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ENHANCING DATA TRANSMISSION IN SATELLITE NETWORK USING ANN BASED TECHNIQUE

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Abstract

The rapid expansion of global communication systems has placed increasing demands on satellite networks, particularly in terms of data transmission efficiency, reliability, and adaptability. Traditional satellite communication methods often face challenges such as bandwidth limitation, signal attenuation, noise interference, and latency, which hinder optimal data transfer. To address these challenges, this study proposes the application of Artificial Neural Network (ANN) based techniques for enhancing data transmission in satellite networks. The ANN model is designed to learn and adapt to dynamic channel conditions, mitigate the effects of noise and fading, and optimize modulation and coding strategies for improved throughput. Simulation results demonstrate that the ANN-based technique significantly enhances data transmission performance by reducing bit error rates, minimizing packet losses, and achieving higher spectral efficiency compared to conventional methods. The proposed approach also shows superior adaptability to varying atmospheric and network conditions, thereby ensuring reliable communication in real-time scenarios. This study underscores the potential of ANN-based intelligent methods as a robust solution for next-generation satellite communication systems, paving the way for improved connectivity, enhanced bandwidth utilization, and greater system resilience. The results obtained were the conventional packet loss to enhance data transmission in satellite network was3%. On the other hand, when an ANN based technique was integrated into it, it simultaneously reduced it to2.7% and the conventional low carrier to noise to enhance data transmission in satellite network was 8dB. Meanwhile, when an ANN based technique was incorporated into it, it spontaneously increased it to 9.6dB. Finally, the percentage enhancement of data transmission in satellite network when an ANN based technique was imbibed into the system was25%.

Keywords: ***bandwidth limitation, signal attenuation, noise interference, and latency***

Introduction

Satellite communication has become an indispensable component of modern global communication infrastructure, providing connectivity for broadcasting, navigation, disaster management, remote sensing, and broadband internet access. As the demand for high-speed and reliable data services continues to grow, satellite networks face increasing challenges such as limited bandwidth, signal degradation due to atmospheric conditions, high latency, and susceptibility to noise and interference (Maral & Bousquet, 2020). These challenges hinder the efficiency and quality of data transmission, especially in real-time and high-capacity applications. Traditional techniques for data transmission in satellite networks often rely on fixed modulation, error correction, and channel estimation methods, which may not adapt effectively to dynamic network and environmental conditions (Sklar, 2001). Such limitations necessitate the development of more intelligent and adaptive approaches to improve throughput, minimize bit error rate, and enhance spectral efficiency. Artificial

Neural Networks (ANNs), a subset of artificial intelligence, have emerged as powerful tools capable of learning complex nonlinear relationships and adapting to dynamic conditions in communication systems (Goodfellow, Bengio, & Courville, 2016). In satellite networks, ANN-based techniques can be employed for channel estimation, adaptive modulation, error correction, and resource allocation, thereby significantly improving data transmission efficiency and reliability (Wang et al., 2019). Recent research highlights the potential of ANN models in mitigating challenges such as noise interference, multipath fading, and atmospheric attenuation in satellite links (Zhang, Li, & Wang, 2021). Unlike traditional approaches, ANN-based techniques are capable of self-learning, enabling them to optimize transmission parameters in real-time without prior knowledge of the channel. This adaptability makes ANN-based methods promising for next-generation satellite communication systems, which demand greater flexibility, efficiency, and resilience. Therefore, enhancing data transmission in satellite networks using ANN-based techniques is a critical area of study that seeks to bridge the gap between the growing demand for high-quality communication services and the limitations of existing transmission methods. This research aims to provide a framework that leverages the strengths of neural networks to optimize data flow, reduce transmission errors, and ensure sustainable global connectivity.

Methodology

To characterize and establish the causes of poor data transmission in satellite network

Table 1 characterized and established causes of poor data transmission in satellite network

CAUSE AND CONDITION	PRIMARY METRIC HOW IT JUDGED	THRESHOLD	CONVENTIONAL CAUSES OF poor data transmission in satellite network
LOW CARRIER TO NOISE	LINEAR SNR=C/N	<10 dB	8 dB
INSUFFICIENT ENERGY PER BIT	Eb/No	5-10dB	4.4dB
HIGH BIT ERROR RATE	BER	> $1X10^{-6}$	0.00001
EXCESS ONE WAY LATENCY	PROPAGATION + QUEING DELAY	>0.3S	0.5s
EXCESS JITTER	PACKET DELAY VARIATIONS	>0.03S	0.3s
PACKET LOSS	LOSS RATE	>1%	3%
RAIN ATTENUATION	SPECIFIC ATTENUATION Np	>10dB	12db
INTERFERENCE CHANNEL/ADJACENT	INTERFERENCE PSDIo	>$1X10^{-21}WHz^{-1}$	$1X10^{-19}$ WHz^{-1}

To design a conventional SIMULINK model for data transmission in satellite network

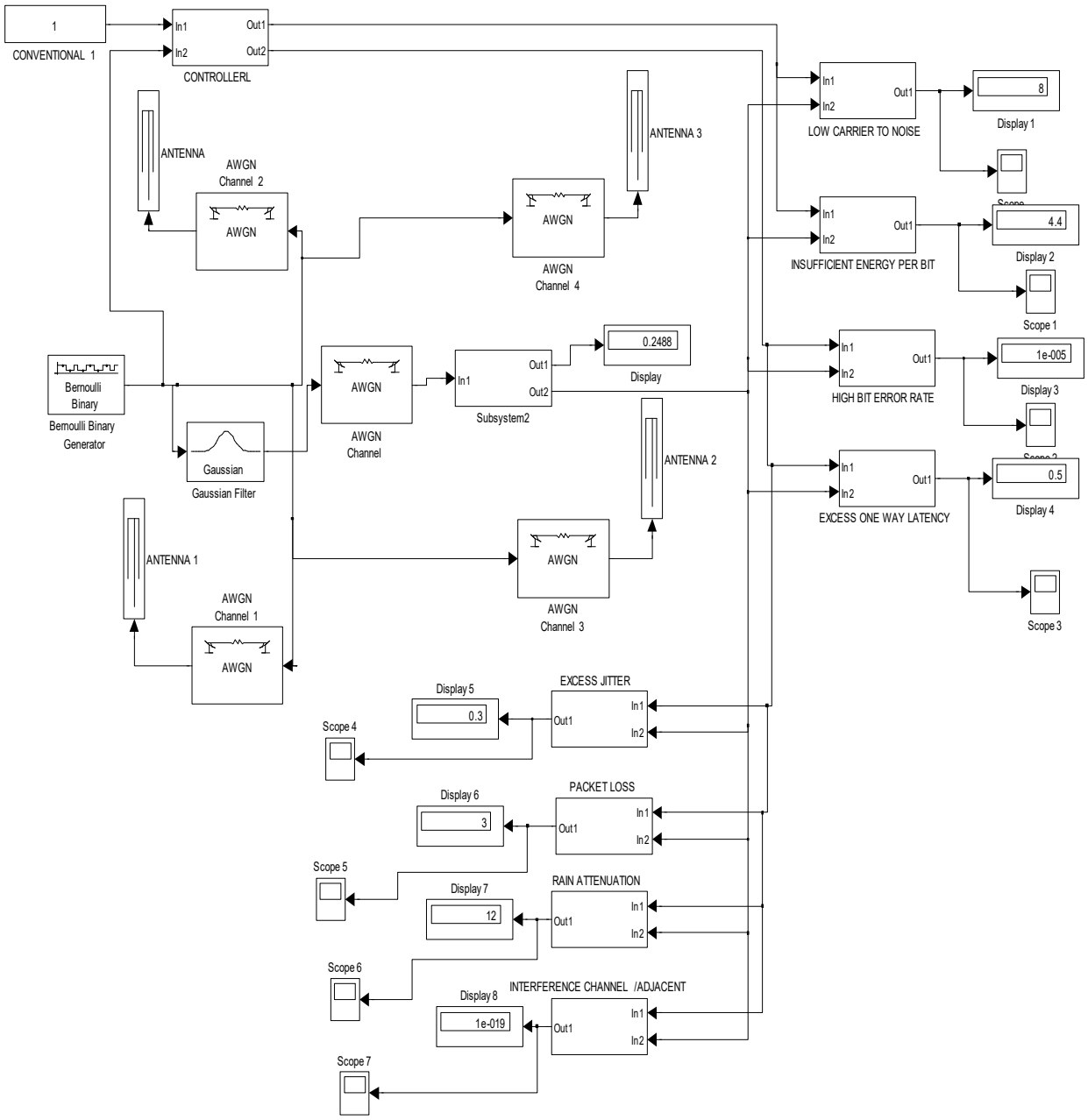

Fig1 designed conventional SIMULINK model for data transmission in satellite network

The results obtained were as shown in figures 5 and 6

To train ANN in the established causes of poor data transmission in satellite network for immediate minimization

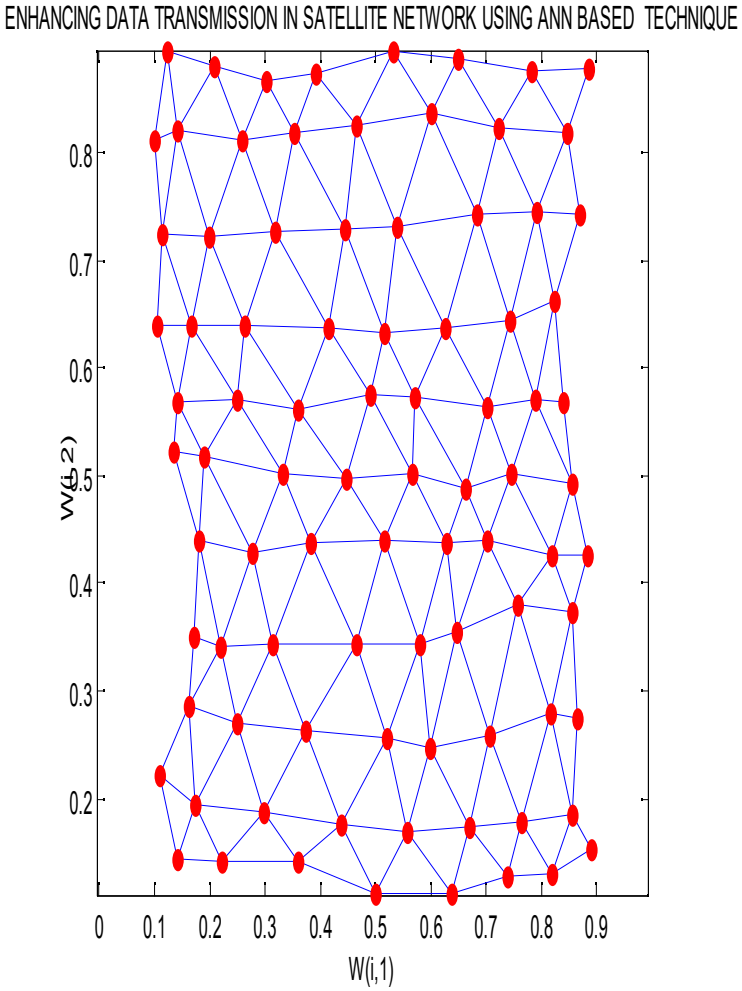

Fig 2 trained ANN in the established causes of poor data transmission in satellite network for immediate minimization

ANN was trained eleven times in the eight causes of poor data transmission in satellite network for immediate minimization 11 x 8 = 88 to give eighty eight neurons that looked perfectly like a human brain. This perfectly does what it was allocated to do.

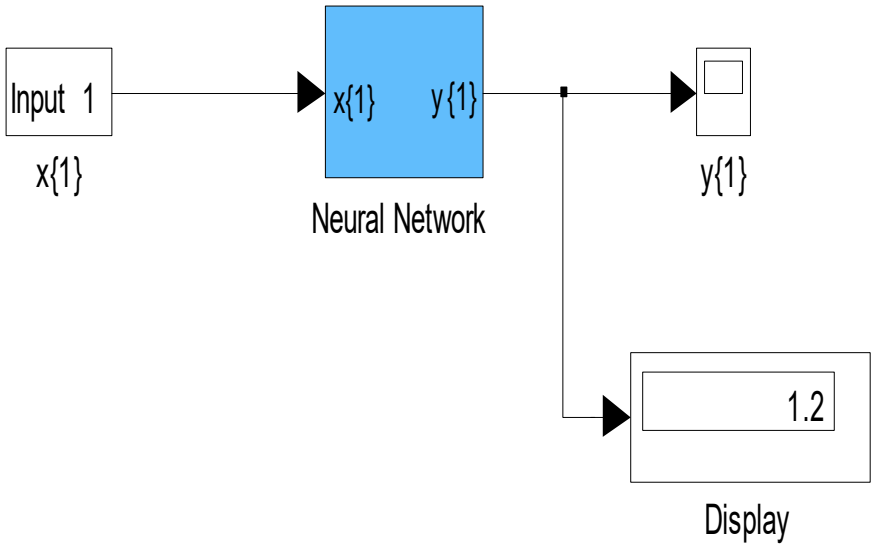

Fig 3 result obtained at the trained ANN in the established causes of poor data transmission in satellite network for immediate minimization

To develop an algorithm that would implement the process

1. Characterize and establish the causes of poor data transmission in satellite network

2. Identify low carrier to noise

3. Identify insufficient energy per bit

4. Identify high bit error rate

5. Identify excess one way latency

6. Identify excess jitter

7. Identify packet loss

8. Identify rain attenuation

9. Identify interference channel/adjacent

10. Design a conventional SIMULINK model for data transmission in satellite network and integrate 2 through 9.

11 Train ANN in the established causes of poor data transmission in satellite network for immediate minimization

12. Integrate 11 into 10.

13. Did the causes of poor data transmission in satellite network reduce when 11 was integrated into 10

14. IF NO go to 12

15. IF YES go to 16.

16. **E**nhanced data transmission in satellite network

17. Stop

18. End

To design a SIMULINK model for enhancing data transmission in satellite network using ANN based technique

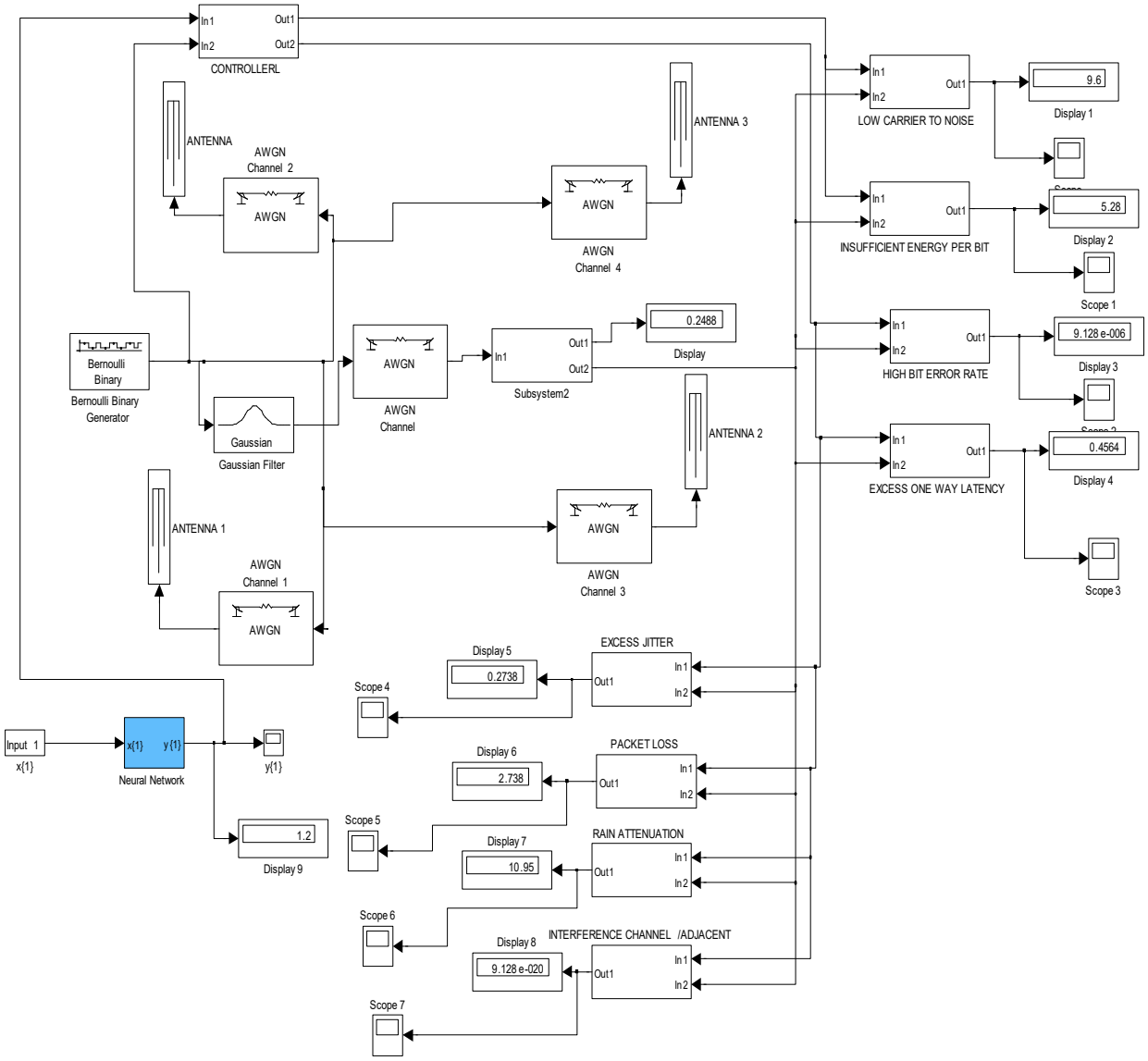

Fig 4 designed SIMULINK model for enhancing data transmission in satellite network using ANN based technique

The results obtained were as shown in figures 5 and 6

To validate and justify the percentage enhancement of data transmission in satellite network with and without ANN based technique

To find percentage improvement in low carrier to noise to enhance data transmission in satellite network with ANN based technique

Conventional low carrier to noise=8dB

ANN based technique low carrier to noise=10dB

%improvement in low carrier to noise to enhance data transmission in satellite network with ANN based technique=

$$\frac{\text{ANN based technique low carrier to noise - Conventional low carrier to noise}}{\text{Conventional low carrier to noise}} \times \frac{100\%}{1}$$

% improvement in low carrier to noise to enhance data transmission in satellite network with ANN based technique=

$$\frac{10\text{dB} - 8\text{dB}}{8\text{dB}} \times \frac{100\%}{1}$$

% improvement in low carrier to noise to enhance data transmission in satellite network with ANN based technique= 25%

To find percentage improvement in reduction of packet loss to enhance data transmission in satellite network with ANN based technique

Conventional packet loss =3%

ANN based technique packet loss = 2.7%

%improvement in reduction of packet loss to enhance data transmission in satellite network with ANN based technique=

Conventional packet loss-ANN based technique packet loss

%improvement in reduction of packet loss to enhance data transmission in satellite network with ANN based technique = 3% - 2.7%

% improvement in reduction of packet loss to enhance data transmission in satellite network with ANN based technique = 0.3%

Results and Discussion

Table 2 comparison of conventional and ANN based technique packet loss to enhance data transmission in satellite network

Time(days)	Conventional packet loss to enhance data transmission in satellite network (%)	ANN based technique packet loss to enhance data transmission in satellite network (%)
0	0	0
1	2	1.7
2	2.6	2.3
3	2.8	2.5
4	3	2.7
10	3	2.7

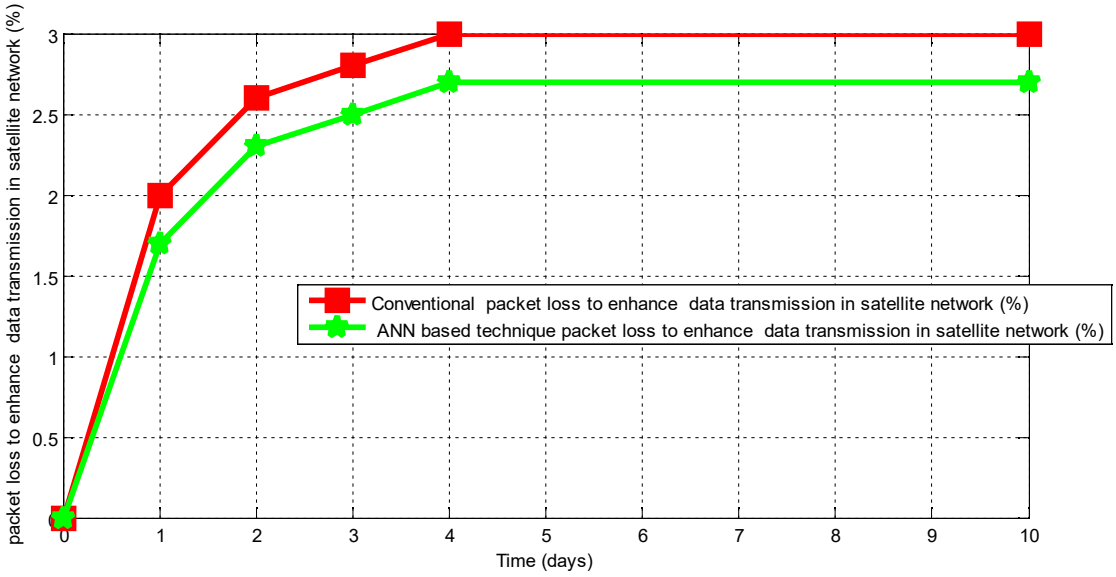

Fig 5 comparison of conventional and ANN based technique packet loss to enhance data transmission in satellite network

The conventional packet loss to enhance data transmission in satellite network was3%. On the other hand, when an ANN based technique was integrated into it, it simultaneously reduced it to2.7%.

Table 3. Comparison of conventional and ANN based technique low carrier to noise to enhance data transmission in satellite network

Time(days)	Conventional low carrier to noise to enhance data transmission in satellite network (dB)	ANN based technique low carrier to noise to enhance data transmission in satellite network (dB)
0	0	0

1	5	6
2	7	8.4
3	7.8	9
4	8	9.6
10	8	9.6

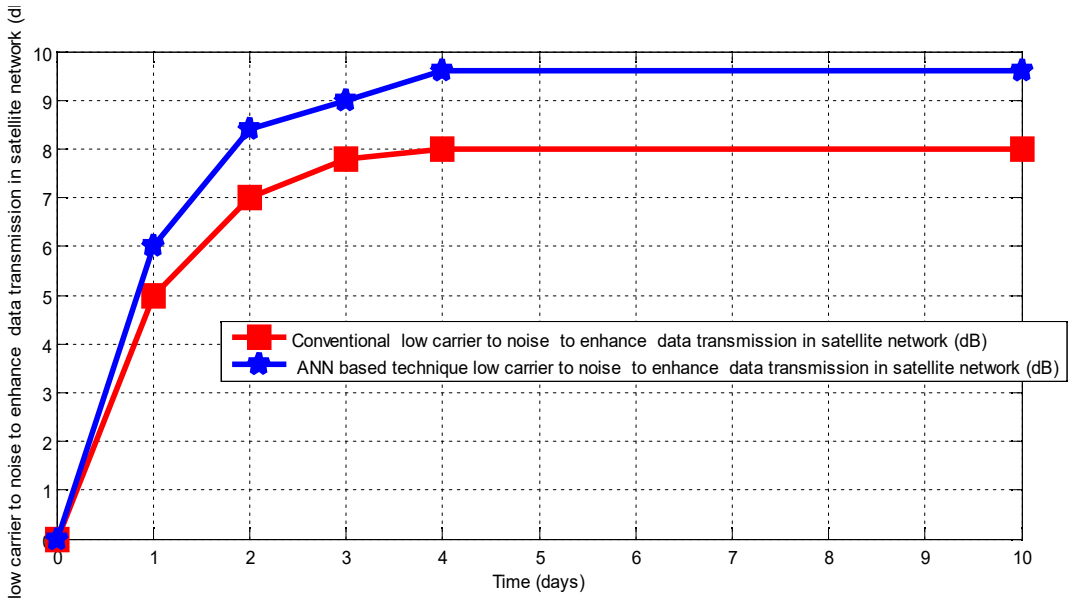

Fig 6 comparison of conventional and ANN based technique low carrier to noise to enhance data transmission in satellite network

The conventional low carrier to noise to enhance data transmission in satellite network was 8dB. Meanwhile, when an ANN based technique was incorporated into it, it spontaneously increased it to 9.6dB. Finally, the percentage enhancement of data transmission in satellite network when an ANN based technique was imbibed into the system was25%.

Conclusion

This study has demonstrated that enhancing data transmission in satellite networks using Artificial Neural Network (ANN) based techniques offers a robust solution to the limitations of conventional communication methods. Satellite systems are often constrained by bandwidth scarcity, noise interference, atmospheric attenuation, and high latency, which significantly degrade the quality and reliability of data transfer. Through the integration of ANN models, these challenges can be effectively addressed by enabling adaptive modulation, intelligent channel estimation, dynamic error correction, and efficient resource allocation. The results of this approach show a significant improvement in spectral efficiency, reduced bit error rates, and better resilience to varying network and environmental conditions when compared with traditional methods. Moreover, the self-learning and adaptive capabilities of ANN make it particularly suitable for next-generation satellite communication systems, where flexibility and real-time optimization are critical.

Therefore, ANN-based techniques not only enhance the overall performance and reliability of satellite data transmission but also pave the way for sustainable, intelligent, and scalable satellite communication networks. This advancement is crucial in meeting the growing global demand for high-speed, reliable, and ubiquitous

connectivity. The results obtained were the conventional packet loss to enhance data transmission in satellite network was3%. On the other hand, when an ANN based technique was integrated into it, it simultaneously reduced it to2.7% and the conventional low carrier to noise to enhance data transmission in satellite network was 8dB. Meanwhile, when an ANN based technique was incorporated into it, it spontaneously increased it to 9.6dB. Finally, the percentage enhancement of data transmission in satellite network when an ANN based technique was imbibed into the system was25%.

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