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A Multi-Channel Multimedia Content Distribution Strategy using Multiple Description Coding

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Abstract: Recently multi-channel media broadcast systems on P2P network have emerged in applications such as long-distance education and multimedia broadcast television. As these systems suffer from an obvious serious conflict between huge amounts of data and limited available bandwidth over the Internet, it's unpractical to provide the best network service for the all multimedia service channels. So, there are two key issues for the multi-channel systems: (1) how to reduce transmission delay that multimedia stream of each channel is distributed to all consumers and (2) how to guarantee the QoS metrics of some concernful channels, such as bit rates and latencies. Legacy relevant approaches mainly focus on the assignment of priorities to different peers and provide differentiated service quality to them thereafter. However, the issues of low-delay transmission and service differentiation for the entire channels have not addressed yet. In this study, we propose a multi-channel multimedia dissemination strategy named DiffStream. In DiffStream, Multiple Description Coding (MDC) technology is utilized and each channel disseminates partial streaming data instead of all. And service differentiation is also achieved by treating different channels with varying priorities and reserving bandwidth in advance to different channels in application layer. In addition, an extensive mechanism of vacant bandwidth preemption for improving bandwidth utilization is also raised. Experiments are carried out on NS2 and the results have demonstrated DiffStream's effectiveness in achieving our design objectives.

Key words: Multi-channel media broadcast, peer-to-peer, multiple description coding, service differentiation, low-delay

INTRODUCTION

Several multi-channel systems have been proposed on peer-to-peer (P2P) network recently (Wu *et al*., 2008; Hei *et al*., 2007), which have applied in long-distance education and multimedia broadcast television. How to distribute efficiently multiple channels' media to a group of receivers simultaneity is a key issue for these systems. To address this issue, we focus on dissemination of multiple channels which run concurrently in the P2P application-layer overlay. The overlay network is formed by the same group of participating peers and streaming data of each channel is distributed to all the participants.

There are three primary challenges to distribute multi-channel media content to a group of receivers simultaneity: (1) large amounts of streaming data that multiple channels have produced exhaust the limited bandwidth over the overlay nodes. So, it results in high delay especially when request bandwidth exceeds the node bandwidth capacity; (2) available bandwidth of overlay nodes is quite heterogeneous, that is, some nodes possess high bandwidth and others relatively low bandwidth, because of which already existed high delay problem has been aggravated and (3) at each overlay node, its bandwidth is shared by multiple channels in unpredicted ways. So, it makes multiple channels together fight for overlay node bandwidth with preemption mode. It is probable that some channels take up the bulk of available bandwidth and bring others to their knees.

The conflict between huge amounts of streaming data and limited available bandwidth over the internet make these challenges very difficult. However, in practical applications some significant phenomena are concerned by us: (1) some channels ought to be distributed quickly having no high requirement for multimedia presentation quality. And so it is not necessary to distribute all the streaming data for these channels. Therefore, the delay may be reduced to some degree by deceased streaming

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data in a multi-channel system and (2) the demands of QoS (delay, multimedia presentation quality), for all concurrent channels, are not quite the same and depend on specific applications. Because the transmission delay of some channels is sensitive at receivers, the strategy of disseminating multi-channel media needs to allocate more bandwidth to these channels than others in order to guarantee their QoS. As good examples, a live peer-to-peer streaming session of premium television channels to paid subscribers should enjoy a higher priority and a better quality than another streaming session of regular broadcast television channels to the general public.

Distributing multi-channel media stream on the same overlay network takes the risk of draining limited network bandwidth. There are several application layer strategies for multi-channel content dissemination in existing literature (Akkus *et al*., 2006, 2007; Xuan *et al*., 2008; Zhang *et al*., 2008). Akkus *et al*. (2006) mainly adopted a chain-topology overlay to disseminate multi-channel media streams considering lack of network bandwidth and use layered video coding to reduce communication traffic to satisfy the network capacity at the expense of multimedia presentation quality. The approach decreases packet loss effectively and adapt different overlay nodes that provide heterogeneous bandwidth. However, it suffers from high delay by the chain architecture. Furthermore, Akkus *et al*. (2006) improve this approach at a certain degree in the literature. Zhang *et al*. (2008) proposed another similar scheme to reduce delay or packet loss, which is deployed in multi-channel media delivery. They find a PLR (Packet Loss Rate) matrix for multi-channel delivery paths, which can help to locate exactly the links resulting in network congestion. Furthermore, the transport traffic of the links is decreased efficiently by adjusting the output bit rate of some senders and network congestion control is achieved consequently. The common idea of these schemes is: by decreasing the throughput produced by sources at the expense of multimedia presentation quality, the performances of delay and packet loss are reduced for multi-channel media delivery at a certain degree. But these schemes do not eliminate the conflict that multiple channels fight for overlay nodes' bandwidth in non-friendly way yet. The necessary bandwidth for each channel at overlay nodes is not guaranteed. Even the data of some channels with higher priorities are not disseminated smoothly and poor performances of delay and packet loss still exist. In addition, the basic layer data must be delivered with a very little packet loss to be decoded correctly by receivers. For DiffStream, however, service differentiation is obtained through treating each channel with varying priorities and reserving corresponding network resource to each channel, avoiding bandwidth conflict. And with the MDC technology adopted, more sub-streams received and higher multimedia presentation quality at the receiver are achieved.

There are some schemes that share the network resource (esp. bandwidth) friendly for multiple priority-based channels. Emma protocol (Nakamura *et al*., 2003) constructs firstly an overlay network in which traffic of the logic links and the out-degree of the nodes are restricted. Each channel priority of Emma is determined according to each overlay peer's favor to the channel. Then Emma allocate the logic link bandwidth for different channel streams to maximize the total priorities of all streams distributed on the overlay considering limited links bandwidth and nodes' out-degree. Unlike Emma, Wu and Li (2007) present Diverse, a peer-to-peer communication paradigm that priority-varying channels share network resources in another friendly way. The different channels are treated with different priorities. The network resources of bandwidth and nodes' computing service are allocated for different channels according to different priorities. There are other similar approaches aiming to distribute multi-channel streams smoothly (Gupta and Ammar, 2003; Ma *et al*., 2006; Clevenot *et al*., 2005). All of these schemes adopt different priority-based strategies to allocate network resources in different optimal ways. But it is very difficult for them to reduce delay for some channels require low communication delay, because the network bandwidth is limited when multiple channel streams are disseminating on the same overlay. None of channels can be treated with very high priority. Otherwise, low priority channels are starved by bandwidth drain of high priority channel. However, DiffStream customize the parameter MQR, disseminating part instead of all streaming data of each channel and lots of communication bandwidth can be saved. The saved bandwidth can be utilized to extend the out-degree of each delivery tree; more out-degree for delivery tree can load to lower delay accordingly.

In this study, we propose a novel multi-channel content dissemination strategy, namely DiffStream, which is tailored to achieving not only low overall delay in all channels but also effective service differentiation across priory-based channels responding to the major challenges appeared in multi-channel content dissemination system. To reach the two objectives, MDC (Multiple Description Coding) technology is utilized to divide single stream into multiple sub streams for each channel and any subset of these descriptions can be received and decoded into a signal with distortion (with respect to the original signal) commensurate with the number of descriptions received;

that is, the more descriptions received, the lower the distortion (i.e., the higher the quality) of the reconstructed signal. Our contributions are concentrated on two aspects accordingly: (1) the concept of Multimedia Quality Requirement (MQR for short) is brought forward to measure presentation quality demand at receivers. DiffStream divides each channel stream into multiple sub-streams using MDC technology and thereafter distributing part of them instead of all according to multimedia quality requirement and (2) service differentiation is implemented through treating channels with varying priorities and reserving corresponding bandwidth on all overlay nodes, avoiding bandwidth contention of multiple-channel stream, because of which some channels with high priority may take up the bulk of available bandwidth and bring others to their knees.

In addition, DiffStream strategy is designed to hold extended mechanism-Vacant Bandwidth Preemption. If some source is not delivering its media content during some period, reserved bandwidth for it can be reused to distribute other sources' pending sub-streams. This mechanism makes full use of bandwidth for better presentation quality with little control overhead.

PROPOSED STRATEGY

DiffStream is a novel disseminating strategy for multi-channel live multimedia content dissemination system and aims at low overall communication delay cost and effective service differentiation across the channels, responding to the phenomena that there is no need for channels to distribute all their streaming data and that varying channels with different priorities demand differentiated service. The strategy consists of two main components: distribution scheme with economized bandwidth and priority-based optimal bandwidth allocation strategy. The attribute of MQR measures how much streaming data can be reduced and the priority value reflects varying QoS requirement for differentiated bandwidth allocation strategy and so the two parameters, MQR and Priority, together constitute the foundation of DiffStream strategy.

Distribution scheme with economized bandwidth: As is known that the conflict between huge amounts of streaming data and limited and heterogeneous bandwidth is the essential challenge to face for multi-channel dissemination and so the most effective solution is to decrease the amount of streaming data at senders. According to the characteristic that some channel has no more demand for multimedia presentation quality but disseminated with rapidness. In the case, we can choose to disseminate part instead of all streaming data at a ratio based on certain demand for presentation quality of the channel at receivers. This scheme involves dividing one stream into multiple sub-streams and making sure these sub-streams can be merged to provide required presentation quality at receivers. Therefore, we employ Multiple Description Coding (MDC) technology (Goyal, 2001) to satisfy such requirements, encoding each channel stream into multiple separate sub-streams. And the more sub-streams received by a receiver; the higher quality of the multimedia presentation at the receiver achieved (Padmanabhan *et al*., 2002).

The parameter of Multimedia Quality Requirement (MQR for short) is brought up to measure the demand for presentation quality at receivers, indicating the ratio at which the sender disseminates their sub-streams for the required presentation quality. The MQR is expressed numerically as:

$$Q(i) = \frac{m_i}{M_i} \tag{1}$$

where, M_i is the total number of sub-streams encoded by MDC technology from channel i and m_i the number in real dissemination. m_i should be equal or above M_i^{min} and M_i^{min} indicates the minimal number of sub-streams for minimized presentation quality at receivers, otherwise the channel stream presentation at receivers is unacceptable. Therefore, the inequality of $M_i^{min} \le m_i \le M_i$ must be satisfied and then Q (i) is customizable adapting various applications.

The dissemination strategy is illustrated in Fig. 1 with n channels ranging from S_i to S_n and an overlay network including six overlay nodes receiving multi-channel streaming data. We construct a delivery tree to disseminate each sub-stream to all peers and then a forest-based disseminating structure for each channel is shaped; from the view of all channels, the P2P overlay network is formed by overlapping delivery trees. The stream data produced from channel S_i (I = 1, 2, 3, ..., N) is encoded into M_i independent sub-streams and m_i sub-streams are disseminating, while M_i-m_i sub-streams pending. Note that the size of each sub-stream encoded by MDC technology is just a bit more than $1/M_i$ of original stream size and for simplicity of distributing control strategy the study proposes, each sub stream encoded designed in DiffStream is nearly the same in size for all channels.

In DiffStream a sub-stream is disseminated along a newly-constructed delivery tree or even an existing tree. In other words, a delivery tree can be shared for distributing more than one sub-streams even if they

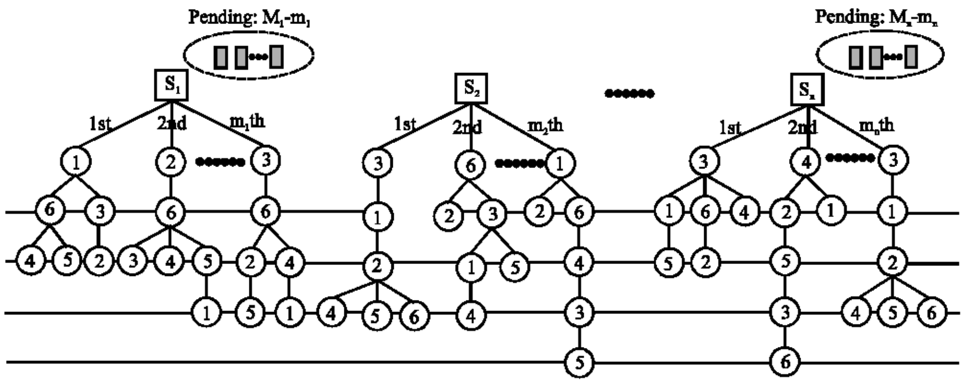

Fig. 1: Overlapping delivery trees in multiple concurrent channels

belong to different channels. As we see from Fig. 1, both the m_nth sub-stream of source S_n and the 1st sub-stream of S_2 share the same delivery tree.

In summary, DiffStream provides low-delay dissemination scheme through dividing each original stream into multiple independent fine-grained sub-streams and distributing some of these sub-streams with a customizable number to all peers referring to multimedia quality requirement. By distributing partial instead of all streaming data of each channel, a lot of communication bandwidth can be saved. The saved bandwidth can be utilized to extend the upload degree of each delivery tree and so the delivery trees constructed by DiffStream for each channel can achieve low-delay content dissemination to overlay peers.

Priority-based optimal bandwidth allocation: As for multi-channel content dissemination system, different channels have varying demand for delay or bandwidth due to their application kinds while bandwidth contention of overlay nodes makes it unavailable to obtain corresponding resources; to attain effective service differentiation, an available method that statically reserves bandwidth on each overlay node, referring to varying priority values of all channels, is taken into discussion. With the bandwidth for each sub stream to be reserved in advance, bandwidth contention for multiple concurrent channels can be avoided effectively, unlike what legacy relevant approaches and best-effort model have supplied. The priorities based strategy reservation is in two granularities: general idea of channel stream based allocation and specific bandwidth allocation to each sub-stream, detailed description and specific allocation strategy selection will be illustrated in the following.

The overlay network formed as the infrastructure can be defined as a directed graph G (V, E) logically, where V is the set of nodes representing overlay nodes and E the set of edges representing connections in the overlay network. We define here D (v) as total upload degree reserved at the node v , S_i as streaming data for channel i, D_i (v) and D_{ij} (v) reserved upload degree for S_i and its jth sub-stream delivery tree for S_i at the node v, respectively. Meanwhile we denote d_i (v) as the real load of node v for the channel i and d_{ij} (v) for the jth sub-stream of channel i. P_i is the priory of the ith channel and the number of channels is set to n.

General idea of priority-based bandwidth reservation: Originally varying priority values are designed to all channels with theirs application kind considered; bandwidth reservation strategy is adopted as an effective method on overlay nodes to ensure service differentiation for channels. In this allocation strategy, we seek to allocate bandwidth based on specific priority values of varying channels; higher priority channel have more bandwidth reserved on overlay nodes for the whole channel. That is, sub streams belonging to specific channel obtain shared bandwidth referring to channel's priority, for each channel is disseminated through multiple sub streams. The reserving method is expressed as this:

$$D_i(v) = D(v) \times \frac{P(S_i)}{\sum_{i=i}^{n} P(S_i)} \tag{2}$$

$$D_i(v) \geq \sum_{j=1}^{n} d_{ij}(v) \tag{3}$$

From Eq. 2, the upload degree for each channel on overlay node can be calculated by each channel's priority value, by which corresponding degree constraint for channels having varying priorities is set.

In Eq. 3, variable d_{ij} (v) , real load of sub stream j for channel i on the node v is employed and so total load of all sub streams, say:

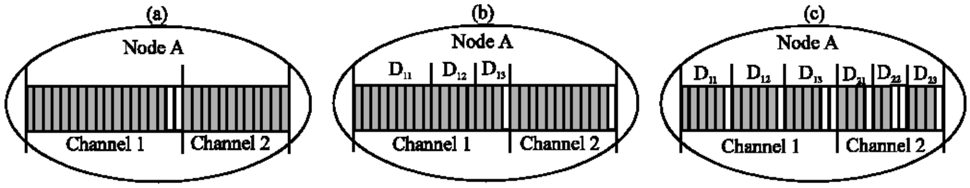

Fig. 2: (a) Channel priority based allocation; (b) specific bandwidth allocation of channel based allocation and (c) sub-stream based bandwidth allocation

$$\sum_{j=1}^{n} d_{ij}(v)$$

should never be beyond the upload degree constraint reserved. One instance of bandwidth reservation can be illustrated in Fig. 2a.

In the case there are two channels and there are two channels with the priority of channel 1 higher than channel 2 and each channel has three sub streams to deliver. The total upload degree for node A is set to 30, for channel 1 priority set to 3 and B set to 2. According to two channels' priority values node A reserve 18 upload degrees for channel 1 and 12 for channel 2. In that bandwidth reservation is in allusion to the entire channel and so the channel's sub streams share the portion of reserved bandwidth and that each sub stream uses one single tree to disseminate, tree construction algorithms designed for the mode are more flexible if only such algorithms meet Eq. 2 and 3, bandwidth reservation could then be obtained. To make great use of node bandwidth, specific tree construction process should be as close to upload degree constraint as possible, expressed as.

$$\sum_{j=1}^{m_i} d_{ij}(v) \Big/ D_i(v) \to 1$$

Specification of concrete bandwidth allocation: Here, we mainly discuss the specific bandwidth allocation strategy over reserved bandwidth. Note that specific tree construction for sub streams belonging to the same channel share the reserved bandwidth. Specific tree construction algorithms are flexible and still take example of Fig. 2a, an realistic delivery trees are constructed, shown in Fig. 2b, grey panes shows the real load at the node A for channel 1 and 2 and according to such realistic trees construction case, real load of channel 1 is $d_{11}(v) = 9$, $d_{12}(v) = 5$, $d_{13}(v) = 3$, respectively. Other tree construction methods can also be accepted.

From Fig. 2b, we can see that each sub stream adopt independent method building the trees orderly, first built sub streams' trees are inclined to occupy more upload degree and then the later unpredictable constructed trees will be greatly influenced. Then the later built trees are inclined to be built with more latency then the first built ones. By reason that for each channel the decode process is initialized when sub streams of it all arrive at overlay nodes; Cannikin law must be obeyed, that is, sub stream with greatest latency is the key factor for determining channels' latency. To obtain better performance, specific tree building algorithm, sub streams' delivery tree construction algorithm for each channel should be projected holistically in case that some sub stream has low bandwidth caused great latency.

We then propose the idea of equally dividing reserved bandwidth for all sub streams in DiffStream. We choose to designate priority for each sub stream inheriting the value of the channel from which it encodes. Differentiated upload bandwidth is then reserved statically for further constructing sub-stream delivery tree on each overlay node. By splitting equally the shared bandwidth reserved for the entire channel into the same portion for each sub stream of the channel, imparity of bandwidth occupation and the consequent delay differences for sub streams of the same channel can be avoided, considering specific tree construction algorithms.

Our priority-based bandwidth allocation is expressed as follows:

$$D_i(v) = D(v) \times \frac{P_i \times m_i}{\sum_{i=1}^{n}(P_i \times m_i)} \tag{4}$$

$$D_{ij}(v) = D_i(v)/m_i \tag{5}$$

In Eq. 4, the upload degree for each channel is allocated in advance referring to the all channels' priorities and their real number of sub-streams in transmission. From Eq. 5, we deduce that the upload degree for each sub-stream of certain channel share the same value.

More detailed bandwidth allocation is illustrated in Fig. 2c, in which an example of realistic bandwidth allocation is shown. There are two channels with the priority of channel 1 higher than channel 2. At overlay node A, three sub streams of channel 1 ranging from D_{11} to D_{13} share the same upload degree with $d_{11}(v) = d_{12}(v) = d_{13}(v) = 6$ and each sub-stream of channel 2 has reserved upload degree of 4 based on different priorities of two channels.

As realistic delivery trees are constructed, shown in Fig. 2c, grey panes shows the real load at the node A for channel 1 and 2 and real load of channel 1 is $d_{11}(v) = 5$, $d_{12}(v) = 5$, $d_{13}(v) = 4$, respectively with specific tree construction algorithms referred to.

The following two inequalities are satisfied:

$$d_{ij}(v) \le D_{ij}(v)$$

and

$$\sum_{j=1}^{m_i} d_{ij}(v) \le D_i(v)$$

the two formulas designate bandwidth constraint for both one sub stream and all sub streams of specific channel. Along with the inequality

$$\sum_{j=1}^{m_i} d_{ij}(v) \le D_i(v)$$

bandwidth requirement of each channel for service differentiation can be satisfied through bandwidth resource reservation. Meanwhile, to achieve better overall performances, we should make maximum use of upload bandwidth of each node, that is, when constructing specific delivery trees for sub streams

$$\sum_{j=1}^{m_i} d_{ij}(v) \Big/ D_i(v)$$

should be as close to 1 as possible for delivery trees construction.

In that one delivery tree is used to distribute a sub stream, if some node joins the overlay network, it is then affiliated into these delivery trees. Considering cannikin law and for simplicity, each sub stream belonging to one channel can adopt the same delivery tree; benefits of this are that it greatly simplifies node joining procedure and that for each sub stream has the same delivery path, delay cost at receivers are pretty much the same.

VACANT BANDWIDTH PREEMPTION IN MULTIPLE AVAILABLE CHANNELS

Here, an extension of DiffStream strategy. In multi-channel multimedia broadcast system, the available duration of a channel is always periodic and interleaved with other channels. Once one channel is not available, the bandwidth reserved at each node for the channel in advance is vacant. Benefiting from fine-grained stream dissemination scheme of DiffStream, vacant bandwidth preemption mechanism is introduced to reuse the vacant delivery trees to distribute pending sub-streams in other channels for improving multimedia presentation quality, without reassigning priorities and then building more delivery trees. Meanwhile, vacant bandwidth preemption in multiple channels takes available channels' priorities into consideration.

Each channel has M_i sub-streams, only transfers mi ($m_i \le M_i$) of them and the residual M_i-m_i sub-streams can be disseminated reusing the existing delivery trees using vacant bandwidth preemption mechanism. Suppose channel S_{vacant} is unavailable, m_{vacant} delivery trees of it are vacant for others to occupy. The available channels acquire delivery capacity of m_{vacant} trees in proportion with respective priority value to further disseminate residual M_i-m_i sub-streams. Through this way, channels with various priorities gain specific number of vacant sub-streams, as it is in such formulas:

$$a_i = m_{vacant} \times \frac{P_i \times m_i}{(\sum_{i=1}^{n} P_i \times m_i) - P(S_{vacant}) \times m_{vacant}} \quad (6)$$

$$A_i = \mathrm{Min}(a_i, M_i - m_i) \quad (7)$$

where, a_i indicates how many trees can be obtained for each available channel in theory and A_i is the adjusted value based on practical tree number requirement. If there is still vacant trees through such re-allocations, then polling among all available channels ,also referring to each channel' priority, will get the tree number they need until all vacant trees are reused to transfer other channels' pending sub streams. The pseudo code is described as follows:

As is shown in Fig. 3, if S_2 is not in the process of dissemination for some reason, according to dynamic preemption mechanism, S_1 occupies two delivery trees (colored in blue) originally reserved for S_2 to disseminate its residual sub streams for better presentation quality at receivers, S_n one tree(in light green) and other sources certain number based on Eq. 6 and 7.

PERFORMANCE EVALUATION

Simulation setup: The performance of DiffStream strategy is demonstrated by means of simulation in NS2 network simulator (http://www.isi.edu/nsnam/ns/). The entire overlay peers are attached to a set of the stub nodes

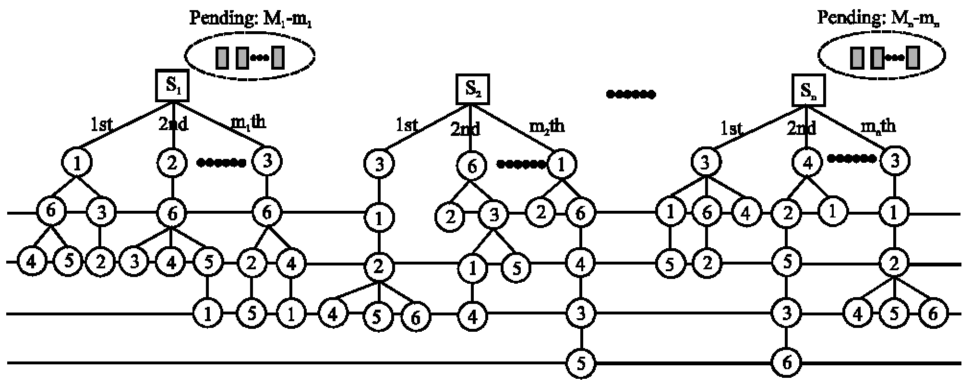

Fig. 3: Vacant bandwidth preemption in multiple available channels

(at the verge) in GT-ITM technology that is used in a variety of ways, most often to create topologies. The simulation sets the overlay processing delay value as 40 msec and the overlay peers are attached to the stub nodes with an access delay of 20 msec. Therefore, the total relay latency caused by crossing an overlay node is 80 msec (40 msec + 20 msec *2). The overall node degree threshold D(v) is set up to be 30. In the simulation, several multicast channels are built on the same overlay network, with dynamic session durations.

RESULTS ANALYSIS

The experiment includes three scenarios functioning to demonstrate: (1), effectiveness of service differentiation in channels with varying priorities; (2), the relation of communication delay cost and varying MQRs and (3), benefits of vacant bandwidth preemption mechanism in terms of throughout and communication delay cost. Three scenarios are designed to prove the availability about above objectives in simulation environment.

Scenario 1: Service differentiation: The first scenario is implemented on overlay topology with nodes scale ranging from 10 to 50 with the step 5 and compares overall communication delay cost in three channels. Two groups of simulation are carried out to depict availability of bandwidth reservation for service differentiation. Meanwhile we define MQR of all three sessions to be exactly 1 in this scenario, that is to say, all sub-streams encoded by MDC technology from each channel stream data are distributed without part of them pending. For the first group, three channels have the same priority and their priorities are all set to 5. From its simulation result shown in Fig. 4a, we can see that three channels have close delay cost. Since, all sub streams encoded from the three channels share the same bandwidth and deliver along similar delivery tree, average delay of overlay nodes are pretty much the same. For the second group, channel priorities are set to 7, 5 and 3, respectively. The simulation result is shown in Fig. 4b, from which the channel with the highest priority, say S_1, has lowest delay cost while S_3, with lowest priority has greatest delay and S_2 between them both in priority and delay. Since, more bandwidth reservation has done for the high priority channel, or rather for sub stream of the channel and the delivery trees have more real upload degree reserved than the delivery tree in low priority channel does. Therefore, we can such conclude that the higher priority one channel has, the lower delay cost it achieves and vice versa.

Scenario 2: delay in relation to MQR: The second scenario aims to demonstrate the relationship between communication delay cost and the factor of MQR. The scenario is divided into two groups. Group 1 is designed over three channels with the same priority of 5 and the overlay node scales from 10 to 50 with the step 5. Channels 2 and 3 have constant MQRs, while channel 1 has its MQR set to 1, 0.75 and 0.5, respectively. From what have illustrated in Fig. 5a, channel 1 has varying delay cost corresponding to the changed MQRs. The smaller the MQR value is, the lower the delay cost is. This is because when MQR of channel 1 increases, total number of sub streams in delivery is increased consequently; then each sub stream will have less reserved bandwidth and delay cost increases accordingly. As for group 2, there are two channels with priorities of 7 and 5. The MQRs for them are set up to 1, 0.75 and 0.5, respectively. The simulation results are shown in Fig. 5b; Fig. 5 shows the comprehensive relationship between communication delay cost and MQR with the influence of channel priority. As what is illustrated, the channel with lower MQR and higher priority value will achieve lowest communication delay. This result is apparent taking the

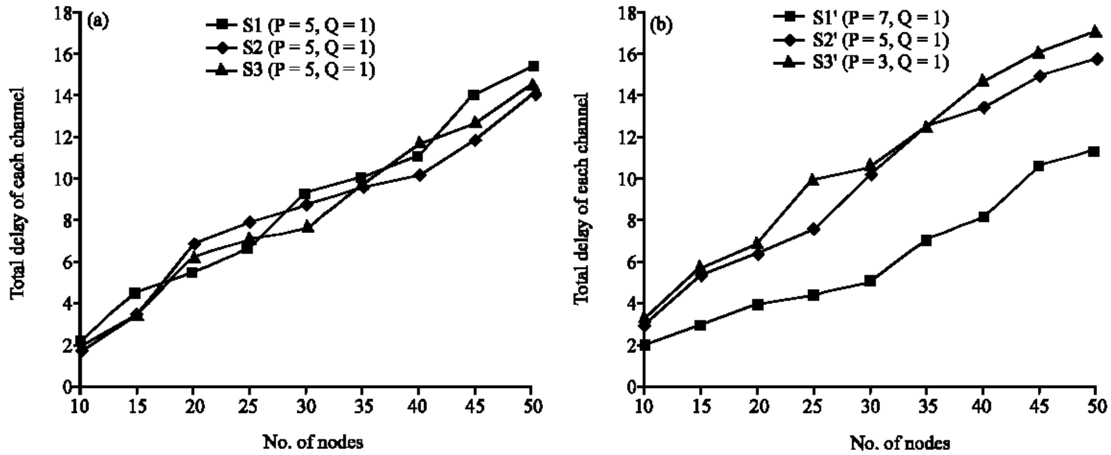

Fig. 4: Relationship between delay and priority

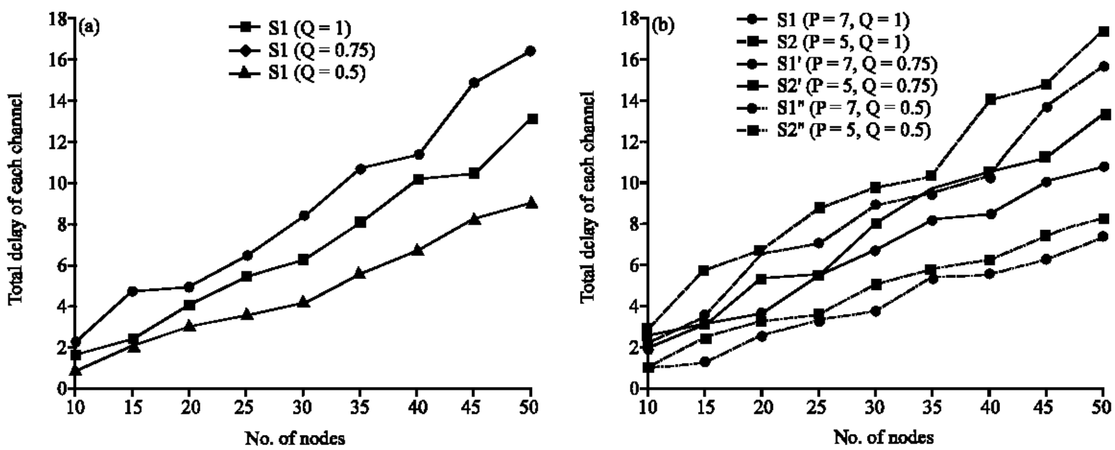

Fig. 5: Comprehensive relationship among priority, MQR and delay

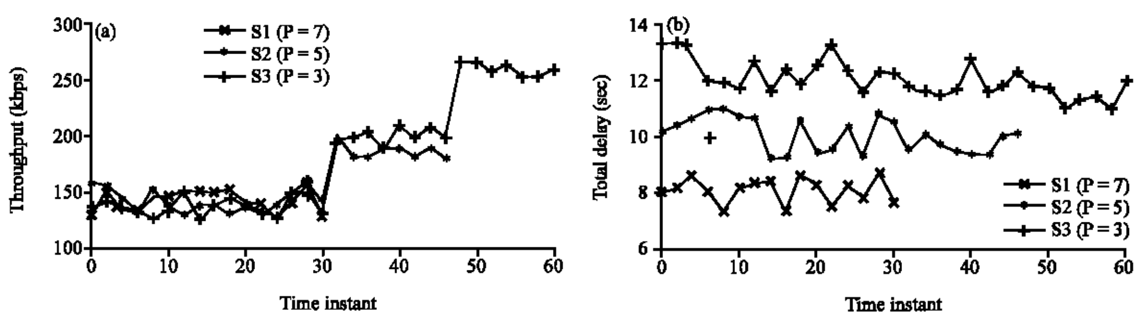

Fig. 6: Vacant bandwidth preemption mechanism

above experiment as the foundation. Over limited upload bandwidth, greater priority value lead to more reserved bandwidth and less MQR value can also result in even more bandwidth reserved in advance and then less delay cost is produced consequently.

Scenario 3: Vacant bandwidth preemption: In this scenario, vacant bandwidth preemption mechanism is simulated on overlay node scale of 50 for three channels with priorities of 7, 5 and 3 respectively. At the beginning, each channel transfers only 2 of total 4 sub streams according to their MQRs, namely, MQR is set to 0.5 for all.

Figure 6a shows average throughput and latency for each channel as time goes in one minute. At time period 0-30 sec, three sources transmitting 2 sub streams along their forest based dissemination topology; then an equilibrium is reached. At time instant 30, S_1 exits and leaves 2 vacant delivery trees for S_2 and S_3. In the following 16 sec, S_2 and S_3 acquire more throughout by occupying 1 vacant tree belonging to S_1 originally with dynamic preemption mechanism adopted. After that, S_2 and S_3 have both have 3 sub streams in dissemination. Then at time instant 46, S_2 exits the dissemination process, leaving more bandwidth for S_3 causing all 4 sub streams of it to be disseminated. Vacant bandwidth preemption in multiple channels refers to channel priorities. Figure 6b shows each channel has stable latency all the time in the bandwidth preemption process because S_2 and S_3 both preempt delivery tree with high-priority, avoiding extra latency induced probably by reserved delivery tree built for low-priority source.

CONCLUSIONS

This study analyzes the dilemma confronted in multiple channels dissemination system to find that it is not necessary to transmit all stream data of each channel according to real application. By distributing part instead of all sub-streams of each channel, related to specific multimedia presentation quality, the size of bandwidth consumption can be cut down to some extent and it's an effective method providing relatively low delay cost to huge amounts of data communication in bandwidth-limited overlay network. Furthermore, priority-based bandwidth allocation is applied at the peers to assign up load bandwidth of delivery trees in advance, guaranteeing effectively that service quality of a channel with high priority is better than that with lower priority. As for specific tree construction algorithms, the study proposes in detail related upload degree constraints referring to originally reserved bandwidth for trees construction. Besides, highlight of DiffStream involves vacant bandwidth preemption mechanism. That is, the vacant bandwidth produced by multi-channel application system can be reused to serve other available channels to enhance their multimedia presentation qualities. Multiple available channels then occupy the vacant bandwidth referring to each own priority; the real number of vacant trees acquired by each available channel is confirmed through negotiation between the number calculated, considering each channel's priority and the number in need. With the examples, analysis and experimental results, DiffStream strategy proves to supply service differentiation of multiple channels and achieve low-delay communication. The positive experimental results have revealed the effectiveness of DiffStream in multi-channel media content dissemination system. The future work includes implementing DiffStream strategy in our bluesky distance collaboration system project, which has been deployed at junior and high schools in the midwest China for remote education. And this project is an open source project (http://incubator.apache.org/bluesky/) which is being incubated in Apache Software Foundation.

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REFERENCES

Akkus, I.E., M.R. Civanlar and O. Ozkasap, 2006. Peer-to-peer multipoint video conferencing using layered video. Proceedings of the IEEE International Conference on Image Processing, Oct. 8-11, Atlanta, GA., pp: 3053-3056.

Akkus, I.E., O. Ozkasap and C.M. Reha, 2007. Multi-objective optimization for peer-to-peer multipoint video conferencing using layered video. roceedings of the Packet Video 2007, Nov. 12-13, Lausanne, Switzerland, pp: 182-190.

Clevenot, F., P. Nain and K.W. Ross, 2005. Multiclass P2P networks: Static resource allocation for bandwidth for service differentiation and bandwidth diversity. Performance Evaluat., 62: 32-49.

Goyal, V.K., 2001. Multiple description coding: Compression meets the network. IEEE Signal Process. Maga., 18: 74-94.

Gupta, M. and M. Ammar, 2003. Service differentiation in peer-to-peer networks utilizing reputations. Group Commun. Charges, 2816: 70-82.

Hei, X., C. Liang, J. Liang, Y. Liu and K.W. Ross, 2007. A measurement study of a large-scale P2P IPTV system. IEEE Trans. Multimedia, 9: 1672-1687.

Ma, R.T.B., S.C.M. Lee, J.C.S. Lui and D.K.Y. Yau, 2006. A game theoretic approach to provide incentive and service differentiation in P2P networks. IEEE ACM Trans. Network., 14: 978-991.

Nakamura, Y., H. Yamaguchi, A. Hiromori, T. Higashino and K. Taniguchi, 2003. On desiging end-user multicast for multiple video sources. Proc. Int. Conf. Multimedia Expo., 3: 497-500.

Padmanabhan, V.N., H.J. Wang, P.A. Chou and K. Sripanidkulchaik, 2002. Distributing streaming media content using cooperative networking. Proceedings of the 12th International Workshop on Network and Operating Systems Support For Digital Audio and Video, May 12-14, Miami, Florida, USA., pp: 177-186.

Wu, C. and B.C. Li, 2007. Diverse: Application-layer service differentiation in peer-to-peer communications. IEEE J. Selected Areas Commun., 25: 222-234.

Wu, C., B. Li and S.Q. Zhao, 2008. Multi-channel live P2P streaming: Refocusing on servers. Proceedings of the 27th IEEE Conference On Computer Communications, Apr. 13-18, Phoenix, AZ., pp: 1355-1363.

Xuan, Z., L. Chongrong and L. Xing, 2008. Hybrid multicast scheme for many-to-many videoconferencing. Networked Comput. Adv. Inform. Manage., 2: 482-487.

Zhang, X., C. Li, X. Li and C. Bao, 2008. Multicast congestion control on many-to-many videoconferencing. Proceedings of the 2008 2nd International Conference on Future Generation Communication and Networkin, Dec. 13-15, IEEE Computer Socity, pp: 260-263.