WDM and SEC assisted FSO

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Abstract- The spectrum licensing issues and interference at unlicensed ISM bands limits the market penetration. Though emerging license-free bands appear promising, they still have certain bandwidth and range limitations. The advantage of FSO communication over Fiber Optic communication (FO) is that, there is no time and money wasting trench digging involved, for laying the optical fiber cables underground and no acquiring of road digging permission from the municipality, because the optical carrier signal travels through the atmosphere. Optical wireless (FSO) can augment RF and milli meter wave links with very high (>1 Gb/s) bandwidth. In fact, it is widely believed that optical wireless is best suited for multi-Gb/s communication. As this is a telecommunication technology that transmits data in the form of optical signals across the air and, as such, can be considered as a wireless (line-of-sight) transmission system; which is being capable of handling data rates at the Gbps level, does not require licensing, and can be deployed at one-fifth of the cost of fiber; also, the narrow beams employed in the transmission of signals are very difficult to be affected by jamming ,interception or interference. This article reviews the FSO Link suitability for achieving reduced error communication. With its high-data-rate capacity and wide bandwidth on unregulated spectrum, FSO communication is a promising solution for the "last mile" problem, however its performance is highly vulnerable to adverse atmospheric conditions. A number of phenomena in the atmosphere, such as absorption, scattering, and turbulence, can affect beam attenuation, but in the case of wavelengths typical of FSO systems operation, only scattering and turbulence are appropriate to be taken into consideration.

Index Terms- Dispersion interleaving, WDM, ONSR, BER switch-and –examine.

I. INTRODUCTION

In recent years, free-space optical (FSO) communications has received much attention, from both industry and academia, as an alternative solution for terrestrial broadband wireless access over short distances . This is thanks to its advantages of cost-effectiveness, quick and easy deployment, and high data-rate provision. Especially, when the radio-frequency (RF) spectrum has been heavily congested, the feature of license-free service becomes a significant advantage of FSO communications .In terrestrial FSO communications, the primary factors that degrade the system performance of are atmospheric attenuation and turbulence.

1) The atmospheric attenuation-It is caused by absorption and scattering processes ,it is variable and difficult to predict hence significantly limits the covering range of FSO systems. Fog is one of the most significant factors influencing the range and reliability of optical links. Fog events usually persist from minutes to several hours. This phenomenon can be regarded as changing relatively slowly in comparison with atmospheric turbulences. The major challenge to FSO communications is fog. Rain and snow have little effect on FSO, but fog is different. Fog is vapor composed of water droplets, which are only a few hundred microns in diameter but can modify light characteristics or completely hinder the passage of light through a combination of absorption, scattering and reflection. The primary way to counter fog when deploying FSO is through a network design that shortens FSO link distances and adds network redundancies.
2) Atmospheric turbulence-It is a phenomenon occurring when there are the variations in the refractive index due to inhomogeneity in temperature and pressure changes. Atmospheric turbulence causes phase disturbances along propagation paths that are manifested as intensity fluctuation (scintillation), beam broadening and beam wandering at the receiver. These disturbances are generally considered to be a multiplicative noise source that reduces the capability of receiver to distinguish the information contained in the modulated optical wave . They make the received signal fade and impair the link performance. Due to atmospheric turbulence, signals are affected. This atmospheric turbulence leads to fading of the channel. The variations in the temperature and pressure of the atmosphere cause variations in the refractive index. Thus there comes fluctuations in the intensity (scintillation) and phase of the received laser beam signal. If the propagation distance is small, then the number of scatterers will be finite and random in nature.

These index in homogeneity and attenuation could deteriorate the quality of the received signal and lead to an increase in the bit-error rate (BER) of the FSO systems.

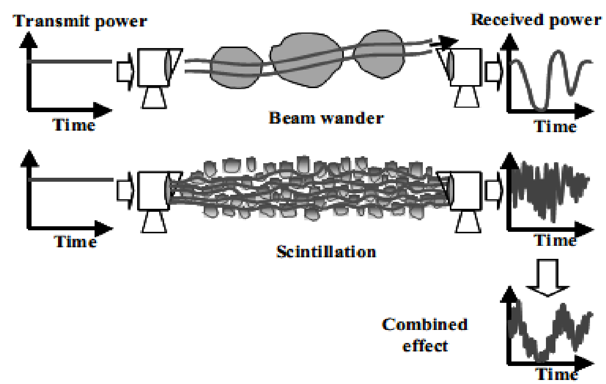

Fig no.1 Atmospheric attenuation and turbulence affecting FSO system

In the air the areas with different temperatures and pressures create zones with different refraction indices. Various in homogeneities in the atmosphere affect the beam distortion.

II. RESEARCH

If the optical signals are subjected to different turbulence conditions **,**fluctuations in the intensity (scintillation) and phase of the received laser beam signal occurs , also due to the propagation temperature and wind velocity, there will be fluctuations in the intensity of the signal which occurs in random.

Thus in order to mitigate the effect of turbulence, error control codes and spatial diversity schemes are used. Single laser transmitter and multiple receivers can be placed at both ends to mitigate the turbulence fading and exploit the advantages of spatial diversity. Spatial diversity is particularly crucial for strong turbulence channels in which single-input single-output (SISO) link performs extremely poor.In this paper, we propose the concept of limiting the the error rate performance of FSO systems for atmospheric turbulence channels and potential advantages of spatial diversity deployments at the transmitter and/or receiver**.** A comparative study of SIMO and MISO links shows that the efficiency of adding diversity in error rate and outage capacity appears more in SIMO, both in the weak and strong turbulence conditions.

The WDM technique is used to transmit multiple wavelengths, multiple data channels simultaneously, as a single optical signal along the FSO communication link. When FSO is combined with WDM technology, then the transportable bandwidth is yet higher and WDM-FSO becomes suitable to disperse-grid . In such case, WDM FSO combined with short-distance EM wireless clusters, allows for a large product {bit rate} × {distance} which can be several orders of magnitude than pure E-M technology .Although WDM network offers much higher bandwidth than copper cable and is less susceptible to various kinds of electromagnetic interferences and other undesirable effects.WDM history started with opaque network, in which there was O-E-O conversion at each node that means that the optical signal carrying traffic terminate where it undergo O-E-O conversion. This approach had full independence between the network and physical layer but it also requires a large amount of O-E-O conversion devices that increased the network cost and energy consumption. In transparent optical networks, no O-E-O conversion is involved and the optical signal at the source node reaches the destination nodes. This approach reduces the cost, but also implies that physical layer must support end-to-end communication ,but in due course , transmission is affected due to impairments that occurs in the so used channel. These impairments cause the transmitted data not to be received correctly at the destination. Since the data that has been transmitted for the entire light path, remains in optical domain, the signal is degraded due to the accumulation of noise and signal distortions. Thus due to the accumulation of these impairments at the destination the received signal quality may be so poor that BER can reach an unacceptably high value and thus the light path is not usable.

III. FREE SPACE OPTICAL LINK DESIGN

A. The Transmitter

1. Multi-wavelength EDFL source: To achieve high bandwidth based on WDM technique, multi -wavelength EDFL is needed. The purpose of using a multi-wavelength laser is to increase the bandwidth of the link using the wavelength division multiplexing technique (WDM).The WDM technique is used to transmit multiple wavelengths, multiple data channels simultaneously, as a single optical signal along the FSO communication link .
2. De-multiplexer:The signal is split into different wavelengths by a de-multiplexer.
3. Intensity modulator: The purpose is to modulate each wavelength separately by data signals. These wavelengths are then modulated with data by the intensity modulator
4. Multiplexer: The modulated wavelengths/data-channels are multiplexed into one optical signal by a wavelength -division -multiplexer (WDM),but often it becomes hard to increase the number of multiplexed channels, which otherwise is made on account of decreasing the channel spacing, as a resultant ,due to the very small channel spacing, the power leakage from one channel to its adjacent channels occurs and hence exhibit high insertion loss,and often cause large intersymbol interference (ISI).

The usage of dispersion-interleaving facilitates the amplitude of the adjacent channel leakage to be reduced . In dispersion interleaved system, the dispersion-compensating fiber (DCF) is removed from either the first or the last span of the link and placed at the transmitter side for the odd channels and at the receiver side for the even channels. As a result, the channel signals arrive at their receivers with dispersion fully compensated, thus the performance improves. With Dispersion interleaving the improvement is nearly independent whether the signal channel is completely synchronized or delayed by a half bit interval with respect to adjacent channel. Hence there is a significant improvement in the performance of the system as per the earlier researches on dispersion interleaving, that is both signal power and OSNR have improved significantly. Noise power also increases but increase in noise power is less than the increase in signal power. As a result OSNR increases considerably. The improvement in signal power and OSNR slightly decreases with increase in data rate and decrease in the channel spacing.

5. Beam collimator: The purpose of this device is to collimate the optical signal to be transmitted so that the divergence of the signal is minimized. Too much divergence of the signal results to the decrease in the received optical power.

B. *The Receiver*

1. Laser beam receiver: The device collects the light sent from the transmitter.
2. De-multiplexer: The purpose of this device is to split the received optical signal into separate wavelengths. Switch-and-examine combining (SEC) technique is our suggestion for the diversity combining solution in multi-transceiving configuration. As only a handful of diversity approaches are potentially viable for switched diversity. Based on a switch-and-stay combining (SSC) scheme where the combiner switches to a new branch only after the existing received SNR fall below a threshold(T). This switching occurs regardless of the new branch SNR—even if it is inferior to the original branch. A major deficiency for SSC is the high probability that the optical beam will fail to illuminate the receiving branch, that is, half of the receivers are not illuminated

rendering it an unacceptable choice for FSO. SEC diversity scheme is similar to SSC, albeit with minor modification.

Each of the demultiplexed signal is followed separately by the SEC , where a low SNR reading initiates branch switching; however, the SNR of the new branch is considered first, for example, if the SNR is above the threshold level, the original branch is maintained. Branch evaluation continues to alternate branches until an acceptable SNR is observed, and a branch selection is made. SEC is designed on a switching threshold basis and proposes to reduce the volume of processing load and thus implementation complexity in the receiver design .When an SEC scheme is employed ,branch switching is initiated only when the active branch SNR drops below a defined threshold, thus limiting the switching repetitiveness that persists in an SC scheme. An SEC receiver examines in sequence the SNR of each of its branches and switches to the branch with an SNR deemed acceptable.

3. Demodulator: The purpose of this device is to demodulate the separated wavelengths. For each wavelength, the device makes use of photo-detectors, such as Avalanche photo diodes, to recover the data that has been sent.

IV. FUTURE SCOPE

1. Control coding suggested as per earlier researches

The error control codes usage like FEC (forward error correction codes) on top of multi-hop approach can be made to improve link reliability. If we manage to tightly bound error variance within certain limits, we can design more efficient error control codes for a given FSO link. Some other researches going on the issue of the error control coding for FSO show through simulations that multi-hop end-to-end error is lower and also has a smaller variance than single hop.

LDPC error-correction codes with outstanding correction capabilities for the FSO channel may also be used as these codes provide very large SNR gains over Reed-Solomon codes of similar rate for a wide range of turbulence conditions.Researchers has observed that the uncoded channel becomes practically useless as the turbulence strength (or the propagation length) increases. However, the use of these LDPC codes can provide a large improvement and make the FSO links a realistic communication alternative. In strong turbulence conditions, code provides good performance at realistic SNR values. These codes have low encoder and decoder complexity, a feature that makes them practical for FSO communication system.

2. Adaptive optical methods suggested as per earlier researches

Nevertheless, when the system bit rate increases and the transmission distance is far, the FSO systems using PPM signaling critically suffer from the impact of pulse broadening caused by dispersion, especially when the modulation level is high therefore of multi-wavelength PPM (MWPPM) signalling to overcome the limitation of PPM. To further improve the system performance, avalanche photodiode (APD) is also used. To model the impact of intensity fluctuation caused by the atmospheric turbulence, by using MWPPM, the effects of both intensity fluctuation and pulse broadening are mitigated, the BER is therefore significantly improved. Additionally, the system performance is further improved by using APD, especially when the average APD gain is chosen.

V. CONCLUSION

With the above proposed system model we will be able to efficiently deploy the wavelengths corresponding to the transmission of various data onto the SIMO structure without it's power (wavelengths) being leaked into each other , hence at the transmitter section itself the ISI is inhibited while as many signals are sent to the receiver side by the means of the FSO , where after the signal's demultiplexing it is subjected to the switch – and – examine circuit where the appropriate OSNR is switched from thereafter it is demodulated.

The scope of this model is that a robust type of structure towards the atmospheric disturbances like attenuation and turbulence is proposed which perhaps intercept the optically transmitted signal but its mitigation is successfully carried out

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ISSN 2250-3153

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