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Different Routing Techniques in Free Space Optics for Quality Based Network

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Abstract: FSO is communication system where free space acts as a medium between transceivers and they should be in LOS (line of sight) for successful transmission of optical signal. Medium can be air, outer space or vacuum. This system has many advantages like high bandwidth, no spectrum license and economically less. The transmission in FSO is dependent on the medium because the presence of foreign elements like rain, fog and haze, physical obstruction, scattering and atmospheric turbulence are some of these factors. There are many routing techniques available for the transmission of light wave in free space. A comparative study of different routing techniques used in FSO is discussed in this paper.

Keywords: FSO, Link margin, RWA, modulation, routing, nodes, routing techniques.

I. INTRODUCTION

Optical communication without fibers is so called free space optics (FSO). It provides a very high. The main limitation of FSO link is due to atmospheric attenuations (i.e., rain, fog, snow). Attenuation created by rain plays a major role and reduces the power level at the receiver limiting the FSO link availability over a distance. The availability of FSO link is estimated based on the threshold bandwidth digital data transmission between remote sites and provides a key solution to the last hundred meters of broadband problem. Implementation of FSO technology mainly depends on the atmospheric conditions. The most important thing in the deployment of FSO link is determined by Link Margin. It is the parameter which analyses the acceptable power level at the receiver for reliable communication. The theory of FSO is exactly the same as that of the fibre optical transmission system. The difference is that the energy beam is collimated and sent through clear air or space from the source to the destination, rather than guided through an optical fiber. It has drawn attention in telecommunication industry, due to its cost effectiveness easy installation, quick establishment of communication link especially in the disaster management scenario, high bandwidth provisioning and wide range of applications. With FSO communication, maximum data transfer rates up to 2.5 Gbps is possible, unlike the maximum data transfer rates of 622Mbps offered by RF communication system.

Design of FSO system

FSO is a technology that uses line of sight to transmit laser beam for a very high bandwidth data transfer from one point to another in free space. It can be obtained by modulating a narrow beam of laser launched from a transmission station to transmit it through atmosphere and receives correspondingly at the receiver station. The general block diagram of FSO system is shown in Figure it consists of transmitter section, channel and a receiver section.

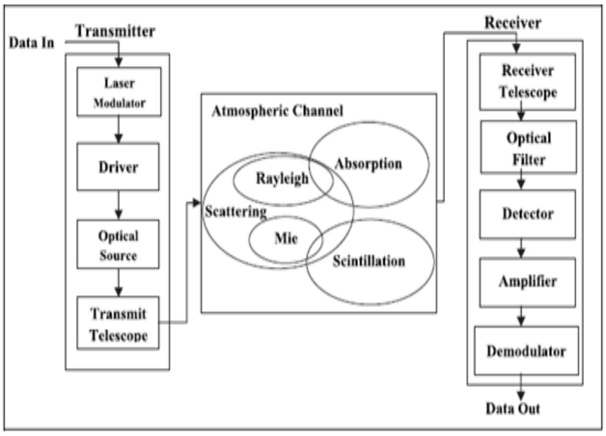

Figure 1: Block Diagram of FSO System

Transmitter

Transmitter section converts the electrical pulses to an optical signal which corresponds to modulation of a laser beam for transmission of data, which is to be collected at the receiver through the free space channel. The transmitter can be divided into four parts i.e., modulator, driver circuit, optical source and transmit telescope.

Laser modulator

Modulation is carried by the laser beam which modulates the data using a laser modulator. The modulation methods

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can be broadly classified as: internal modulation and external modulation. Power consumption generating a laser beam which is highly coherent is impractical. The neodbymium (ND:YAG) laser and the popular helium-neon (He-Ne) laser are less efficient due to poor interfacing with electronic circuitry, but has a high power compared to other. Fortunately, semiconductor lasers, which are very efficient usually made of a direct band gap materials which converts electrical current to corresponding photons, are very efficient and can be easily integrated to electronic circuits. In comparison, power amplifiers for the Very Low Frequency (VLF) up to the High Frequency (HF) bands are highly efficient, with conversion efficiencies from 85 to 90% however, Microwave amplifier biasing arrangements have typical conversion efficiencies of only between 10 and 20 percent. Therefore, while microwave amplifiers are much more efficient than the Nd:YAG and He-Ne lasers, they are generally less efficient than semi-conductor lasers.

Modulation

Modulation can be obtained usually inside the laser resonator and it relies on the change produced by the components which are added like the directional couplers which varies the light intensity of the laser in accordance to the baseband signal. The simplest modulation technique adopted is amplitude-shift keying (ASK). It is also referred as on-off keying (OOK).

This form of modulation scheme is also known as NRZ (non-return-to-zero) OOK. It is an intensity modulation scheme where the light source (carrier) is used to turned on when a logic one is transmitted and turned on when a logic zero is transmitted.. The most common one is the RZ (return- to- zero) line coding, RZ has the main advantages in comparison to NRZ are its higher sensitivity and the clock frequency used generally lies within the range of modulation spectrum.NRZ and RZ ,unfortunately suffers from clock synchronization.

Driver and Optical source

A Driver circuit is used to transform an electrical pulse into an optical signal with variation in current low of the optical source. Laser Diode (LD), light emitting diode (LED) fall under the category of optical sources. This source converts the electrical signal to corresponding optical signal. A laser diode produces radiation by stimulated emission of radiation.

Here photons are emitted from atoms by population inversion, which have been excited from a ground level state to a higher energy level. The light emitted by a laser source is highly directional and monochromatic, which has a narrow spectral width and a small beam divergence angle. There are two basic sorts of laser diode: Nd:YAG solid state laser and fabry-perot and distributed feedback laser.

Wavelength

Wavelength selection for a FSO system depends on several factors, such as transmission distance, components availability, eye safety considerations, and cost. The availability of components is light sources and detectors. Eye safety is an important issue in consideration for designing the FSO system. Lasers sources of higher power can be used more safely with wavelength 1550nm systems rather than with 850nm and 780nm systems, since this wavelength is lesser compared to 1400 nm which is focused on the human cornea forms a concentrated spot falling on the retina which can cause damage to eye.

Transmitter telescope

The transmitter section is equipped with a telescope which collects and directs the light beam on to the receiver telescope at the other side of the channel.

FSO channel

FSO links uses atmosphere as the medium for the propagation. The atmosphere can be considered as series of layers around the earth with concentric gas. Three basic atmospheric layers for consideration are the troposphere, stratosphere and mesosphere. These layers are different from each other based on their temperature gradient with respect to the altitude. Troposphere region plays a key role, because this is the region where the weather phenomena predominate and FSO links operate at the lower part of this layer. Also, there are small particles that contribute to the composition of the atmosphere, which includes particles (aerosols) such as haze, fog, dust, and soil. Propagation characteristics of FSO communication through atmosphere changes according to the environmental effects created mainly due to weather condition. The received signal power fluctuates within the atmosphere and attenuates the power reaching at the other end. The attenuation is due to the atmospheric conditions such as rain, fog, haze and turbulence in the propagation channel. The effects on free space optics communication are mainly due to absorption, scattering, and scintillation.

Receiver and Receiver telescope

The receiver system which receives the optical power and determines the data consists of five parts i.e., receiver telescope, optical filter, detector, amplifier and detector. Optical light from the transmitter is collected and focused using the receiver telescope on to the photo detector. It should be noted that a large receiver telescope capture area is desirable to collects multiple uncorrelated radiation and focuses their average on the photo detector. The receiver on the other side is used to detect the optical pulse and compares its power level with an optimum threshold level. Coherent modulation schemes can also be employed in optical communications. A binary coherent modulation, binary phase shift keying (BPSK) can be used where the phase of the laser is varied between two states. Coherent

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detection depends on the received light in coherence with local oscillator tuned to the transmitting beam. It is employed in differential phase shift keying (DPSK) systems, which are less sensitive than the BPSK. The sensitivity of coherent receiver implementations is better than the sensitivity of OOK systems.

Optical filter

Optical filters are mainly used to allow energy at the wavelength of interest to impinge on the detector and reject the unwanted wavelengths, with this the effect of solar illumination can be significantly minimized.

Detector

The detector section consists of device which should be capable to provide a proportional electric current from the received photon energy. Photodiode (PD) is a semiconductor devices which converts the photon energy of light into an electrical signal by releasing and accelerating current conducting carriers within the semiconductors. Photodiodes operate based on the principle of photo conductivity. The diode operates in reverse-biased and capacitive charged.

The two most commonly used photodiodes are the pin photodiode and the avalanche photodiode (APD). These have good quantum efficiency and are made of semiconductors that are widely available. The sensitivity of the receiver is the performance characteristic which indicates the minimum light energy it can detect. Selection of a particular detector depends on the application. To understand the descriptions of detector performance and to be able to pick a detector for a specific application, one should understand these detector characteristics.

In general, the following properties are needed:-

- A high response at the wavelength to be detected
- A small value for the additional noise is introduced by the detector.
- Sufficient speed of response.

Routing and Wavelength Assignment

RWA is a key feature of optical network where the process of data path selection i.e selection of a path for a particular connection request with specified source and destination edge nodes and then allocating one designated wavelength for the selected path occurs.

It is generally addressed by a two-step approach: first finding a connection for a source-destination pair using a routing technique, and second, selection of a free wavelength on the chosen connection by using wavelength assignment (WA) algorithm. For establishing a connection, we consider both selection of data path i.e. routing and wavelength assignment for the selected path.

Routing Technique

Selection of a path for a particular connection request with specified source and destination edge nodes is Routing. There are typically three paradigms of routing for dynamic routing they are:

- Fixed routing (FR)
- Fixed-alternate routing (FAR)
- Adaptive routing (AR)

Fixed routing (FR)

Here, there is a single fixed route for each pair of network nodes. This fixed route is pre computed offline, and any connection between a pair of source and destination nodes uses the same fixed route, which imposes a strict restriction on route selection. If there is a link failure on the shortest-path route, a connection from node a to node d will be disrupted and blocked as shown in figure:

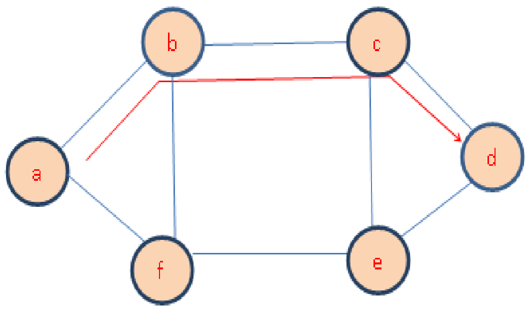

Figure 2: Fixed Routing from node a to d.

Fixed-alternate routing

In Fixed-alternate routing, there is a set of alternate routes for each pair of network nodes. The actual path for a connection request can be chosen from the available alternate paths, which also imposes a restriction on route selection. These alternate routes are recomputed offline and are stored in an ordered manner within the routing table maintained by the network controller. A couple of routes alternate to the original, from node a to d are as shown in Figure.

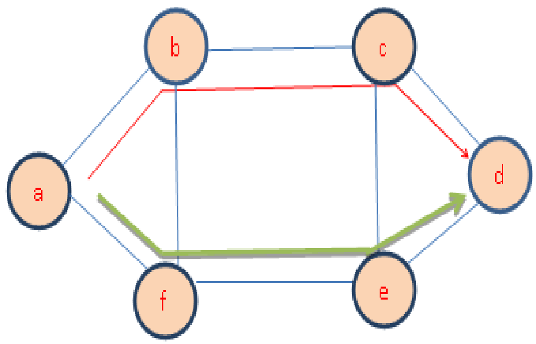

Figure 3: Fixed Alternate Routing from node a to d.

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Adaptive routing

In adaptive routing there is no restriction on route selection. Any possible route between a pair of source and destination nodes can be chosen as an actual route for a connection. The choice of route is based on the current network state information as well as a path selection policy, such as the least-cost path first or the least congested path first. A least cost route from b node 'a' to node 'd', where the label on each link presents the cost for using that link as shown in Figure. This is the most efficient routing technique for dynamic systems like FSO, so we have taken this for consideration in our paper work.

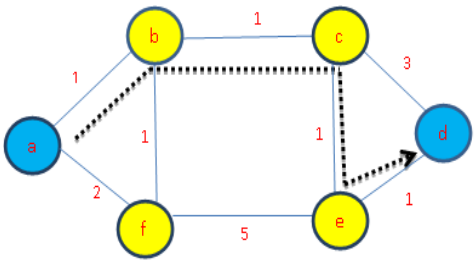

Figure 4: Adaptive Routing from node a to d.

Wavelength Assignment (WA)

The WA task is to assign wavelength to each link on the selected connections. If there is no path available from a source to destination nodes with a wavelength available in every link of the route, the connection request is blocked.

The RWA problem is subjected to various constraints such as wavelength continuity, wavelength distinct, physical layer impairment and traffic engineering.

CONCLUSION

In this paper, we introduce the routing network architecture to extend routing efficiency from different routing techniques. Above survey of various routing techniques in free space optics gives some important conclusions. It clearly observed that static routing is easy to implement in a small network. Static routes stay the same, which makes them fairly easy to troubleshoot. Static routes do not send update messages and, therefore, require very little overhead. The disadvantages of static routing include that they are not easy to implement in a large network. Managing the static configurations can become time consuming. If a link fails, a static route cannot reroute traffic. Though in dynamic routing protocols the network administrator manages the process of maintaining static routes. Dynamic routing protocols work well in any type of network consisting of several routers. They are scalable and automatically determine better routes if there is a change in the topology. Although there is more to the configuration of dynamic routing protocols, they are simpler to configure in a large network. Comparison of different routing techniques is shown in table below the basis of different parameters.

S. No	Parameters	Fixed Routing	Fixed Alternative Routing	Adaptive Routing
01.	Complexity	Simplest	Moderate	More Complex
02.	Static/Dynamic	Static	Static	Dynamic
03.	Performance	Not Good	Moderate	Very High
04.	No. Of Routers Available B/W Two Nodes	Only One	More Than One	Multiple
05.	Example	Dijkstra Algorithm	Yen's Algorithm	Lora, Pabr, Iabf, Iaff, Etc
06.	Congestion	High	Moderate	Very Low

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