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Probing Packets Efficiency and Effectiveness on Network Performance and Measurements

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Abstract. Quality of Service (QoS) has become more widely recognized as an important issue since network applications with real-time requirements have started to spread on a larger scale. Measuring QoS in the internet today is difficult as notions of what constitutes QoS vary. Additionally, service Level Agreements (SLA) between customers and network service providers are often poorly defined. Therefore, all the information needed to infer the network performance must be monitored in order to extract the network QoS parameters: latency, jitter, packet loss and throughput. This paper presents a direct estimation of active one-way delay, throughput, and losses measurements precision compared to the actual user measurements. This evaluation allows us to objectively evaluate the network applications performance for delivering user acceptable quality.

Keywords: Active measurements, monitoring, Quality of Service, Biasness, Network performance.

1. Introduction

Measurements, monitoring and estimation of IP networks performance and Quality of Service (QoS) are becoming imperative for today's network operators, service providers, network diagnosis, etc... Additionally, measuring QoS parameters such as the delay and loss for network is also important since these are used as key parameters in service level agreements (SLAs) between an Internet service provider (ISP) and its customers. Therefore, these information are very crucial for controlling, managing, and provisioning the network. Any monitoring system must support a daily operation, traffic control and planning of an operator's network with relevant and timely measurements and estimates [2].

Many tools have been developed to measure network performance or QoS like [3], [4], and [5]. Generally, Monitoring and measurement network performance/QoS schemes usually fall into two categories: passive and active methods. The idea behind passive techniques is to capture packets in order to store and collect information from various fields of the packet header within a flow of application packets. Passive measurement is mainly used to monitor and track the volume and the behaviour of traffic flow but can be used to measure the per-flow QoS as well because it allows the properties of carried traffic to be observed [1], [5]. Moreover, it is a traditional technique used to obtain measurements of QoS parameters related to a certain network element [6], [7], [8] and [9]. This is based on monitoring the performance of packet streams through a network (element) by tracking the traffic passing by a measurement point without creating or perturbing it. These measurements can be done by collecting traffic flow data, from routers, switches or end-point hosts or by adding a stand-alone server at the location of interest (e.g., core or edge) of the network, which acts as a traffic meter or a monitoring device for the crossing traffic. This can be done using either two-point monitoring or one-point monitoring [10].

On the other hand, active measurement measures network performance and/or QoS by injecting probe packets into a network path and monitoring them [11], [12], [13]. Active measurement method is a very

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popular mean for estimation of the network performance and it becoming increasingly important due to its great flexibility, ability to achieve end-to-end measurements, and freedom from the need of accessing the core of network. In this method, QoS and the performance of a network are measured by inserting of some artificial probing packet streams into the network and monitoring them from a source to a destination. Active measurements can determine the QoS experienced by the probe flow for a particular path and then measure the QoS as it is seen by applications. The purpose of these probing packets is to provide some insight into the way the user traffic is treated within the network. The QoS and performance of the probe-packet stream are monitored to infer the performance of the user's packets and the network directly. There are several tools which are based on active methods like, the Internet Control Message Protocol (ICMP) Echo Reply/Request messages (ping) which is defined in RFC 729 [14], traceroute [15], Service Monitoring Management Information Base (SMMIB) [16], Cisco Internet Performance Monitor (IPM) [17], [18], The Active Measurement Program (AMP) [19], and [20] .

For every measurement based on probing experiment, the sender generates and transmits a probe stream, which traverses some route in the network and terminates at the receiver (the sink). Together with the probe sequence numbers available from the payloads, the packet arrival and departure timestamps are recorded. They are recorded by the sender monitor and the receiver monitor, respectively. By selecting particular properties at the sender (like packet size, departure time, bit rate, etc.), it is potential to compute metrics by analyzing the probe flow characteristics (e.g. arrival time) at the destination so, one can determine end-to-end metrics (from the source to the destination) [23]. Examples of measured metrics that can be derived from the active measurement methods are: connectivity, delay, delay variation (jitter), packet losses, link bandwidth (capacity), bottleneck bandwidth, and available bandwidth.

It is implicitly assumed that the QoS and performance of the user/network are the same as the values measured (obtained) from the active probe packets. Sometimes, the measurements of the probing packets do not accurately represent and estimate the performance experienced by the actual traffic [5]. This accuracy depends on the specifications of both the probe traffic and the actual user traffic. Therefore, in order to produce accurate results, the active probe traffic pattern must have the same pattern of the user traffic pattern being measured [23]. The accuracy of the measurements depends on many factors: packet size of the probe packet, generation rate (i.e. number of injected probe packets), and its packet type. Excessive probe packets generation produce a significant load which can disturb the operation of the network. On the other hand, low probing rates can not reveal the performance accurately [5]. So, underestimation or overestimation of the user performance and application QoS will occur if probe packet properties are very different than the user packet properties under estimation. Therefore, the active monitoring schemes may suffer from the following problems [24]:

- If a probe packet stream is used to simulate an actual user traffic:
  - The probe packet incurs non-negligible extra traffic into the network and it affects QoS and the performance of user's traffic, and
  - The QoS and performance obtained from the probe packets will not be equal to the unbiased one i.e. the results obtained without the presence of the probe packet stream.
- If probe packets of small length have been used and sent periodically, the extra traffic may be negligible, but the QoS and performance results obtained from the probe packets are not exactly equal to the QoS and performance experienced by the user.

In [2], monitoring and estimating the performance of the user traffic parameters has been done based on using Operation, Administration, and Maintenance (OAM) packets. The basic idea is to use these OAM probe packets in conjunction of the user traffic to infer the network performance. OAM packets are inserted between blocks of the user packets (e.g. one OAM packet for every N user packets).

In some cases, it is very hard to specify a probe packet pattern, which will represent the user traffic being measured without degrading its performance. In this paper, the throughput, delay and losses QoS parameters of the user traffic will be estimated based on injecting the network with 1, 5, 10, 20% probe packets of the user traffic. In addition to that, sensitivity calculations will be presented to measure the degree of influence of the intensity of probe packets inserted to the network on the user traffic performance.

2. Active Measurements Precision Evaluation

Active measurement methodology provides efficient tools to infer the network QoS/performance. On the other hand, it perturbs the actual traffic running over the network. Therefore, it is important to glimpse to