Video on Demand
Over Optical Wireless Communication Links

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Video on demand technology is a modern wireless communication application which requires a large bandwidth. Optical wireless networks, as a potential alternative to radio frequency, is an emerging technology that is easier to set up and provides a cost effective solution, where a physical network is difficult to deploy. Optical wireless networks can be used as a backbone to provide the much needed bandwidth for video on demand application. In this paper, Wavelength Division Multiplexing modulation scheme is proposed for the optical wireless networks due to its significance of transmitting distinct data channels at different wavelengths. Wavelength Division Multiplexing can be easily integrated with optical wireless networks, consequently resulting in an increased data rate. This paper presents a novel approach of integrating video on demand with the state of art Wavelength Division Multiplexing based optical wireless networks. Furthermore, the paper discusses the challenges and advantages over the convention modulation schemes.

1. Introduction

The video on demand application (VoD) is a very popular internet service occupying 27% of the internet traffic [1]. According to a survey more than 74.1% of business and personal users access streaming media at least twice or thrice a week [2]. In the United States, 66 percent of tablet owners stream video twice or thrice or more [3]. According to a study, in United Kingdom, VoD generates £200 million revenue and another £100 million in advertisement by 2013 [4]. In 2015, VoD network traffic will be equivalent to 3 billion DVDs per month [5]. This estimated figure is much less than the present day figures. Unfortunately, we don't have the current figures. Internet VoD applications such as YouTube [6], PPLive [7], iPlayer [8] and Hulu [9] are very popular with the users. PPLive is a very popular VoD in China. Researchers [10–16] have used this service to study VoD. As they require a high amount of bandwidth, they are very costly. Video over the internet poses some important challenges. Sometimes the network may be down or there could be congestion in the network leading to service loss. A VoD system can be configured in one of the following types, a) distributed, b) centralized and c) networked. In a distributed VoD system, the media content is stored on one central server with smaller servers around it to cater for high-demand requests. In a centralized system, the entire media content is on a centralized server. This server handles all clients' requests. In a network environment, the media servers are spread across the network. Each server handles requests from a small group of clients only to provide an interrupted high-quality video playback. In a VoD system, the two major hurdles are high bandwidth required and the high requests associated with it. It has been a challenge for researchers to make VoD efficient, reliable, robust and affordable.

Free space optical (FSO) communications have gained a considerable attention due to increasing demands of higher bandwidth and nomadic application. WDM is the technology which multiplexes multiple optical carrier signals on a single medium by using different signals.

FSO links are highly dependent on weather conditions. The fog, smoke, rain and scintillations are the main challenges which significantly degrade the FSO link performance. Many techniques have been proposed to improve the performance of FSO link, like aperture increasing, using of low pass Bessel filter, wavelength of 1550 nm and amplification of optical signal using an optical amplifier.

Here we will study the WDM based FSO system for different atmospheric conditions.

2. Related work

Researchers have used wireless mesh networks (WMNs) [17] for a higher bandwidth. WMNs bandwidth was further increased by choosing appropriate routing metric [18] and decreasing interference [19]. In [20] authors presented an efficient cognitive VoD model for a higher bandwidth, whereas in [21] network connectivity was enhanced by exploiting all-optical multicast in semiconductor ring laser.

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Free-space optical links gained considerable importance for higher data rate and are potential candidates for future communication applications. FSO systems can be used to meet the broadband communication needs for both terrestrial and space applications [22]. Possible applications include satellites, deep-space probes, ground stations, unmanned aerial vehicles (UAVs), high altitude platforms (HAPs), and other nomadic communication applications. Moreover, FSO links can be used for military and civilian purposes [23].

Most commonly FSO links are based on intensity modulation and direct detection, because of their relatively simple implementation. The current trend is the implementation of wavelength division multiplexing based FSO system to achieve higher data rates [24, 25]. Here we presented WDM based FSO system for VoD applications at the data rate of 1.25 Gbps.

3. Proposed model

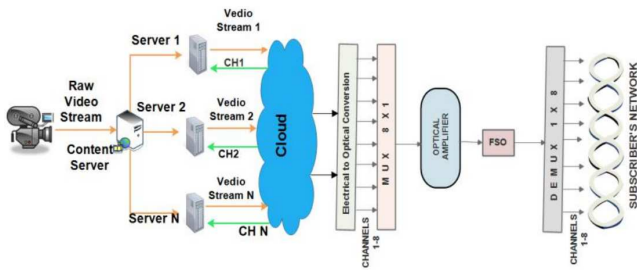Figure 1 below shows the block diagram of our proposed VoD model of video streaming over FSO Links.

Fig. 1. Block diagram of VoD over FSO links.

The VoD model is a distributed VoD system where the media content is stored on one central server called content server with smaller servers (Server 1, Server 2, Server N, etc.) around it to cater for high demand requests. It is assumed that all the clients maintain a buffer space which keeps a record of the recent viewed popular movie (movies with high demand). As all the incoming requests vary from one client to another, they are independent of each other. Therefore, the incoming process of normal requests as well as of interactive requests to the content server can be modeled as a Poisson distribution. Whenever a client makes a request for the movie, this request goes to the content server who keeps a track of all the users. If the client is a first-time user, he has to register himself in the content server so that the list of clients watching video is maintained. The content server will guide him to the peer through which the client will be able to get the streaming video. The scheme shown in Fig. 1 has the following advantages, a) client can download from multiple sites over multipath, b) traffic load is balanced.

4. Simulation

Figure 1 shows the block diagram for FSO system for VoD application at the link distance of 2 km. In the

block diagram the eight channels range from 193.1 THz to 193.8 THz with a fixed channel spacing of 0.1 THz. They are combined together by using WDM. The system parameters are shown in Table I.

TABLE I

WDM based FSO system parameters.

Parameters	Values
Frequency	193.1–193.8 THz
Optical amplifier type	EDFA
Channel spacing	0.1 THz
Bit rate	1.25 Gbps
CW laser power	20 dBm
Line width	10 MHz
Amplifier Gain	20 dB
Link Range	200 m to 2 km
Tx Aperture	2.5 cm
Rx Aperture	30 cm
Amplifier Noise figure	4 dB
Beam Divergence	2 mrad
APD gain	3
Responsivity	1 A/W
Dark current	10 nA
Filter type	Low pass Bessel

The FSO link is modeled with carrier frequency of 193.1–193.8 THz with the channel spacing of 0.1 THz. At the transmitter end, on each channel, a 1.25 Gbps data is generated by using a pseudorandom bit sequence generator, this data is coupled to NRZ encoder and further modulated by using Mach-Zehnder Modulator. A CW laser diode of line width of 10 MHz with a power of 20 dBm is used. The optical amplifier with gain of 30 dB is used for pre-amplification technique. At the receiver end 1×8 Demux is used and the optical signal is received by avalanche photo-detector having the dark current of 10 nA.
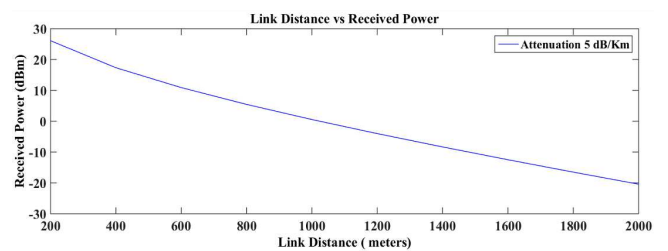

Fig. 2. Received power for WDM-FSO link operating at 2.5 Gbps with atmospheric attenuation of 5 dB/km.

As local weather conditions pose significant challenge for FSO system to get carrier class availability and reliability. Therefore, we consider the haze and light fog scenario for simulation. Haze can cause the attenuation up to 20 dB/km and light fog can cause the attenuation up to 30 dB/km. Figures 2 and 3 show the received

power for haze condition. Here, in both figures, the received power is shown when the attenuation is 5 dB/km and 15 dB/km.
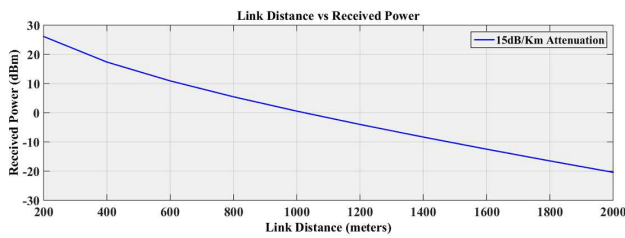

Fig. 3. Received power for WDM-FSO link operating at 1.25 Gbps with atmospheric attenuation of 15 dB/km.
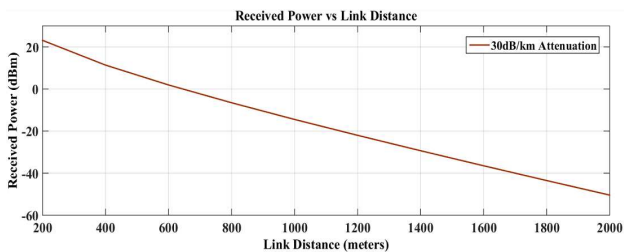

Fig. 4. Received power for WDM-FSO link operating at 1.25 Gbps with atmospheric attenuation of 30 dB/km.

Figure 4 shows the received power for WDM-FSO link operating at 1.25 Gbps with atmospheric attenuation of 30 dB/km.

5. Conclusions

In this study, from the simulation results it is concluded that the system can perform well to get high availability and reliability under haze and light fog conditions where attenuation may go as high as 30 dB/km. It was also observed that there was enough receiving power for signal detection.

It can be concluded from the simulation results that WDM based FSO system can be implemented up to a link distance of 2 km at the data rate of 1.25 Gbps with high reliability and link availability.

Acknowledgments

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