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OCDMA Performance on FSO Turbulent Weather Channel on Li-Fi Systems

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Abstract

Because of advances in Light-Emitting Diodes LEDs and visible-light communication (VLC), future technology is light fidelity. The interference problems with radio frequency (RF) communication was overcome by using visible light communication (VLC) technology, which has higher bandwidth and greater security. On the other hand, the FSO link is affected by complex weather, Where Different atmospheric conditions affect the optical power of the FSO system very significantly, decreasing significantly. The effects of turbulent weather on OCDMA technology are examined in this paper and compared with and without using this technology at different distances in L-Bands in light of the increased number of users. There are various challenges that Li-Fi technology faces in maintaining the system performance with the increase in the number of users. These issues will cause a decrease in the system's performance parameters, such as BER. Further, the challenges that exist are the total bandwidth usage and the number of users without affecting the system. Finally, security should be maintained at the highest level at the lowest cost. With the best results, the research shows that Optical Code division multiple access OCDMA technologies enhance system performance and stability, especially over long distances. On the contrary, the system will fail to function correctly over the same distance if the technology mentioned above is not utilized. For example, the heavy dust, the system achieved approximately from 1.02 * 10-12 to 9.5 * 10-11 with our proposed technology, whereas it achieved approximately from 2.8 * 10-7 to 4 * 10-4 without the proposed technology at a distance ranging from 60m to 160m. the system was tested during heavy fog weather, considered the most challenging situation, with an n attenuation of 340dB/M. The results revealed that the system achieved roughly 1.11*10-12 to 9.25*10-11, but without OCDMA technology, it achieved between 3.8*10-8 and 1.4*10-4 at 20 m to 120 m. These include heavy dust, fog, and moderate attenuation of 340, 242, and 85 dB/m, which have been used.

Keyword:s- light fidelity, visible-light communication Optical Code division multiple access, Light-Emitting Diodes, line of sight, free-space optic.

1_ Introduction

Significant growth in mobile data transmission is expected within a few years since wireless internet has evolved necessary products. Many benefits come with using free-space optics (FSO) communication technology, such as data security, speed, a free spectrum license, and large bandwidth. However, as a result, this technology is vulnerable to environmental factors like rain, snow, sand, and fog. Fog and rain will significantly impact the most because the FSO generates a light signal using light-emitting diodes [1, 2]. Technology that uses a direct line of sight to transmit information is called Free Space Optic (FSO). Laser or light-emitting diodes produce an optical signal (LEDs) [3]. The VLC technology offers several advantages, such as a large unlicensed spectrum, ease of availability, long lifespan, small size, and low power consumption; therefore, the VLC technology arises as a new present communication technology choice. VLC Technology.com [4]. VLC technology, which combines lighting and communication via LED and other solid-state electrical technologies and is known as such, has additional to offering higher security. Furthermore, it does not suffer from radio-frequency interference difficulties, making it appropriate for communications in an indoor environment [5].
Asynchronous access networks, dynamic bandwidth allocation, and multimedia services are all supported by OCDMA methods [6, 7]. Advantages of Optical Code Division Multiple Access Multiple users can share bandwidth to access an optical network using (OCDMA) techniques, which provide moderate security communication. [8]. FBGs (fiber Bragg gratings) are a promising candidate in our case because they offer several advantages. To select specific wavelengths, A new class of narrow-band reflecting filters is presented with the name "FBGs" [9]. An optical fiber strand, it is possible to selectively transmit and reflect specific light wavelengths using a distributed Bragg grating (FBG). Reflectivity as high as 100% is possible with grating bandwidths ranging from 0.1 nm to more than tens of nanometers. Since they are reflective, filter, and disperse, Bragg gratings are ideal for use in telecommunications [10]. As the grows number of users and weather conditions change, Especially the most difficult, the system's BER and other performance metrics decrease, making it increasingly difficult to use the total bandwidth while growing the number of users without adversely affecting the system. We conducted a study on the OCDMA method and its implications. In addition to using a single wavelength, we used this technology to enhance the number of users in most weather circumstances, Especially turbulent ones. UFBG has been employed in this system because of its previously stated advantages, and study whether this approach can keep system performance and BER rate within allowed ranges. The previous study focused on modulation mechanisms, external noise, and the

influence of reflection on indoor radio transmission performance. In this case, Aditi Malik and Preeti Singh [11]. This technology can be used in a matter of hours and at a fraction of the cost. FSO has several benefits, including a large bandwidth and the absence of a spectrum license. Also, Somia A. Abd El-Mottaleb and others. This research investigates the performance of spectral amplitude coding optical code division multiple access systems using a single photodiode (SPD) detection approach (SAC-OCDMA). To compensate for the GVD produced by the single-mode fiber, a dispersion compensating fiber (DCF) is utilized [12]. Also, in Alnajjar et al., Satea H. Compared to the standard FSO, the suggested system exhibits a similar level of performance across the whole research range of 200 m to 2,000 m. At the same time, the hybrid link's communication range is 40 kilometers greater than that of a standard FSO [13]. The remainder of the paper it's laid out like this. This document has four parts: Research Elaborations are discussed in section II, Finding in section III, and Conclusions in section IV.

2_ Research Elaborations

As shown in Fig. 1, the suggested system was created using the Optisystem tool V19 FSO channel with bath, and a 1-Gbps data rate is supported. Fig1 depicts the FSO system used in this study, Where the transmitted data used a system that generates random numbers for each bit. After that, these bits are converted into electrical pulses using the NRZ technique. Then, it has to be sent across long distances using a continuous-wave laser that a Mach-Zehnder modulator had modulated. Finally, the signals will be demodulated into bits at the receiving end. The receiver includes a photodetector, a DC block to stop the voltage entering the electrical input signal, and a low-pass cosine roll-off filter to eliminate interference. The receiver side arrangement has four rooms, and each room has four end users, for a total of 16 end users.

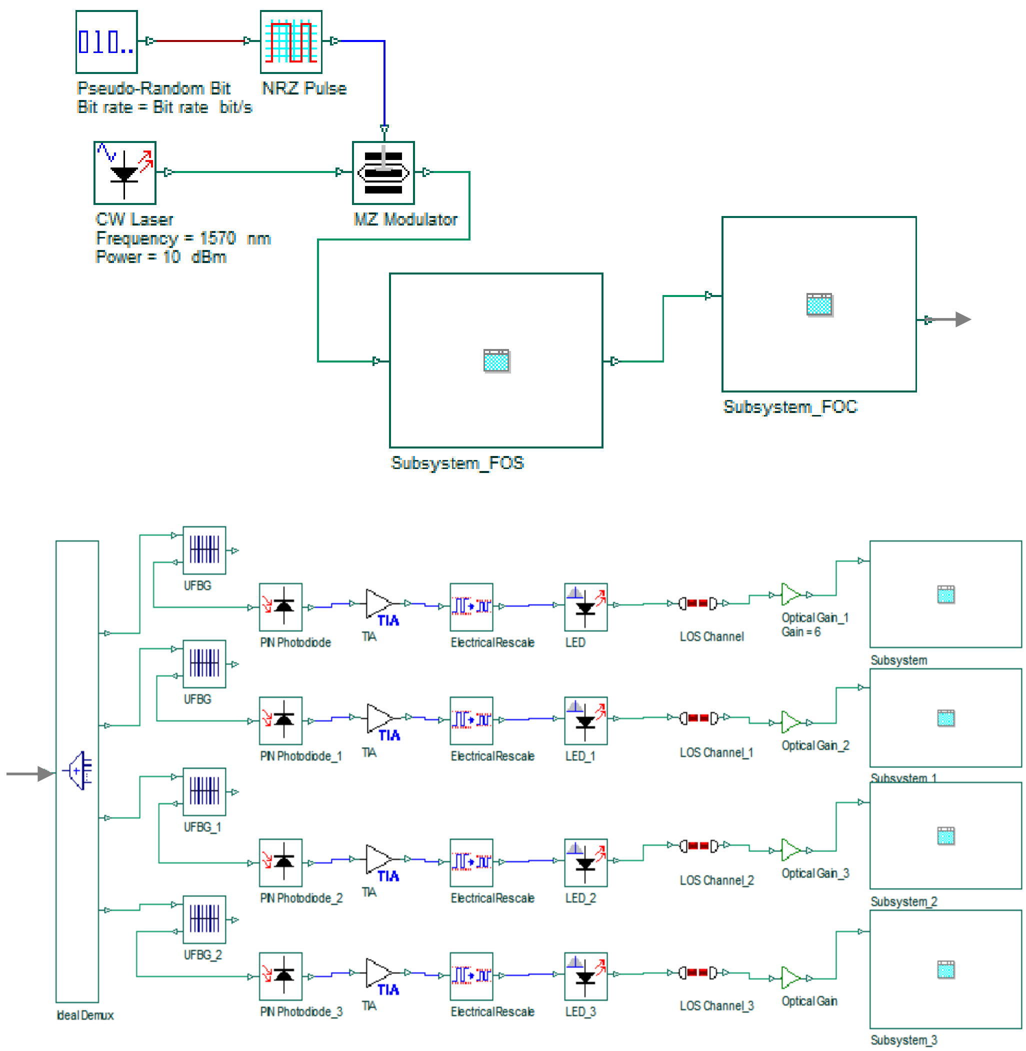

Fig1. The Suggested system design.

2.1. FSO channel

FSO uses lasers to deliver optical bandwidth connections wirelessly and an optical communications system that transports data for telecommunications and computer networking. FSO systems are designed to be multi-channel in nature. The FOS elements are shown in Table (1) and. Fig 2. The Free space optical system design.

Table (1) FSO elements.

FSO elements	Value
Attenuation	4 , 85 , 242,340 dB/m
Beam divergence	2mred
Aperture's diameter of the transmitter	5cm
Aperture's diameter of the receiver	20cm

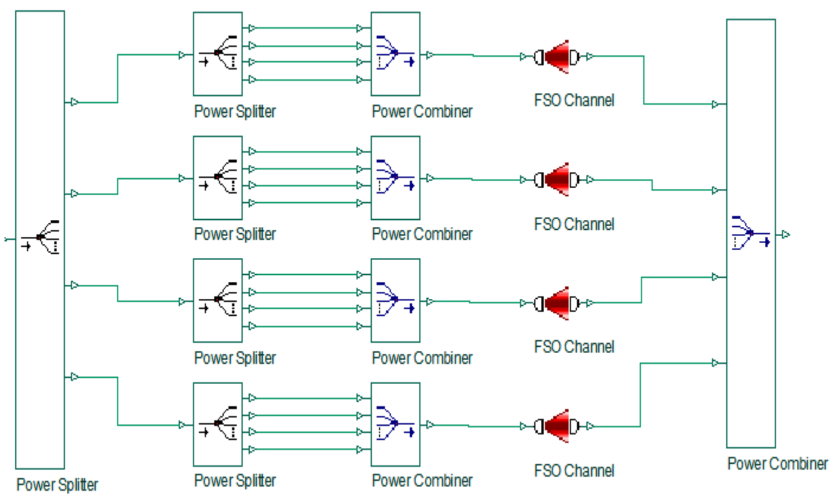

Fig 2. The Free space optical system design.

2.2. Fiber Optic Channel

As a fiber optic channel, we used a 40-kilometer single-mode fiber (SMF) and two 3.2-kilometer dispersion-compensating fibers (DCF) (FOC). An optical amplifier is required to test the efficiency of the FOC system performance design shown in Figure 3.

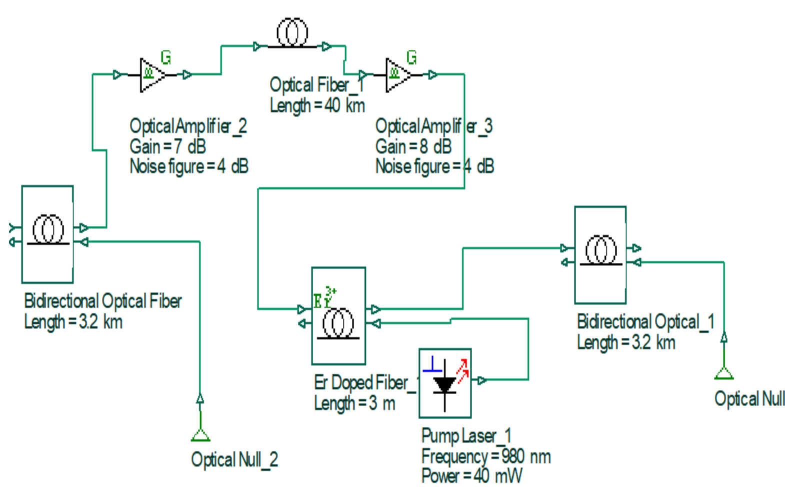

Fig. 3. Design of the Fiber Optic Channel.

2.3. Light-Emitting Diodes

Half-angle LEDs may be used to cover the whole transmitter area, which is about 60 degrees. Because of their low power consumption and great brightness, LEDs outperform incandescent and fluorescent lights in terms of energy efficiency. Listed in Table (2) are the suggested LED requirements

Table (2) elements of the LED.

LED elements	Value
wavelength	550nm
Electron carrier lifetime	1×10^{-12} s
RC time constant	1×10^{-12} s
Quantum efficiency	0.65

The optical strength of the (LEDs) given by [14] is as follows: $\rho = \eta . h . f \frac{i(t)}{q}$ (1)

2.4 line-of-sight

LEDs provide an emitted beam that travels straight from the source to the receiver (PD). The simulator's elements are listed in the following table(3).

Table (3). LOS channel elements

LOS elements	Value
range	3m
Irradiance half-angle	20deg
Incidence	20deg

The style is as follows when the emission density has a Lambertian [16]: $R_{\emptyset} = \begin{Bmatrix} \frac{m+1}{2\pi} \cos^{m} \emptyset, \text{for } \emptyset \in \left[-\frac{\pi}{2}, \frac{\pi}{2}\right] \\ 0, \text{otherwise} \end{Bmatrix}$ (2)

The radiation angle and *m* is the Lambertian order, both of which are coupled by the transmitter's semi-angle

$$m = \frac{-\log 2}{\log[\cos(TransmitterHalfAngle)]} \quad (3)$$

The following connection exists between the optical transmitter power and radiant intensity when taking into account the transmitter's axially symmetric radiation pattern (measured in W/sr): $P_t . R_0(\emptyset)$ (4)

This is the effective collection area:

$$A_{eff}(\varphi) = \begin{Bmatrix} A_{det}\, T_s(\varphi) \cos\varphi \text{ if } 0 \le \varphi \le \varphi_c \\ 0 \text{ if } \varphi > \varphi_c \end{Bmatrix} \quad (5)$$

2.5 fiber Bragg grating

Revolution in telecommunications systems has been created by fiber Bragg grating. When using an optical fiber amplifier and filter, it is necessary to have a fiber Bragg grating. For optical devices, they may be employed as a band-reject filter or a band pass filter. There will be some light reflection as it passes through the fiber that includes an FBG segment. Due to its wavelength matching Bragg's, the reflected light is sent back to the source while other wavelengths are transmitted. [15]. Table (4) shows UFBG.

Table (4). UFBG elements

UFBG elements	Value
Frequency	1570 nm
Bandwidth	125 GHz
Reflectivity	0.99

3. Finding

The BER and eye diagram are included in the findings. In addition, in The haze weather, a comparison between OCDMA and without OCDMA technology has been made, as illustrated in fig 4, which shows the eye diagram generated at a distance of 4 kilometers when the OCDMA performance has been clearly enhanced.

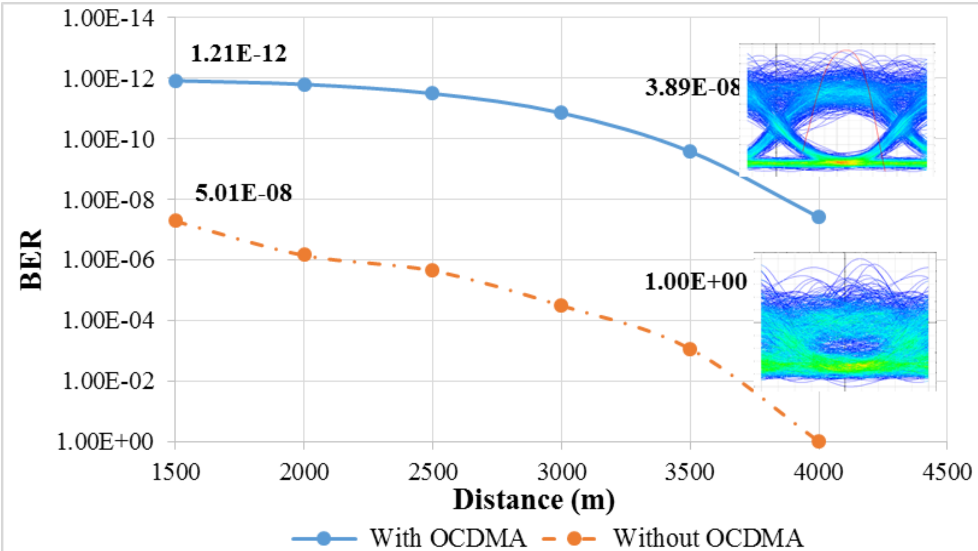

Fig.4. the difference between using and without using OCDMA technology in haze weather

Furthermore, in moderate weather, Figure 5 Shows BER in the different distances with and without using OCDMA. The quality and consistency of the findings achieved using the proposed methodology with OCDMA have increased. The eye diagram was obtained at 380 meters.

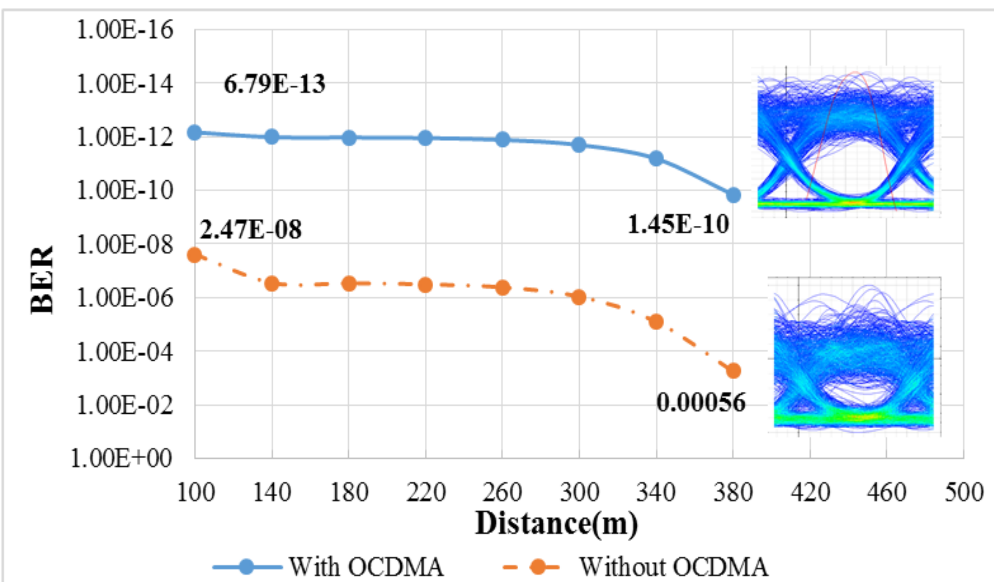

Fig. 5. The difference between using and without using OCDMA technology in moderate weather

Heavy dust weather is recognized as one of the most challenging atmospheric conditions. This is due to its 242 dB/m attenuation rate. Nevertheless, figure 6 demonstrates that the BER measurements have shown high stability and improvement. The system behaviors have achieved approximately $1.02 * 10^{-12}$ to $9.5 * 10^{-11}$ with our proposed technology, whereas it achieved approximately $2.8 * 10^{-7}$ to $4 * 10^{-4}$ without our proposed technology at a distance ranging from 60m to 160m. The eye diagram was Created based on a distance of 60 meters.

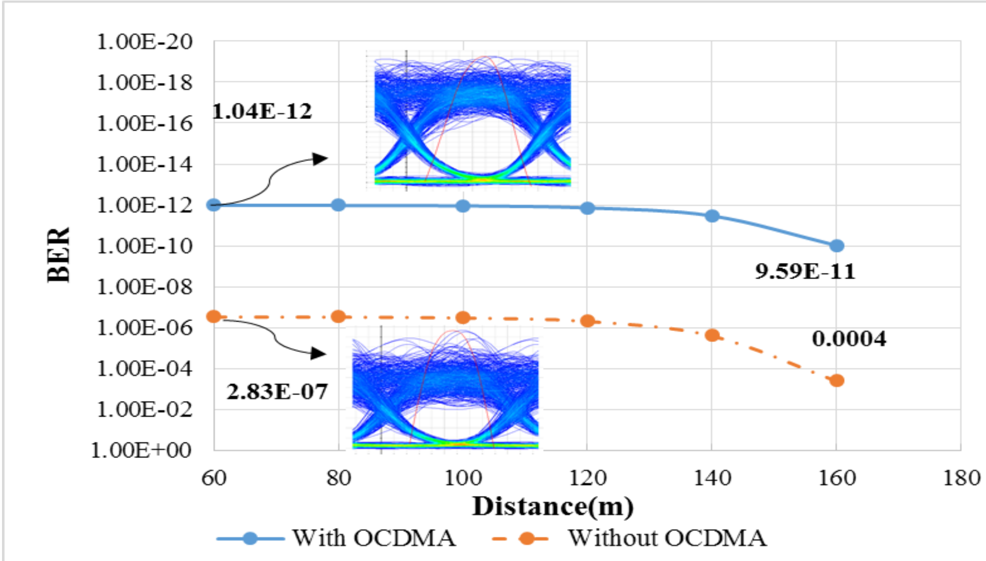

Fig. 6. The difference between using and without using OCDMA technology in heavy dust weather

Due to its attenuation rate of 340 dB/m, heavy fog is the most problematic weather condition. Figure 7 depicts the results of the steady BER based on the recommended method. Even when the distance is increased, there are satisfactory results have been achieved by the proposed system, which is roughly $1.11*10^{-12}$ to $9.25*10^{-11}$. Still, without OCDMA technology, it achieved between $3.8*10^{-8}$ and $1.4*10^{-4}$ at 20 m to 120 m.

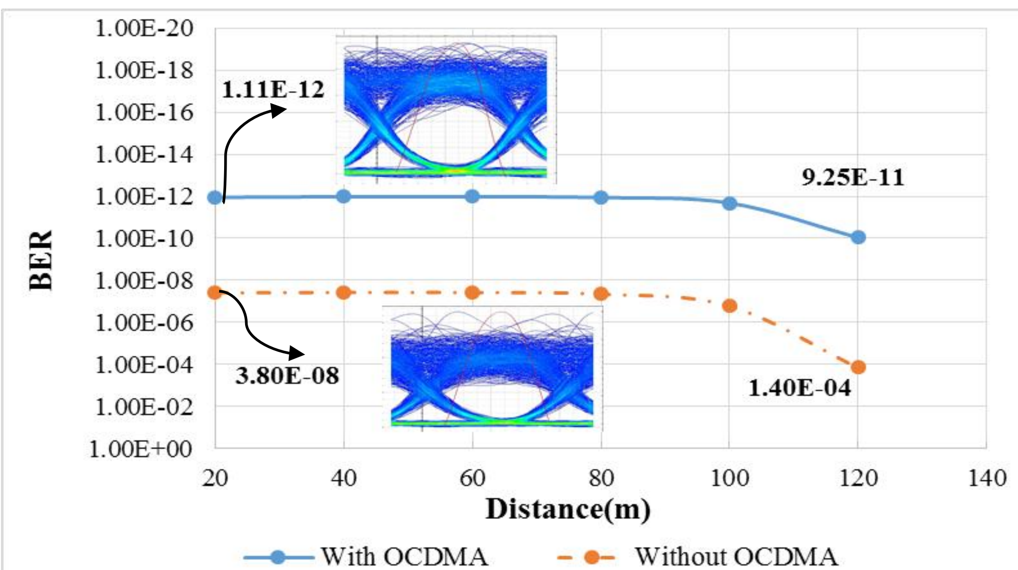

Fig. 7 The difference between using and without OCDMA technology in heavy fog weather.

Our proposed system performs better than others under normal conditions and at various distances. Still, when considering the more complex requirements, it was discovered that OCDMA technology improved system stability and that the results did not deteriorate as quickly as they would have otherwise if it hadn't been used.

5. Conclusions

Various weather conditions, particularly challenging ones, were researched for their impact on OCDMA technology, and we found that it was susceptible to these situations. In addition to a considerable increase in system performance, our suggested solution, the system's stability, is greatly enhanced using this technology. It had an almost BER of $1.04*10^{-12}$ to $9.25*10^{-11}$. In heavy fog weather, the approximation is reached from 3.80810^{-8} to $1.40*10^{-4}$without OCDMA. In moderate weather, an approximation is accomplished from $6.7*10^{-13}$ to $9.5*10^{-10}$ with OCDMA technology and $2.4*10^{-8}$ to $5.6*10^{-4}$ without using OCDMA and approximations from $1.04*10^{-12}$ to $9.2*10^{-11}$ were obtained with OCDMA technology. $2.8*10^{-7}$ to $4*10^{-4}$ may be reached without OCDMA technology in heavy dust weather. As a result, we can say that OCDMA technology keeps systems running well even when the weather is terrible and the number of users increases.

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