

Free Space Optical Link Performance Evaluation using AODV and DYMO

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ABSTRACT

Free space optical network gained increasing visibility as a broadband communication network over traditional wireless networks because of their high bandwidth (up to Gbps), low cost easy installation and also license free long range spectrum. Existence of line of sight and alignment between the nodes is one of the key requirements for free space optical communication. In this paper the free space (FSO) communication is briefly elaborated and performance of optical link is evaluated for reactive routing protocols. The protocols used for simulation are AODV and DYMO. The results are compared for the aggregate received packets in the network and signals received with error. A good routing mechanism enhances the performance of the network. The protocol performing better in the simulation scenario is suggested for the free space optical communication.

Keywords—Free space optical communication, routing protocol, AODV, DYMO

I. INTRODUCTION

Optical wireless technology has emerged as a viable technology for next generation indoor and outdoor broadband wireless applications. These applications range from short range wireless communication link providing network access to portable computers to bridging the last mile links between the end users and existing fiber optic communication backbones and even laser communication for outer space links[1]. The indoor wireless communication often referred to as infrared communication and outdoor is commonly known as the free space optical communication. FSO communication offers several advantages over the RF and microwave systems such as greater information capacity (up to 300 THz, for wavelength of 1 μm compared to 300 GHz of RF and 300 GHz of microwave), easy installation, improved security due to narrow laser beam and most importantly the nonexistence of spectrum licensing for frequencies above 300 GHz [2].

A recent trend in wireless communications has been the desire to leverage directional forms of communications e.g. directional smart antennas, FSO transceivers for more efficient medium usage and scalability [3]. Directional communication for example, using directional antenna for free space optics has a potential to increase the capacity in multi hop wireless mesh and ad hoc network. There are different reactive and proactive routing protocols which can be utilized to route the traffic in the

network. With various routing methodologies the link performance varies. The performance for some parameters is evaluated for AODV and DYMO. The results justify that while using the same simulation parameters AODV performs better than DYMO.

We have conducted an extensive performance evaluation of free space optical link for reactive routing protocols. Results indicate that AODV surpasses the other protocols. The rest of the paper is organized as follows. In section 2 we discuss the FSO communication followed by description of routing protocols used for the simulation in section 3. Next section 4 represents the simulation model. The results are compared in section 5. Finally this paper is concluded in section 6 highlighting the most efficient routing solution for free space optical link.

II. FREE SPACE OPTIC COMMUNICATION

FSO communication is a line of sight technology that uses laser beam for sending high bandwidth digital data for one point to another using the free space. This can be achieved by using a modulated narrow laser beam launched from a transmitter at one node and subsequently received at the receiver side. The system typically consists of transmitter, FSO channel and a receiver.

A block diagram of an FSO communication link is presented in Fig.1. The transmitter modulates the data onto the instantaneous intensity of an optical beam. The optical beam travels in line of sight to the receiver and the data is recovered using the photodiode and the de modulator [4].

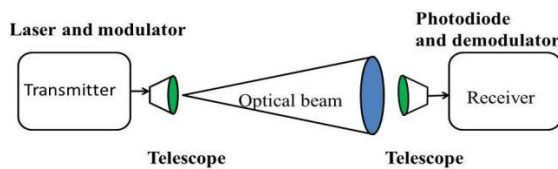


Fig.1: Block diagram of an FSO link

2.1 PARAMETERS OF OPTICAL LINK PERFORMANCE

The FSO link performances can be determined by several parameters including geometrical loss, link margin, received power and BER. There are two parameters to evaluate the FSO link performances- the received power and BER. Theoretically, the basic communication principle states that received power must be less than transmitted power, $P_R \leq P_T$, according to [5] :

$$P_R = P_T - \text{Total losses} \quad (1)$$

Where P_R (dBm) is the received power, P_T (dBm) is the transmitted power. According to [5], total losses in a FSO communication system would cover all the losses caused by the atmospheric phenomena, L_{ATM} (dB) which can be calculated as in Eq. (5), geometrical loss, L_{GEO} (dB) and system loss, L_{SYS} (dB). Therefore, the new equation for FSO received power is as in Eq. (2):

$$P_R = P_{Tcomb} - L_{ATM} - L_{GEO} - L_{SYS} \quad (2)$$

The total transmitted power can be obtained in Eq. (3):

$$P_{Tcomb} = P_T + 10 \log_{10}(N_T) \quad (3)$$

Where, N_T is the number of transmitter lenses on a single FSO unit. Geometrical loss and system loss are the internal losses occurred within the FSO transceiver. Both losses are fixed on all FSO link and cannot be neglected. L_{SYS} Is manufacturer defined; meanwhile in [5] L_{GEO} can be calculated as in Eq. (4):

$$L_{GEO} = -10 \log_{10} \left[\frac{A_{RTotal}}{\pi(l\theta)^2} \right] \quad (4)$$

l (km) is the distance of the optical path where the laser beams travel and θ (mrad) is the divergence angle which is the angle of the cone of light emitted from the transmitter. Meanwhile, $(m^2) A_{RTotal} (m^2)$ is

the total area of the receiver apertures on a single FSO unit.

According to Beers-Lambert Law, the atmospheric losses for any laser power is in a form of exponential equation of:

$$L_{ATM} = e^{-\gamma l} \quad (5)$$

Where l (km) is the transmittance range of the laser and σ is the typical attenuation coefficients (0.1 for clear air)[6].

The robustness of the design of any optical communication system can be effectively verified by critically applying performance checks on the system. The evaluation criteria should provide a precise determination and separation of dominant system limitations, making them crucial for the suppression of propagation disturbances and performance improvement. The Bit Error Rate (BER) of an optical link is the most important measure of the faithfulness of the link in transporting the binary data from transmitter to receiver. The BER quantifies the rate of errors and is defined as the probability of an error occurring per transported bit. The bit error rate takes the simple form

$$BER = \frac{1}{2} \text{erfc} \left(\frac{Q}{\sqrt{2}} \right) \quad (6)$$

Where Q is quality factor and 'erfc' denotes the complementary error function.

III. ROUTING PROTOCOLS

In the wireless communication the nodes may be placed randomly in the whole network. Each follows a certain set of rules during the data transmission in the network known as the routing protocols. Routing protocols are categorized in two subclasses reactive and proactive routing protocol. In this section we summaries the various key features of AODV and DYMO.

3.1 Proactive routing protocol

Each node in the network has routing table for the broadcast of the data packets and want to establish connection to other nodes in the network. These nodes record for all the presented destinations, number of hops required to arrive at each destination in the routing table. The routing entry is tagged with a sequence number which is created by the destination node. To retain the stability, each station broadcasts and modifies its routing table from time to time. Example of proactive routing protocol is destination sequenced distance vector (DSDV).

3.2 Reactive routing protocol

It employs flooding (global search) concept by constantly updating route tables of individual nodes. Reactive protocol searches for the route in an on-

demand manner and sets the link in order to send out and accept the packet from a source node to destination node. Reactive Protocol has lower overhead since routes are determined on demand. Route discovery process is used in on demand routing by flooding the route request (RREQ) packets throughout the network. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV) and Dynamic MANET On-Demand Routing Protocol (DYMO).

3.2.1 AODV

AODV is a modification of the DSDV algorithm. When a source node desires to establish a communication session, it initiates a path-discovery process to locate the other node. The source node broadcasts a RREQ packet with its IP address, Broadcast ID (BrID), and the sequence number of the source and destination. While, the BrID and the IP address is used to uniquely identify each request, the sequence numbers are used to determine the timeliness of each packet.

3.2.3 DYMO

DYMO is not a new protocol but an improvement of basic AODV routing protocol and easier to implement. Typically, all reactive routing protocols rely on the quick propagation of route request packets throughout the MANET to find routes between source and destination, while this process relies on broadcasting route reply messages that are returned to the source. DYMO [7][8] determines unicast between DYMO routers within the network in an on-demand fashion, offering improved convergence in dynamic topologies. The basic operations of the DYMO protocol are route discovery (by route request and route reply) and route maintenance. In networks with a large number of routers, it is best suited for sparse traffic scenarios. In each DYMO router, minimal state routing is maintained and therefore it is applicable to memory constrained devices. In this protocol only routing information relative to active sources and destinations is maintained. The routing algorithm in DYMO may be operated at layers other than the network layer, using layer-appropriate addresses. For operation at other layers only modification of the packet/message format is required. To ensure predictable control overhead, DYMO router's rate of packet/message generation should be limited.

IV. SIMULATION ENVIRONMENT

Qualnet 5.0 is used for the simulation of protocols. The free space model is simulated for 15 nodes. The simulation area is $1800 \times 1800m^2$. The nodes are placed randomly in the given simulation area. The other specifications used for the simulation are as follows:

Radio type: abstract

Data rate: 1.5 Gbps

Transmission power: 15 dBm

Antenna model: steerable antenna

Laser beam angle: 10 degrees

Simulation time: 30 minutes

V. RESULTS

The simulation results are compared for the total number of packets received in the network along with the signals received with error. Fig.2 shows the aggregate number of packets received in the network using AODV as the routing protocol and Fig.3 shows the same using DYMO.

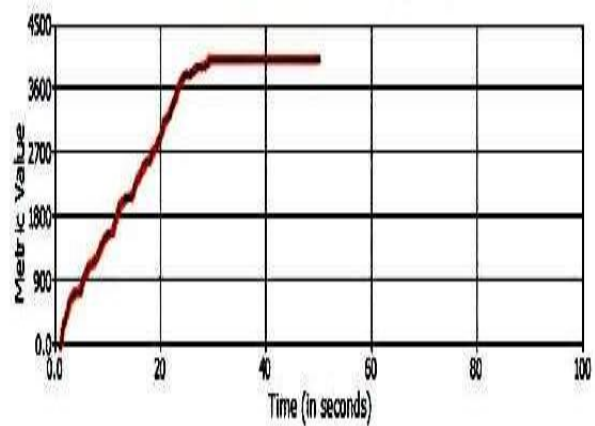


Fig.2: Aggregate number of packets received in the network with AODV.

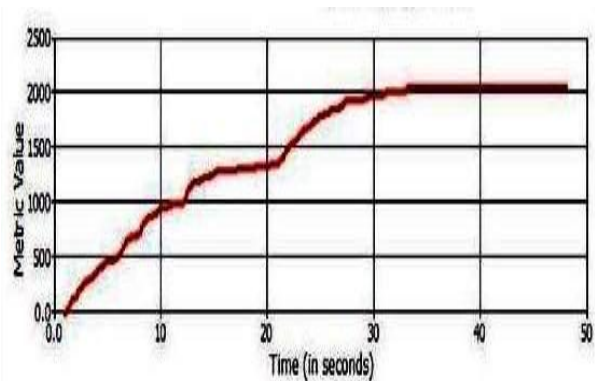


Fig.3: Aggregate number of packets received in the network with DYMO.

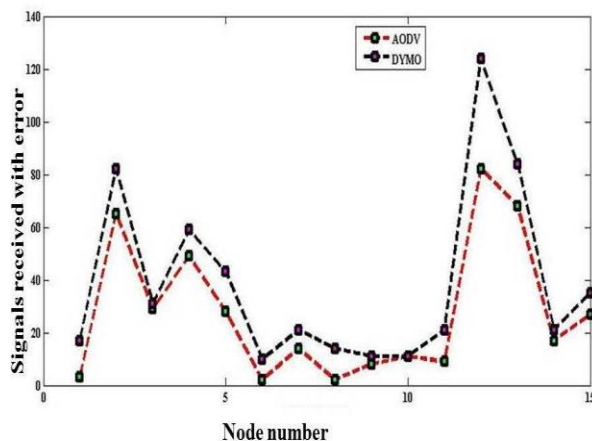


Fig.4: Comparison of signals received with error for AODV and DYMO.

VI. CONCLUSION

As the results are compared for AODV and DYMO the aggregate number of packets received are more for AODV then DYMO also the network stabilizes faster for AODV with gradual increase in the total number of packets in the network. When comparing the signals which are received with error the error rate is higher in DYMO. The error rate increases gradually when DYMO is used as the routing protocol. For the overall simulation of the optical link AODV performs better than the DYMO. The network efficiency would be more for AODV.

ACKNOWLEDGEMENTS

The authors acknowledge the encouragement and support provided by Dr Sandeep Vijay ,Professor and Head(ECE AND AEI Dept) and Dr Rashmi Chaudhary Professor(ECE Dept), DIT University, Dehradun.

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