International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 / https://doi.org/10.14445/22315381/IJETT-V70I7P234
Volume 70 Issue 7, 329-338, July 2022
© 2022 Seventh Sense Research Group®

*Original Article*

# Conceptual Modeling of Narrow Band Communication System for Interference Free Channel Allocation

S. Vandana[1], T. Madhavi[2]

[1] *Department of Electronics and Instrumentation, VNR Vignana Jyothi Institute of Engineering and Technology, Telangana, India.*
[2]*Department of Electrical, Electronics and Communication Engineering, GITAM School of Technology, Telangana, India.*

[1]vandanahasini@gmail.com

Received: 07 May 2022 Revised: 14 July 2022 Accepted: 17 July 2022 Published: 25 July 2022

***Abstract*** - *Channel bandwidth allocation plays a vital role in Narrow Band Communication. In COTS Based 802.11 systems, the bandwidth of > 20MHz was utilized because the number of noninterference channels used for data communication is less than 4. Acquiring one of the noninterference channels for data transfer will increase the waiting time of the node for data transfer, and the communication range will be less. Several commercial devices like Lora and Sigfox are available with fixed bandwidth, and building a communication network is not possible with these devices. So, a conceptual model was demonstrated using open source 802.11 modules by changing its firmware to 1 MHz bandwidth. The narrow bandwidth of the channel is enough when the communication data is very low. In this 1 MHz bandwidth, a total of 9 channels, each with 2.3KHz, is allocated, with a guard band of 123KHz between channels to make the communication interference-free. This model can still increase the number of channels in contrast to less than 4 noninterference channels in COTS-based systems by allocating lesser bandwidth to the guard band or utilizing more bandwidth in the available 20 MHz.The model's performance evaluation shows required data and packet delivery rate values.*

***Keywords*** - *Channel Bandwidth, COTS Based 802.11 system, Guard band, Narrowband Communication.*

## 1. Introduction

Recent technological advancements have created revolutionary progress in communication systems, from changing wired networks to wireless networks. Wireless networks will not have a fixed infrastructure and are called Wireless Adhoc Networks(WANETs). WANETs have been a popular research area due to their self-configurable and mobile nature. Without any fixed infrastructure or centralized access point, a WANET connects mobile devices anytime and from any location. When you need to share files or other data with another computer but don't have access to a Wi-Fi network, Adhoc networks are helpful. Nodes serve as routers to transport packets for peer nodes and to construct the Adhoc network. In an environment with limited node networking, transmission range, and high mobility, forming an efficient network for data transfer becomes a major challenge. So, the necessity for an efficient and cost-effective system in which secure data transmission between nodes without interference are highly appreciated.

Several works are proposed for the effective communication of data between different nodes. In digital wireless communication systems, the channel estimate is an integral aspect of receiver design. Arslan et al. demonstrated how to channel estimation performance can be enhanced for a time-invariant channel by carefully designing training sequences and using previous information about the channel and noise. Pilot symbols can be used to estimate a time-varying channel utilizing interpolation for a time-varying channel. Data-directed tracking can be employed when pilot symbols are not accessible. Approaches to channel tracking are based on a model of how the channel evolves [1].

On a high abstraction level, the three technologies LoRa, Sigfox, and NB-IoT were demonstrated[2]. The measurement data is taken by a sensor and relayed using the narrow band technology. A gateway receives these and forwards them to a server for storage. The data can be viewed in a web browser by the server. It was shown that several technologies could be used to accomplish temperature measurement and demonstrated how the sensor and visualization could be replaced.

This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

The main contribution of the study done by Ganesh et al. is to tackle the problem of narrowband speech prediction from wideband speech. An increase in frequency bandwidth improves the perceived speech by artificially introducing some spectral components. Artificial bandwidth extension (ABWE) improves quality and intelligibility by utilizing information from the narrowband speech stream. When using spline curves procedures, expanding wideband speech is favored over band constricted small band speech with a level of relevance [3].

The communication range of a wireless communication system is an important characteristic, and the communication data rate determines the range. There are a few technological ways to enhance range by lowering the data rate. Scaling the receiver bandwidth to the signal to reduce noise observed by the receiver (narrowband system) and putting coding gain on a faster rate signal to battle high receiver noise in a wideband receiver are the two options in this proposed system [4].

Based on mathematical morphology, a new co-channel interference method for detecting interference in satellite communication is proposed, especially when many signals have varying properties. To deal with spectrum data that is perceived as a one-dimensional gray-scale image, search the gradient of interference edges to locate its position. Simulation results show that the proposed method can detect interference when multiple signals interfere simultaneously and have low computational complexity [5].

The study looked at the design modifications brought on by the NB-IoT standards and specific research developments in the Physical and MAC layers. The NB-IoT design is based on LTE, with certain modifications to meet the requirements of mMTC. Only single-antenna and low-order modulations are supported in the physical (PHY) layer. In the Medium Access Control (MAC) layer, only one physical resource block is allocated for resource scheduling. The survey also examines how the Evolved Packet Core (EPC) is evolving to support the Service Capability Exposure Function (SCEF), which manages both IP and non-IP data packets via the Control Plane (CP) and User Plane (UP), as well as future NB-IoT deployment scenarios in heterogeneous wireless networks (HetNet) [6].

The failure to consider the structure and timing characteristics of the noise bursts in prior analyses of the challenge of calculating bit error rates for narrowband digital communications in the presence of atmospheric burst noise is highlighted. It is suggested that these parameters be introduced via a method of analysis. Areas where more noise data should be collected, are identified[7].

Aamir et al. proposed a buffer management technique in which data packet transport in MANETs via static and dynamic nodes was done. An active queue management method was devised to accomplish efficient queuing in a centrally communicating MANET that assigned dynamic buffer space based on the number of packets received from neighbors. Because all neighbors share the buffer space, none of the nodes consume the entire buffer space by transmitting packets at a greater data rate [8].

The performance of six wireless protocols, Bluetooth, UWB, ZigBee, Wi-Fi, Wi-Max, and GSM/GPRS, are examined by Chakkor et al. [9]. After having a quantitative analysis of bit error rate, transmission time, data coding efficiency, power, energy consumption, and network size, the best protocol based on intelligent sensors was discovered. The aim is to design a gateway that allows data to be exchanged across these various infrastructures while maintaining a high level of service. Solving this challenge requires a fresh perspective and builds on earlier efforts. It turns out that the modulation type chosen is always decided by the constraints and requirements of the application [9].

A route discovery strategy was presented by Haas et al. in which the negative impacts of malicious activity while also giving reliable connection information was studied. According to the protocol, fake, hacked, or replayed route replies will be refused or never reach the requesting node. The protocol's responsiveness is also secured against a range of attacks aimed at the routing protocol. The suggested system's only requirement is that the querying node and the targeted destination share a security association[10]. An active queue management strategy was designed to achieve efficient queuing in a centrally communicating WANET node's buffer. By allocating dynamic buffer space to all neighboring nodes in proportion to the number of packets received from neighbors, thereby controlling packet drop probabilities. The research shows that the recommended technique can improve packet loss ratio and transmission efficiency for packet queues in MANET nodes [11].

The interference effect in a robust UWB system was studied, which promised required protection levels as in NB systems. A proper understanding of the effects of interference is an essential tool for spectrum management in this technology[12]. The performance of wideband communication systems in narrowband interference is examined in Narrow Band Interference research [13]. For spread-spectrum systems closed-form, bit-error probability equations were developed by modelling narrowband interferers. The findings of simulations for NBI such as GSM and Bluetooth match with analytical results, indicating that the approach effectively examines ultrawide bandwidth systems' coexistence with existing wireless networks.

A narrowband LTE-M solution for LPWA networks has been proposed[14], which meets the capacity, cost target, and coverage requirements for low data rate M2M. It is demonstrated that a narrowband LTE-M system may be deployed using just one GSM channel and multiplexed with LTE. According to the analysis, the system can coexist with a GSM system and requires few adjustments to the installed LTE system. Furthermore, the LTE-M system has enormous capacity and can provide a 20-dB coverage extension beyond LTE.

LPWA networks are considered the most efficient solution to support the wide range of low-end MTC applications [15]. Since its inception, NB-IoT, as a new 3GPP proposal, has attracted a lot of attention. A full overview of its evolution and major technologies is studied. Furthermore, the key issues that NB-IoT is now facing are identified. Continuous development of NB-IoT technologies to push the boundaries of future device connectivity is identified.

A system consists of NB devices, an IoT cloud platform, an application server, and a user app. The system's main component is a development board that combines an NB-IoT communication module and a subscriber identity module, as well as a microcontroller unit and power management modules. The IoT cloud setup was proposed for data storage and analysis and a firmware design for NB device wake-up, data sensing, computing, and communication [16].

The above discussions focus on different communication systems in which buffer space, packet delivery ratio against multiple attackers, link breaks, route repairing strategies, and queue management strategy for effective data communication between Adhoc networks. Some of the above systems effectively communicated by compromising the distance between nodes, some compromised by reducing the number of nodes to be connected, and some forego security; here, a system was proposed in which effective communication of data between different nodes was designed. It can be further increased by reducing the channel bandwidth allocated to the node so that they can communicate effectively over a long distance. In this paper, a basic system model was proposed for data transmission where node networking between nodes was increased, and also performance metrics were studied

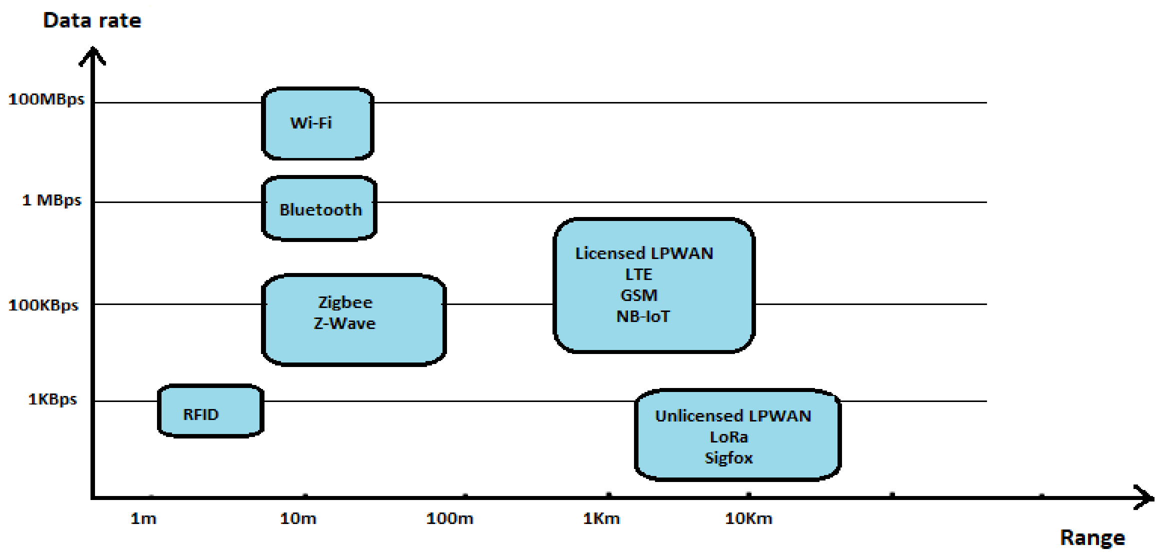


**Fig. 1 Different Communication Technologies Data Rate and Range**

The communication medium between two nodes can be wired, wireless, or acoustic. In a wireless medium, the communication can be through Radio Frequency waves, Infrared transmission, satellite communication, and acoustic underwater. Infrared wireless communication is used for short and medium-range communication. (Radio Frequency range is from 3KHz to 300GHz ).RF wireless communication is used for medium-range communication, and Satellite communication is used for long-range communication. Different transmission medium used for data communication is shown in Fig. 2.

Several commercial devices (LoRa, Sigfox.)are available for long-range communication. Still, the implementation cost of building a network with the available commercial devices will be higher, even though secure narrow band communication is impossible. So, IEEE 802.11 standard communication device was used, a short-distance communication device used as a long-distance communication device by modifying the node's firmware using LUA scripting language. Users in Open-source modules can change the fixed channel bandwidth of the device(node).

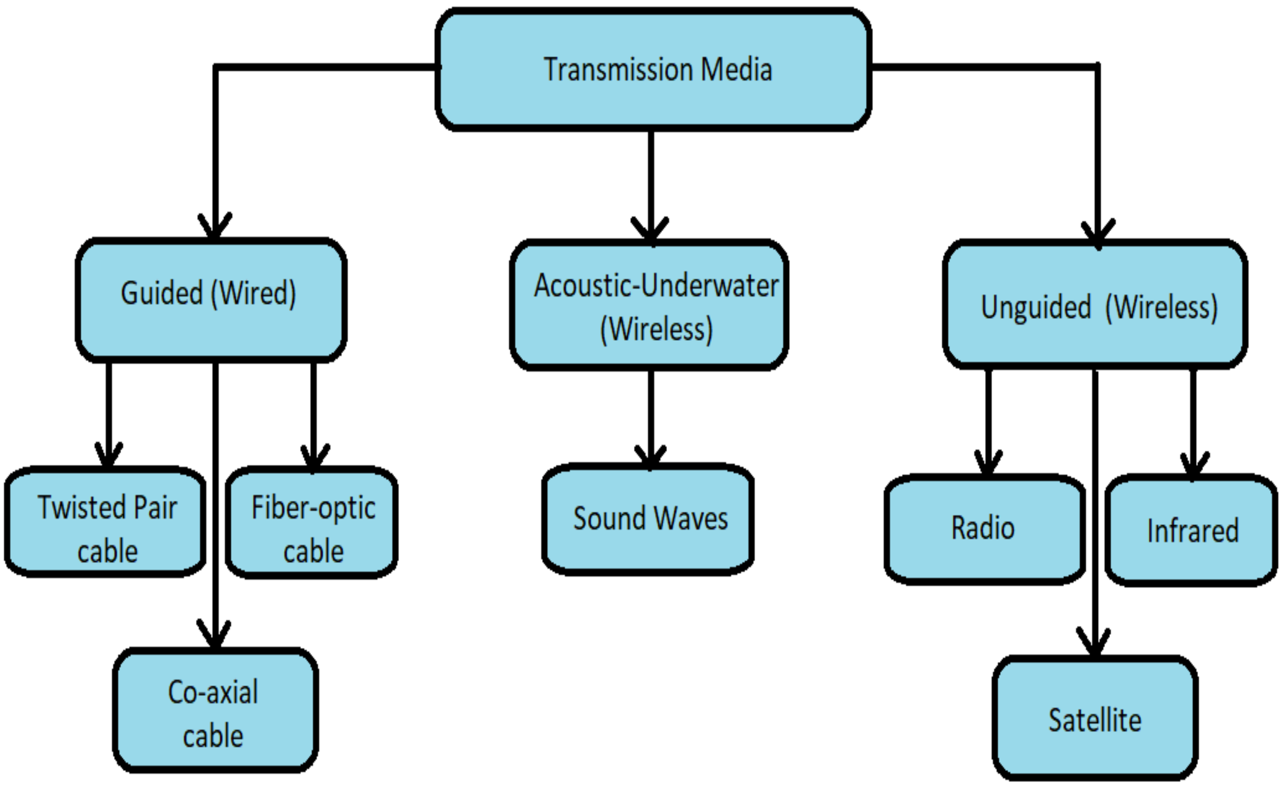


**Fig. 2 Different Transmission Mediums for Data Communication**

## 2. Proposed Conceptual Model

Using a concept similar to Software-defined Radio, the module's bandwidth is changed to the required range with the help of an RF transceiver. The design of the RF front end is as shown in Fig. 3.

By modifying the module's firmware, the number of channels with the required bandwidth that the nodes can acquire can be increased. A system with only 1 MHz of available 20 MHZ for 9 Nodes, allocating 2.3KHZ for each node and a guard band of 123KHz were designed as shown in Fig. 4. The number of channels can be increased by allocating lesser bandwidth to the guard band or utilizing more bandwidth in the available 20 MHz.

Using this concept, 9 nodes were connected to Server through Access Point, as shown in Fig. 5. Each node acts as a client when receiving data from the server and can also act as another server by building the network.

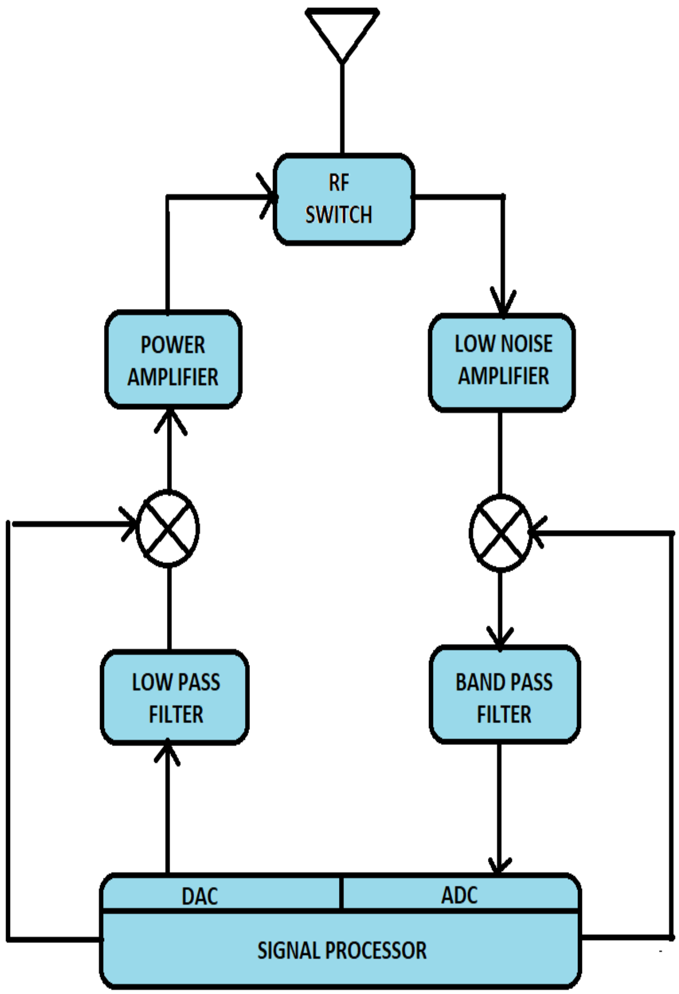


**Fig. 3 COTS RF Module**

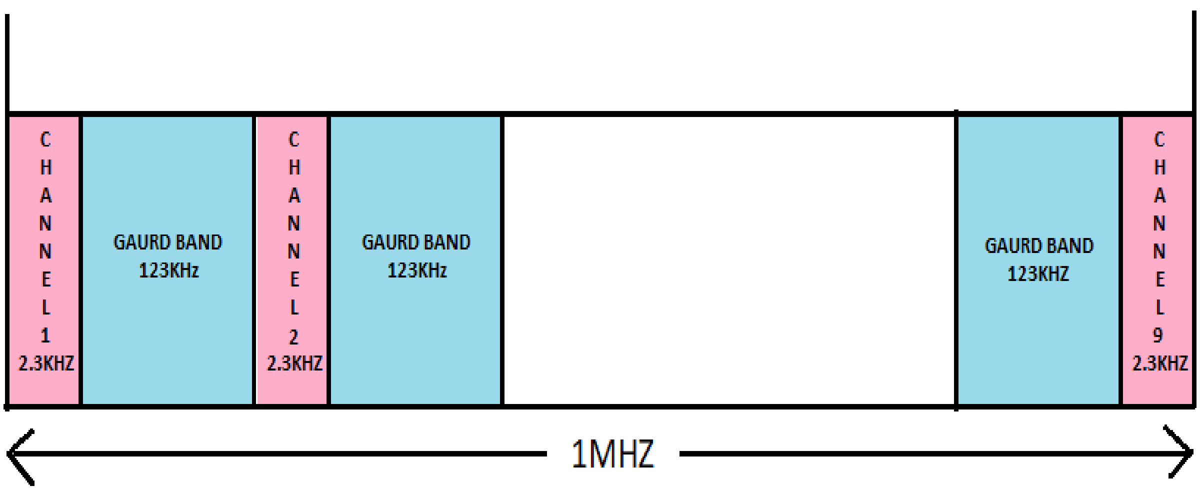


**Fig. 4 Bandwidth allocation for 9 channels and 8 Guard bands**

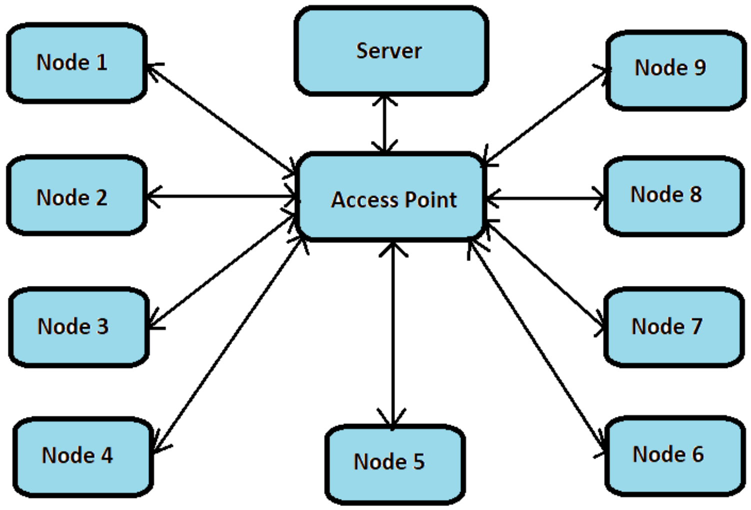


**Fig. 5 Block diagram of the proposed system with 9 Nodes connected to Server through Access Point**

## 3. Results

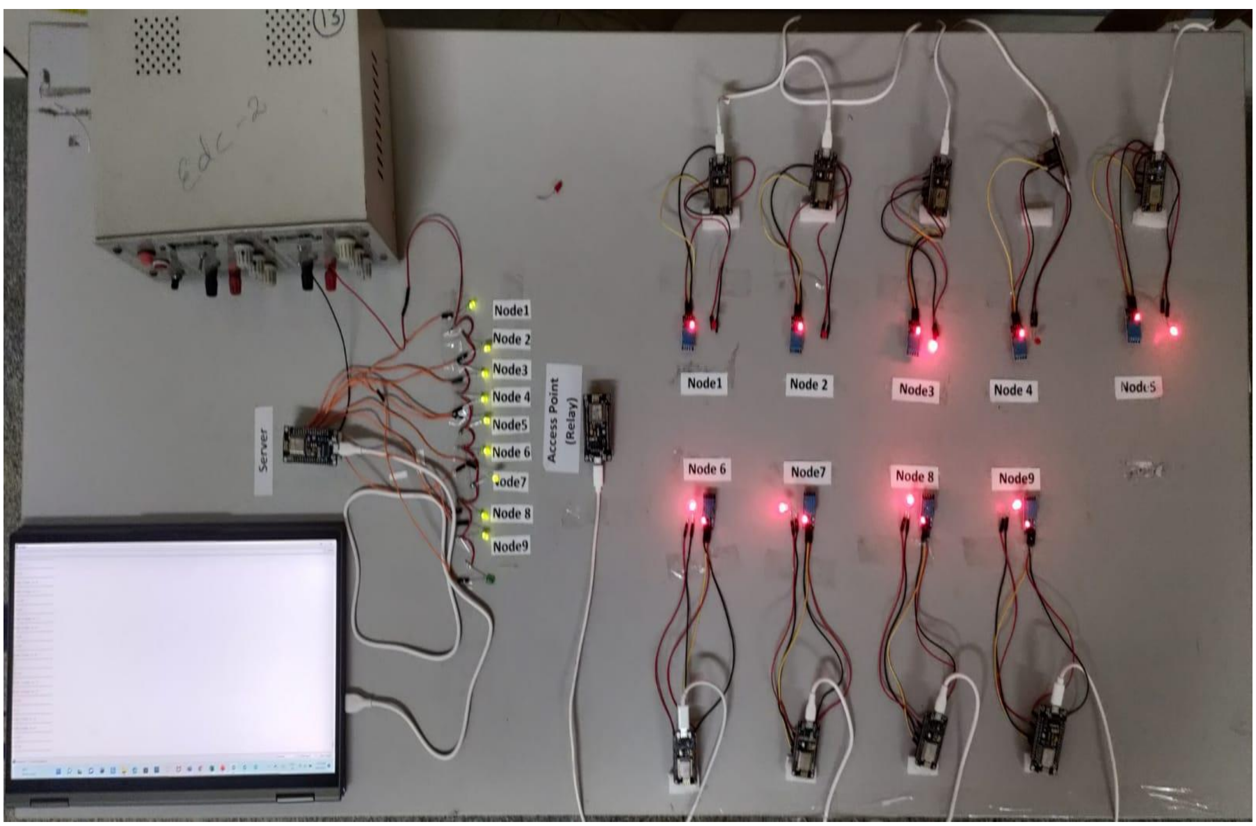

**Fig. 6 Hardware Implementation of Conceptual model with NODEMCUs as Nodes, Access Point, and Server**

The above system is tested first, with 9 Nodes connected to DHT sensors and acquiring the temperature and pressure values. The values from the nodes are sent to the server, acknowledgment from the server to the node is received, and data can be sent from server to node. Fig. 6. shows the hardware implementation of a conceptual model. Fig. 7. To Fig. 9. shows the serial monitor ports of the Server and Nodes during data transfer.

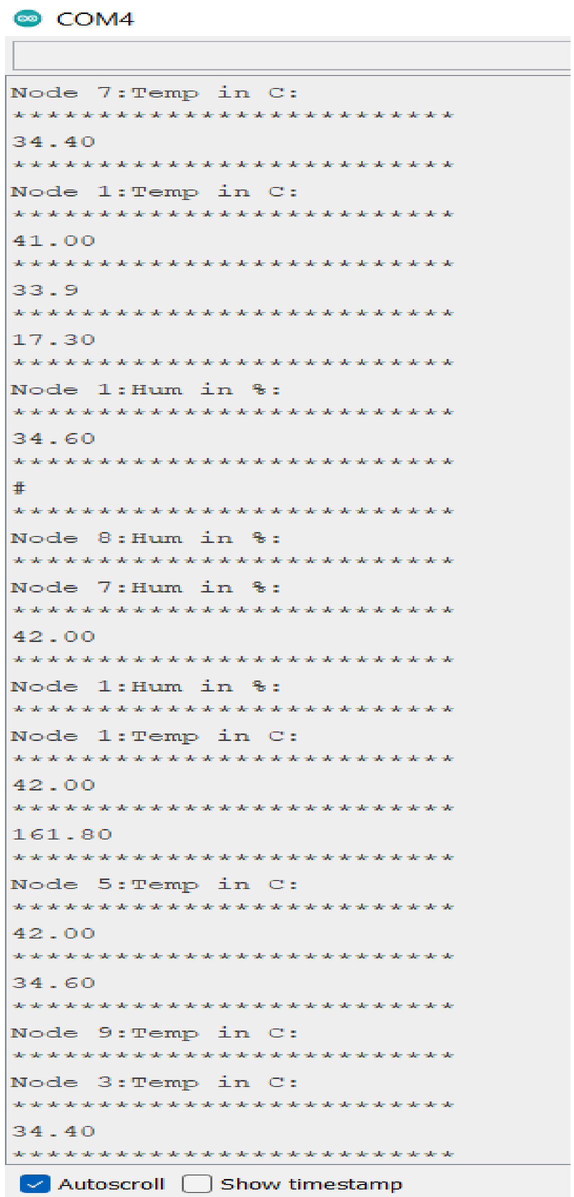


**Fig. 7 Serial Monitor of Server showing the temperature and humidity values from different Nodes**

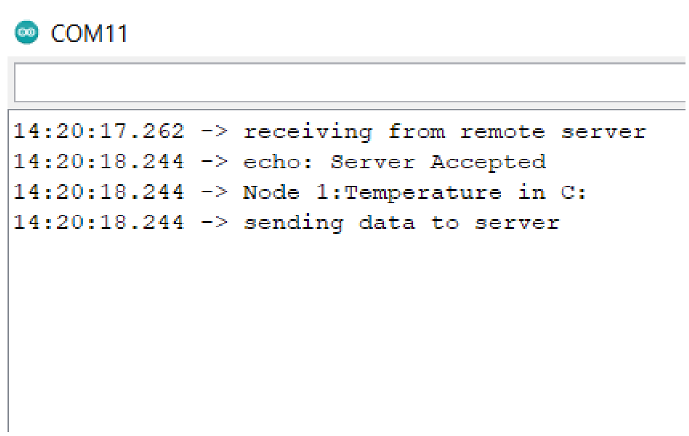


**Fig. 8 Serial Monitor of one of the Nodes showing the acknowledgment from server**.

### *3.1. Performance Parameters*

The performance parameters data rate and delay are measured by constructing the packet with the format shown in Fig. 9. The packet is 8000 Octets. The Header is 36 Octets, the Frame body is 7960 Octets, and the Frame Check Sequence is 4 Octets.

The data rate and packet delivery delay values of sending the standard 802.11 Packet Frame with frame body, as defined in Fig. 9, are shown in Table1. Fig. 10. and Fig. 11.shows the performance parameter values in the serial monitor and acknowledgment received from the server.

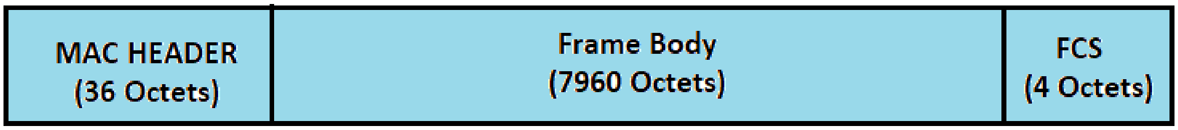


**Fig. 9 IEEE 802.11 Frame Format**

```
COM9

14:51:12.732 -> ***************************************************
14:51:12.766 -> Received length of string is
14:51:12.766 -> 3215
14:51:12.766 -> Payload of the received data
14:51:12.766 -> 25720
14:51:12.766 -> Time of Travel in Micro Seconds
14:51:12.766 -> 12860.00
14:51:12.766 -> Delay in milliseconds
14:51:12.766 -> 43The increasing rate of users and network capacity creates a necessity
14:51:19.048 -> ***************************************************
14:51:19.048 -> Received length of string is
14:51:19.048 -> 8136
14:51:19.048 -> Payload of the received data
14:51:19.048 -> 65088
14:51:19.048 -> Time of Travel in Micro Seconds
14:51:19.095 -> 32544.00
14:51:19.095 -> Delay in milliseconds
14:51:19.095 -> 97#
14:51:24.544 -> ***************************************************
14:51:24.592 -> Received length of string is
14:51:24.592 -> 1
14:51:24.592 -> Payload of the received data
14:51:24.592 -> 8
14:51:24.592 -> Time of Travel in Micro Seconds
14:51:24.592 -> 4.00
14:51:24.592 -> Delay in milliseconds
14:51:24.592 -> 0The increasing rate of users and network capacity creates a necessity
```

**Fig. 10 Serial Monitor of Server showing the Performance parameter values**

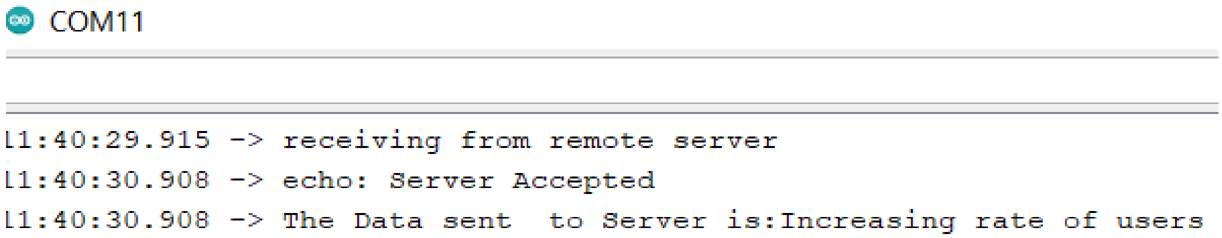


**Fig. 11 Serial Monitor of one of the Nodes showing the acknowledgment from server.**

**Table 1. Performance parameters obtained for Low, Medium, and High Data**

| | Low Data(Bytes) | Medium data(Bytes) | High Data(Bytes) |
|---|---|---|---|
| Received Length of String(Character) | 1 | 3215 | 8136 |
| PayLoad (Bits) | 8 | 25720 | 65088 |
| Time of Travel in (µSec) | 4 | 12860 | 32544 |
| Delay in(mSec) | 0 | 43 | 97 |

## 4. Conclusion

An effective, cost-efficient data communication conceptual model was developed in which 9 nodes have successfully communicated with the server through the Access point. It was proved that the narrow bandwidth of the channel is enough when the sensory communication data is very low. The communication was interfered free by allocating 9 channels, each with 2.3KHz in 1 MHz bandwidth and a guard band of 123KHz between channels. It is obvious from this conceptual model that the number of channels can still be increased in this model contrary to less than 4 noninterference channels in COTS-based systems by allocating lesser bandwidth to the guard band or by utilizing more bandwidth in the available 20 MHz. The performance parameters data rate and packet delivery delay are also evaluated. This system does not include the concept of security as the Narrowband Communication is secure.

## References


[1] Arslan, H., & Bottomley, G. E, "Channel estimation in narrowband wireless communication systems," *Wireless Communications and Mobile Computing*, vol.1, no.2, pp. 201-219, 2001.

[2] Herlich, M., & von Tüllenburg, F, "Introduction to Narrowband Communication," *In Wireless Congress: Systems and Applications* , pp. 1-15, 2018.

[3] Ganesh, M. S., Patnaik, B., & Karthik, M, " Narrowband speech signal bandwidth extension for intelligible speech communication," *In 2017 IEEE International Conference on Intelligent Techniques in Control, Optimization and Signal Processing* , no.INCOS) , IEEE, pp.1-5, 2017.

[4] Lassen, T, " Long-range RF communication: Why narrowband is the de facto standard," White Paper.

[5] Hu, J., Bian, D., Xie, Z., Li, Y., & Fan, L, "An approach for narrow band interference detection in satellite communication using morphological filter," *In International Conference on Information Technology and Management Innovation*, Shenzhen, China, 2015.

[6] Mwakwata, C. B., Malik, H., Mahtab Alam, M., Le Moullec, Y., Parand, S., & Mumtaz, S, " Narrowband Internet of Things , no.NB-IoT): From physical , no.PHY) and media access control , no.MAC) layers perspectives," Sensors, vol.19, no.11, pp.2613, 2019.

[7] Sastry, A, "Estimation of Bit Error Rates for Narrow-Band Digital Communication in the Presence of Atmospheric Radio Noise Bursts," IEEE Transactions on Communication Technology, vol.19, no.5, pp.733-735, 1971.

[8] Samara, L., Gouissem, A., Abdellatif, A. A., Hamila, R., & Hasna, M. O. "On the performance of tactical communication interception using military full duplex radios," *In 2019 IEEE 30th Annual International Symposium on Personal, Indoor and Mobile Radio Communications* , no.PIMRC, pp.1-6, 2019.

[9] Aamir, M., & Zaidi, M. A, "A buffer management scheme for packet queues in MANET," *Tsinghua Science and Technology*, vol.18, no.6, pp. 543-553, 2013.

[10] Chakkor, S., Cheikh, E. A., Baghouri, M., & Hajraoui, A, "Comparative performance analysis of wireless communication protocols for intelligent sensors and their applications," arXiv preprint arXiv:1409.6884,2014.

[11] Chiani, M., & Giorgetti, A, "Coexistence between UWB and narrowband wireless communication systems," *Proceedings of the IEEE*, vol.97, no.2, pp. 231-254, 2009.

[12] Giorgetti, A., Chiani, M., & Win, M. Z, "The effect of narrowband interference on wideband wireless communication systems," *IEEE Transactions on Communications*, vol. 53, no.12, pp. 2139-2149.

[13] Ratasuk, R., Mangalvedhe, N., Ghosh, A., & Vejlgaard, B, "Narrowband LTE-M system for M2M communication," *In 2014 IEEE 80th vehicular technology conference* , no.VTC2014-Fall) , pp. 1-5 IEEE, 2014.
[14] Xu, J., Yao, J., Wang, L., Ming, Z., Wu, K., & Chen, L, "Narrowband internet of things: Evolutions, technologies, and open issues,' *IEEE Internet of Things Journal*, vol.5, no.3, pp. 1449-1462, 2017.
[15] Chen, J., Hu, K., Wang, Q., Sun, Y., Shi, Z., & He, S, "Narrowband internet of things: Implementations and applications," *IEEE Internet of Things Journal*,vol. 4, no.6, pp. 2309-2314, 2017.
[16] Sinha, D., Verma, A. K., & Kumar, S, "Software defined radio: Operation, challenges and possible solutions," In 2016 10th *International Conference on Intelligent Systems and Control* , no.ISCO) , pp. 1-5, 2016.
[17] Ronnberg, S. K., Bollen, M. H., & Wahlberg, M, "Interaction between narrowband power-line communication and end-user equipment," *IEEE Transactions on Power Delivery*, vol. 26, no.3, pp. 2034-2039, 2011.
[18] Chen, M., Miao, Y., Hao, Y., & Hwang, K , "Narrow band internet of things," *IEEE access*, vol.5, pp.20557-20577, 2017.
[19] Zemrane, H., Baddi, Y., & Hasbi, "A Internet of things smart home ecosystem," In Emerging Technologies for Connected Internet of Vehicles and Intelligent Transportation System Networks , Springer, Cham , pp. 101-125, 2020.
[20] Desai, R., & Patil, B. P, " Analysis of routing protocols for Ad Hoc Networks. In 2014 International Conference on Circuits, Systems," *Communication and Information Technology Applications* , no.CSCITA) , pp. 111-115, 2014.
[21] Shaji K.A.Theodore, K. Rajiv Gandhi, V. Palanisamy, "Privacy Preserving Lightweight Cryptography Scheme for Clustered Vehicular Adhoc Networks" *International Journal of Engineering Trends and Technology*, vol. 70, no. 7, pp. 24-31, 2022.
[22] Vinodray Thumar, Dr. Saurabh Shah, Dr. Vipul Vekariya, "Design and Implementation of IPFS Enabled Security Framework for Multimedia Data Files," *International Journal of Engineering Trends and Technology*, vol.70, no.1, pp. 355-361, 2022.