Weekly Report

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Locality of P2P live streaming

The streaming capacity of P2P streaming system with locality limit:
Before we discuss the impact of traffic locality on the performance of P2P live streaming systems, let's see the optimal performance of a live streaming system without locality.

We intend to model the live streaming system as a discrete time system. Due to the reason that the size of chunks can be changed, we suppose a time unit is a fixed length of time.

The maximum streaming rate of a P2P streaming system is:

$$R_{max} = minU_s, \frac{1}{N}(U_s + \sum_{i=1}^{N} U_i)$$

Because the servers' upload capacity is usually powerful enough. So,

$$R_{max} = \frac{1}{N}(U_s + \sum_{i=1}^{N} U_i) = \frac{U_s}{N} + U_a$$

Then, let's see the minimum delay of the streaming. The P2P streaming is to delivery a chunk to every peer. We first see the minimum delay for one chunk's transmission to every peer. We divide this question into two parts: 1) Homogeneous case; 2) Heterogenous case; 1)Homogeneous case: All the peers' upload capacity are the same, denoted by U_p. The maximum streaming rate that could be sustained is:

$$R_{max} = \frac{U_s}{N} + U_p$$

If N tends to infinity, $R_{max} = U_p$. If we assume the streaming playback rate is R, then the average upload capacity of the system is larger than or equal to the playback rate. We set the size of the chunks so that in one time unit, r chunks are played.

We first assume that the server and the peer's bandwidth is 1, which means the server and the peer bandwidth equal to the playback rate. So, in one time unit, the server and peer could upload r chunks. Using snow-ball chunk dissemination, the maximum delay for all peers to receive a chunk is:

$$D_{pmax} = 1 + \lceil \log_{(r+1)} N \rceil$$

The average delay is:

$$\bar{D_p} = \frac{1}{N}\{1 + \sum_{i=2}^{D_{max}-1} ir(r+1)^{i-2} + D_{max}[N - (r+1)^{D_{max}-2}]\}$$

When a peer uploads the chunk simultaneously to r children peers, and when a peer uploads the chunk to children peers sequentially, the maximum delay for all peers to receive a chunk is:

$$D_{smax} = \frac{1 + \lceil \log_2 N \rceil}{r}$$

The average delay is:

$$\bar{D_s} = \frac{1}{r \cdot N}[1 + \sum_{i=2}^{K^*-1} i2^{i-2} + K^*(N - 2^{K^*-2})]$$

The effect of increasing Server bandwidth:

What's the impact of increasing server bandwidth from 1 to u_s on the streaming performance? The maximum streaming rate is $R_{max} = \frac{U_s}{N} + U_p$. The maximum streaming rate just increases by $\frac{1}{N}$ of the increasing part of the server bandwidth. On the other hand, what is the improvement on the delay? Let z(k) be the number of peers (including the server) with the chunk at the beginning of time unit k. Then,

$$z(0) = 1; z(1) = 1 + u_s; z(k) = r \cdot [z(k-1) - 1] + z(k-1)$$

$$z(k) - 1 = (r+1)[z(k-1) - 1]$$

We need $z(k) \geq N$, so $D_{pmax} = k = \lceil log_{r+1} \frac{N}{u_s} \rceil + 1$. This delay improvement could be reached. We can divide N peers into u_s groups, the server simultaneously upload the chunk to one peer in each group within one time unit. Then, in each group, the peers could use snow-ball algorithm to distribute the chunk, the delay for the chunk dissemination will be $1 + \lceil log_{r+1} \frac{N}{u_s} \rceil$.

If the peers take sequential uploading, transmitting the chunk to another peer only after finishing the current transmitting, the improvement on the delay is calculated as follows:

$$z(k) = 2^r[z(k-1) - 1]$$

$$z(1) = 2^{(r-1)} u_s + 1$$

$$D_{smax} = k = \frac{1 + \lceil log_2 \frac{N}{u_s} \rceil}{r}$$

The effect of increasing peer bandwidth If we increase the peer bandwidth from 1 to u_p, then, every time unit one peer could upload u_p chunks.

$$D_{pmax} = 1 + \lceil \log_(r u_p + 1) N \rceil$$

$$D_{smax} = \frac{1 + \lceil \log_2 N \rceil}{r u_p}$$

The relationship between Streaming Rate and Delay.

One peer's buffer size B should be no less than the maximum delay D.

2) Heterogenous case: