Draft of VoD modeling

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Modeling of Traffic Locality in VoD Streaming Systems

The primary objective is to determine the performance of VoD streaming systems when locality-aware peer selection strategy is applied in the VoD streaming systems. The locality-aware peer selection strategy is that peers have the limited number of neighbors who are in other ISPs. In this paper, we intend to use differential equations to derive the needed downloading time for video chunks demanded by peers.

System Model

There are K ISPs. The number of peers in ISP k is n_k. The peer arrival rate in ISP k is λ_k.

A movie is composed of M chunks. Chunk is used to advertising to neighbors what parts of a movie a peer holds. The size of a chunk is L. The streaming rate is R. So the playback time for a chunk is $\frac{L}{R}$.

At one moment, every peer is downloading a specific chunk. We denote $n_{0,m}$ as the number of peers who is downloading chunk m, $1 \leq m \leq M$. When there are no user interactions, the peer after finishing downloading chunk m will download chunk $m+1$.

Performance

Calculate the downloading time for different video chunks demanded by peers under two situations: locality-unaware peer selection and locality-aware peer selection.

locality-unaware peer selection strategy: When locality-unaware peer selection strategy is taken in the VoD system, the number of peers downloading chunk m in all ISPs is n^m. We don't consider the user interactions first. We can use the following differential equations to describe the change of number of peers downloading different chunks:

$$\frac{dn_{0,1}}{dt} = \lambda - \gamma_{0,1} n_{0,1}$$

$$\frac{dn_{0,m}}{dt} = \gamma_{0,m-1} n_{0,m-1} - \gamma_{0,m} n_{0,m}, 2 \leq m \leq M$$

$$\gamma_{0,M} = \frac{R}{L}$$

$$\gamma_{0,M-1} = \frac{U_p \cdot n_{0,M}}{(n_{0,1} + ... + n_{0,M-1})L}$$

$$\gamma_{0,m} = \gamma_{0,m+1} + \frac{U_p \cdot n_{0,m+1}}{(n_{0,1} + ... + n_{0,m})L}, 1 \leq m \leq M-2$$

In this case, the inter-ISP traffic is:

$$T_1 =$$

locality-aware peer selection strategy:

$$\frac{dn_{k,1}}{dt} = \lambda_k - \gamma_{k,1} n_{k,1}$$

$$\frac{dn_{k,m}}{dt} = \gamma_{k,m-1} n_{k,m-1} - \gamma_{k,m} n_{k,m}, 2 \leq m \leq M$$

$$\begin{aligned}
\gamma_{k,M} &= \frac{R}{L} \\
\gamma_{k,M-1} &= \frac{U_p \cdot n_{k,M} \cdot p}{n_{k,1} + ... + n_{k,M-1}} \\
&+ \sum_{i=1, i \neq k}^{M} \frac{U_p \cdot n_{i,M} \cdot (1-p)}{(n_1 + ... + n_{M-1}) - (n_{i,1} + ... + n_{i,M-1})} \\
\gamma_{k,m} &= \gamma_{k,m+1} + \frac{U_p \cdot n_{k,m+1} \cdot p}{n_{k,1} + ... + n_{k,m}} \\
&+ \sum_{i=1, i \neq k}^{M} \frac{U_p \cdot n_{i,m+1} \cdot (1-p)}{(n_1 + ... + n_m) - (n_{i,1} + ... + n_{i,m})}
\end{aligned}$$

In this case, the inter-ISP traffic is:

$$T_2 =$$

The key points are how to calculate the average downloading rate of a specific chunk. One way to calculate the average downloading rate of a specific chunk is based on the statement that the total downloading rate of all downloaders is equal to the total upload rate from uploaders.

The second way to calculate the average downloading rate of a specific chunk is to calculate the probability that a peer connects to neighbors that can upload chunks to it.

The next step is to add the model of user interactions in the differential equations.