Delivery of Multiple Description Coding Streaming Media over Peer to Peer Networks

Zhou SU　Jiro KATTO　Yasuhiko YASUDA

School of Science and Engineering, Waseda University

1． Introduction

Multiple description coding (MDC) has been proposed as an alternative to layered coding for streaming because of its independency between different descriptions. Recent research shows that carrying out MDC with path diversity can improve the performance of Peer to Peer (P2P) networks. However, the peer replication problem, which addresses how to select optimal multiple peers to replicate different descriptions of one stream to reduce response time and network traffic, has not been resolved. In this paper we propose a novel replication algorithm to deliver MDC over P2P to deal with the above problem.

2． Previous Work

In [1] the performance of MDC and path diversity in Content Delivery Networks (CDN) is studied. In [2] MDC and path diversity are extended to distribute streaming media over P2P systems and algorithms for constructing and maintaining the path distribution tree are talked about.

3. Multiple Description Coding Streaming

MDC codes a media stream into two (or more) complementary descriptions. If each description alone is received it can be used to decode baseline quality video, and every additional description can further improve video quality. This is different from the conventional layered coding, where the enhancement layers serve only to refine the base layer quality and can not be used alone. MDC combines particularly well with path diversity, in which different descriptions are explicitly sent over different route to a client. How to deliver MDC Streaming over P2P networks has been an attractive topic including some advantages:

（1）Because each description can be independently decoded, to keep different descriptions onto more peers can provide the client the requested stream more efficiently and directly, then the overhead of searching object within P2P system can be reduced.

（2）Since there is much smaller chance that all paths delivering all descriptions of one stream simultaneously suffer from losses, MDC with path diversity is beneficial for delay-sensitive. （3）As a given peer may be up (online) or down (offline) at a given time, MDC with path diversity is helpful to decrease the search failure caused by the sudden offline of a given peer.

4. Proposed Algorithm

We consider a P2P community with I Peers. Each Peer i($i=\{1,\ldots,I\}$), which might be a powerful workstation, a personal computer, or a PDA an so on, has S_i bytes of storage capacity and has clients that request objects at aggregate rate λ_i. Let $\Lambda=\sum_i \lambda_i$, be the total request rate of all peers. We define a up ratio U_i as the fraction of the time that Peer i is up. We assume that there are J streams and each stream (stream j, $j=\{1,\ldots,J\}$) is encoded into Q separate streams, or descriptions. We define $B_{q,j}$ as the data size of the q'th description of stream j and $P_{q,j}$ is the request probability for the q'th description of stream j. $\boldsymbol{X}$ means an existing matrix, where:

$X_{i,q,j}=1$ (if the q'th description of stream j is avalable at Peer i), (Eq.1)

0 (otherwise)

$\sum_q\sum_j B_{q,j}\cdot X_{i,q,j}<=S_i \quad i=\{1,\ldots,I\}$ (Eq.2)

This heuristic algorithm aims to minimize joint path and total path length between a client (Peer c) and peers which provide different descriptions of the requested stream.

Assume that (among all I peers) there are Q peers (Peer i, $i=\{1,\ldots, Q\}$, $Q<=I$) providing Q different descriptions of the requested stream j to the client (Peer c). $N_{i,c}$ is the path length in hop counts from Peer i to the Peer c.

Here, $N_{i,c}=N_{\text{joint } i,c} + N_{\text{disjoint } i,c}$, (Eq.3)

where $N_{\text{joint } i,c}$ is the joint portion of the path with other Q peers and $N_{\text{disjoint } i,c}$ is the portion of the path (from Peer i to the Peer c) which is not overlayed with any other Q peers, respectively. The total path length during the delivery of all descriptions of stream j to Peer c can be obtained as follows:

$$T_{c,j}=\sum_i N_{i,c}=\sum_i(N_{\text{joint } i,c}+N_{\text{disjoint } i,c}) \quad i=\{1,\ldots, Q\} \qquad \text{(Eq.4)}$$
$$=\sum_i(N_{\text{joint } i,c})+\sum_i(N_{\text{disjoint } i,c})$$
$$=\sum_i\{(1/\Lambda)\cdot U_c\cdot\lambda_c\cdot U_i\cdot P_{i,j}\cdot D_{i,c}(\boldsymbol{X_0})\}$$
$$+Q(1/\Lambda)\cdot U_c\cdot\lambda_c\cdot D_{\text{joint } i}(\boldsymbol{X_0}))\cdot\sum_i(U_i\cdot P_{i,j})$$
$$=(1/\Lambda)\cdot U_c\cdot\lambda_c\cdot\{\sum_i(U_i\cdot P_{i,j}\cdot D_{i,c}(\boldsymbol{X_0}))+Q\cdot D_{\text{joint } i}(\boldsymbol{X_0})\cdot\sum_i(U_i\cdot P_{i,j})\}$$

Where $\boldsymbol{X_0}$ is the placement of streams to P2P community and $D_{i,c}(\boldsymbol{X_0})$ denotes the disjoint distance during the path from Peer i to Peer c under the placement $\boldsymbol{X_0}$.

We introduce a path diversity degree β, where β is defined as:

$$\beta_{c,j}=\sum_i(N_{\text{disjoint } i,c})/\sum_i(N_{\text{joint } i,c})$$
$$=Q\cdot D_{\text{joint } i}(\boldsymbol{X_0})\cdot\sum_i(U_i\cdot P_{i,j})/\sum_i\{U_i\cdot P_{i,j}\cdot D_{i,c}(\boldsymbol{X_0})\} \qquad \text{(Eq.5)}$$

If the β is increased, the path diversity will also be increased. When a request for stream j originally comes from the Peer c and we need to select a group of peers to keep its different descriptions in, the groups with the lowest $T_{c,j}$ and highest $\beta_{c,j}$ will be selected to replicate its different descriptions to satisfy the future request for the same stream.

5. Conclusion and Further Work

In this paper, we proposed a replication algorithm for MDC streaming over P2P. We gave a mathematical analysis of our proposal and discussed how to decrease path length and keep path diversity. Performance evaluate will be done as further work.

Reference:

[1] J.Apostolopoulos, T.Wong, W.Tan, and S.Wee: "On Multiple Description Streaming with Content Delivery Networks", IEEE INFOCOM, June 2002

[2] V.N.Padmanabhan, H.J.Wang, P.A.Chou: "Resilient Peer to Peer Streaming", IEEE ICNP Nov. 2003