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Estimating Available Bandwidth using End-To-End Delay Increase Rate

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Abstract: *For real-time services such as voice over internet protocol, video conferencing and peer-to-peer streaming, end-to-end bandwidth estimation is very essential. Several available techniques for estimating bandwidth have been suggested such as Magictrain, IGI / PTR, pathChirp, Yaz and ASSOLO. However, in terms of the accuracy of available bandwidth estimation and/or network load efficiency, these techniques have disadvantages. In this article, we present an available technique of estimating bandwidth consisting of two features to provide high accuracy estimation and low efficiency of network load. One feature is the accessible bandwidth assessment feature that uses the end-to-end delay increase rate to directly calculate the available bandwidth. The other feature is the rate adjustment algorithm which adjusts the mistake calculated using the available bandwidth assessment feature between the real accessible bandwidth and the accessible bandwidth. The suggested method's rate adjustment algorithm is based on Magictrain's because Magictrain offers high precision in estimating accessible bandwidth. Finally, in terms of estimation precision and network load efficiency, we compare the suggested technique with Magictrain using computer simulation and show the effectiveness of the suggested technique.*

Keywords: *Available bandwidth, queuing delay, rate adjustment, probe rate model.*

I. INTRODUCTION

The fast development of broadband networks and improved efficiency of desktop personal computers (PCs) as well as tablet PCs in latest years has resulted to the widespread use of real-time facilities such as voice over internet protocol (VoIP) and video conferencing in addition to web and email services. Network carriers should know the efficiency of their networks and provide high communication quality to end-users in order to provide these services satisfactorily to end-users. The Internet, however, consists of distributed autonomous systems that manage different parts of the network as a whole.

In addition to providing network operators with helpful data on network features and efficiency, active bandwidth measurement instruments can also allow end users (and user apps) to conduct independent network audit, load balancing, and server selection tasks, among many others, without requiring access to network components or administrative resources. There are two primary phases recognized in these instruments: measurement and estimation. Measurement includes creating a pattern for a probe packet, transmitting it through the network, and receiving and measuring it.

According to some network model, estimation includes statistical and heuristic handling of measurements. What we call probe packet generation system is a significant element; it depends on both measurement and estimation phases. Isolating this feature as a element makes it possible to efficiently implement instruments for a set of measuring methods, as equipment for generating prevalent traffic patterns can be reused. The element of probe packet generation should provide generic facilities such as packet train generation, which can presently be found implemented in most packet train-based instruments as features or techniques.

Thus, knowing the general network's end-to-end network performance is a significant problem. Estimation techniques for end-to-end network performance were suggested to fix this issue. In addition, the writers outlined the significance of accessible peer-to-peer (P2P) or video streaming services bandwidth assessment in[1]. Therefore, in this research, we concentrate on accessible estimation of bandwidth. Available techniques for estimating bandwidth have been suggested such as Path load[4], IGI / PTR[3], pathChirp[2], Yaz[5], and ASSOLO[6]. In order to estimate accessible bandwidth, these techniques require introducing probe traffic into the network.

In order to estimate accessible bandwidth, these techniques require introducing probe traffic into the network. Pathload and IGI / PTR boost network load as these techniques use a heuristic search procedure to assess the accessible bandwidth based on the highest original sending frequency. PathChirp, on the other hand, does not boost the network load as it estimates the accessible bandwidth based on the original minimum transmitting speed.

In this article, we present a technique of estimating bandwidth available to provide high accuracy estimation and low efficiency of network load. The technique suggested consists of two features. One feature is the available bandwidth assessment feature that uses the end-to-end delay increase rate to directly calculate the available bandwidth. Hereafter, the available bandwidth was calculated as the main accessible bandwidth by the available bandwidth assessment feature. The other feature is the algorithm for rate adjustment, which decreases the network load needed to estimate the accessible bandwidth. The algorithm for rate adjustment adjusts the error between the real bandwidth available and the main bandwidth available.

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II. INTRODUCTION

In prior literature, several available techniques for estimating bandwidth were suggested. These techniques were intended to estimate the bandwidth accessible for the same purpose but were based on distinct principles. We present the significant techniques suggested in prior literature in this chapter. Using the probe rate model (PRM)[7], Magictrain [8] is based on self-loading regular streams. It also utilizes constant bit rate streams and changes the sending rate on the basis of a binary search during each round. PRM-based methods send probe traffic at various prices.

If the probe traffic sending frequency is greater than the available bandwidth, the probes will be obtained at a reduced speed. The bandwidth available is the highest rate at which the rate of transmitting matches the rate of receiving. Yaz is an overhead minimizing calibrated variant of Magictrain. The suggested method's rate adjustment algorithm is based on Magictrain, and Magictrain details are further explained.

The probe gap model (PGM) is used by IGI / PTR[3]. PGM-based methods send back-to-back test traffic and estimate accessible bandwidth based on the dispersion observed at the node of the receiver. They need a priori knowledge of the bottleneck link's ability.

PathChirp decreases the overhead traffic of the probe compared to Magictrain by sending a packet train with exponentially reducing inter packet spacing that samples a wide variety of rates. The basic idea of pathChirp is that if the sending rate is lower than the available bandwidth, a test packet's queuing delay will be zero, and if the sending rate is higher than the available bandwidth, the packet will experience a queuing delay. ASSOLO is another technique based on the above principle, but it has a distinct traffic sampling profile and utilizes a filter to enhance precision and stability.

In[8], the writers contrasted the outcomes achieved for both a steady bit rate (CBR) and Poissonian cross traffic with several instruments on a true test bed. The authors evaluated for the different tools the accuracy, intrusiveness and convergence time. The authors showed that the highest accuracy was provided by Magictrain and Yaz.

In[9], a test bed equipped with a suitable measuring station was used to compare IGI / PTR, pathChirp and Magictrain, and in[9] the results of Magictrain, pathChirp, Spruce[3], IGI / PTR and C probe was assessed using computer simulation under multiple network circumstances.

As mentioned above, in many past research, Magictrain, IGI / PTR and pathChirp were assessed under different circumstances. The suggested techniques rate adjustment algorithm is based on Magictrain because Magictrain is one of the methods that offers a high accuracy estimate and has been assessed in many past researches. In the suggested technique, Magictrain's speed adjustment algorithm is improved to adjust the mistake between the real bandwidth available and the accessible bandwidth calculated using the bandwidth assessment feature available.

III. PROPOSED METHOD

In this, we first define the suggested method's fundamental policy. We then describe the process flow of the proposed method and the bandwidth estimation function available to calculate the primary bandwidth available. Finally, we define the algorithm for rate adjustment to search within a tiny search range for the accessible bandwidth.

A. Basic Policy

The available bandwidth can be correctly estimated if the number of relay nodes, the available bandwidth of the relay nodes and the connection power between the relay nodes are provided. However, obtaining this data at the sender and receiver nodes is hard because the application layer provides overall accessible techniques for estimating bandwidth such as Magictrain, IGI / PTR and path Chirp. We set the transmitting frequency of a fleet (R(0)) as the connection capability of the bottleneck link in the first phase of the suggested technique and evaluate the end-to-end delay increase rate between the sender and receiver nodes. The measured end-to-end delay increase rate is then applied to the accessible bandwidth assessment feature, which can be used to calculate the available bandwidth directly.

B. Quality Available bandwidth estimation formula

We first calculate the maximum and minimum end-to-end delay increase rate in this section on the condition that all connection capacities are the same on a route. The case in which the maximum end-to-end delay increase rate is achieved is shown in Fig.1 when the available bandwidth is A, and the case in which the minimum end-to-end delay increase rate is achieved is shown in Fig.1.

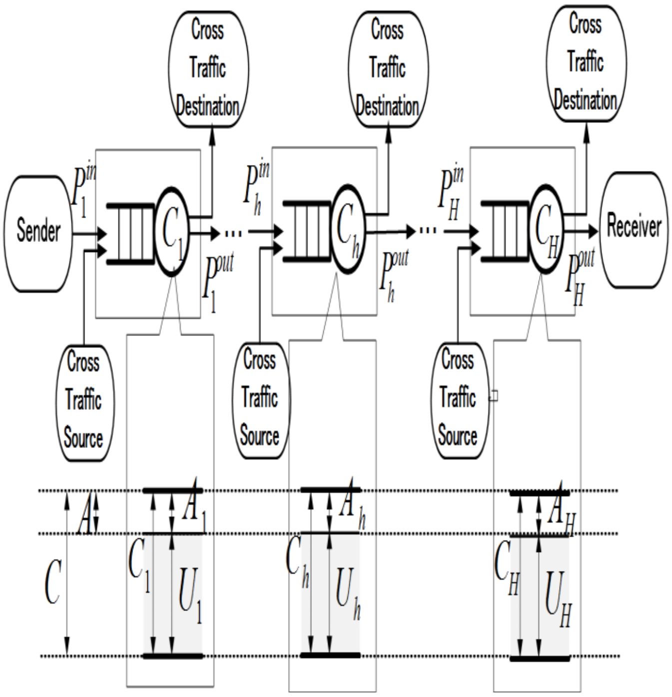

Fig.1: Case in which maximum and minimum end-to-end delay increase rate is achieved.

C. Rate adjustment algorithm of the proposed method

The steps involved in this algorithm are stated below.

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if $(R(n) < A)$ **then**
/* If the current sending rate $R(n)$ is less than the available bandwidth A, $R^{min} \leftarrow R(n)$ */
$R^{min} = R(n)$;
if $(R^{max} == 0)$ **then**
/* If R^{max} is not determined, the next sending rate $R(n{+}1) \leftarrow R(n){+}\Delta$ (i.e. the search range is restricted using Δ) */
$R(n+1) = R(n) + \Delta$
else
/* If R^{max} is determined, the next sending rate $R(n+1)$ is set according to a binary search within a small range */
$R(n+1) = (R^{max} + R^{min})/2$
end if
else if $R(n) \geq A$ **then**
/* If the current sending rate $R(n)$ is greater than or equal to the available bandwidth A, $R^{max} \leftarrow R(n)$ */
$R^{max} = R(n)$
if $(R^{min} == 0)$ **then**
/* If R^{min} is not determined, the next sending rate $R(n{+}1) \leftarrow R(n){-}\Delta$ (i.e. the search range is restricted using Δ) */
$R(n+1) = R(n) - \Delta$
else
/* If R^{min} is determined, the next sending rate $R(n+1)$ is set according to a binary search within a small range */
$R(n+1) = (R^{max} + R^{min})/2$
end if
end if
/* Termination conditions */
if $(R^{max} - R^{min} <= \omega)$ **then**
return(R^{min}, R^{max})
end if

IV. PERFORMANCE EVALUATION

In this, we first compare the original sending rates of the suggested method's probe traffic with Magictrain's because the original sending rate has a powerful impact on the efficiency of network load. The proposed method's original transmitting rates and Magictrain are the main accessible estimate of bandwidth (A1st)(Eq.(2)) and ADR (Eq.(1)), respectively.

$$ADR = \frac{1}{Q}\sum_{q=1}^{Q}\frac{L^{max}}{D_q} \tag{1}$$

$$A^{1st} \;=\; wA_{max} + (1-w)A_{min} \tag{2}$$

Next, we compare the network load of the suggested technique with that of Magictrain using computer simulation provided that the assessment of the accessible Magictrain bandwidths and the suggested method are the same. In this simulation, to match the accuracy of the estimated available bandwidths of both methods, we set all the parameters of the proposed method to be the same as those of Magictrain.

A. Simulation Conditions

Fig.2 shows the assumed network model in which the probe traffic in the network goes through N relay nodes. Relay node numbers are 10 (i.e. N= 10). Send the probe traffic to the receiver from the sender and then estimate the accessible bandwidth. At the relay node h, cross traffic is launched at the transmitting speed Uh. The patterns of cross traffic sending frequency Uh can be found in Table 1.

Table 3: Parameters of cross traffic (A = 25Mbps)

Case #	Sending rate of cross traffic (Mbps)									
	Relay node (h)									
	1	2	3	4	5	6	7	8	9	10
1	75	0	0	0	0	0	0	0	0	0
2	75	75	0	0	0	0	0	0	0	0
3	75	75	75	75	0	0	0	0	0	0
4	75	75	75	75	75	75	75	0	0	0
5	75	75	75	75	75	75	75	75	75	75

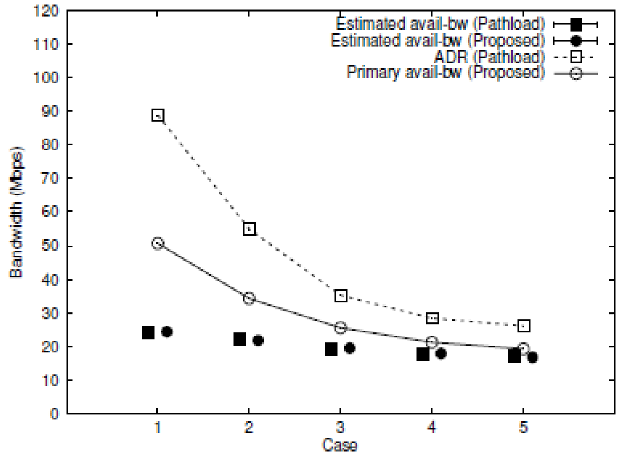

Fig. 2: Estimated avail-bw, ADR, and primary avail-bw (A = 25 Mbps)

We refer in all figures to the available bandwidth as avail-bw. Furthermore, the estimated available bandwidths of the suggested technique and Magictrain are marked in Fig.2 respectively by the black circles and black squares. The estimated available bandwidths of the proposed method and Magictrain are nearly the same since the parameters used in the proposed method and Magictrain are set to be the same.

V. CONCLUSION

In this paper, we suggested an accessible technique of estimating bandwidth that consists of two features to provide high accuracy estimation and low efficiency of network load. One feature is the accessible bandwidth assessment feature that uses the end-to-end delay increase rate to calculate the available bandwidth directly. The other feature is the rate adjustment algorithm which adjusts the mistake calculated using the available bandwidth assessment feature between the real accessible bandwidth and the accessible bandwidth. From the simulation outcomes, it was discovered that the suggested method's main available bandwidth was more precise than Magictrain's ADR. Moreover, when the suggested method's parameters are assigned the same values as Magictrain's, the estimated available bandwidth of the suggested method is almost the same as Magictrain's. In addition, we intend to introduce a fresh accessible bandwidth estimation technique involving end-to-end hop count measurement as it is anticipated that end-to-end hop count data will further enhance the estimation precision of available bandwidth.

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