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RESEARCH ARTICLE

DESIGN OF OPEN SHORTEST PATH FIRST PROTOCOL –A LINK STATE PROTOCOL USING OPNET MODULAR

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Abstract*— *Open Shortest Path First (OSPF) is an Interior Gateway Routing Protocol, based on Shortest Path First (SPF) or link-state technology. Open Shortest Path First (OSPF) is a link state routing protocol which was first defined as version 2 in RFC 2328. This is used to allow routers to dynamically learn routes from other routers and to advertise routes to other routers. OSPF router keeps track of the state of all the various network connections (links) between itself and a network it is trying to send data to. This makes it a link-state routing protocol.

Optimized network engineering tool (OPNET) modeler is an interactive graphical user interface (GUI) that provides hierarchical structure of problem solving. Moreover, it includes lot of documentation on learning and application of software in networking domain. In this thesis work it has been attempted to find out the best route in OSPF through simulation. The work was started with the basic idea of Wired and Wireless LANs and how these networks perform under various types of circumstances. In particular, the effect of various parameters and configurations on the network performance was analyzed using the network simulator- OPNET. The work further extends to design a virtual model of OSPF, link state protocol in OPNET. The comparison of traffic sent (bits/sec), traffic received (bits/sec), bit error rate, bit error rate per packet, throughput (packets/sec) and throughput (bits/sec) have been investigated in simulation medium. The results show the proper route making in OSPF. Some delays in Received packets have been observed due to network congestion parameters. The amount of packet received is more than the packet sent due to addition of IP addresses. The work can be extended to inculcate other network traffic parameters and to design another protocols using simulation and to compare them.

Keywords: - OSPF, OPNET, GPS, GUI, TCP/IP

I. PREAMBLE

Data communication and networking is the fastest growing technology in the modern era. Advanced research projects agency network (ARPANET) added fuel to the growth of computer network industry and since then computer networks are emerging as social networks which are linking people, organizations and knowledge worldwide. This radical change in the computer networking domain over the decades is the result of convergence of internet coupled with engineering advances in the field of information and communication technologies. The new trends in computer networking like global positioning systems (GPS) with wireless internet access and wearable networking devices are transforming every aspect of our life. This work is a practical implementation of open shortest path first (OSPF) protocol using network software OPNET.

II. INTRODUCTION

A comparative study of route transfer between different nodes using open shortest path first is made by varying the physical characteristics and logical conditions of computer networks. Physical characteristics involved number of nodes and type of cabling [1, 4, 7]. The size of data packet is chosen from logical domain. The delay may be measured as a global parameter or as a nodal parameter. In global sense, the delay may be defined as an average time gap experienced by all the nodes in a network between transmission and reception of data packets or between request and response. The delay in nodal [5, 16] sense is defined as the average time taken by the data packets to reach a particular node. It is measured in seconds. Load is the amount of data packets transmitted by a particular node, thereby adding load on network. It is a nodal characteristic and is measured in bits per second (bps). Traffic received is the amount of throughput measured for the particular node. It is measured in bits per second or packets per second.

The comparison of traffic sent (bits/sec), traffic received (bits/sec), bit error rate, bit error rate per packet, throughput (packets/sec) and throughput (bits/sec) is computed by varying type of link which may be categorized depending upon its speed of carrying data.

The analysis was done on an Ethernet based local area network (LAN) having physical design of OSPF topology. The choice of Ethernet LAN having OSPF was made because Ethernet is the most common local area network worldwide.

III. OPNET MODELER

Optimized network engineering tool (OPNET) modeler is an interactive graphical user interface (GUI) [23, 25] that provides hierarchical structure of problem solving. Moreover, it includes lot of documentation on learning and application of software in networking domain. The IT guru academic edition of the software is available free of cost on OPNET website. OPNET modeler works smoothly on system having a 32 bit processor, working on windows or UNIX platform with a minimum of 256 MB of random access memory (RAM).

IV. OPEN SHORTEST PATH FIRST PROTOCOL

OSPF protocol was developed due to a need in the internet community to introduce a high functionality non-proprietary Internal Gateway Protocol (IGP) for the TCP/IP protocol family. The discussion of the creation of a common interoperable IGP for the Internet started in 1988 and did not get formalized until 1991. At that time the OSPF Working Group requested that OSPF be considered for advancement to Draft Internet Standard.

The OSPF protocol is based on link-state technology, which is a departure from the Bellman-Ford vector based algorithms used in traditional Internet routing protocols such as RIP. OSPF has introduced new concepts such as authentication of routing updates, Variable Length Subnet Masks (VLSM), route summarization, and so forth.

OSPF detects changes in the topology, such as link failures, very quickly and converges on a new loop-free routing structure within seconds. It computes the shortest path tree for each route using a method based on Dijkstra's algorithm, a shortest path first algorithm.

The link-state information is maintained on each router as a link-state database (LSDB) which is a tree-image of the entire network topology. Identical copies of the LSDB are periodically updated through flooding on all OSPF routers.

The OSPF routing policies to construct a route table are governed by link cost factors (external metrics) associated with each routing interface. Cost factors may be the distance of a router (round-trip time), network throughput of a link, or link availability and reliability, expressed as simple unitless numbers. This provides a dynamic process of traffic load balancing between routes of equal cost.

An OSPF network may be structured, or subdivided, into routing areas to simplify administration and optimize traffic and resource utilization. Areas are identified by 32-bit numbers, expressed either simply in decimal, or often in octet-based dot-decimal notation, familiar from IPv4 address notation.

By convention, area 0 (zero) or 0.0.0.0 represents the core or backbone region of an OSPF network. The identifications of other areas may be chosen at will; often, administrators select the IP address of a main router in an area as the area's identification. Each additional area must have a direct or virtual connection to the backbone OSPF area. Such connections are maintained by an interconnecting router, known as area border router (ABR). An ABR maintains separate link state databases for each area it serves and maintains summarized routes for all areas in the network.

OSPF does not use a TCP/IP transport protocol (UDP, TCP), but is encapsulated directly in IP datagrams with protocol number 89. This is in contrast to other routing protocols, such as the Routing Information Protocol (RIP), or the Border Gateway Protocol (BGP).

V. SHORTEST PATH FIRST ALGORITHM

OSPF uses a shorted path first algorithm in order to build and calculate the shortest path to all known destinations. The shortest path is calculated with the use of the Dijkstra algorithm. The algorithm by itself is quite complicated. This is a very high level, simplified way of looking at the various steps of the algorithm:

1. Upon initialization or due to any change in routing information, a router generates a link-state advertisement. This advertisement represents the collection of all link-states on that router.
2. All routers exchange link-states by means of flooding. Each router that receives a link-state update should store a copy in its link-state database and then propagate the update to other routers.
3. After the database of each router is completed, the router calculates a Shortest Path Tree to all destinations. The router uses the Dijkstra algorithm in order to calculate the shortest path tree. The destinations, the associated cost and the next hop to reach those destinations form the IP routing table.
4. In case no changes in the OSPF network occur, such as cost of a link or a network being added or deleted, OSPF should be very quiet. Any changes that occur are communicated through link-state packets, and the Dijkstra algorithm is recalculated in order to find the shortest path.

The algorithm places each router at the root of a tree and calculates the shortest path to each destination based on the cumulative cost required to reach that destination. Each router will have its own view of the topology even though all the routers will build a shortest path tree using the same link-state database. The following sections indicate what is involved in building a shortest path tree.

VI. OPEN SHORTEST PATH FIRST ALGORITHM IMPLEMENTATION

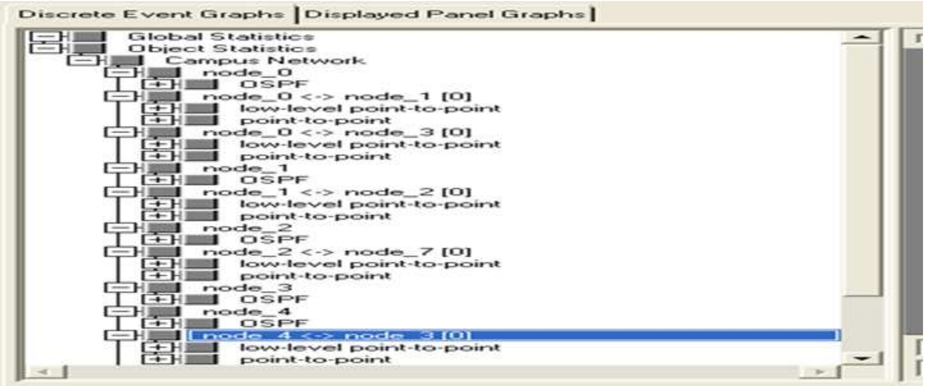

Fig. 1 Discrete Event graphs and panal Graphs evaluated for OSPF in OPNET

Above figure shows the Discrete Event graphs and panal Graphs evaluated for OSPF in OPNET. The GUI for low level point to point of OSPF in a campus network for node 0,node 0-1,node 0-3,node 1-2,node 2-7,node 3,node 4,node4-3 have been simulated and analyzed.

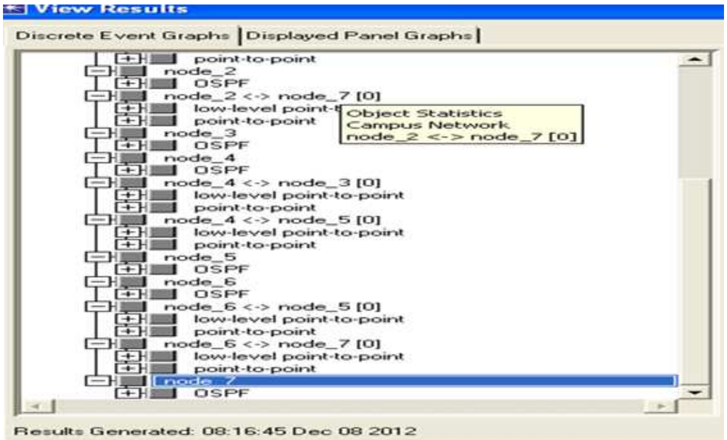

Fig. 2 Discrete Event graphs and panal Graphs evaluated for OSPF in OPNET

Above figure shows the Discrete Event graphs and panal Graphs evaluated for OSPF in OPNET.The GUI for low level point to point of OSPF in a campus network for node 2,node 2-7,node 3,node 4,node 4-3,node 4-5,node 5,node5,node 6-7,node 6-7and for node 7 have been simulated and analysed.

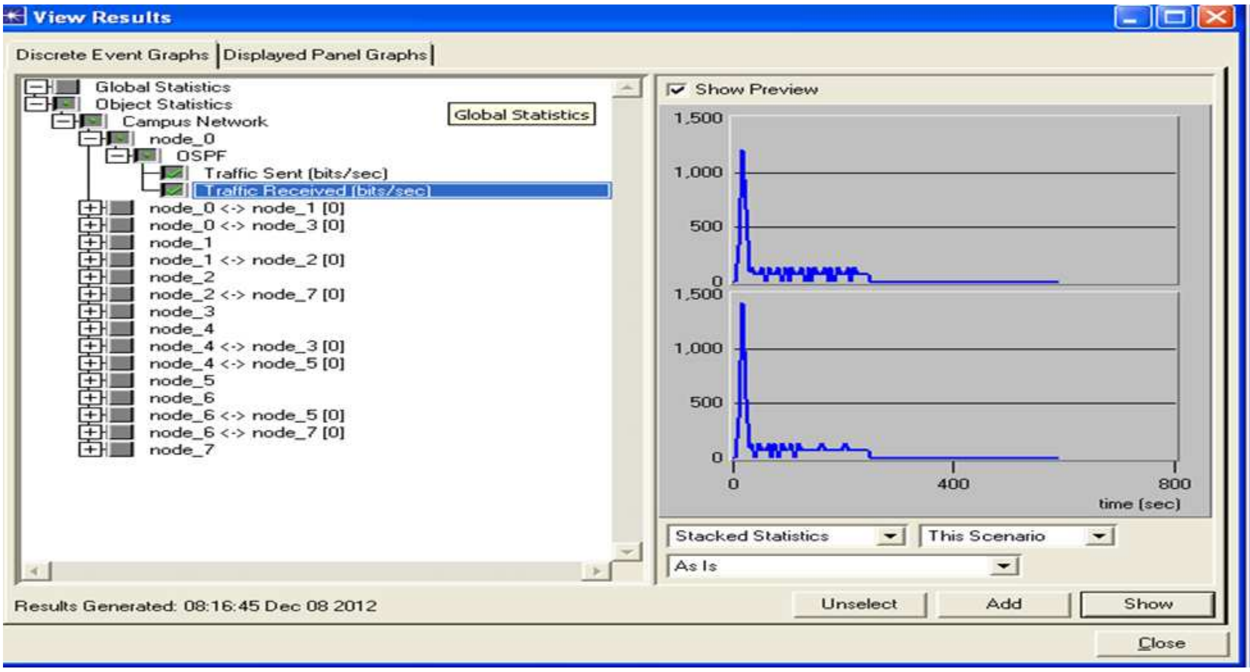

Fig. 3 Traffic Sent vs. Traffic Received for node 0 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for a campus network, node 0 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

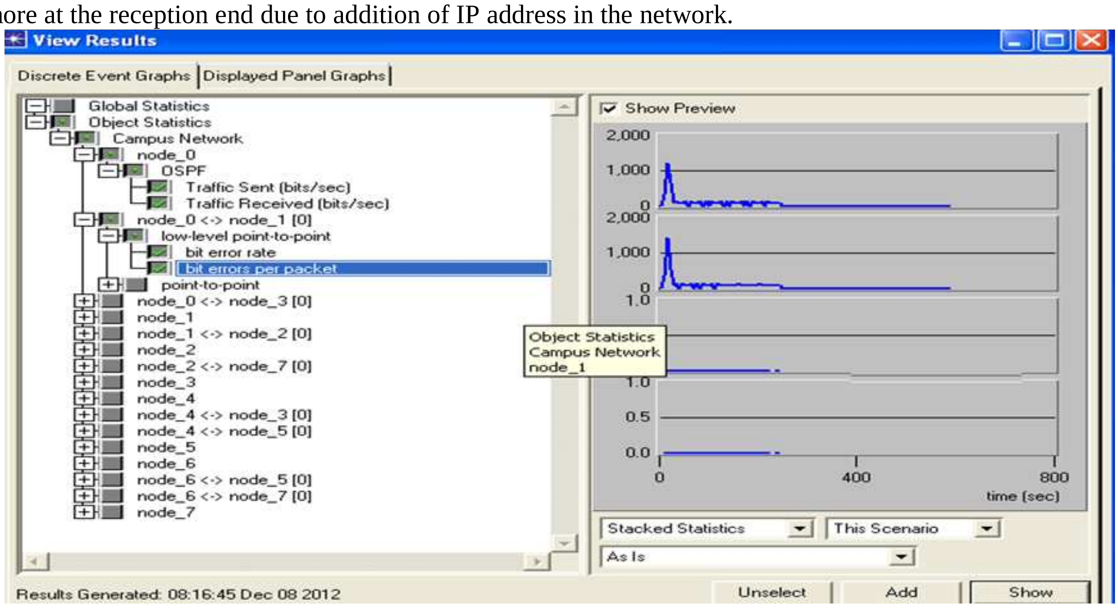

Fig. 4 Low level Point to point Bit Error rate per packet for node 0

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec, Low level point to point and bit error rate and bit error rate per packet for a campus network, node 0-1 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

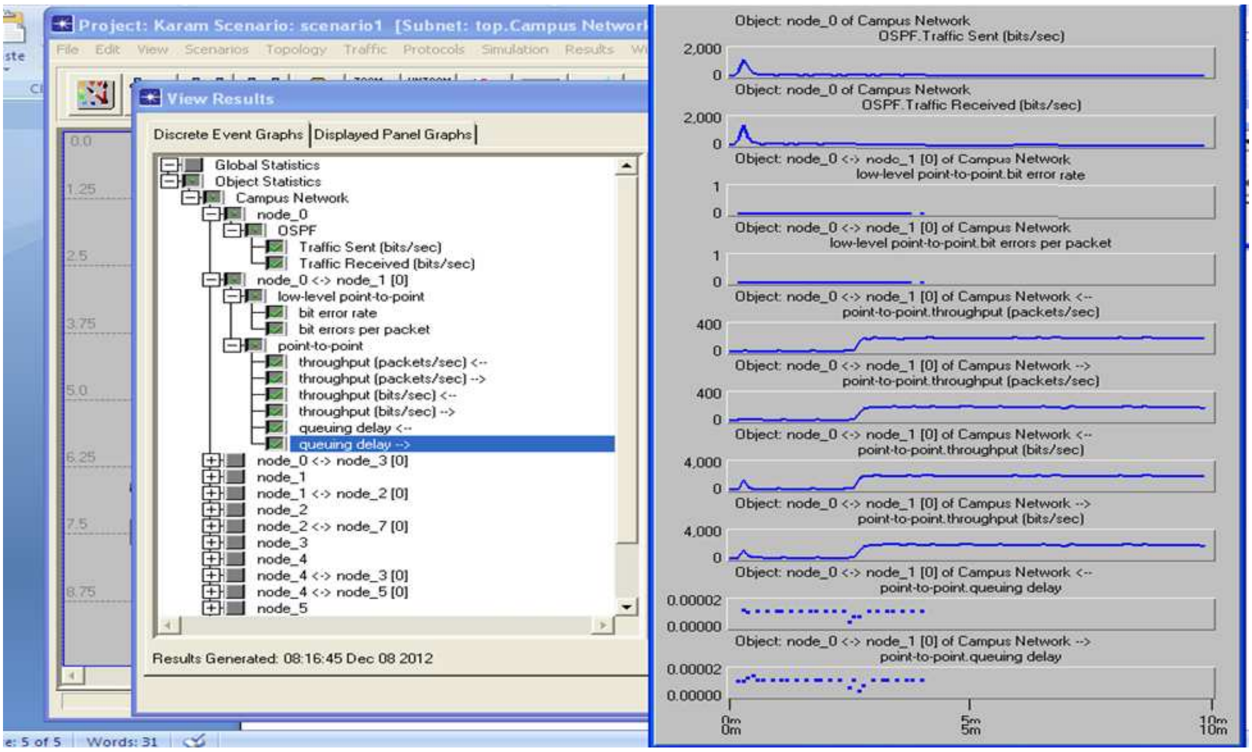

Fig. 5 Discrete Event graphs and panal Graphs evaluated for node 0-1 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for node 0, Low level point to point and bit error rate and bit error rate per packet for a campus network in node 0-1 in OSPF.

Point to point throughput (packets/sec) and throughput (bits/sec), point to point queuing delay for node 0-1 is evaluated in the above graph.

A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network. Some distortions in bits at the reception are observed.

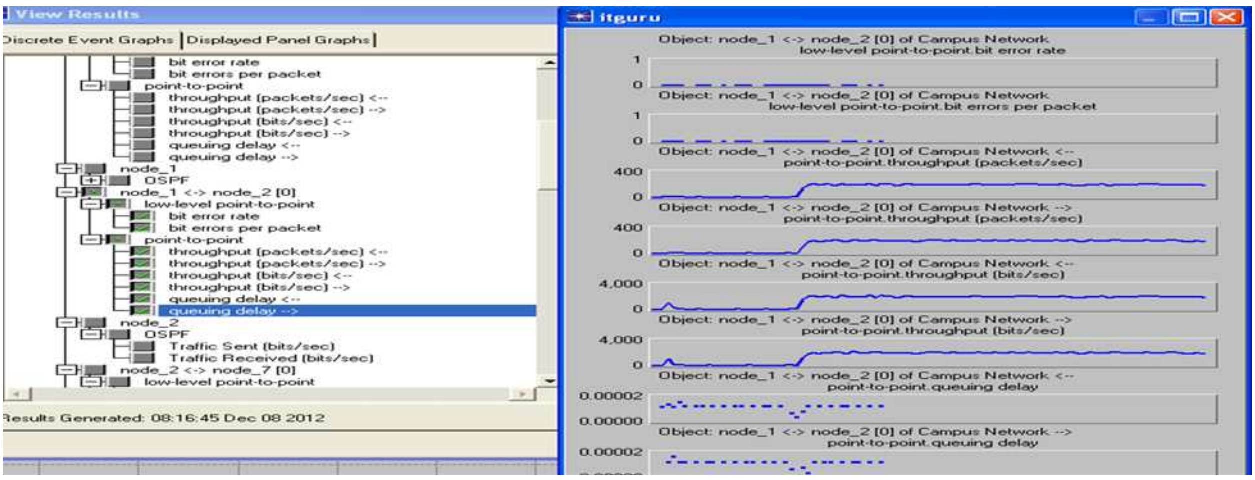

Fig. 6 Discrete Event graphs and panal Graphs evaluated for node 1-2 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for node1-2, Low level point to point and bit error rate and bit error rate per packet for a campus network in node 1-2 in OSPF.

Point to point throughput (packets/sec) and throughput (bits/sec), point to point queuing delay for node 1-2 is evaluated in the above graph.

A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network. Some distortions in bits at the reception are observed.

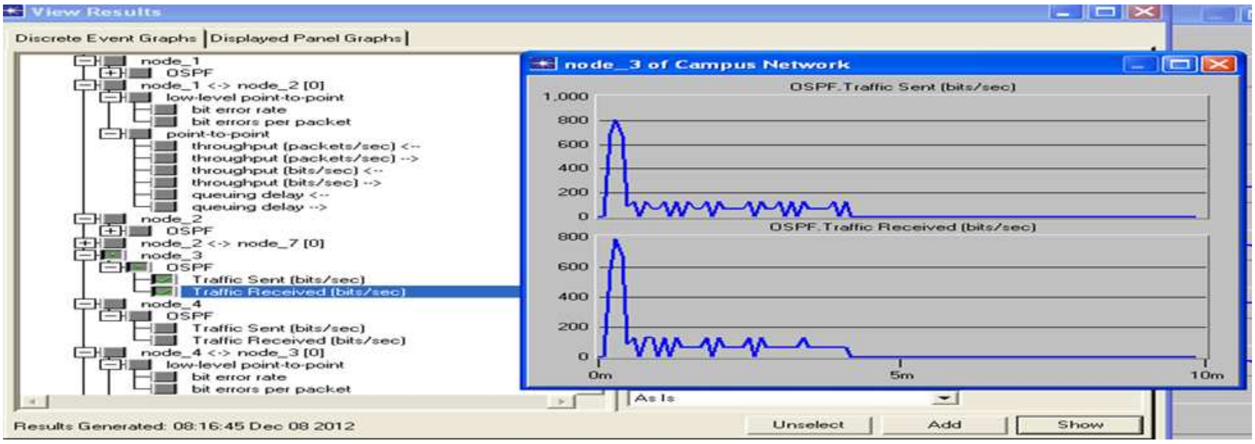

Fig. 7 Traffic Sent Vs Traffic Received for node 3 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for a campus network, node 3 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

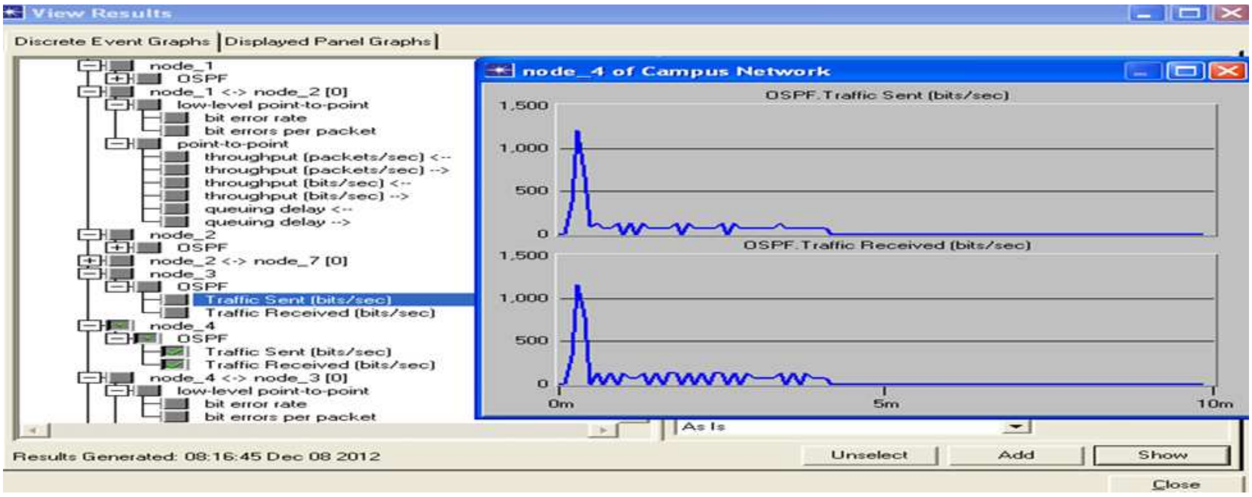

Fig. 8 Traffic Sent Vs Traffic Received for node 4 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for a campus network, node 4 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

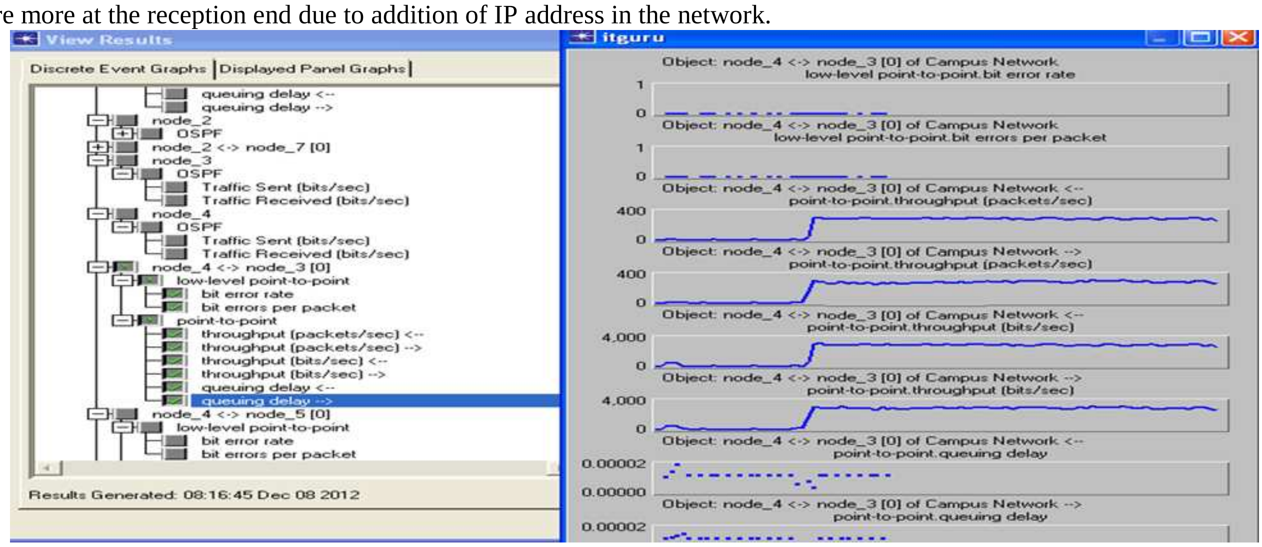

Fig. 9 Discrete Event graphs and panal Graphs evaluated for node 1-2 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for node4-3, Low level point to point and bit error rate and bit error rate per packet for a campus network in node 4-3 in OSPF.

Point to point throughput (packets/sec) and throughput (bits/sec), point to point queuing delay for node 4-3 is evaluated in the above graph.

A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network. Some distortions in bits at the reception are observed.

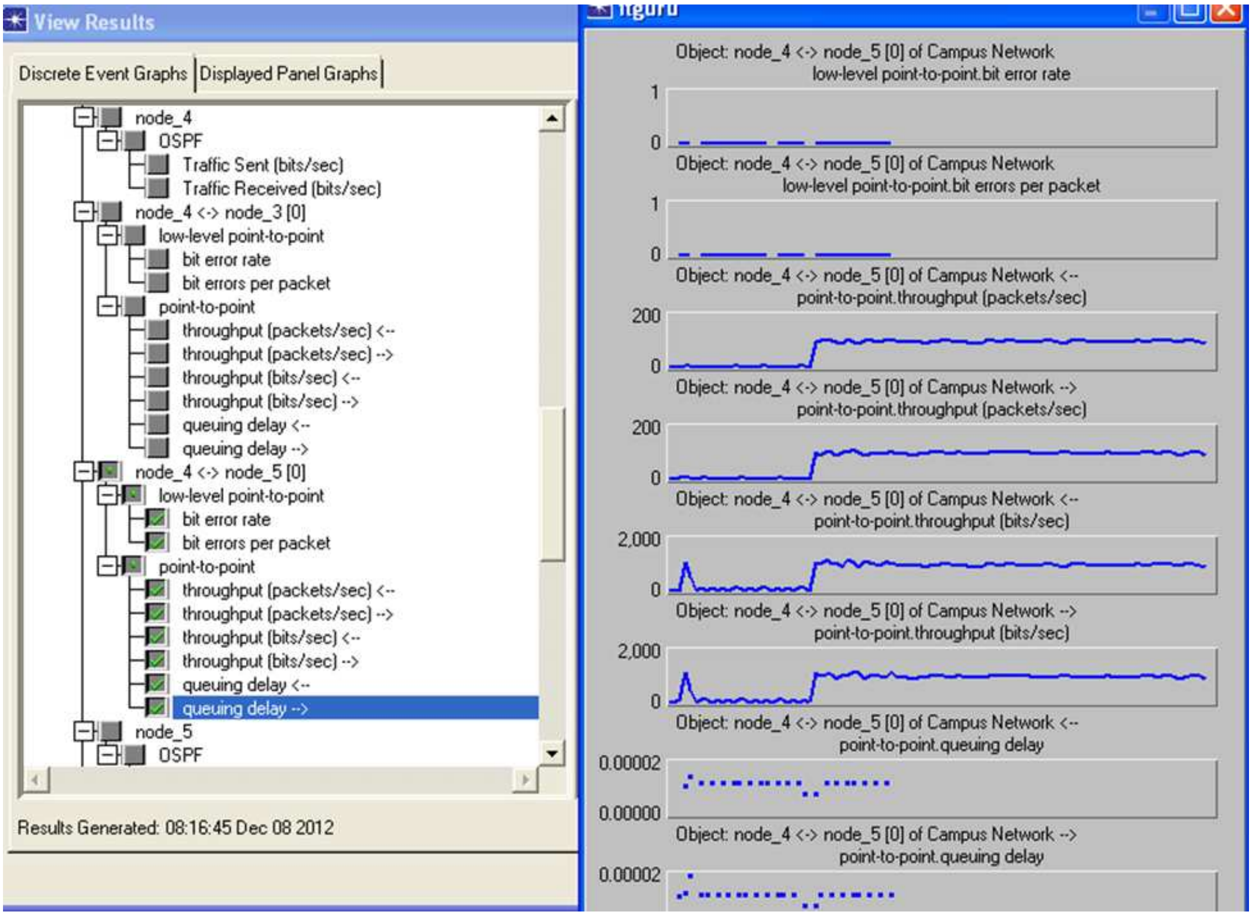

Fig. 10 Discrete Event graphs and panal Graphs evaluated for node 4-5 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for node4-5, Low level point to point and bit error rate and bit error rate per packet for a campus network in node 4-5 in OSPF.

Point to point throughput (packets/sec) and throughput (bits/sec), point to point queuing delay for node 4-5 is evaluated in the above graph.

A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network. Some distortions in bits at the reception are observed.

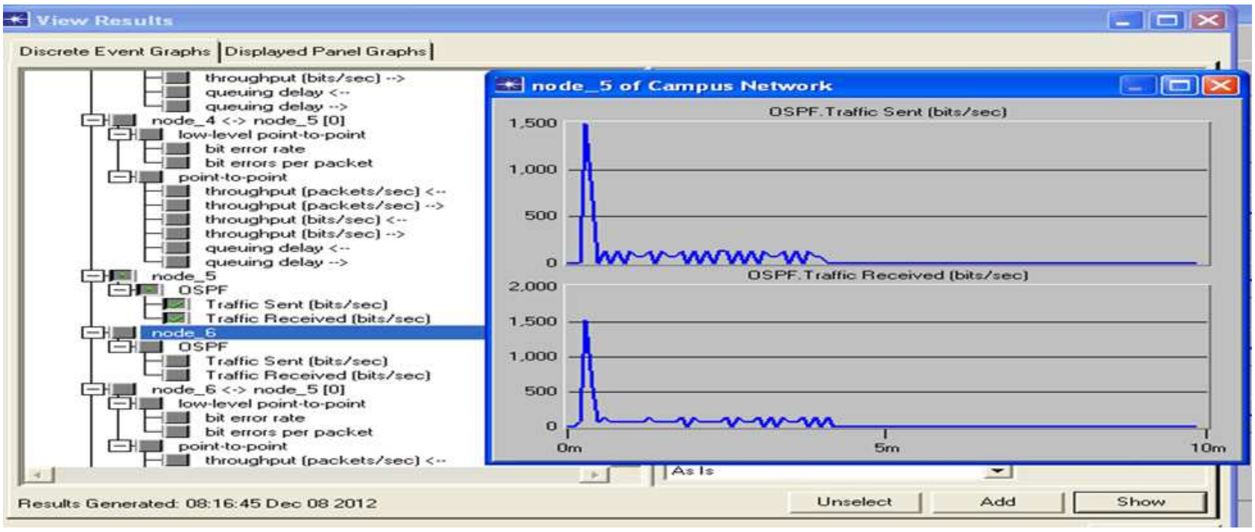

Fig. 11 Traffic Sent Vs Traffic Received for node 5 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for a campus network, node 5 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

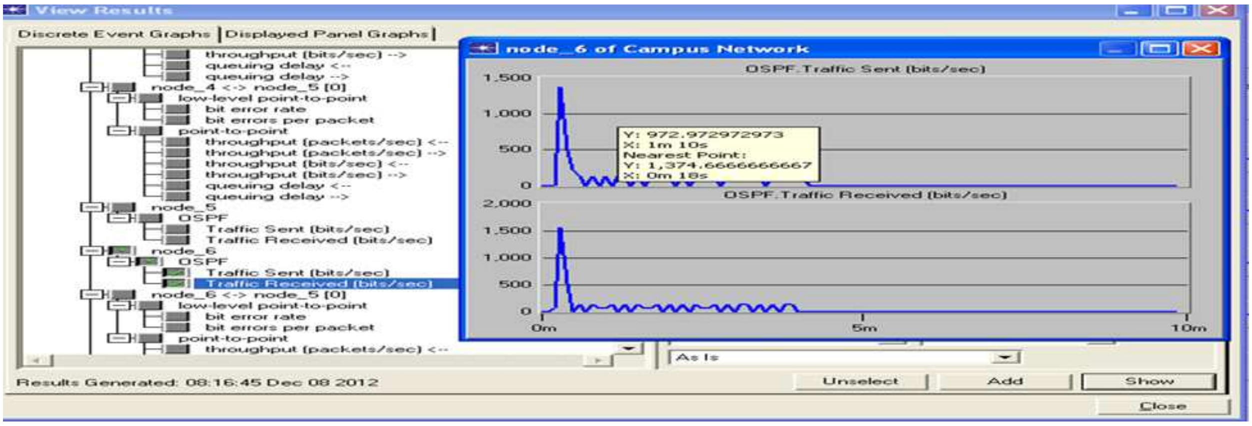

Fig. 12 Traffic Sent Vs Traffic Received for node 6 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for a campus network, node 6 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

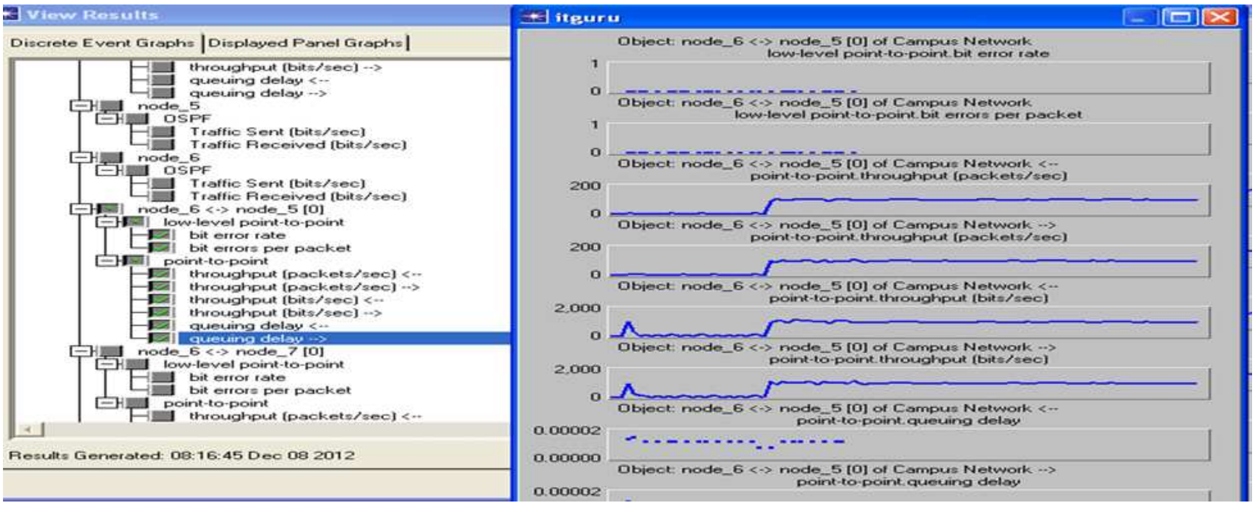

Fig. 13 Discrete Event graphs and panal Graphs evaluated for node 6-5 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for node6-5, Low level point to point and bit error rate and bit error rate per packet for a campus network in node 6-5 in OSPF.

Point to point throughput (packets/sec) and throughput (bits/sec), point to point queuing delay for node 6-5 is evaluated in the above graph.

A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network. Some distortions in bits at the reception are observed.

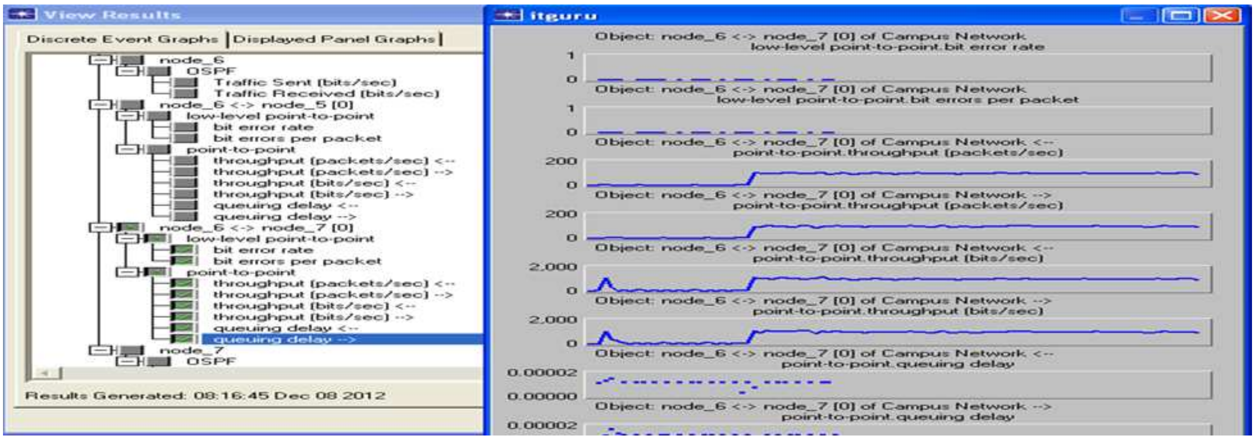

Fig. 14 Discrete Event graphs and panal Graphs evaluated for node 6-7 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for node6-7, Low level point to point and bit error rate and bit error rate per packet for a campus network in node 6-7 in OSPF.

Point to point throughput (packets/sec) and throughput (bits/sec), point to point queuing delay for node 6-7 is evaluated in the above graph.

A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network. Some distortions in bits at the reception are observed.

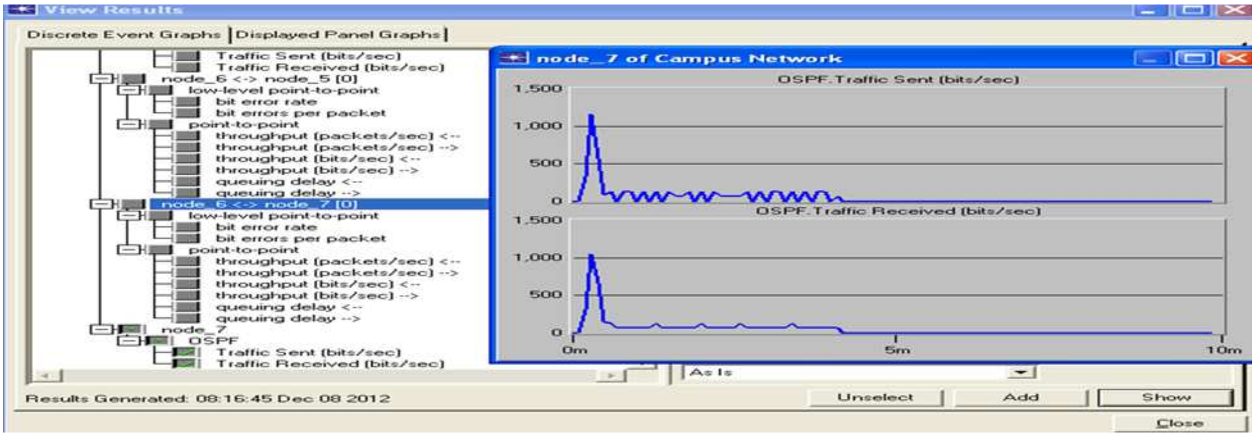

Fig. 15 Traffic Sent Vs Traffic Received for node6-7 in OSPF

Above figure shows the comparative analysis of traffic sent vs traffic received in bits/sec for a campus network, node 6-7 in OSPF.A small amount of distortion is observed in the traffic received. The Packets received are more at the reception end due to addition of IP address in the network.

VII. CONCLUSIONS

In this Research work, it has been attempted to find out the best route in OSPF through simulation. The work was started with the basic idea of Wired and Wireless LANs and how these networks perform under various types of circumstances. In particular, the effect of various parameters and configurations on the network performance was analyzed using the network simulator- OPNET. Different configurations of the networks were studied in addition to the effect of variation of parameters on the networks. The network is designed in simulator OPNET to perform the operation of OSPF protocol. An OSPF protocol was designed with different IP‘s and the data transfer is through the network IP nodes. For the analysis, seven different IP’s have been investigated. The

OSPF have been designed and simulated using OPNET simulator as per guidelines given in Appendix-I. An analysis was made for selecting a reliable, node data transfer using the OPNET simulating tool.

Various factors which impact the network design and performance of Wired and wireless LAN were analyzed using the network simulator- OPNET. The simulator results indicate that OPNET can be used to estimate and predict the performance of wireless protocols including OSPF. The main conclusions based on the simulation are:

- The network data is transferred between the dependent nodes with fewer distortions.
- But throughput can be improved by varying the modulation techniques. (It was proved that infrared type technology is better).
- The increase in the data rate can help increase the throughput by decreasing the end-to-end delay in OSPF.
- The increase in Buffer size can help increase the throughput marginally as it reduces the queuing delays.
- Bit Error rate and Bit error rate in Packet/seconds is also analyzed for different independent and dependent nodes.

VIII. FUTURE SCOPE OF WORK

This Research mainly focused on the performance analysis of Open shortest path first protocol. Future research may include the schemes and techniques to:

- Optimize the security of the nodes.
- Determining the other parameters available

IX. SUMMARY

OPNET modeler presents the most realistic approach in modeling and simulation of computer networks. Its object oriented approach and hierarchical methodology in problem solving makes it more preferable. Seven nodes with different IP Addresses have been taken to design OSPF. The various parameters in OSPF have been investigated viz. traffic sent, traffic received, bit error rate, throughput, queuing for independent and other dependent nodes have been evaluated. The features like choosing of network setup area, defining the data packet size, process modules definition and duplicating the scenarios provided the in depth knowledge of network hardware and software components and their dependency on each other. Overall, it provides a flexible solution to understand, implement, diagnose or simply stating explore the world of computer networks.

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