Activity-Based Congestion Management (ABC)

Concentration occurs in packet-based communication networks when more traffic temporarily enters a network than can be forwarded. Congestion management detects congestion in a communication network and drops or marks packets to mitigate congestion. Still, a few heavy users can monopolize the bandwidth of a bottleneck link, e.g., by opening many flows or using non-responsive transport protocols to send at large data rate. A challenge is to drop or mark the right packets if fair capacity sharing and low delay are desired in a network.

We propose activity-based congestion management (ABC), with which users can share a network’s capacity fairly within an ABC domain while keeping packet delays low. To that end, activity meters and markers equip user traffic with activity information that reflects a user’s traffic rate. In case of congestion, traffic with high activity is preferentially dropped on bottleneck links. Thereby, users can achieve a fair share of the network’s transmission capacity.

低延时是通过在路由器或交换机上启用活动队列管理（AQM）来实现的，当出现拥塞时，AQM会增加高活动度流量的丢包概率，同时减少低活动度流量的丢包。这种机制可以轻松地应用于各种AQM中。

Innovation

Up to now: To enforce fairness on bottleneck resources, scheduling mechanisms are used which require per-user information.

Now: ABC achieves fairness without per-user information on bottleneck resources. Advantage: simplicity, scalability, extensibility to realtime.

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Applications

- Communication networks with limited transmission resources
- Prevention of denial-of-service attacks
- Fair-resource sharing
- Enforcement of low-delay networking

Advantages

- Scalable, as switches do not require user states, multiple queues, or signaling
- Works for TCP traffic, non-responsive traffic that does not reduce its sending rate in case of congestion, or mixes thereof
- ABC provides an ecosystem that incentivizes the use of congestion control protocols and protects TCP traffic against overload through non-responsive traffic
How ABC works

ABC requires any upload traffic of a user to be activity-metered and equipped with activity information, which may be done in a single location close to the source. If ABC should be applied to downloads, the user’s traffic needs to be metered at possibly many network ingresses by a distributed activity meter.

ABC then assigns a reference rate $R_r$ to every user in the network. The activity of a user is the logarithmic value of the factor by which his transmission rate $R_t$ exceeds his reference rate $R_r$.

The activity meter is a token bucket with a bucket size $B$ expressing a burst allowance and an activity inertia $I$ controlling how quickly the activity adapts in response to rate changes and traffic bursts.

ABC adapts AQM probabilities such that packets from users with a larger or lower activity value than the average $A_{avg}$ face larger or lower mark/drop probabilities. To that end, the AQM is extended to average activity values $A$ of received packets by an exponentially weighted moving average (EWMA) as follows:

$$A_{avg} = w_A \cdot A_{avg} + (1 - w_A) \cdot A$$

The AQM probability $p$ of dropping a packet is adapted to:

$$p_A = p^{2 - \gamma(A - A_{avg})}$$

Fair Sharing of Bandwidth at Bottlenecks

In this example, a single heavy user is sending UDP traffic at rate $R_t^0$, competing for the bandwidth of the bottleneck link with 10 light users. All users are assigned the same reference rate $R_r = 0.05$ Mb/s.

The graph shows that without ABC ($\gamma = 0$) the throughput ratio $T_R$ (the ratio of the traffic of the heavy user to the traffic of all light users) exceeds a value of 10 for a transmission rate of $R_t^0 = 5$ Mb/s, i.e. the heavy user monopolizes the link.

With ABC ($\gamma = 3$), the throughput ratio is kept between 0.6 and 1.5, limiting the unfairness between heavy and light users.

Adapting the Reference Rate for Various User Numbers

By adjusting the reference rate $R_r$, ABC ensures fair bandwidth sharing for small or large numbers of users.

Here, the throughput ratio is shown for two scenarios:
- 1 heavy user and 10 light users
- 9 heavy users and 90 light users

ABC can be configured to ensure fairness ($T_R \approx 1$) for any number of users by defining the reference rate appropriately.