

# Available Bandwidth Measurement of Campus Wide Optical Fiber Network using Packet Pair Technique: A Study of Himachal Pradesh University

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## ABSTRACT

Information and communication technology (ICT) plays an important role in computer networking and networks are the major component of ICT. Available bandwidth is an important bandwidth metric used today. This paper presents the measurement of available bandwidth of Himachal Pradesh University- Campus Wide Optical Fiber Network (CWOFN) through packet pair technique. The packet pair technique is a most popular active probing technique to measure available bandwidth. This work has been done with the help of IPERF and JPERF that estimates the end-to-end available bandwidth at the bottleneck link of the path. This study also presents the comparison of various bandwidth measurement techniques and tools. Finally, a study of architecture of campus wide optical fiber network has been done to test the major network segments for available bandwidth using MGEN tool which act as traffic generator and Ethereal, a traffic analyser and at last IPERF results are compared to IGMP results in the same network configuration i.e HPU-CWOFN.

## Keywords

Available bandwidth, bandwidth, network measurement, packet pair, probing.

## 1. INTRODUCTION

Information and communication technology (ICT) plays an important role in computer networking. Information and Communication Technology (ICT) is not only a single technology but it is a combination of multiple technologies. ICT is a term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning. There are two main components of ICT: Hardware and Software and Networks are the major component of ICT (Information & Communication Technology) communication [19][21]. A better network performance can be achieved through Quality Of Service (QoS). QoS parameter is the instance to represent the quality of service to customers. It should be easy for customers to understand the degree of assuring the service. QoS parameters can be different according to the type of services [12]. Generic QoS parameters required in network service are: Availability, Delivery, Latency, Bandwidth, MTBF, MTTR. Network Performance monitors and management tools help an administrator optimize a network and maintain its health.

In the context of data networks, the term bandwidth quantifies the data rate that a network link or a network path can

transfer. It also relates to the amount of data that a link or network path can deliver per unit of time. There are three main bandwidth related metrics: Capacity, Available bandwidth, Bulk-Transfer-Capacity (BTC). The first two are defined both for individual links and end-to-end paths, while the BTC is usually defined only for an end-to-end path [2].

There are many available bandwidth estimation tools. Some of them are: Cprobe, Pathload, Pathchirp, IGI, Spruce, IPERF/JPERF and IGMP.

**Cprobe** was the first tool to attempt to measure end-to-end available bandwidth. *Cprobe* measures the dispersion of a train of eight maximum-sized packets. However, the dispersion of long packet trains measures the “dispersion rate”, which is not the same as the end-to-end available bandwidth. In general the dispersion rate depends on all links in the path as well as on the train’s initial rate. In contrast the available bandwidth only depends on the tight link of the path [14].

**Pathload** implements the SLoPS methodology. *Pathload* [10] requires access to both ends of the path, but does not require super user privileges because it only sends UDP packets. *Pathload* reports a range rather than a single estimate. The center of this range is the average available bandwidth during the measurements while the range itself estimates the variation of available bandwidth during the measurements.

More recently, three new tools have been proposed for available bandwidth estimation: **IGI**, **pathChirp** and **spruce**. These tools modify the ‘self-loading’ methodology of TOPP or SLoPS, using different probing packet stream patterns. Spruce is the tool that offers the best performance and we concluded that Spruce is the fastest, the most accurate tool and one of the least intrusive. The main objective in *IGI* [12] and *pathChirp* [17] is to achieve similar accuracy with *pathload* but with shorter measurement latency.

IPERF/ JPERF is a commonly used network testing tool that can create TCP and UDP data streams and measure the throughput of a network that is carrying them. Iperf is a tool for network performance measurement written in C++. Iperf was developed by the Distributed Applications Support Team (DAST) at the National Laboratory for Applied Network Research (NLANR). Iperf allows the user to set various parameters that can be used for testing a network, or alternately for optimizing or tuning a network. Iperf has a client and server functionality, and can measure the throughput between the two ends, either unidirectionally or bi-directionally. It is open source software and runs on various platforms including Linux, Unix and Windows.

Jperf is graphical version of Iperf, a command line based tool used for network performance measurement. Jperf [23] provides us GUI to Iperf functionality. It provides us functionality to test end to end performance of various transport, application and network layer protocols on various parameters. In this paper, Iperf has been used to measure the performance of CWOFN of Himachal Pradesh University. For this experiment, MGEN is used as traffic generator and Ethereal is used as traffic analyser. Also we are using an active measurement tool called IGMPs (Improved gap model using packet size parameter) that estimates the end to end available bandwidth at the bottleneck link of the path. When IGMPs is compared to other tools like IPERF/ JPERF it has been concluded that IGMPs gives the best performance.

The rest of the paper is organized as follows. In section II, the author discuss the previous work related to our study. Section III contains the objectives of our study. In section IV, author introduce the various research methodologies used in our study. Section V shows the performance analysis and results. Conclusion and future work are discussed in Section VI.

## 2. RELATED WORK

Ali *et al.* [1] in his paper developed a new deterministic model of packet pair delays for end-to-end available bandwidth estimation in IP network paths. He investigated the quantitative relationship of IGMPs measurement accuracy to several probing parameters such as the packet size and the number of probing packet pairs and concluded that introducing the packet size parameter in the probe gap model formula improves considerably the accuracy of the measurements.

Calyam *et al.* [13] in his work presented the analysis of the active and passive measurement. The active measurement data has been obtained by using "ActiveMon" software, which they have developed and deployed along the above network backbone paths. The passive measurement data has been obtained using SNMP, Syslog and NetFlow data available at the intermediate routers located at strategic points along the same network backbone paths. They concluded that in academic networks, the utilization levels are lower than 10% as reported by SNMP data. They also showed that these networks generally have 100% availability with negligible or low amounts of router interface-level discards and errors. Finally, using Netflow data, they showed that various kinds of traffic flows in these networks have a predominant amount of TCP traffic and an insignificant amount of IPv6 traffic.

Prasad *et al.* [14] in his paper described the techniques for accurate bandwidth estimation. In this survey he reviewed the recent bandwidth estimation literature focusing on underlying techniques and methodologies as well as open source bandwidth measurement tools.

Velasquez *et al.* [8] in his paper offered a compilation of currently used network benchmarking tools, with the intention of guiding the selection of one tool over others, by outlining their main features, strengths and weaknesses.

Tirumala *et al.* [4] in his paper, described how with an instrumented TCP stack (Web100), we can estimate the end-to-end bandwidth accurately, while consuming significantly less network bandwidth and time. They modified Iperf to use Web100 to detect the end of slow-start and estimated the end-to-end bandwidth by measuring the amount of data sent for a

short period (1 second) after the slow-start, when the TCP throughput is relatively stable.

## 3. Objectives of study

The broad objective of the study is to measure the available bandwidth of the Himachal Pradesh University (Campus Wide Optical Fiber Network) through Packet Pair Technique and to identify the bottleneck in campus wide optical fiber network.

The specific objectives are:

- Study of HPU- CWOFN architecture.
- Identification of major network segments of HPU.
- Testing of major network segments for available bandwidth using "IPERF", "MGEN" and "ETHEREAL".

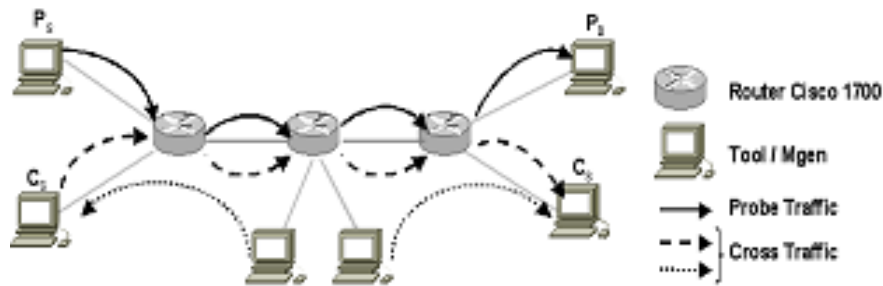
## 4. Research Methodology

The steps involved in achieving the given objectives are as follows:

- For performance evaluation the Campus Wide Network of Himachal Pradesh University has been selected as a site of study.
- A study of CWOFN architecture has been done and the major network segment has been identified.
- Iperf has been selected as a available bandwidth measurement tool.
- Jperf which is a graphical version of Iperf, has been used for network performance measurement. Jperf provides us GUI to Iperf functionality.
- MGEN has been used as a traffic generator, whereas ETHEREAL has been used as a traffic analyzer.
- Available bandwidth has been measured by Jperf tool after sending packets of different size through mgen.
- JPERF results have been compared to IGMPs results.

## 5. Performance Evaluation

This section shows measurement results. For that purpose, author ran several experiments on an isolated testbed configuration using IPERF to measure available bandwidth of the network path. The topology is shown in Figure 1. [1] In this figure, Ps and Pd are the probing source and destination. This configuration consists of three Cisco 1700 series routers. The capacity of the bottleneck is 100 Mb/s and all of the links from the end-hosts to the routers have a 100 Mb/s bandwidth. IPERF is installed on both the sender and the receiver parts. The sender part is set up on Ps and the receiver part is set up on Pd. Cs and Cd are used to generate cross traffic using an MGEN traffic generator. The traffic analyzer Ethereal is installed both on tool and traffic generator receiver parts. The results presented here are collected using IPERF/JPERF to measure the available bandwidth along the path.

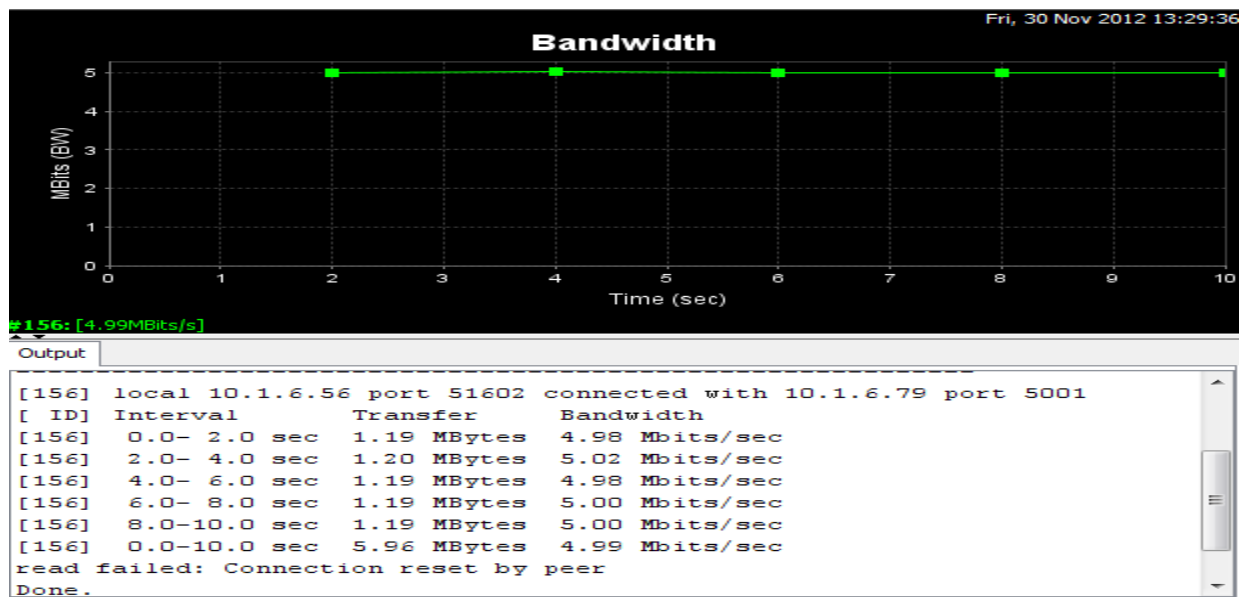


**Fig 1: Available Bandwidth Measurement Testbed.**

To evaluate the accuracy and performances of active probing tool, we use MGEN traffic generator to create constant cross traffic. By varying this rate, it is possible to have a wide range of available bandwidth values. Varying the cross traffic rate from 0 to 100 Mb/s in a 100 Mb/s path will make the available bandwidth vary from 100 to 0 Mb/s.

The measurement results obtained with JPERF are presented in figure 2.

It shows the JPERF measurement results in 100 Mb/s path when UDP bandwidth is 5 Mb/s.



**Fig 2: JPERF measurement results in 100 Mb/s path when UDP bandwidth is 5 Mb/s**

According to this diagram when UDP bandwidth is 5 Mb/s then the amount of data transfer is 5.96 Mbytes in 10 seconds.

From this collected data we concluded that available bandwidth in 100 Mb/s path is 0.97 Mb/s.

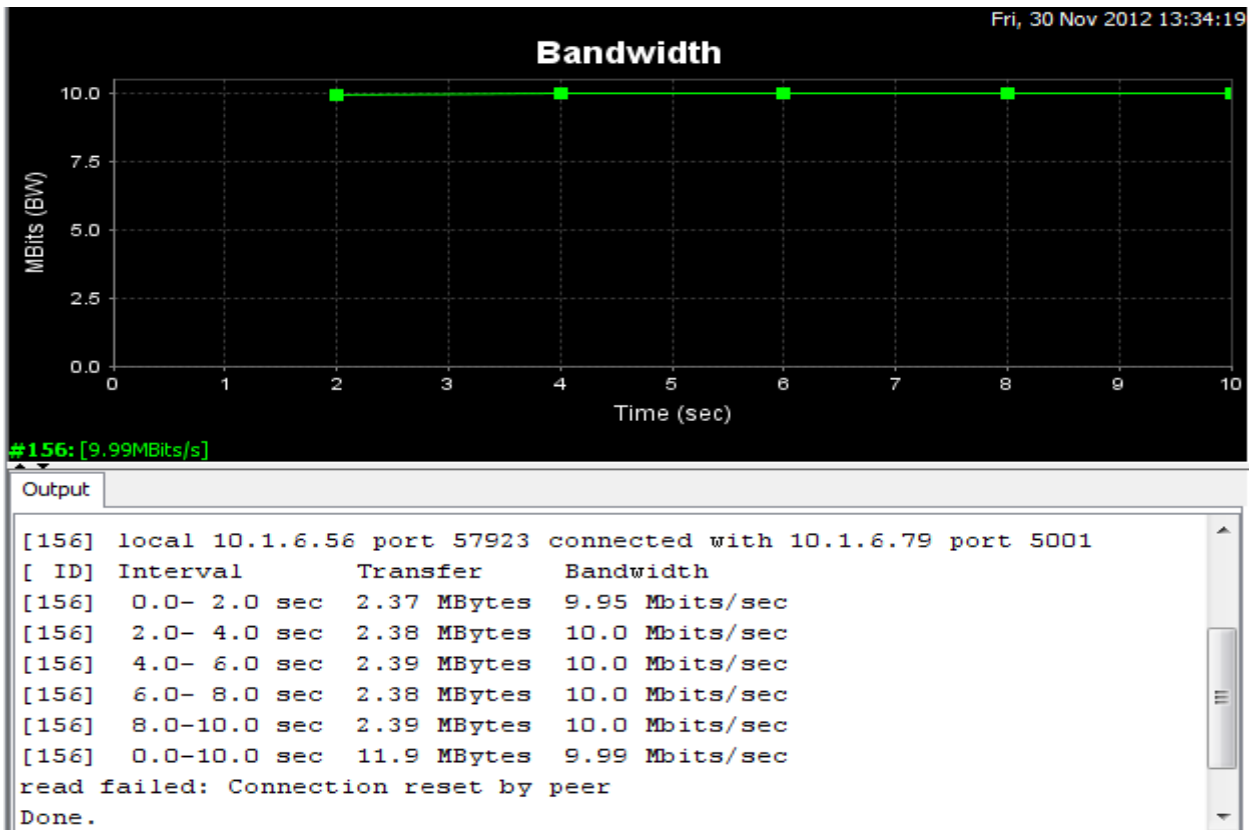


Fig 3: JPERF measurement results in 100 Mb/s path when UDP bandwidth is 10 Mb/s

This diagram shows that when UDP Bandwidth is 10 Mb/s then the amount of data transfer is 11.9 Mbytes in 10 seconds. From this collected data it has been concluded that available bandwidth in 100 Mb/s path is 1.91 Mb/s.

This study concluded that available bandwidth increases with the increase in UDP bandwidth.

#### Comparison of JPERF with IGMPs

To compare the performance of IGMPs with JPERF experiments are carried out in the same network configuration shown in fig. 1. Compared to IGMPs, JPERF is less accurate and according to given figure IGMPs gives the best performance.

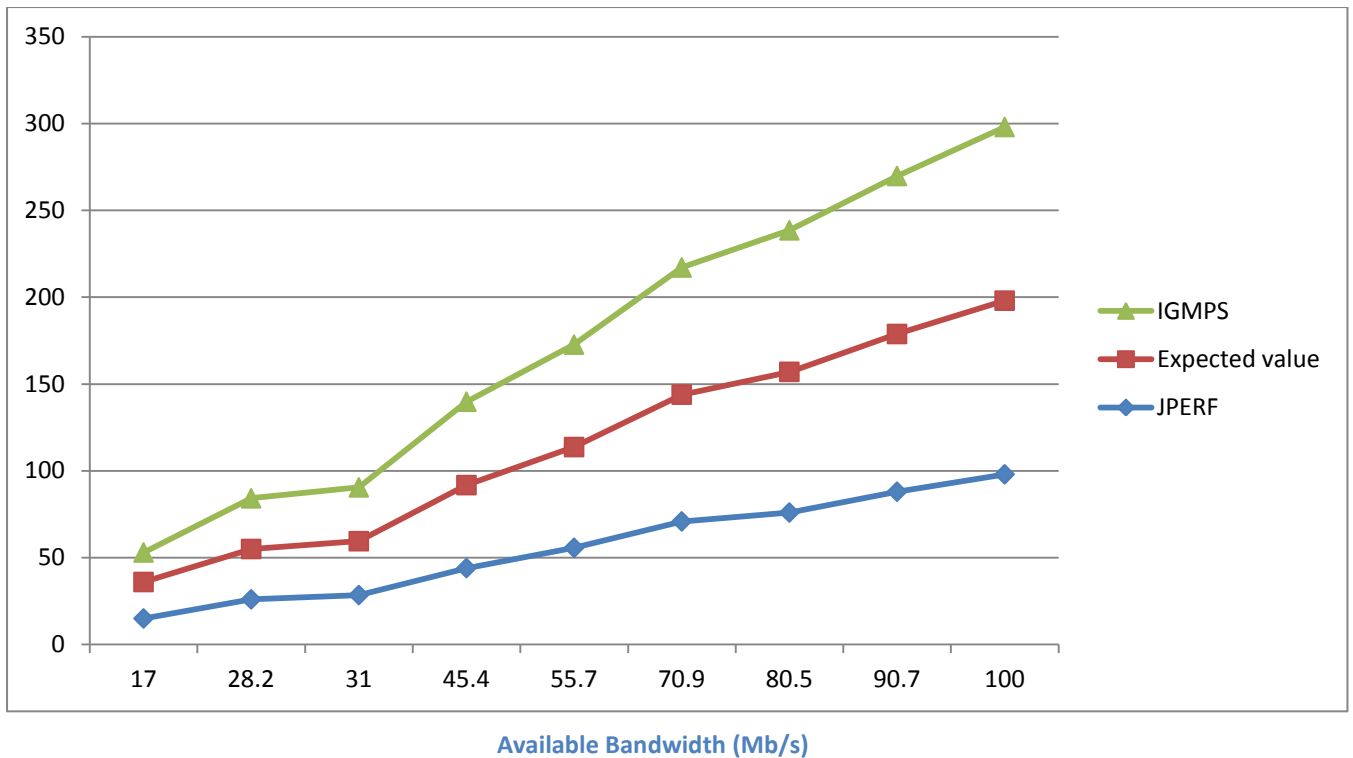


Fig 4: Comparison of IGMP and JPERF in 100 Mb/s path

## 6. CONCLUSION AND FUTURE SCOPE

Through this study authors came to know about network measurement techniques and various available bandwidth measurement tools like cprobe, pathload, pathchirp, IGI, spruce, IPERF and IGMP. IGMP is a new deterministic model of packet pair delays for end-to-end available bandwidth estimation in IP network paths and introducing the packet size parameter in the probe gap model formula improves considerably the accuracy of the measurements.

This study concluded that IGMP is the tool which gives the best performance. In comparison to JPERF, IGMP is very accurate.

The study presented here was focused on a small number of criteria i.e bandwidth which seemed to be the most important.

However, this study must be completed by considering other parameters like delay, jitter etc. and by evaluating these tools on other network settings.

Finally, this study aims to provide reliable, redundant and useful services on campus wide optical fiber network (CWOFN) by measuring the available bandwidth of the network.

## 7. ACKNOWLEDGMENTS

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