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Joint admission control algorithm in access network

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Abstract To deal with long probing delay and inaccurate probing results in the endpoint admission control method, a joint local and end-to-end admission control algorithm is proposed, which introduces local probing of access network besides end-to-end probing. Through local probing, the algorithm accurately estimated the resource status of the access network. Simulation shows that this algorithm can improve admission control performance and reduce users' average waiting time when the access network is heavily loaded.

Keywords admission control, quality of service management, access network, differentiated service

1 Introduction

Along with the development of the Internet, many multimedia services, are emerging, such as video conferencing, VOIP, etc. These services have demanding quality-of-service (QoS) requirements in terms of bandwidth, packet loss rate, delay and delay jitter. The best effort mechanism of the traditional Internet cannot fulfill these requirements any more [1]. Therefore, the IETF presents two new QoS mechanisms: integrated service (IntServ) [2] and differentiated service (DiffServ) [3]. IntServ depends on resource reservation method, which can satisfy the user's QoS requirement in the worst network situation. However, it does not scale well because it has to hold the information of each flow in the router. In addition, it may result in low resource utilization rate when the flows are bursty. On the contrary, DiffServ extends the information scattering scale and provides QoS services on several aggregate flow classes, which makes it more scalable. Though it provides QoS services

on aggregate class, it cannot satisfy tight requirements of each user. The quality of each class will become worse when too many flows are admitted. Therefore, admission control as an important method of network management becomes an essential element besides the DiffServ mechanism [4].

This paper presents a joint local and end-to-end admission control method, which introduces local probing of the access network besides end-to-end probing. Simulations demonstrate that this method has higher network resource utilization rate, lower loss rate in access network and costs shorter average user's waiting time when the access network is heavily loaded.

2 Related work

To achieve better QoS reservation, many admission control methods have been proposed.

2.1 Parameter-based admission control

Parameter-based admission control calculates characters of traffic flow, such as average transmitting rate and peak rate to estimate the status of network resource utilization. In Refs. [5,6], the bandwidth broker (BB) method is utilized, which uses one BB node to collect the resources utilization rate of every router in the network and makes admission judgment according to the information. Its benefits lie in separating the admission control layer and the routing data layer and simplifying the design and burden of routers. To put in detail, Ref. [5] uses only one BB node in the whole network, which makes it scale badly when the network is large and too many traffic flows are admitted. Reference [6] uses the distributed method. It divides the whole network into several sub-domains. Each sub-domain has its own BB node and the management of the whole network depends on the cooperation of BB nodes. This method avoids the scalable problem of Ref. [5] to some extent. The common problem in Refs. [5,6] is that gathering information costs time, resulting in longer user's waiting time so that the information may become obsolete. In addition, the failure of BB node

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may paralyze part of the admission control function, and even give severe impact to the whole network. On the other hand, the resource utilization rate will become low when the traffic flows are bursty.

2.2 Measurement-based admission control

This method uses end-to-end probing to measure network resource status. Reference [7] presents the end-point admission control algorithm, which makes admission judgment according to end-to-end probing and resource calculation. The method needs no extra support of the router and makes it easy to deploy. However, it may result in wrong judgment because it only probes one realization of traffic characteristics stochastic on the end-to-end path. The user's average waiting time also becomes longer and the probing result may be obsolete due to the long probing time. Reference [8] depends on the local resource status calculated by each router. The probing packet just gathers the calculation results on the path. Its deployment is complex because it entails the cooperation of each router, and it is not suitable to be deployed in the core router. Whereas this method has the advantages of more accurate estimation of network resources status and less transmission costs than the end-point admission control method.

Another important research direction is deploying different QoS management mechanisms according to different features of each network region. In Ref. [9] the network is divided into DiffServ region and non-DiffServ region. In the non-DiffServ region, the IntServ mechanism is deployed. The combination of the two regions depends on the RSVP signaling cooperation. Since access network is easy to manage, Ref. [10] dynamically adjusts the schedule weight and admission threshold, which improves the network efficiency and combines parameter-based and measurement-based admission control. Parameter-based component of the algorithm avoids too many flows to be admitted in a short period. Measurement-based component can achieve high resource utilization even when the flows are bursty.

3 Joint admission control

3.1 Network model

The network model is illustrated in Fig. 1. In the model, access network includes access router (*A,G*), relay router (*B, C* and *F*) and edge router (*D, E*). Generally speaking, the access network is combined with narrow bandwidth links, and the devices have poor capabilities in buffering, scheduling and shaping. Therefore, compared with the core network, the access network usually has higher probability of encountering congestion.

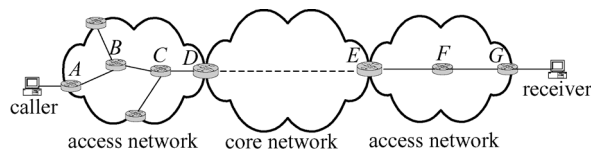


Fig. 1 Network model

This paper proposes a joint local and end-to-end admission control algorithm. On the basis of end-to-end probing, the algorithm introduces local probing of access network besides end-to-end probing and dynamically records the resource status of the access network. In the local probing, router-based resource calculation and path recording methods are adopted. Local probing and end-to-end probing are independent, thus it does not affect the procedure of end-to-end probing.

On one hand, joint admission control avoids the disadvantages of bad scalability, single point of failure and low resource utilization rate in the BB method. On the other hand, it avoids the deployment problem on the core router and reduces the effect of inaccurate probing results of end-point admission control.

Compared with end-to-end admission control, the new algorithm does not need special cooperation of the core router and the state of each flow, while simply needing resource calculation mechanism in the access network router.

3.2 Admission control procedure

Admission control procedure includes local probing and end-to-end probing. End-to-end probing is only performed under the condition that new flow is admitted by the local probing. The signaling protocol is session initiation protocol [11]. The procedure is illustrated in Fig. 2.

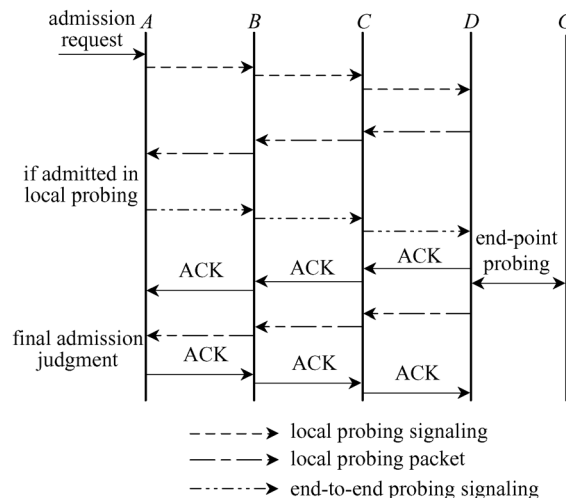


Fig. 2 Admission control procedure

In the local probing, the access router *A* will send a local probing signaling packet after admission request is

received. The packet records the router information on the transmitting path. After the edge router D receives the local probing signal, it sends local probing packet to A according to the path information of signaling, records the residual resource information of the routers on the path (C , B and A), and makes local admission judgment in router A . If the residual resources of the path cannot satisfy the admission request, A will deny the request. Otherwise, if the request is satisfied, A will start the end-to-end probing procedure. In the procedure, A sends a local probing signaling to router D and records the path information. D sends ACK message to A after it receives the signaling and estimates residual resources information of the path $D-G$ through end-point probing. After D finishes the end-point probing, it sends probing result to A , recording the residual resource information of the transmission path (C , B and A) in the access network. A makes final admission judgment on the basis of these probing results and request is admitted if its QoS requirement is satisfied.

The costs of signaling are too low to affect the burden of the access network because of the limited number of arriving flows.

3.3 Source model

The source model of the algorithm is on/off model, which exhibits long range dependence characteristics at the aggregate level. The distribution of on/off duration is negative exponential. In the 'on' period, packets are generated at a fixed rate of p (packets/s) and the average number of packets is N . I is the average time of the 'off' period. Then the average packet rate can be calculated by the equation below:

$$\frac{1}{a} = \frac{I}{N} + \frac{1}{p}. \quad (1)$$

To shape sources, we add token bucket in the model. The depth of the token bucket is b token. The generating speed of the token is r token/s. There is no buffer between the source and the token bucket. The arrival interval and duration of flows belongs to negative exponential distribution and the average value is d s and L s accordingly.

3.4 Local measurement model

The available bandwidth is the criterion of local resources measurement, which is

$$C_1 = u \times C - \hat{C}. \quad (2)$$

In above equation, C_1 is available bandwidth. The parameter u is the link utilization rate. C is the total bandwidth. \hat{C} is the load of the link, which is measured through time window method. There are many sampling periods S in one measurement period T , that is,

$T = nS$ ($n \in \mathbb{N}, n > 5$). The average load of the sampling period is \hat{C}_s . Traffic load \hat{C} can be calculated through the following steps:

1) Once one measurement period is over, the maximum \hat{C}_s will be traffic load \hat{C} of next T .

2) If \hat{C}_s is larger than \hat{C} of the current measurement period, the \hat{C}_s will become the \hat{C} and a new measurement period will be started.

3.5 Admission control formula

One probing packet records the available bandwidth of each link on the path. The bandwidth of the path is:

$$C_r = \min\{C_1[i] | i = 1, 2, \dots, n\}. \quad (3)$$

In the formula, C_r is the available bandwidth of the whole path. $C_1[i]$ is the available bandwidth of link i . n ($n \in \mathbb{N}$) is the number of links on the path.

The admission formula is:

$$C_r \geq \gamma. \quad (4)$$

That is, if the available bandwidth of the path is larger or equal to the request peak rate γ , the new flow is admitted, otherwise, it is denied.

4 Simulation analysis

4.1 Simulation topology

The simulation tool is NS2 and multi-bottleneck topology, as illustrated in Fig. 3, is used to test the performance of joint admission control. The bandwidth of every link is 10 Mbit/s. H_1 – H_4 denote background data flows. The broken line shows the transmission direction of data flows. We adopted session initiation protocol as the signaling protocol. Delay is introduced as the end-point probing procedure.

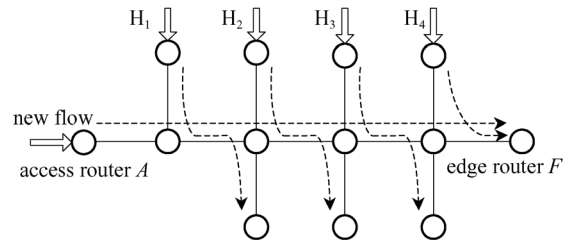


Fig. 3 Simulation topology

4.2 Simulation parameters

Data flows used in the simulation are listed in Table 1. The flow β has larger average rate and burstiness (p/a)

Table 1 Simulation flows

parameter	flow α	flow β	background flow
p	40	160	50
N	40	160	50
I	1.35	4	2
p/a	2.35	5	3
r	40	160	50
b	40	160	50
d	0.5	0.5	1.0
L	300	300	300

than the flow α . In the simulation, T is 0.5 s. The packet length is 1 kbit. The buffer of each router is 200 kbit. End-point probing delay is 2 s. Simulation results are collected by adjusting utilization rate u and flow arriving rate ($1/d$). The simulation time is 8000 s and data are collected in the later 5000 s.

4.3 Simulation results

We use the performance frontier curve as the comparison method. The performance frontier of admitted flows is shown in Fig. 4. As indicated by the results, joint admission control has better performance because the end-point may induce wrong judgment as a result of long end-to-end delay. The wrong judgment happens in two situations. One is to admit flows that should not be admitted, such as when the traffic of aggregate flows is increasing. The criterion is too low. Another situation does not admit flows that should be admitted, such as when the traffic of aggregate flows is decreasing. The extra flows admitted in the former situation induce congestion. Once extra flows are admitted, it will result in higher loss rate. Worse still, once the flows are wrongly admitted, it will exert continuous bad effect in the whole life cycle. In the latter situation when the legitimate flows are not admitted, the utilization rate will be reduced. Although the latter one decreases loss rate, the scale of decreasing is smaller than the scale of increase introduced by the

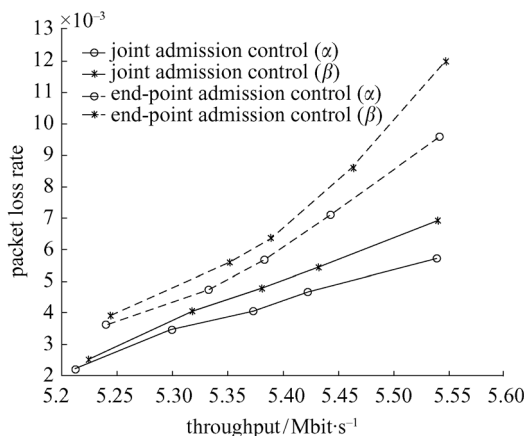


Fig. 4 Performance frontier

former, because the network has extra bandwidth for the missing flows.

When average rate and burstiness of the flow become larger, the loss rate of the two methods increases. However, the joint admission control is still better than the end-point admission control. The reason is that wrong admission has much more bad effects in higher average rate and burstiness.

The comparison of user's average waiting time is shown in Fig. 5. In the simulation results, when the flow arrival rate is low, joint admission control has an additional delay of tens of milliseconds. This is because the access network is in the light loaded state, most flows need end-point probing besides local probing. This delay is a little larger than transmission delay of the access network and much smaller than end-to-end probing time, so it can be tolerated by the user. When the flow arriving rate increases, more and more users do not need end-point probing because of the heavy-load status of the access router. The avoidance of end-to-end probing reduces much of the user's waiting time, so the average waiting time is lower than that of the end-point admission control.

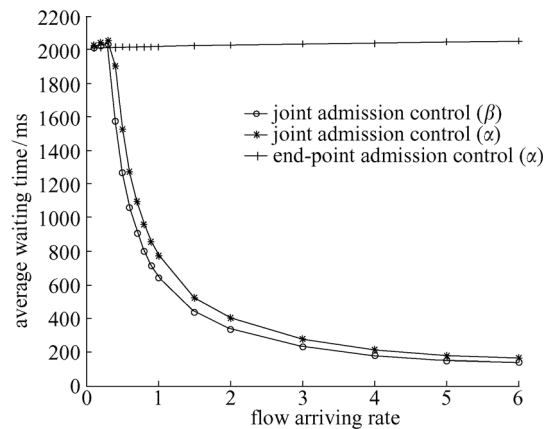


Fig. 5 Average waiting time

Another cost of joint admission control is the signaling and router support in the access network. Joint admission control also has some difficulties with deployment, because the router needs extra algorithm and protocol mechanism. Even when the access network is lightly loaded, the cost is useful. On one hand, the costs reduce the burden of manual management. On the other hand, in end-to-end probing procedure, the costs also realize the accurate estimation of resources status in the access network, and partly avoids the obsolete probing information problem in end-point admission control.

5 Conclusions

Although DiffServ avoids the scalability problem of IntServ, it cannot guarantee each user's QoS requirement.

Therefore, the combination of DiffServ and admission control method has become an important mechanism. Endpoint admission control algorithm scales well and has high resources utilization rate, but has the problem of long probing delay and inaccurate probing result. To solve these problems, a joint admission control method is proposed in this paper. Simulation results show that this algorithm can improve admission control performance and reduce users' average waiting time when the access network is heavily loaded. Our further work is to study buffer scheduling, load balancing mechanism in admission control algorithm and improve the performance of admission control besides delay analysis. We are also preparing to design a new admission control algorithm for Ad-hoc networks.

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