



International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

Throughput Analysis of Real Network Architecture: “Alive Project Study of H.P University, Shimla”

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Abstract: This paper describes a live project study carried out for the implementation of Optical fibre Network backbone in the Himachal Pradesh University, Shimla, India. In this study following work has been reported (i) ICT based Challenges and different phases of broadband connectivity provided during last ten years (ii) Architectural Design of Optical Fibre network backbone. (iii) Throughput analysis of real network using S/w tool CommView. (iv) Efficiency of the campus network of H.P. University, Shimla, India.

Keywords: Efficiency, Throughput, Information and Communication Technology (ICT), Broadband connectivity.

I. INTRODUCTION

In today's competitive world, reliable and efficient access to information has become an important asset in the quest to achieve an advantage with the help of ICT tools. Computer networking technologies are the glue that binds various elements of ICT together. Networking [1] allows one computer to send information to and receive information from another. We can classify network technologies as belonging to one of two basic groups. Local Area Network (LAN) [2] technologies connect many devices that are relatively close to each other, scattered around the campus with different buildings.

Wide Area Network (WAN) technologies connect a smaller number of devices that can be many kilometers apart. In comparison to WANs, LANs are faster and more reliable, but improvements in technology continue to blur the line of demarcation. Fiber optic cables have allowed LAN technologies to connect devices tens of kilometers apart, while at the same time greatly improving the speed and reliability within LAN and WAN.

As far as the technologies are concerned, Ethernet technology has been a relatively inexpensive, reasonably fast and very popular in Local Area Network (LAN) technology for several decades. Two scientists at Xerox PARC, Metcalfe and Boggs [3,4] -- developed Ethernet Technology beginning in 1972 and specifications based on this work appeared in IEEE as 802.3 standard in 1980. Ethernet has been most widely deployed network technology globally. Keeping this in mind, above mentioned technologies have been deployed in the H P University, Shimla using Terra Byte Optical Fibre Cable (OFC), as backbone, between buildings on the university campus and Giga Byte cable within buildings, being the most robust/reliable and tested solution.

A live ICT project study for the implementation of campus wide optical Fibre Network in the Himachal Pradesh University, Shimla, India has been depicted. This backbone is extremely helpful for providing internet facility and e-journals to the academic community of this university.

Section 2, of this paper discusses the ICT based challenges posed for successful implementation of this project. The different phases of Broadband connectivity provided since 2004, are given in Section 3. Architectural design of Optical Fibre Backbone has been discussed in Section 4. The section 5 deals with throughput analysis of real network architectural design and efficiency of network implemented on campus of Himachal Pradesh University, Shimla, India.

II. ICT BASED CHALLENGES POSED

The academic community in the state of Himachal Pradesh, faced till Oct 2007 (Mainly) following challenges in respect of access to ICT services:

- i. No Optical Fibre Backbone (OFB) and UTP Cabling (CAT 6) on the University Campus.
- ii. Lack of funds in order to lay optical fibre cable (OFC) backbone and UTP cabling (CAT 6) within buildings.
- iii. In the absence of any intra-university/inter-university communication facilities were available, one had to go personally to get desired information. It led to a situation in which many university employees (both academic and non academic) were not available on their seats, resulting in loss of valuable time. Thus the desired work culture was missing.
- iv. Low bandwidth internet connectivity, using dialup facility, was available (Limited to 56.6 Kbps).
- v. The dedicated broadband facility 512 Kbps (1:1) through Very Small Aperture Terminal (VSAT) was available at H P University, since 11th May 2004, had not reached at the desk of each potential user in the University. Access to connectivity at remote places by the academic community of the university was also missing.
- vi. Non-availability of e-journals to researchers.
- vii. No electronic communication available, to maximise paperless work culture in various offices of the university.

- viii. Non availability of Educational Resource Planning software on campus including computerization of examination.
- ix. Lack of computer/ ICT awareness among academic community of the university till 2011

Initiatives

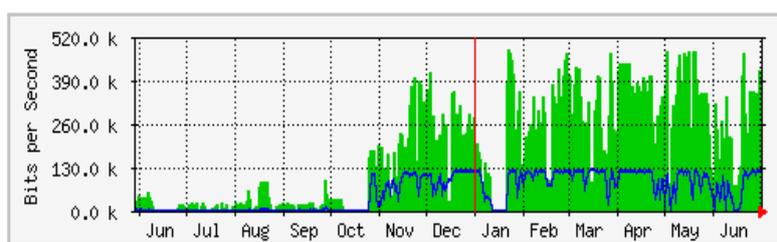
A proposal for the development of IT infrastructure with the internet connectivity linked through VSAT, on the H.P.University campus was originally submitted to University Grants Commission(UGC), New Delhi, India, in 1999. Almost around that time it was decided by the IT Task Force set up by Government of India that University Grants Commission (UGC) would provide complete connectivity through VSAT (Broadband Services) to all the Indian Universities. In the year 2002, H.P.University was selected to be one of the centers to have such a facility. At the same time a functional UniversityInformationTechnologyCenter was also made available to the academic community of the university for e-journal and internet access. As per the norms of the UGC a survey was conducted and a proposal was finally submitted with all the desired details for VSAT connectivity in order to have 24 hour broadband internet facility. VSAT was installed in the library building, a central place on the campus and a facility of internet was also made available in the year 2004. It was decided to extend this facility of internet connectivity to all the faculty members in various departments and officers of the university, located in 19 different buildings spread over 2.4 hectares in the hilly terrain, near Indian Institute of Advanced Studies (Formerly known as Viceroy lodge), Shimla. Thus an initiative was taken to lay down "Campus Wide Optical Fibre Network". In this connection, all the necessary steps and formalities were completed in a time bound manner and order was placed to lay the Optical Fibre Backbone (OFB) on the campus and UTP cabling (CAT 6) in all the 19 buildings of the campus in June 2006. In Oct 2007, all the 19 buildings (Academic and Administrative) OFC Backbone has been laid down connecting all the 19 buildings on the campus as per the execution plan chart along with UTP (CAT6) cable. Now the facility of available internet facility alongwith more than 4000 national and international online e-journals have reached to all the 19 buildings.

III. BROADBAND CONNECTIVITY DURING LAST TEN YEARS.

The dedicated broadband internet facility of VSAT 512 kbps wasreached at the desk of each potential user in the University on 25th Oct 2007.

Access to connectivity at remote places other than these nineteen buildings on the campus, will also be provided to the academic community of the university through a Remote Access Server (RAS) placed at the central location.RAS has got 8 ports in total. This facility is very important because students, academic community including those, who are enrolled through correspondence and staying in rural areas, will be able to access from remote in order to see lectures notes/journals/assignments available.

'Yearly' Graph (1 Day Average)



Max In:487.5 kb/s (20.3%) Average In:172.3 kb/s (7.2%) Current In:388.9 kb/s (16.2%)
Max Out: 124.9 kb/s (5.2%) Average Out: 61.3 kb/s (2.6%) Current Out: 118.1 kb/s (4.9%)

FIGURE 1.Utilisation Graph Of VSAT At H P University, Shimla

It is a tangible transformation within the university for the academic community, ICT infrastructure is being used very effectively. A utilisation graph of Network used by the academic community of the H. P University, Shimla as on 3rd July 2008, is given in Fig. 1.The figure depicts that once the optical fibre backbone got started functioning on 25th Oct 2007, the utilization has increased drastically as comparison to June to mid of Oct.

The main features of ICT infrastructure including different phases of broadband connectivity provided since 2004, are given as below:

- (i) **VSAT:** VSATBroadband connectivity facility (512 kbps) was commissioned on May 11, 2004. This bandwidth connectivity is available round the clock, throughout the year.
- (ii) **INFLIBNET:** UGC has allowed another window through the VSAT, providing e-journals bouquet of more than 4,000 research journals to research and teaching community of the university.
- (iii) **2 Mbps Internet Connectivity:** Infilibnet[5] upgraded the internet connectivity to 2 Mbps in the year 2008. This bandwidth was in-sufficient because on campus for more than 800 active users were available. Initiative has been taken in order to enhance the bandwidth upto 10 Mbps.
- (iv) **10 Mbps Internet Connectivity:** The internet connectivity from 2 Mbps to 10 Mbps in the year 2010 was upgraded,as user's awareness got increased and started using internet with much higher applications.
- (v) **NKN Connectivity (1 Gbps):** Due to the initiative taken by the university and the policies of Govt of India, National Knowledge Network (NKN)[6]facility got implemented on 30th March 2012. The main advantages of

NKN are a) **Best Services** (such as Highest bandwidth connectivity i.e. 1Gbps/2.5 Gbps, highest scalability b) **Excellent Applications** (such as Virtual classrooms facility/connectivity, E-Governance, Sharing of computer resources. By NKN connectivity Himachal Pradesh University started getting high end services and better applications which are useful for the academic community of this university. The utilization of NKN has been increasing day by day. Despite better utilization, it will take long years to touch and utilize 1 Gbps bandwidth provided by NKN. The yearly utilization graph of NKN for the year 2014 is given in Figure 2. It is clearly eminent that higher utilization is reported (i.e 60 Mbps) between August 14 to December 2014. January reported minimum utilization due to winter vacations.

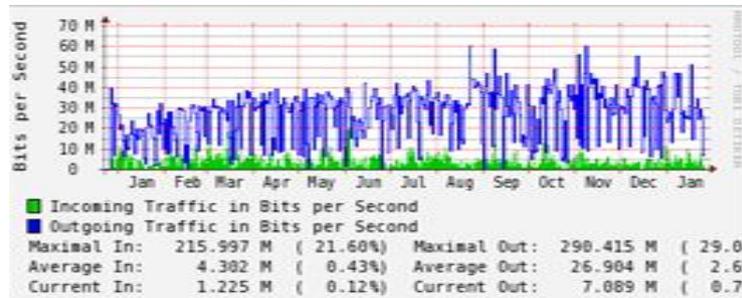


Fig: 2. Utilisation Graph of National Knowledge Connectivity at H.P. University, Shimla

IV. ARCHITECTURAL DESIGN OF OPTICAL FIBRE BACKBONE

D) Hierarchical star/treetopology:

The most relevant and meaningful topology today is Hierarchy star/tree topology, which has following objectives:

- Higher performance.
- Easy to set up and to expand.
- In case of any non-centralised failure, it will have little effect on the network. In case of any central failure then routing/communication will still be possible with their respective as zonal switch.
- Easy to detect faults
- Data Packets are sent quickly as they do not have to travel through any unnecessary nodes.
- Integration with wireless (WiFi) implementation.
- Redundancy feature of optical link/path is also taken care while laying, figure 3. In case of any path failure then other link becomes active automatically using Spanning –Tree Protocol. Features of spanning tree protocol [7] are:
 - Spanning-Tree Protocol is a link management protocol that provides path redundancy while preventing undesirable loops in the network. For an Ethernet network to function properly, only one active path can exist between two stations.
 - To provide path redundancy, Spanning-Tree Protocol defines a tree that spans all switches in an extended network. Spanning-Tree Protocol forces certain redundant data paths into a standby (blocked) state.

If one network segment in the Spanning-Tree Protocol becomes unreachable, the spanning-tree algorithm reconfigures the spanning-tree topology and reestablishes the link by activating the standby path.

II) Optical Fibre Backbone Architecture designed in Hierarchical Star topology:

Hierarchical star topology or Tree topology is formed into a network by hierarchical in-series connection of multiple star topologies. In practice, it may consist of a combination of fiber optic cables and UTP (CAT5/6) cables, depending on the demands placed on the individual transmission links. Figure 2, schematic representation hierarchical star topology is being shown below which has been implemented in the H P University, Shimla during 2006- 2007.

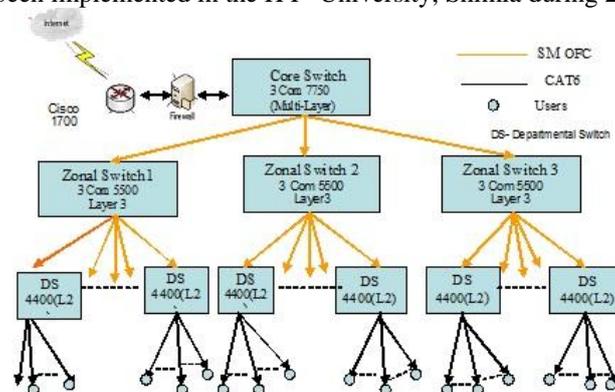


Figure 3.

As per Figure 3, Core Switch is a multilayer switch and connected with Cisco router 1700 through firewall. H.P. University, Shimla campus was divided into three different zones where zonal switches (i.e. layer 3) are located and

able to cater the needs of their respective zones. These zonal switches are connected to different departmental switches (layer 2) in the framework of ISO OSI model.

III. Architecture approach of switches are as follows:

The technical important details of core, zonal, departmental switches are as follows:

- a) **high performance:** 10-Gigabit, Gigabit, and Fast Ethernet switching, reduces congestion to enable applications to run faster, improving the quality of video and voice traffic.
- b) **Hardware Multicast Routing:** Reduced packet loss and latency times are vital for voice and video
- c) **Security:** Blocks all packets onto the network until users are authenticated (IEEE 802.1X RADIUS) to increase network security and enables user accountability.
- d) **Access Control Lists:** Constrains users to areas of the network they are authorized for, using Layer 2/3/4 content-based packet prioritization and traffic filtering.
- e) **Layer 3 Protocol Authentication:** Prevents unauthorized Layer 3 devices joining the network, reducing snooping.
- f) **Traffic classification:** rule based packet identification (e.g. voice) and prioritization to improve quality, or block unwanted applications.
- g) **Bandwidth limitation:** both input and output queues control traffic and prevent saturation based on application or location.
- h) **Bandwidth management:** both input and output queues provide packet prioritization and management to prevent packet discard or delay due to congestion; vital for voice and video.
- i) **Wirespeed Routing** - Wirespeed architecture routes every packet individually on all ports. It is often referred to as packet-by-packet Layer 3 switching. Using advanced ASICs to perform Layer 3 routing in hardware, it implements dynamic routing protocols such as OSPF (Open Shortest Path First) and RIP (Routing Information Protocol). In addition to basic IP routing, it supports IP multicast routing, VLAN segregation, and multiple priority levels to assist in quality of service.
- j) **VLAN:** Authenticated users can be automatically placed into a specific virtual LAN (VLAN), restricting access only to the data needed. Secure Shell (SSH) encryption of login passwords, management VLANs, and management station "trusted IP address" lists help protect network from rogue management threats.

V. THROUGHPUT ANALYSIS OF REAL NETWORK ARCHITECTURE

The Throughput of the implemented network architectural design in the H.P. University, Shimla is being analyzed through downloadable tool [8] "CommView", which is a program for monitoring Internet and Local Area Network (LAN) activity capable of capturing and analyzing network packets. Following are the details:

- a) Network throughput [9] is similar in concept to network utilization. The throughput of a network represents the amount of network bandwidth available for a network application at any given moment, across the network links. As network applications use network bandwidth, the amount of bandwidth left over for other applications is decreased. The amount of bandwidth left over is considered the network throughput. Network throughput is defined as number of user information bits transmitted per unit time⁴. Throughput is being used as criterion for performance evaluation [10,11,12].
- b) The experimental data captured on real campus network from Feb 2015 to April 2015, during peak hours, reveals that the average bytes per sec as 574 bytes per sec as depicted in the figure 4. below:

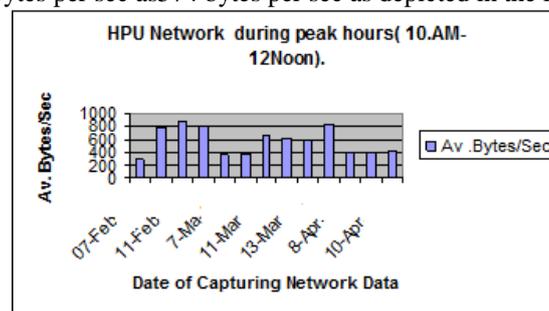


Figure 4. HPU Network Utilisation

- c) As per figure the average bytes per sec are 573 bytes per sec. This is also represented as 0.0043 Mbps. Considering the real network's maximum capacity is 100 Mbps (bottleneck is with Ethernet Cards available in the systems at the user end) and the process of transmission uses 0.0043 Mbps. Therefore, the maximum throughput for the user is 99.9957.
- d) Since maximum throughput for the user is 99.9957, therefore the real network (LAN) is said to have 99.9957% efficiency.
- e) The captured data also reveals that no errors or packets loss within the network.

Therefore it is concluded that the real Network architecture design implemented at H P University, Shimla (India) is reliable, robust and having excellent throughput with 99.9957% efficiency.

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