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Speed Testing for measuring Network Traffic in a Smart Network Switch

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***Abstract*—This work addresses the lack of a comprehensive framework for comparing and evaluating networking algorithms designed for throughput and congestion optimization. Using a network setup in Mininet with smart switches, traffic generator, and bottleneck network, it employs iPerf TCP for measuring TCP flows and OB-UDPST for UDP flows. The simulations cover various network parameters like link latency, capacities, and queue management techniques, facilitating a thorough comparison of different techniques in mixed flow environments. The framework serves as a validation platform for network traffic optimization algorithms, allowing researchers to assess algorithm performance uniformly across diverse network parameters, ultimately advancing the field of network optimization.**

***Keywords*—Smart Switch, iPerf, OB-UDPST, Speed Testing, TCP, UDP**

I. INTRODUCTION

Advancements in wired and wireless technologies aim to enhance communication speed and minimize packet losses in diverse networks. With the growing importance of congestion control in high-latency areas, researchers are actively optimizing algorithms to address delay, congestion, and packet loss. This paper presents a comparative analysis of two Speedtest technologies: iPerf TCP, commonly used for Smart Switches, and OB-UDPST, a novel methodology proposed by the Open Broadband Forum that utilizes UDP flows. The comparative analysis sheds light on their performance under various conditions.

The choice to compare iPerf and Open Broadband-UDP Speed Test (OB-UDPST) is justified by their industry prevalence, representation of different transport layer protocols, and suitability for diverse network contexts. Speedtesting is crucial for assessing network performance, traditionally occurring over TCP. However, our work delves into the alternative OB-UDPST technology, exploring its effectiveness in different network environments. Addressing challenges with existing capacity measurement methods, we aim to guide researchers and practitioners in selecting appropriate technologies. The findings contribute valuable insights into the strengths and limitations of iPerf TCP and OB-UDPST [1]–[4].

Service providers, facing pressure to ensure high-quality broadband services, struggle with challenging capacity measurement methods [5]. Accuracy issues persist in testing internet connections, impacted by factors like slow Wi-Fi and local congestion [6]. Proposed schemes for network traffic optimization often struggle with hybrid flows, necessitating ongoing efforts to develop improved testing approaches.

iPerf, measuring TCP and UDP throughput, has limitations, particularly for ECMP testing [9]. OB-UDPST, an alternative utility, employs adaptive transmission rates and UDP datagrams for network capacity measurements [10]–[13]. The paper is structured as follows: Section II provides background information, Section III presents the System Model, Section IV discusses chosen network parameters, Section V outlines findings and results, and Section VI concludes.

II. BACKGROUND

Government initiatives, such as the FCC's 'Measuring Broadband America,' evaluate ISPs but grapple with outdated technology, leading to unreliable data [14]. Traditional speed tests encounter challenges in representing diverse bottlenecks, necessitating a reassessment of tools to adapt to evolving user behaviors and technology changes. These limitations include shifting bottlenecks, user-related factors, varied client hardware and software, competing cross-traffic, wide-area network considerations, test infrastructure issues, and test design variables, impacting accuracy and reliability.

Client-based speed tests, like Ookla's Speedtest and Measurement Lab's NDT, play a crucial role for consumers, regulators, and ISPs [15]. Recent comparative studies underscored differences, particularly in high-latency networks, underscoring the importance of understanding variations.

Crowdsourced throughput measurements pose challenges in inferring congestion [16]. Accurately identifying congested links, limited path visibility, and inherent sample bias demand fine-grained network tomography and improved measurement infrastructure.

A study on mobile speed test applications in Bangkok revealed significant QoS parameter differences [17]. Diverse application testing is essential for fairness and reliability.

Public domain Internet measurements evaluate broadband infrastructure, empowering consumers and achieving universal service objectives [18]. Despite potential shortcomings, they offer valuable insights. Large-scale crowdsourced open data network testing platforms contribute to broadband infrastructure policy coordination and user experience.

In the context of the global landscape, where mobile networks dominate Internet access [19], measuring end-to-end mobile network performance becomes crucial. A survey on mobile network performance measurement guides future work in this area.

Bringing Nepal into the discussion serves to highlight a unique case despite widespread broadband penetration [20].

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Preliminary investigations using host-based speed tests reveal challenges, emphasizing the need for enhanced internet experiences through rich peering and local infrastructure investment.

While speed testing services and national monitoring programs globally lack thorough study and documentation [21], this paper uniquely sheds light on how test conditions impact results and challenges the reliability of national programs. It urges a reevaluation of the emphasis on speed testing, emphasizing the broader implications of these assessments.

Referencing a study on mobile speed test applications in Bangkok, which emphasizes significant differences [22], underlines the importance of statistical analyses and suggests averaging QoS results from at least three applications for fairness and reliability.

III. System Model

The test employs a simple dumbbell topology with two source/sink pairs connected by a shared bottleneck link, as illustrated in Fig. 1. One pair runs the speed test, while the other introduces cross-traffic on the link. The setup utilizes a virtual testbed network (Mininet) with tools for automation, data handling, and analysis [23]. It facilitates easy development and experimentation with Software-Defined Networking (SDN) systems, compatible with OpenFlow and P4. The Linux VM used Ubuntu 18.04.05 LTS with Kernel Version 4.15.0-112-generic, iPerf 2.0.10, and OB-UDPST 7.2.0. Test scenarios include variations in link speed, latency, and cross-traffic for iPerf vs. OB-UDPST analysis.

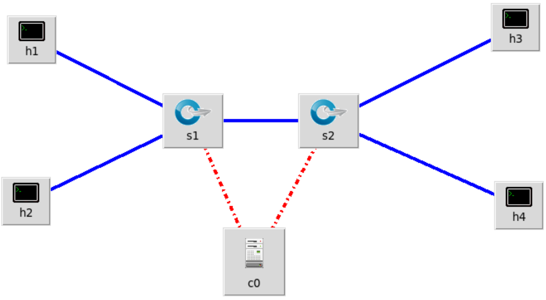

Fig. 1: System Model

IV. Bottleneck Parameters

We examined crucial bottleneck parameters – bandwidth, latency, packet loss, and queue management – vital for link congestion determination and traffic control. Bandwidth, the communication capacity, can be limited for less critical packets through traffic shaping, reducing delays or drops for important packets. Latency, the time for data to reach its destination, and packet loss, often due to network congestion, impact connection speed and quality. Queue Management, prioritizing packet order on an interface, ensures quality of service.

These parameters are essential for congestion control, traffic management, and speed testing. Testing at various bandwidths (10, 20, 50, 100, 200, 500 Mbps) and latencies (5, 10, 20, 50, 100 ms), we considered packet loss scenarios beyond the typical range (10-20 ms), accommodating values both at upper and lower extremes. Rate shaping methodologies (DropTail FIFO, pie, fq_codel) impact network performance differently [24]–[26].

Introducing cross traffic as a bottleneck, we assessed its impact on running Speedtests and vice versa. Various cross traffic scenarios were examined, mimicking real-world conditions, from no cross traffic to multiple file transfer workloads. Speedtests, competing with parallel user activities like video downloads or streaming, demonstrated varying effects in different scenarios. These findings provide insights into the complexities of network congestion and its interaction with speed testing methodologies.

V. Analysis & Findings

A. *Time Series Plots Analysis*

We compared iPerf and OB-UDPST in multiple cross traffic scenarios to assess their speed measurement. iPerf consistently achieved stability faster than OB-UDPST, which exhibited a slower ramp-up phase. In the absence of cross traffic, iPerf reached stability quickly, maintaining low jitter across various queue management types. Conversely, OB-UDPST had a slower ramp-up but achieved a steady state, demonstrating more stability.

In cross traffic scenarios where iPerf started before or after, iPerf's stability outpaced OB-UDPST. Cross traffic introduced significant jitter, with earlier scenarios exhibiting more jitter than later ones. iPerf had more jitter with the "pie" case before and after, while OB-UDPST had more jitter with the "fq_codel" case. Overall, OB-UDPST demonstrated greater stability with less jitter.

Figures 4, 5, 6, 7 illustrate these trends. Similar trends were observed with other queuing models like tc pie and fq codel.

In the burst file transfer cross traffic scenario, OB-UDPST showed more stability across various queue management types. Distortions and unstable bandwidth were more prominent with lower bandwidths. OB-UDPST exhibited stability to jitter and outperformed iPerf in various cross traffic scenarios, where iPerf achieved high speeds and stability faster.

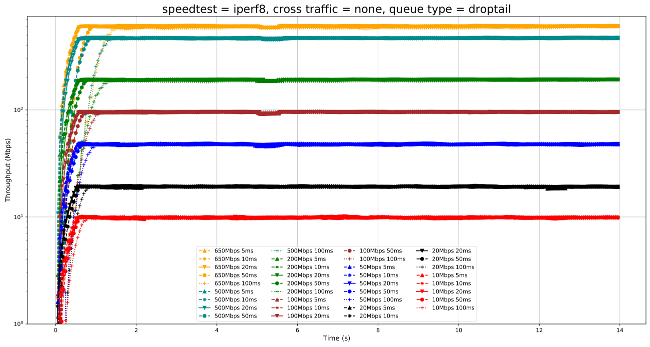

Fig. 2: iPerf implementing droptail queue management with no cross traffic

B. *Stability vs Accuracy*

We compared OB-UDPST and iPerf in terms of stability and accuracy. While both demonstrate comparable prediction accuracy (Fig. 8), OB-UDPST exhibits significantly greater stability (Fig. 9) and lower standard deviation (3% vs. 8%, Fig. 10). Stability assessment focuses on the last 5 seconds to capture equilibrium after the initial ramp-up phase, where Speedtest and cross traffic initially compete, causing

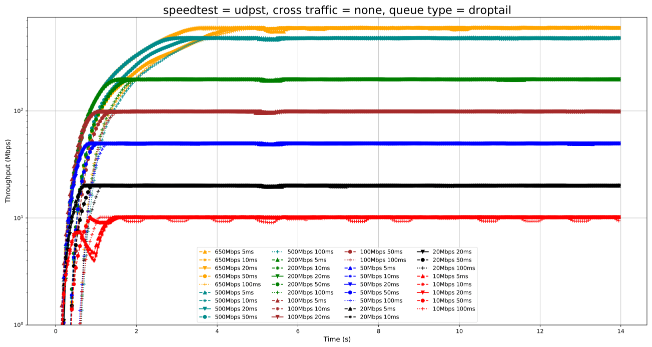

Fig. 3: OB-UDPST implementing droptail queue management with no cross traffic

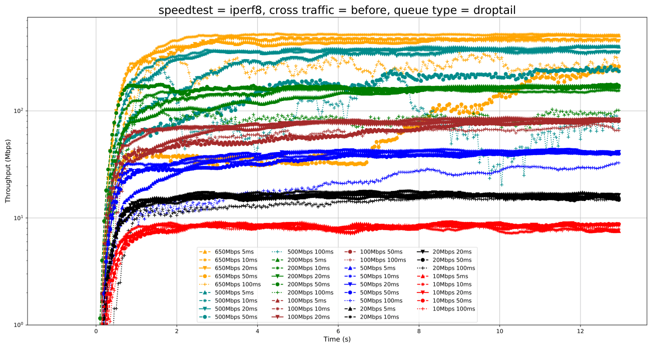

Fig. 4: iPerf implementing droptail queue management with cross traffic starting before Speedtest

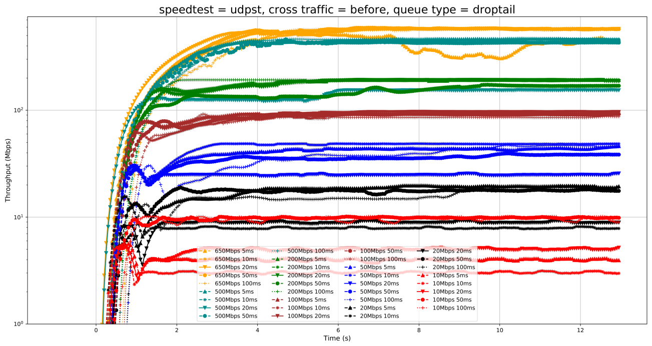

Fig. 5: OB-UDPST implementing droptail queue management with cross traffic starting before Speedtest

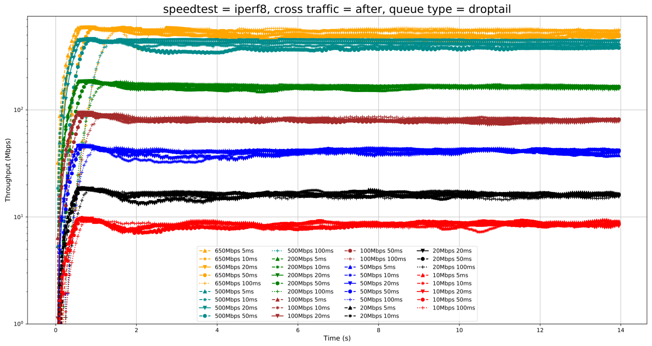

Fig. 6: iPerf implementing droptail queue management with cross traffic starting after Speedtest

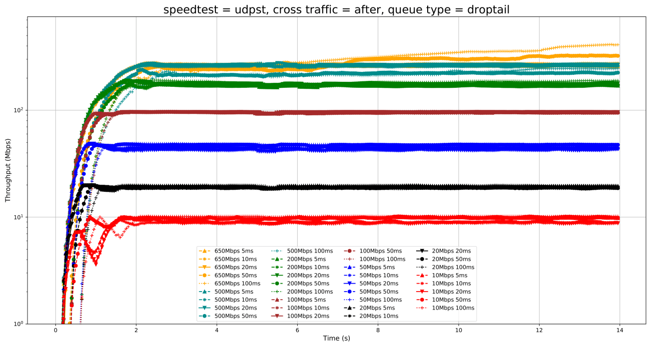

Fig. 7: OB-UDPST implementing droptail queue management with cross traffic starting after Speedtest

instability. It's noteworthy that OB-UDPST's performance diminishes for higher bandwidths, likely due to its algorithmic calculations or limitations in the Mininet emulation environment.

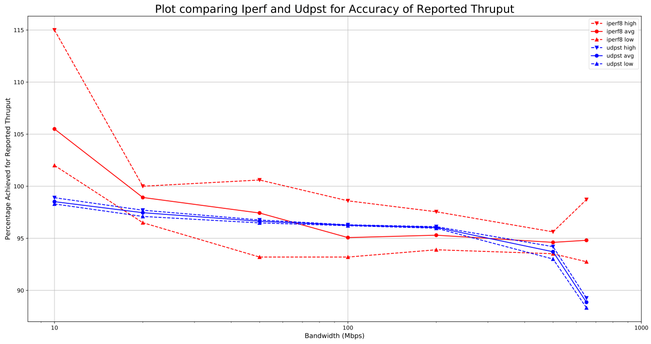

Fig. 8: Plot comparing iPerf and OB-UDPST for accuracy of reported throughput

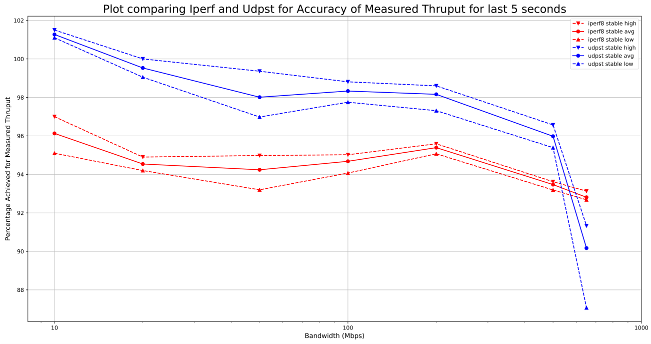

Fig. 9: Plot comparing iPerf and OB-UDPST for accuracy of measured throughput for the last 5 seconds

C. *Impact on Cross Traffic*

In the next part of our analysis, we compared how cross traffic was affected by the Speedtest. From the table below we can easily conclude that iPerf didn't impact cross traffic that much as OB-UDPST. This can be seen from fig. 11 & 12 where cross traffic was able to reach higher values of throughput and have better stability for OB-UDPST as compared to iPerf. Thus, cross traffic took a heavy beating when it came to OB-UDPST. It can be easily inferred that the speed tests affected cross traffic and vice versa and had negative impacts on both sides. This trend is not specific to iPerf or OB-UDPST, but expected [27]–[30].

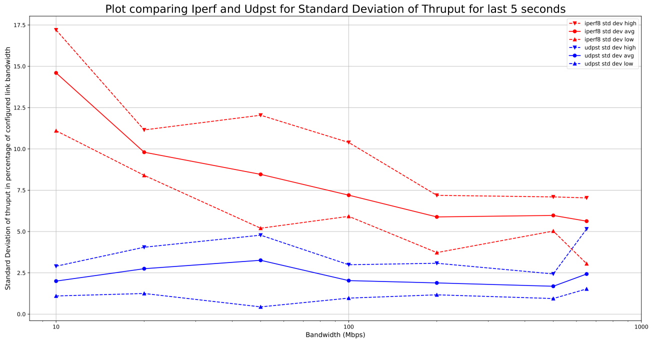

Fig. 10: Plot comparing iPerf and OB-UDPST for standard deviation of throughput for the last 5 seconds

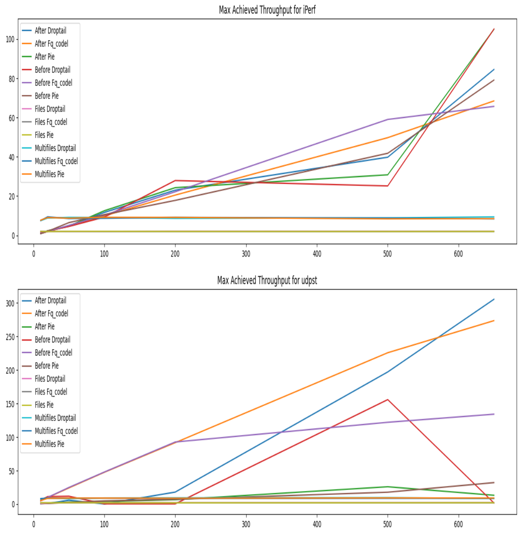

Fig. 11: Plot comparing maximum reported throughput

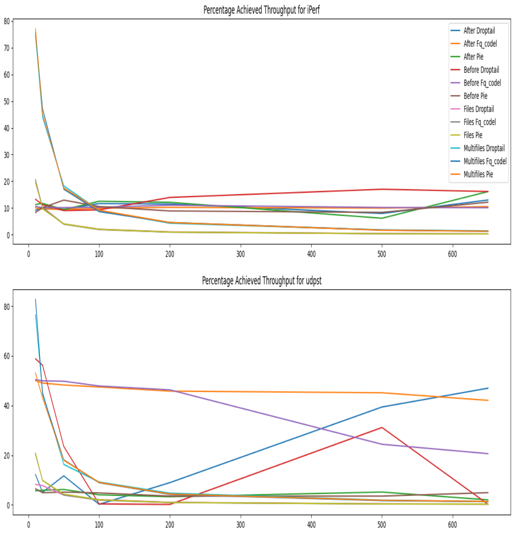

Fig. 12: Plot comparing percentage achieved for reported throughput

D. Network Overhead

We also analyzed network overhead for both iPerf and OB-UDPST. We measure the overhead as a percentage of the original throughput (in terms of bytes of data). Fig. 13 shows the analysis which depicts that OB-UDPST reduces the network overhead almost about 3 times in majority of the cases as compared to TCP based iPerf.

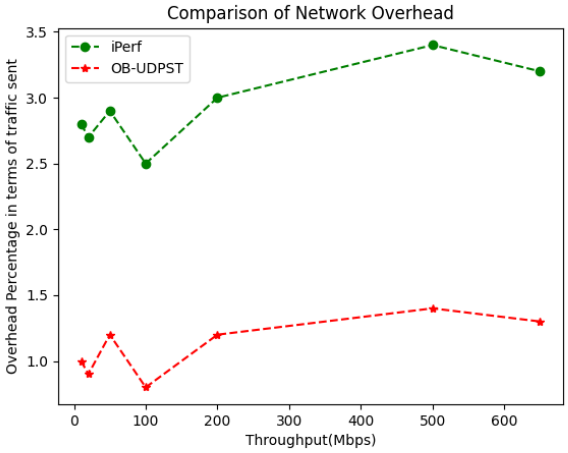

Fig. 13: Plot Comparing Network Overhead

E. Setup Time & Latency

UDPST exhibits minimal setup time, enabling rapid stability attainment compared to iPerf. It proves valuable in quantifying and validating broadband networks, particularly in scenarios prioritizing low latency over speed. This is crucial for deploying gigabit services supporting latency-sensitive applications like gaming, UHD streaming, augmented reality, and virtual reality. With its focus on UDP, UDPST assures consumers of reliable support for time-sensitive Internet transmissions. Its low-latency measurements align with industry interests, catering to applications with stringent response time requirements. The rising prevalence of UDP traffic, including the QUIC transport protocol, underscores the significance of UDP-based methods in addressing evolving network demands [31].

VI. CONCLUSION

Our goal was to assess whether OB-UDPST, utilizing UDP for Speedtesting, could serve as an alternative to the TCP-based iPerf 8 cubic method. The project encompassed diverse test scenarios, bottleneck conditions, and congestion management techniques. Stability, defined as a network's equilibrium with no delays, jitter, or path losses, revealed iPerf's faster achievement of stability compared to OB-UDPST. While both tests exhibited comparable accuracy, OB-UDPST demonstrated greater stability, particularly in bottleneck conditions, suggesting its potential in environments with competing traffic. Although not a direct replacement for iPerf in standard cases, OB-UDPST's enhanced stability, especially in low-latency scenarios crucial for applications like gaming and streaming, positions it favorably. Future research will delve into OB-UDPST's performance in higher bandwidths, exploring its potential as a replacement for iPerf. Real traffic scenarios, server tests outside the Mininet Emulation environment, and evaluations with multiple hops and crowding points will contribute to a more comprehensive understanding. Future considerations encompass throughput, efficiency metrics (data throughput, Bit Error Rate), response time metrics (Round-Trip Time, Time to First Byte), reliability metrics (consistency, failure rate), adaptability to network changes, scalability, and user experience metrics (perceived speed, ease of use).

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