the variations in physical parameters such as temperature, pressure,etc.The changes in the environment are sensed and reported to the other nodes. The sensor nodes are essentially planted in hostile environments or over geographically big areas. [2] Since sensor nodes have limited resources such as power and sense, they need to be used in an efficient manner in order to improve a network's lifetime. The LEACH protocol has been used for clustering and the AODV protocol for routing. Clustering is used in order to make the network energy-efficient as it aims

to reduce the transmission power. A cluster head is assigned to each cluster which is made up of a group of cluster members or sensor nodes. One of the primary functions of the cluster head is to transmit the gathered data over to the base station or the sink node. [3] The LEACH protocol is used in the implementation of this network. It uses cluster-based routing in order to achieve minimum energy consumption, higher throughput, and a longer network lifetime. The prime focus of LEACH is to use the process of cluster head election where the cluster member nodes sense any changes in the environment and transmit this data to the cluster head where data is aggregated and compressed. Compared to traditional routing protocols LEACH is more efficient than other protocols as the vitality and proficiency of the WSN improves through the cluster-based hierarchical approach. [4,5].

The AODV(Ad Hoc On-Demand Distance Vector) routing protocol provides adaptability to altering conditions, memory overhead, low network implementation and determines routes to destinations. AODV helps with routing table management. It also aids in solving link breakages and changes in network topology in a timely manner by allowing sensor nodes to respond accordingly. When the link breaks, AODV notifies the sensor nodes to allow them to negate the routes using the lost link. The routing table is checked for packets to be sent to their destinations and to check if it has the route to the destination. The node then sends the data to the next-hop node if it is true. The two features of AODV are Route Discovery and Route Maintenance where RREQ is broadcasted and the routing table is checked to the destination. If it is true, it will send RREP to the source. RREQ or the route request packet is broadcasted to discover the route whereas the RREP or the route reply packet establishes the forward path [6, 7].

This paper is divided into the following modules based on the chronology of the simulation code as topology module, energy module, cluster formation module,virtual CH selection, fault tolerance mechanism and performance analysis module. The NS-2 simulation tool is used to implement the five modules. A network simulator is an event-driven simulation tool which does not run in real-time and helps in mimicking the mechanism of various protocols in wireless sensor networks. An animation tool called NAM or the network animator helps in visualizing the transportation of packets graphically which in turn helps in analyzing the execution of the system in a more comprehensible fashion. OTcl or the object-oriented version of the Tool Command Language is used for object creation and procedure definition [8]. The paper aims to evaluate performance through a network simulator for the existing system. The enhanced system shows an improvement in energy efficiency, throughput, packet delivery ratio, overhead and delay through simulation result.Additionally, features like fault tolerance, faster data processing rate, and higher transmission range have been incorporated in the system. In this paper, the enhanced wireless sensor network is designed using NS-2 simulation for landslide detection.

2. IMPLEMENTATION MODEL

- **Topology Module*:***
  *T*his module explains the working of the code snipers used in building the network topology which comprises mobile nodes where each node functions with multiple channels. Initially, the topology module concentrates on the node configurations, the creation of a topology and the environmental conditions. A bandwidth and threshold value is assigned to every node in the network. To find the neighbors for each node the concept of Euclidean distance is implemented. Specification of the source node, the destination node and the time interval for data transmission determined. In NS-2, the full process takes a fraction of seconds to execute. The user can view this through a NAM window at any given second. The whole process has a start time and end time defined

- **Energy Module:**
  In wireless sensor networks, there are several sensor nodes which have constrained power of data transmission and processing competence. A dynamic method has to be designed to send information from the sensor nodes to the base station. This method can be implemented using hierarchical cluster-based routing protocol.

  In this paper, K-means method of clustering in the cluster formation module is considered to estimate a weight function to elect a cluster head. This clustering technique is utilized to regulate the sensor nodes into cluster members as while CH selection takes place, nodes with the highest amount of energy in the cluster group are selected to perform the transmission of data followed by aggregation of data in the most effective manner. The weight function uses the primary/initial energy of each node and their respective distances from the neighbouring nodes so as to elevate the value of throughput of the entire system and the lifetime of the sensor nodes. While transmission of data occurs, the multi objective weight function is implemented through link cost by applying the conventional Dijkstra algorithm. This method gives an efficient and equalized consumption of energy in each of the nodes present in the network. The movement of nodes to a position for cluster formation is known as Node Deployment. The deployment of nodes can be random or known beforehand. When its random it's deployed in a random fashion and when its pre-determined to us, the location of nodes is known prior to the deployment.

Algorithm 2*: Node Deployment*

Input: Number of nodes.

Output: Nodes are deployed to their position.
1: Calculate the distance between the nodes using Euclidean distance.
2: while l=d: number of nodes
3: First node position = 0
4: Next node position = previous node position + the distance.
5: Node ID <- i
6: map <- node position + Node ID
7: d<-i+1
8: End while

- **Cluster Formation:**
  The topology of this network is based on the clustering architecture. Here, each cluster has a set of nodes amongst which they elect the cluster head (CH) and the other sensor nodes comprise of the cluster members (CM).Prior to joining any network it is essential for the node to have the valid certificate from the cluster agent (CA) that manages and distributes certificates to all the nodes to enable the communication of nodes with one another. [3]In the system that is proposed when a node appears to be a Cluster head (CH), it gives out a CH hello packet (CHP) to notify the neighbor nodes in a periodic manner.All nodes present in the vicinity of the transmission range of the cluster head (CH) grant them permission to become the cluster members. Alongside that, when a node is assigned as a cluster member (CM), it must wait for the cluster hello packet as a word for its acknowledgment. Next, the CM joins the cluster; alongside, CH and CM maintain a relationship with each other by sending Cluster Hello Packet and cluster member packet in the time period

ALGORITHM 2 *Cluster Formation Method*

Input: Number of clusters, endpoints of clusters,
Number of nodes (in each cluster)

Output: Clusters formation

1:for:i< = number of clusters
2:pick appropriate x endpoints for theith cluster
3:pick appropriate y endpoints for the ith cluster
4: place the nodes in the clusters
5: Generate thecluster-ID
6:i=i+1
7:End for

- **Virtual CH Selection:**
  The cluster head (CH) failure can be identified by the faulty CH members and the sink. Here, firstly the faulty-free CH members analyse that they stop receiving acknowledgement of the data sensed from the environment or signal from the faulty CH and then detects the CH failure. Secondly, faulty CH can be detected by the sink node in the absence of the data sensed from the faulty cluster head for a particular time interval. Depending on the cluster routing technique, the data sensed is appended with the energy information of the CHs and is forwarded to the base station. In our system, we reasonably develop a virtual CH within the cluster depending on the total energy available of all faulty-free cluster members and cluster heads. The virtual CH bears the data originally sensed by the faulty-free cluster members. A constructive keen framework is maintained to portray all the data sensed by the faulty free and the faulty members within their respective clusters.

- **Fault Tolerance Mechanism:**
  In this paper, we've enhanced the existing system by introducing a new mechanism called the Fault-tolerance. The prime focus of this mechanism is to achieve run-time restoration of the nodes from the clusters in which the gateway has cultivated some faults. This mechanism has two phases namely; detection and recovery. In order to recover the data aggregated from the failed cluster head, it is necessary to foresee the faults that can occur in the network on the cluster head. It can be from the environment, through the transmission line, hardware or software faults, energy insufficiency etc. Once the fault is detected, the main cluster head goes down and the second cluster head is chosen with the second highest residual energy functioning as the backup CH. Now, the backup CH performs the second phase of fault tolerance by recovering the data sensed from damaged-free cluster heads and cluster members. The data recovered is compressed, processed and forwarded to the sink node within fraction of micro seconds. This mechanism saves bandwidth, makes the system highly secure, steadfast and accessible to the end users without considering the aftermath of a fault and thus increases network's life. [15] In the proposed system, the transmission range is extended and the data rate is increased with the help of Mac IEEE 802.11 b which plays a dynamic role in the performance and the lifetime of the network.

- **Performance Analysis Module:**
  Performance metrics is the criterion of collecting, analyzing and reporting numeric data based on the performance of the network. This module, specifically for this system, processes the output to compute various performance metrics being throughput, end-to-end delay, PDR, overhead and the average energy consumed by the entire network.

  This information helps analyze the overall efficiency of the network. AWK scripts for the computation process of compute discrete metrics depending on the performance of the network. Graphs are plotted which is further used for the visual analysis. The trace.tr file is obtained to act as a track record file which contains information about all the events taking place in the network. The trace file format also performs a substantialtask in computing the functioning metrics of the network. Using this, the data is processed and the required performance metric is obtained. The performance metrics then lead us to formulate parameters.

3. PERFORMANCE ANAYLSIS AND RESULTS

Simulation Parameter Table

Description of Simulation Parameters

- Throughput:Is the total number of bits or packets delivered successfully to the destination over the entire period of time. Its unit is kilobits per second (kbps).
- Average Energy:It's the ratio of the sum of all the individual energies of each node in the network to the total number of nodes. Its unit is joules.
- End to End Delay:The time taken by a packet to be transmitted across a network from its origin to target. It is measured in millisecond (). Delay may be caused due to buffering during route discovery, waiting in interface queues, retransmission delay at MAC, etc.
- Overhead:To keep the revived data of network routes, routing algorithms generate small-size packets, called HELLO packets. The routing packets are considered to be an overhead in the wireless sensor network since the routing and the data packets are shared within the same network bandwidth most of the time. It's calculated using the AWK script which processes the trace file and produces the final result.
- Packet delivery ratio (PDR): It's the ratio of the number of packets received successfully at the base location to the total number of packets transmitted (including re-transmission).

Performance Evaluation:
This paper focuses at analyzing the performance of each parameter between the proposed and the existing system. The following figures show the graphical representation of the simulation results we have achieved.

The relationship between the throughput and time is shown in figure 1. This data represents a gradual increase in the throughput of the proposed system when the proposed system is compared with the existing system due to the increment in the quantity of packets transmitted to the base station in the same time intermission. The relationship between the average energy and time is depicted in figure 2. This data illustrates the steady decrease of the average energy computed in the proposed system when compared with the existing system as the energy consumed per node is diminished.

The relationship amidst the end-to-end delay and time is shown in figure 3. This data portrays a sharp decline in the delay time of sent packets from one end to the other in the proposed system. The relationship between the overhead and time is shown in figure 4. This data describes that as time progressesin the proposed system, the overall routing overhead is moderately decreased. The relationship amidst the PDR and time is shown in figure 5. This data represents a significant hike in the PDR of the proposed system. Therefore, with the benefit of LEACH protocol, extended transmission range and enhanced data rate, we can visually apprehend from the simulated output that the performance of the proposed system is rapidly increased when examined and compared with the existing system.

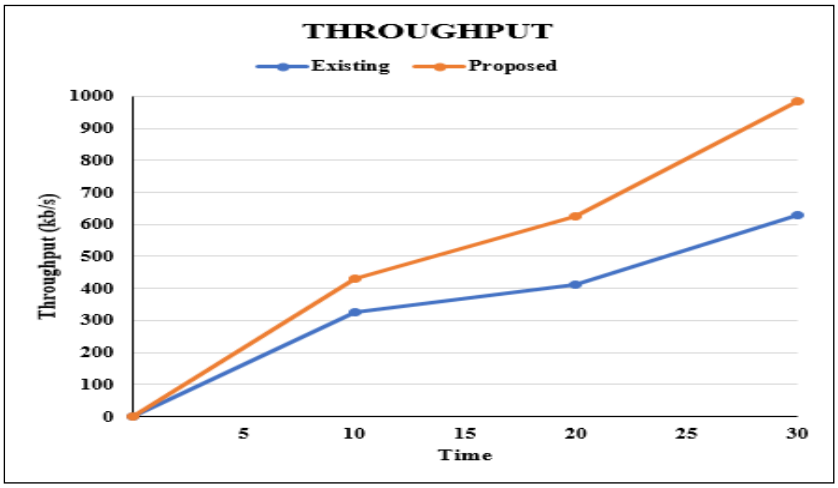

Fig 1: Throughput Vs Time Graph of Proposed Vs Existing System

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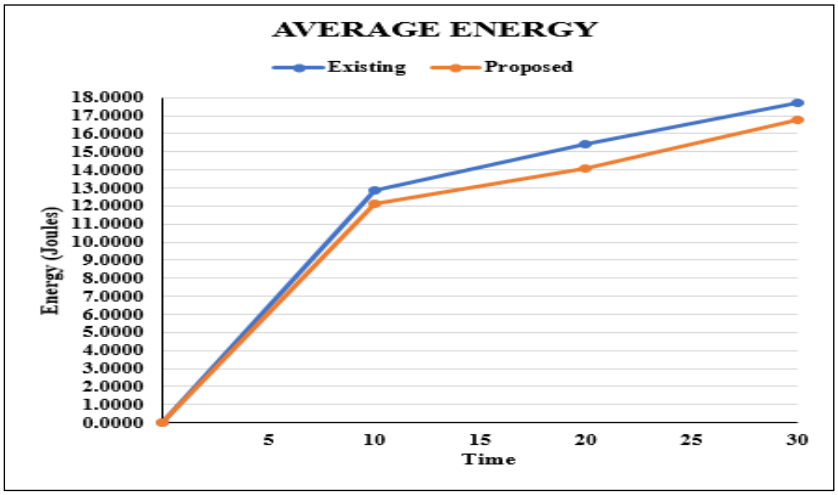

Fig 2: Average Energy Vs Time Graph of Proposed Vs Existing System

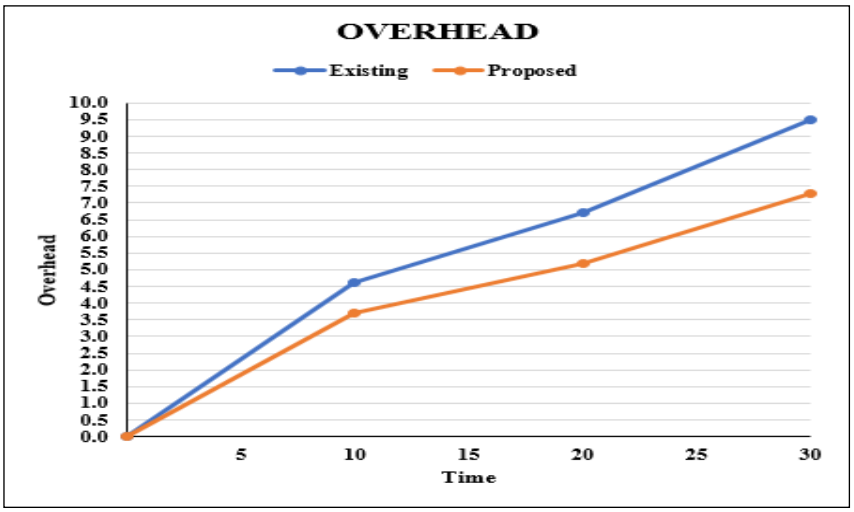

Fig 3: Overhead Vs Time Graph of Proposed Vs Existing System

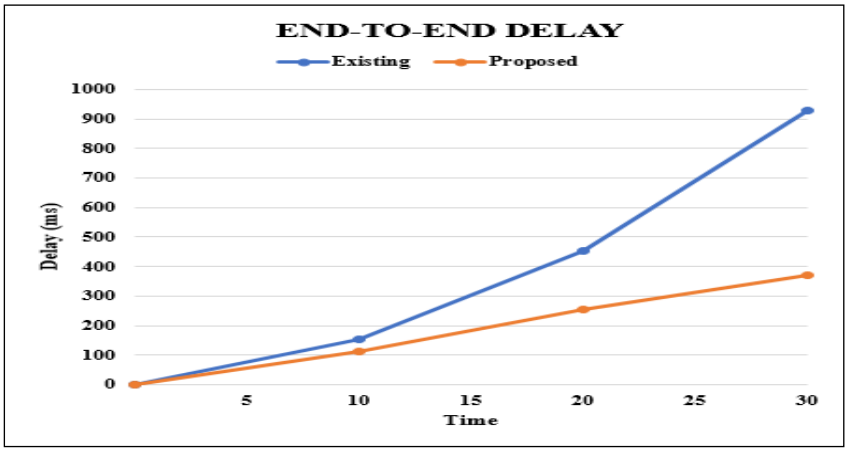

Fig 4: Delay Vs Time Graph of Proposed Vs Existing System

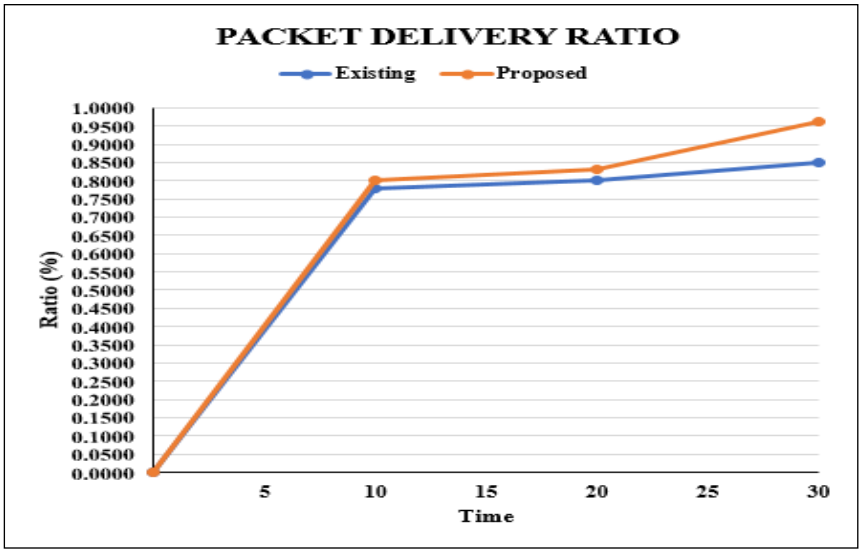

Fig 5: Ratio in % Vs Time Graph of Proposed Vs Existing System.

Table 1: Descriptive Statics

Parameter Name	Parameter Value
Simulation Tool	NS-2
Channel Type	Wireless
Radio Propagation Model	TwoRayGround
MAC Type	802.11
Initial Energy	Energy Model
Link Layer Type	LL
Number of Nodes	50
Routing Protocol	AODV
Simulation Area	1000 x 1300
Connection Type	CBR

4. CONCLUSION

WSNs are predominantly responsible in many of applications like disaster management, precision agriculture, security, and for military surveillance. In this paper, NS-2 tool was used for the simulation of energy-efficient WSN for landslide detection. LEACH protocol was implemented during the sensor node clustering process, while AODV was implemented as an optimal routing protocol. Here, the network performance of the existing system is compared with the enhanced system and then simulated using the tool. The simulation results portrays that the enhanced system is better in terms of energy-efficiency, higher throughput, lower end-to-end delay, reduced overhead, and an increased PDR. These parameters are calibrated optimally in order to achieve an overall efficient system. Fault tolerance, faster data processing rate, and increased transmission range were also integrated into the wireless sensor network. All of the above factors contribute to the design of energy-efficient WSNs simulation for the detection of landslides.

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European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 08, 2020

Forecasting & Detection Of Flood Using Random Forest Learning Method.

Shruthi J[1],Sumathi M S[2] ,Srivatsa Raju S[3], Vidya R Pai[4]

[1,3,4]Department of Computer Science and Engineering,B.M.S Institute of Technology Bengaluru, India

[2]Electronics and Telecommunication and Engineering,B.M.S Institute of Technology Bengaluru, India

Abstract

Flood is one of the most destructive natural phenomena which occurs in the nature. The ability to predict this occurrence well play a huge impact on the well-being of the human kind and other natural beings, from the brief history of the study of weather the ancient Mayan's where able to predict floods by the planetary motions which were not that accurate. With the development of technology and human dependency on computers, humans are able to collect large volume of various kinds of data such as planetary positions using mathematical models, Weather data using rain gauge and wind turbines. It is very complex to analyse these data and produce an outcome but with the help of machine learning algorithm once can obtain higher accuracy to forecast flood and alert the region beforehand and avoid losses of the precious.

Keywords: Artificial Neural Network (ANN), K- Nearest Neighbours, Radial Basis Function (RBF), Bayesian Network, Wireless Sensor Network (WSN), Support Vector machine.

1. INTRODUCTION

This paper sheds light about how Random Forest Learning Algorithm helps to predict flood before it happens and also compares the accuracy with other machine learning algorithm used these days traditionally. This paper also shares insights about various machine learning techniques involved in prediction this study can be utilized for better performance characteristics for flood prediction.

2. Motivation

Floods are incredibly destructive and can happen due to many different factors including snow, wind, and even as a result of other natural disasters like hurricanes. Since floods cause a lot of damage to human life, animals and property, we want to find the way to help with this natural disaster. Having a more accurate prediction will allow the damage to be mitigated so counties can even save money for disaster relief in those areas. Theoretically, anyone could use this application but in particular, county officials as well as disaster and prevention relief groups would use the application to predict flooding around their regions of interest and can warn people in a position to take measures against floods. Interested parties of this application include politicians, city planners, disaster relief groups, and government officials dealing with weather-related issues. The application is ideal to generate more insight alongside with current flood detection and prevention methods to protect areas of the country against unavoidable flooding.

3. Machine Learning Techniques Used For Prediction

In the adaptive environment of the present future the machine learning models helps to make better predictions than the traditional mathematical models in support with these model and the modern data science in the 21st century humans are able to predict with much better accuracy in this section presents a brief about the various techniques and their prediction accuracy in case of flood.

Artificial neural network:
With the backpropagation model the results of prediction of flood using this model is has an average accuracy of 92.03% and 88.14%, also the data error involved during the training process is 0.047% and 4.97%.[1]

K-Nearest Neighbors:
With the KNN model the data set consisting of parameters such as temperature, humidity and pressure used to determine the behavior of the model to predict the disaster with weighted moving average technique in a chronological order. The prediction accuracy of this model was proved to be of about 90% but this model does not consider various other parameters such as direction of wind, water level gauges, inland rainfall and so on which can play a key variable in forecasting the flood with higher accuracy. [2]

Radical Basis Function based on IOT:
The RBF is widely used technique to predict weather forecasting, load forecasting and many more, the RBF has three main layers input layer, hidden layer and output layer with each layer the data is classified for certainty as flood or no flood, this model can be used to predict only for a fixed time period such as thirty days. to predict further more data is needed which is a limitation in this case. The smallest error rate in prediction process with RBF is to use 700 times iterations and use the learning rate equal to 0.0007 units. [3]

Bayesian Network Model:
The Bayesian network model is a data driven model, with the increase of error rate in the data set the prediction model fails to perform accurately there are 2 stages for this model Local Bayesian network stage and Global Bayesian network stage where the first divides dataset into small fragments and implements the appropriate function to predict the outcome whereas the later constructs a model for the whole data set and predicts the outcome. [4]

Random Forest :
The random forest model can consider larger dataset for classification, regression and other tasks that operates by constructing a multitude of decision tress at training time and outputting the classification or mean prediction where with a relative small number of sample data set can get a better accuracy, with the more samples might not improve accuracy but can maintain accuracy when large portion of the sample data are missing relatively the computational cost of training a relatively low compared to other models. [5]

4. Flood Predicting Method

The large volume of metadata consisting of entities such as temperature pressure, elevation are recorded in systems where one can access this data and manage using pandas library for extraction of useful data, the daily reports, storm events and precipitation data is also available from the repository, considering these data here for training the random forest model, the daily report data is obtained in CSV format for pandas to analyse and passed to the algorithm as input. The random forest learning algorithm model metadata are heterogeneous which the attributes associated with them makes it complicated for individuals to understand, these data are obtained from various sources and distinct formats which needs to be integrated uniformly to avoid redundancy across the dataset here in this paper the SK learn open source library is used to implement the Random Forest learning model the data set is first cleaned to remove the

redundancy and the null values in the data set for this operation the use of clean data library is utilized the architecture as show in figure 1.1

The main functionality of Random Forest learning algorithm is to choose the sample data randomly and obtain a decision tree where the majority vote is used to make the predictions of the flood the rainfall data consists of only the average rainfall across the country for the month from certain time period, with the SK library visualizer we can obtain the threshold to decide the point where the rainfall above the certain threshold will result in floods in that month the figure 1.2 shows the threshold decision value from the dataset.

5. Data Split

The data set is split using the SK learn test train split library where the data is divided into testing data and training data in 70% of training and 30% testing split the split data is used accordingly for the mentioned cases, from the training split the random forest model is trained to make predictions where it builds n decision trees for the dataset with the built in library of SK learn we can use the predict function to make the predictions of the test data in which the data set in retrieved randomly from the test split model and decision tree is generated for the test split too the prediction is made by the percentage of true values obtain by the random forest model.

6. Result Analysis

The flood prediction using random forest model, the results obtained are 98% for the training model and 95% for the test data, the limitation of the model is when the data set is above the capacity of the hardware the HPC infrastructure needs to be implemented which attracts ways to improve the performance but the collocation of HPC and Big-Data is not easy because of the differences in concepts. The HPC job rigidity create holes in batch scheduler we can use these idle resources as dynamic adaptability for Big-Data workload with the help of Resource and Job Management System's (RJMS) configured to communicate with both Big-Data Systems and HPC's using prolog techniques.

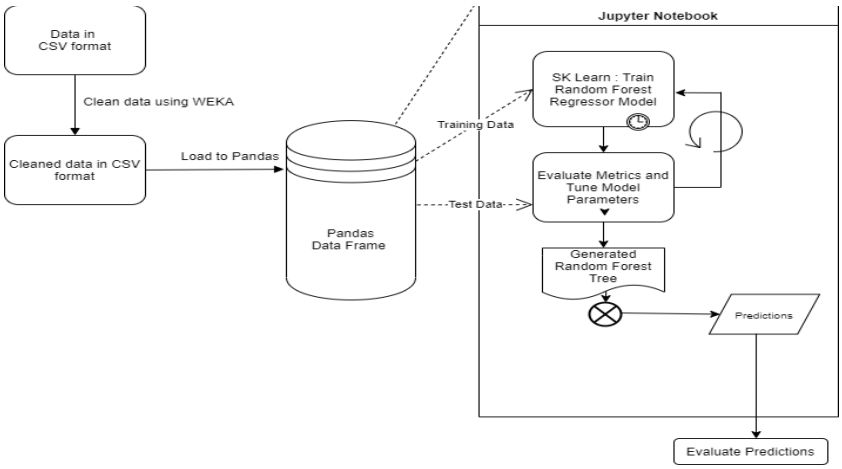

Fig 1: Flood forecasting architecture

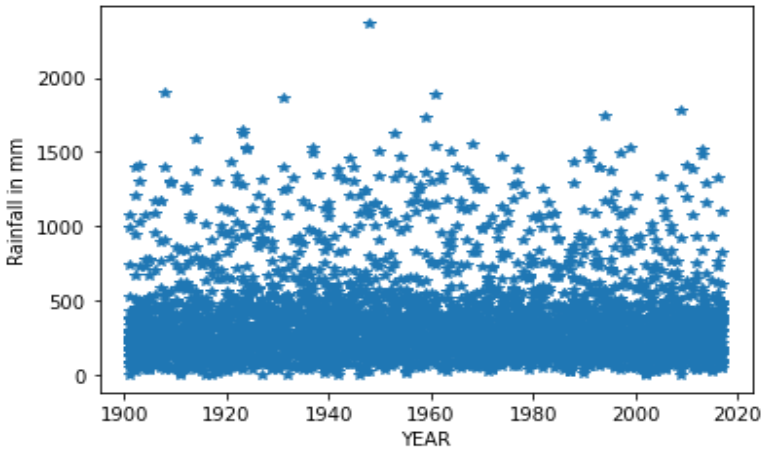

Fig 2: Plot for threshold identification

7. CONCLUSIONS AND FUTURE WORK

This paper discusses about the flood forecasting model using random forest implemented using SK learn library where this can be implemented along with existing architecture for scalability in account of Moore's law where the system must be dynamically scalable and the future work of this paper is where the prediction to be made using much more added parameters such as wind direction, temperature, location specific attributes and so on.

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