A New Fast P2P Video Transmission Method Applied in Asymmetrical Speed Channel Environment

Zhang Wang, Jixian Zhang, Haitao Li, and Jian Liu

Abstract: **In an asymmetrical speed channel environment like asymmetric digital subscriber line, the up-link bandwidth is normally smaller than the down-link bandwidth, which will lead to extremely low utilization of down-link bandwidth when current P2P video transmission is applied. To overcome this, a new fast P2P video transmission method applied in an asymmetrical speed channel environment is proposed in this paper. On the basis of the many-to-one concept, the proposed method uses a new multi-peer aggregation technique to enhance the utilization of down-link bandwidth. In addition, an adaptive peer assignment algorithm is also introduced in order to minimize the overall transmission time. Experimental results show that by using our proposed method, the utilization of down-link bandwidth is significantly improved, and the overall transmission time is greatly reduced.**

Index Terms: **Asymmetrical speed channel, multi-peer aggregation, peer assignment, peer-to-peer (P2P), video transmission.**

I. INTRODUCTION

Peer-to-peer (P2P) overlay networks have emerged as the most dominant source of traffic in the Internet today [1]. Their inherent bandwidth scalability and robustness to single point failures have made them very attractive for content sharing applications among large populations of peer host computers [2]. Unlike traditional content distribution systems based on pure client/server model, P2P networks are self-organized networks that aggregate large amount of heterogeneous computers called nodes or peers (they are inter-changeable in this paper). In P2P systems, peers can communicate directly with each other for the sharing and exchanging of data resources, and each peer is a client and a server at the same time [3]. This property makes the P2P system a better choice for video transmission over IP networks.

Considering a typical P2P-based video streaming application over IP networks, one of the macroscopic features is that, a single receiver peer receives the same video content from multiple sender peers in the whole streaming period, and another microscopic feature of it is that, the receiver peer is receiving one video piece from only one sender peer at any specific time. As a result, we can see that, the real time down-link bandwidth is always less or equal to the up-link bandwidth of the sender peer at that moment.

From the aspect of the transmission channel speed over data communication network, we coarsely classify all channels into two categories: Symmetrical speed channel (e.g., symmetric digital subscriber line (SDSL), and asymmetrical speed channel (e.g., asymmetric digital subscriber line (ADSL)). Further, the main difference between them is that, for SDSL channel, the up-link bandwidth is equal to the down-link bandwidth, while for ADSL channel, it is much smaller than the down-link bandwidth.

When P2P-based video streaming is applied in the SDSL channel environment, since the real time down-link bandwidth (be equivalent to up-link bandwidth) is close to the maximal down-link bandwidth, the utilization of down-link bandwidth is very high. While for ADSL channel environment, the real time down-link bandwidth is much smaller than the rated down-link bandwidth, which will result in very low utilization of the down-link bandwidth.

In order to overcome this problem, we propose a new fast P2P-based video transmission method applied in an asymmetrical speed channel environment in this paper. The proposed method introduces a new technique named multi-peer aggregation (MPA) to enhance the utilization of the down-link bandwidth. The main concept of MPA is based on the many-to-one mode, which means the video pieces from several sender peers should be aggregated first, and then be transmitted to the receiver peer at the same time. In addition, an adaptive peer assignment algorithm is also introduced to minimize the overall transmission time. It employs two factors, aggregation saturation and aggregation intensity, and they are used for determining the number of sender peers that should be aggregated in each turn.

The rest of this paper is organized as follows. Section II presents some related works, and in Section III, the features of ADSL channel environment and P2P-based video application network are introduced first; then, a typical transmission model of P2P video streaming over ADSL channel is also described. Section IV describes our proposed fast P2P video transmission method with the MPA scheme and the adaptive peer assignment algorithm. Simulation results are presented in Section V and the conclusion is drawn in Section VI.

II. RELATED STUDIES

Video transmission over P2P networks attracts many researchers and research activities. For instance, Reza *et al.* have proposed a framework P2P adaptive layered streaming

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(PALS) [4], with a receiver coordinates delivery of layer encoded stream from multiple senders. A peer selection criterion has also been proposed on the basis of the overall effective throughput, but there is no information available in the very beginning, so initial peers are selected on random basis. Padmanabhan *et al.* proposed a system for live and on-demand media streaming using multiple description coding (MDC) layers which presents better performance in flash crowd [5]. Many other researchers have discussed different aspects of P2P media streaming. In literature [6], congestion control mechanisms using bandwidth estimation models have been proposed. In literature [7], a TCP-friendly rate allocation algorithm for multiple sub-stream coding combined with path diversity has been proposed where each sender sends different streams following different paths. Hefeeda proposed a mechanism for P2P media streaming using collectcast that collaborates with multiple sender peers for media streaming [8]. A comparison is done between two selection techniques. In the topology-aware selection technique, all shared communication links are considered for the best selection of sending peers. On the other hand, in end-to-end selection technique, these shared segments are not considered. Topology-aware selection provides better results as it is based on congested links but it offers an overhead of considering each shared path in the network.

In addition, many researches on the P2P architecture are also proposed [9]–[11]. As remedies to IP multicast, some pioneers advocate P2P application layer multicast algorithms including hyper media transport protocol (HMTP) [12] and split-stream [13]. Since tree-based approaches are vulnerable with dynamic group variation, gossip based unstructured framework has become popular owing to its inherent robustness, such as probabilistic resilient multicast (PRM) [14], data-driven overlay network (DONet) [15], etc.

Among these research works discussed above, we find that, they all focus on the basic architecture or video application features of P2P technique, but they do not consider the accordance with transmission channel environments. Hence, this paper addresses the P2P transmission technique over the channel environment of asymmetrical speed and the efficient transmission method to achieve better transmission performance.

III. TRANSMISSION MODEL

In this section, we first introduce the feature of ADSL channel and the principle of P2P-based video networking application, and then a typical transmission model of P2P video streaming over the ADSL channel is built and described in detail.

ADSL [16] is an important variation of digital subscriber line (DSL) family of technologies. It provides both normal telephone service and high-speed digital transmissions on an existing telephone line. This allows a single existing twisted-pair copper wire to carry.

1) Normal telephone communications in the 0 to 4 kHz range
2) Data upload from the terminal in 22 kHz to 138 kHz range
3) Data download to the terminal at up to 1104 kHz

Fig. 1 shows the partitions of ADSL frequency spectra.

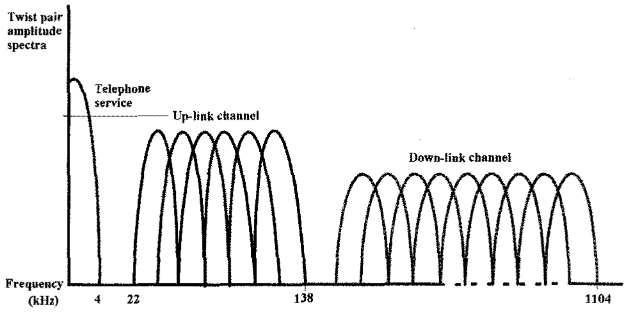


Fig. 1. Partitions of ADSL frequency spectra.

The main modulation method used in ADSL channel is discrete multi-tone (DMT) modulation [17]. The basic idea of it is to split the available bandwidth into a large number of sub-channels which are further divided into two groups, one for up-link and the other for down-link. Hence in ADSL, the available bandwidth of 1104 kHz is split into 256 sub-channels, and about 25 sub-channels are assigned to the up-link channel group while the rest of them are assigned to the down-link channel group. The bandwidth of each sub-channel, B_{sc}, is computed as

$$B_{sc} = 1104/256 \approx 4\,\text{kHz} \tag{1}$$

where a short part of B_{sc}, 0.3125 kHz, is reserved to avoid the interference with adjacent sub-channels.

Assuming that each bandwidth can carry n $(0 < n < 15)$ bits, the transmission bit-rate of the ith sub-channel, R_i, is given by

$$R_i = B_{sc} n_i = 4n_i \ (\text{kbit/s}),\ 0 < i \leq 256 \tag{2}$$

where n_i is the number of bits the ith sub-channel carries.

With (2) and Fig. 1, the maximal speeds of up-link and down-link channels, R_{ul} and R_{dl} are computed as follows:

$$R_{ul} = R_6 + R_7 + \cdots + R_{31} = \sum_{i=6}^{31} R_i = 4\sum_{i=6}^{31} n_i \tag{3}$$

$$R_{dl} = R_{33} + R_{34} + \cdots + R_{256} = \sum_{j=33}^{256} R_j = 4\sum_{j=33}^{256} n_j. \tag{4}$$

Hence, under the condition of $n_i = n_j$ for all sub-channels, the ratio of down-link and up-link speed is

$$\lambda = \frac{R_{dl}}{R_{ul}} = \frac{4\sum_{i=6}^{31} n_i}{4\sum_{j=33}^{256} n_j} \approx 8. \tag{5}$$

The P2P video networking applications mainly have two types of architecture: Pure-P2P and hybrid-P2P. Compared with the former one, the latter one has better stability by using the centralized server called tracker. The main function of tracker is to register and manage all nodes in the network. Now, for illustration, we assume that P_0 is a receiver peer that requests the coded video content bit-stream video pieces (VC) (consisting of VC $vc_1 - vc_4$) from multiple sender peers $P_1 - P_4$. Fig. 2 shows the process flow of P2P video networking application.

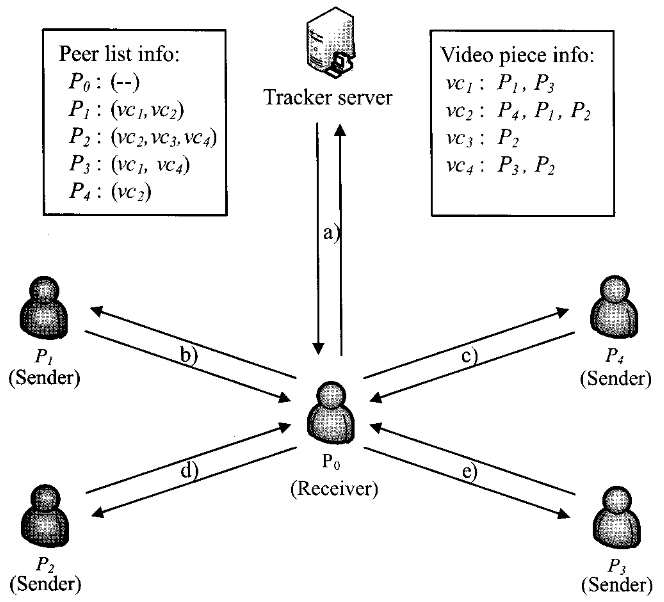


Fig. 2. Process flow of P2P video networking application.

As shown in Fig. 2, when P_0 is requesting for the coded bit-stream VC, the tracker generates two kinds of information tables: Peer list info (PLI) and video piece info (VPI). The PLI table records all the peers containing video bit-stream and which pieces they have, while the VPI table records all available video pieces and part of candidate peers for each video piece. Main steps of the process flow in Fig. 2 are as follows:

a) P_0 sends a registration message to the tracker, and requests for coded bit-stream VC. The tracker generates and returns the PLI and VPI tables.
b) P_0 analyzes the feedback tables, and asks for the first video piece, vc_1 , from P_1 (or P_3, chosen by a peer assignment algorithm). Then, P_1 sends vc_1 to P_0.
c) P_0 asks for the second video piece vc_2 from P_4.
d) P_0 asks for vc_3 from P_2 , and then P_2 sends it to P_0.
e) Finally, P_0 asks for last video piece vc_4 from P_3.

From the description given above, we know that the video bit-stream is transmitted piece by piece in each step. For play-while-downloading video applications, there exists a restriction: video pieces should be transmitted orderly, while for play-after-downloading applications, such a restriction does not exist.

According to previous sections, we obtain following two conclusions:

1) In ADSL channel, the maximal bandwidth of up-link is much smaller than that of down-link, and the ratio is equal to λ.
2) In P2P-based video streaming application, the video content is transmitted piece by piece for each step.

Now we consider the P2P video transmission model over the ADSL channel. In this model, we assume that all peers in the P2P video network are ADSL nodes, which means the maximal up-link speed of a sender peer, R_{ul}, is always much smaller than the maximal down-link speed of a receiver peer, R_{dl}, as defined in (3).

Given following definitions, we extend the process in Fig. 2 to a general case: P_0 is the receiver peer and $P_1 - P_n$ are sender peers. The coded video content bit-stream VC, is divided into a number of m video pieces with the same size, we have

$$VC = vc_1 + vc_2 + \cdots = \sum_{i=1}^{m} vc_i,\ vc_i = \frac{VC}{m}. \tag{6}$$

$t(i)$ is the time slot for transmitting vc_i, $j = \varphi(i)$ denotes the index number of sender peer to transmit vc_i, R_0, $t(i)$ and R_j, $t(i)$ are the real-time speeds of P_0 and P_j in the time slot $t(i)$, respectively. Thus,

$$R_{j,t(i)} \leq R_{ul} \ll R_{ul},\ t(i) = \frac{vc_i}{R_{\varphi(i),t(i)}}. \tag{7}$$

Equation (6) represents that R_0, $t(i)$ is always equal to $R_{\varphi(i),t(i)}$, which means the real-time down-link speed of P_0 is determined by the up-link speed of P_j that being chosen for sending the ith video piece vc_i.

For all video pieces, the total transmission time T is given by

$$T = t(1) + t(2) + \cdots + t(m) = \sum_{i=1}^{m} t(i) = \sum_{i=1}^{m} \frac{vc_i}{R_{\varphi(i),t(i)}}. \tag{8}$$

The average transmission speed, $\overline{R_0}$, is given by

$$\overline{R_0} = \frac{VC}{T} = \sum_{i=1}^{m} vc_i \Big(\sum_{i=1}^{m} \frac{vc_i}{R_{\varphi(i),t(i)}}\Big)^{-1}. \tag{9}$$

The average utilization of down-link bandwidth of P_0 is computed as

$$\mu = \frac{\overline{R_0}}{R_{dl}} = \sum_{i=1}^{m} vc_i \Big(R_{dl} \sum_{i=1}^{m} \frac{vc_i}{R_{\varphi(i),t(i)}}\Big)^{-1} \tag{10}$$

with (4), and $R_{\varphi(i),t(i)} \leq R_{ul}$, we have

$$\mu \leq \sum_{i=1}^{m} vc_i \Big(R_{dl} \sum_{i=1}^{m} \frac{vc_i}{R_{ul}}\Big)^{-1} = \Big(\frac{R_{dl}}{R_{ul}}\Big)^{-1} = \lambda^{-1}. \tag{11}$$

Equation (10) represents that the P2P transmission model over ADSL has extremely low utilization of down-link bandwidth, which makes the video streaming application very inefficient.

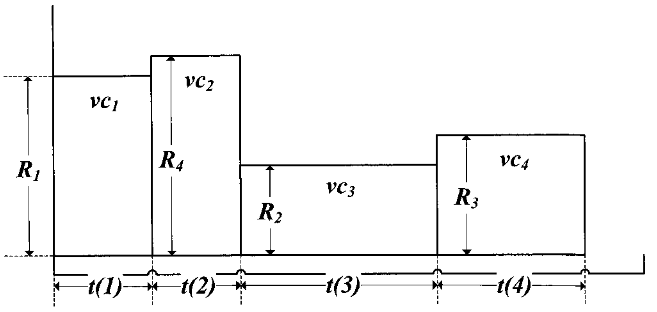
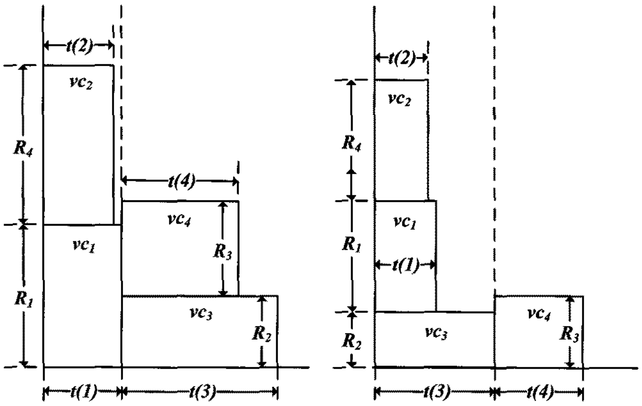


Fig. 3. Data transmission flow of current P2P method.



(a) (b)

Fig. 4. Two cases of MPA method: (a) Case 1 and (b) case 2.

IV. PROPOSED SCHEME

In this section, we describe our proposed fast P2P video transmission scheme with the MPA method and adaptive peer assignment algorithm.

Before explaining the principle of MPA, we briefly retrospect the data transmission flow of current P2P method as illustrated in Fig. 2. Assuming that $R_2 < R_3 < R_1 < R_4$, Fig. 3 shows the data transmission flow related to Fig. 2.

As shown in Fig. 3, since $c_i = t(i)R_{\varphi(i)}$ in (6), all rectangular boxes have the same area, and each one is regarded as a video piece. The transmission order for P_0 is ranked as follows: $(vc_1, R_1) \rightarrow (vc_2, R_4) \rightarrow (vc_3, R_2) \rightarrow (vc_4, R_3)$, where $(vc_i, R_{j=\varphi(i)})$ means the video piece vc_i is sent by P_j with speed of R_j for the ith step.

The main concept of MPA method is based on the many-to-one mode, which means the video pieces from several sender peers should be aggregated first at each step, and then be transmitted to receiver peer at the same time. For example, as derived from Fig. 3, we can achieve two different MPA cases by assuming that one step can send no more than three video pieces. Further, Fig. 4 shows these two cases described as follows:

Case 1

a) In the first step, video pieces vc_1 from P_1 and vc_2 from P_4 are aggregated and sent to P_0 at the same time.
b) Similarly, in the second step, video pieces vc_3 from P_2 and vc_4 from P_3 are also aggregated and sent to P_0 at the same time.

Case 2

a) In the first step, video pieces vc_1 from P_1, vc_2 from P_4 and vc_3 from P_2 are aggregated and sent to P_0 at the same time.
b) In the second step, only video piece vc_4 from P_3 is sent to P_0.

For case 1 in Fig. 4(a), it is obvious to see that, the total transmission time $T_{case1} = t(1) + t(3)$, and the average transmission speed is VC/T_{case1}. Hence, the saved transmission time ΔT_{case1} and the increased average transmission speed $\Delta \overline{R}_{case1}$ are as follows:

$$\Delta T_{case1} = \sum_{i=1}^{4} t(i) - T_{case1} = t(2) + t(4) \quad (12)$$

$$\Delta \overline{R}_{case1} = VC\Delta T_{case1}(T_{case1}\sum_{i=1}^{4} t(i))^{-1}. \quad (13)$$

Similarly, for case 2 in Fig. 4(b), we have $T_{case2} = t(3) + t(4)$. Hence, ΔT_{case2} and $\Delta \overline{R}_{case2}$ are given by

$$\Delta T_{case2} = \sum_{i=1}^{4} t(i) - T_{case2} = t(1) + t(2) \quad (14)$$

$$\Delta \overline{R}_{case2} = VC\Delta T_{case2}(T_{case2}\sum_{i=1}^{4} t(i))^{-1}. \quad (15)$$

Furthermore, as we know $R_3 < R_1, t(4) > t(1)$, and $\Delta \overline{R}_{case2} < \Delta \overline{R}_{case1}$ means case 1 has the larger average transmission speed than case 2 and better efficiency of transmission.

From the description given above, we know that the MPA method is able to save the total transmission time and increase the average down-link speed of the ADSL channel. We also find that case 1 in Fig. 4(a) has a better efficiency of transmission than case 2 in Fig. 4(b), which should be attributable to the more rational peer assignment result of case 1. Here, we give an intensive analysis of both cases with respect to their different peer assignments.

In case 1, the peer assignment process is as follows: The peers P_1 and P_4 are assigned and aggregated for sending vc_1 and vc_2, while P_2 and P_3 are assigned for vc_3 and vc_4. The transmission time for sending vc_1 and vc_2 is $t(1)$, and for sending vc_3 and vc_4 is $t(3)$. Since $R_1 < R_4$, the aggregating part of transmission time T_{ap} is equal to $t(2)$ in the first step and $t(4)$ in the second step, and the non-aggregating part T^{nap} is

$$T^{nap}_{case1} = vc(\frac{R_4 - R_1}{R_1 R_4} + \frac{R_3 - R_2}{R_2 R_3}). \quad (16)$$

Similarly, in case 2, the peers P_1, P_4, and P_2 are assigned and aggregated for sending vc_1, vc_2, vc_3, and P_3 is for vc_4. Hence,

$$T^{nap}_{case2} = vc(\frac{R_1 - R_2}{R_1 R_2} + \frac{1}{R_3}). \quad (17)$$

In the first step in case 2, the transmission time for sending $vc_1 - vc_3$ is $t(3)$, but in case 1, it takes $t(1) + t(3)$ to send the same video pieces. As a result, case 2 costs less transmission time than case 1, and the reason is that, case 2 aggregates three peers which is more than case 1 for this step. Hence, we have the first conclusion: A higher number of aggregated peers for each step should result in less transmission time.

Comparing (14) with (13), since $R_2 < R_4$ as shown in Fig. 3, the sum of $T({}_nap)$ in case 1 is much smaller than in case 2, which results in well aggregating transmission in each step and a better efficiency of total transmission. Hence, we have another conclusion: A smaller non-aggregating transmission time should result in better efficiency of total transmission.

Now we obtain two important conclusions used to design the optimal peer assignment algorithm. First, we give the following definitions.

Definition 1: Aggregation scalability-the number of aggregated peers for each transmission step, and it is denoted as

$$K = \{k_i | i = 1, 2, \cdots, L\},\ 0 < k_i < \lambda \quad (18)$$

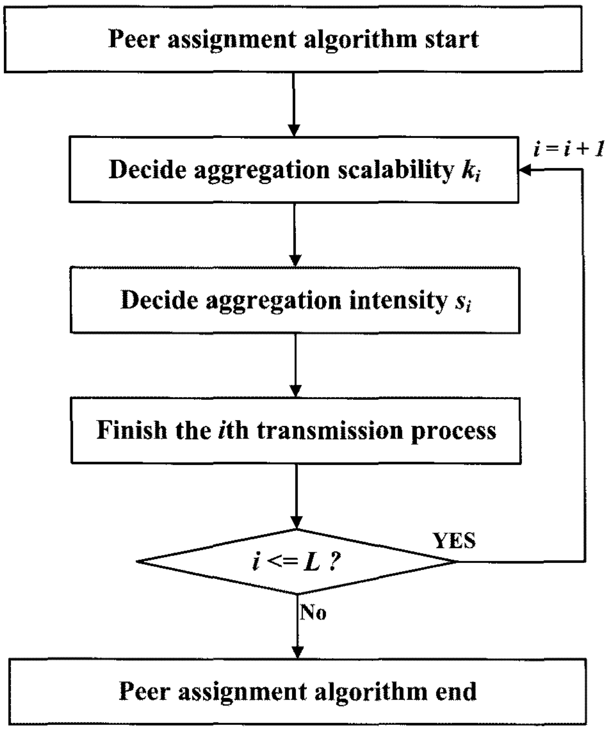


Fig. 5. Process flow of the peer assignment algorithm.

where L is the total number of steps and λ is the ratio of down-link and up-link speed, as defined in (4).

Definition 2: Aggregation intensity-the sum of absolute difference (SAD) of normalized transmission speed within k_i peers, and it is denoted as

$$S = \{s_i | i = 1, 2, \cdots, L\},\ s_i = \sum_{p=1}^{k_i - 1} \sum_{q=p+1}^{k_i} \frac{|R_p - R_q|}{R_{max}} \quad (19)$$

where R_{max} is the maximal transmission speed of k_i peers.

According to the above definitions, we know that k_i should be maximal but s_i should be minimal for the ith transmission step. Hence, our optimal peer assignment algorithm is based on this concept and Fig. 5 shows the process flow of the algorithm. As shown in Fig. 5, the process of peer assignment algorithm for the ith step mainly includes two sections:

1) Decide aggregation scalability k_i–to calculate the maximal length of a possible constant sequence of video pieces, and each of them must have at least one sending peer that differ from each other.
2) Decide aggregation intensity s_i–to select a group of k_i peers from all possible candidate peers, with condition of having the minimal SAD of the selected k_i peers.

V. SIMULATION EXPERIMENTS

In this section, we evaluate the performance of the proposed scheme which is implemented and embedded in the testing P2P video transmission system, HustVTS, of our lab. It is a powerful software platform having the abilities to distribute, transmit and manage video content over P2P networks.

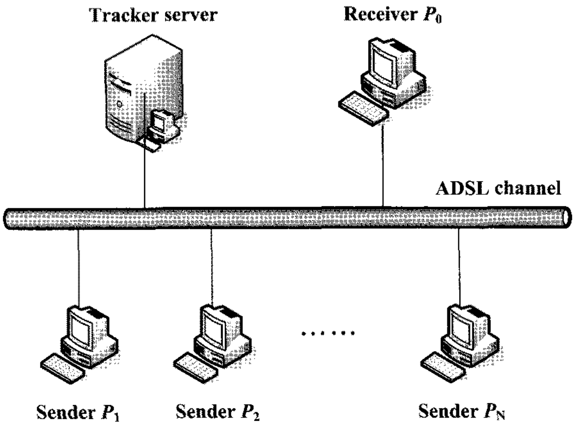


Fig. 6. Network architecture of our experiments.

Table 1. Transmission time results for scenario 1.

K	File size (MB)	NMPA (s)	MPA (s)
2	21.75	618	456
2	87	4816	3852
4	21.75	600	244
4	87	4739	1998

Owing to the restriction of the network conditions, the experimental network architecture is based on our lab local area network (LAN) and Fig. 6 shows the network architecture of our experiments. In order to simulate the ADSL channel environment, both up-link and down-link speeds of each peer in the network are designed as to be configurable in the HustVTS software.

We compare our MPA scheme with the current P2P scheme (called non-MPA) for all experiments, and use two scenarios to measure the separate effect of K and S. Let R_{ui} denote the up-link speed of the sender peer P_i, and R_d denote the down-link speed of the receiver peer P_0 shown in Fig. 6.

Scenario 1: We run the simulation with different values of K and a fixed value $S = 0$.

$(K = 2)$: $R_{u1} = R_{u2} = 40$ kbps, $R_d = 160$ kbps;

$(K = 4)$: $R_{u1} = R_{u2} = R_{u3} = R_{u4} = 40$ kbps, $R_d = 160$ kbps;

Scenario 2: We run the simulation with different values of S and a fixed value $K = 2$.

$(S = 0.00)$: $R_{u1} = R_{u2} = 40$ kbps, $R_d = 160$ kbps;

$(S = 0.25)$: $R_{u1} = 30$ kbps, $R_{u2} = 40$ kbps, $R_d = 160$ kbps;

The video content files employed in the experiments are the typical testing video sequence *City* with CIF and 4CIF formats in the newest SVC standard: *City_cif.yuv* with a size of 21.75 MB and *City_4cif.yuv* with a size of 87 MB.

In simulation experiments, the total transmission time, maximal and minimal real-time down-link speeds of P_0 are collected. The experimental results are listed in Table 1–Table 4.

From simulation results, we find that, the transmission time is less and the down-link speed is larger for all cases (different K and S values, both transmission file) in MPA method, which proves that the overall transmission performance of our

Table 2. Down-link speed results for scenario 1 (kbps).

K	NMPA max	NMPA min	MPA max	MPA min
2	41.2	33.5	54.4	45.9
4	43.6	36.3	97.9	83.7

Table 3. Transmission time results for scenario 2.

S	File size (MB)	NMPA (s)	MPA (s)
0	21.75	618	456
0	87	4816	3852
0.25	21.75	695	671
0.25	87	5441	4598

Table 4. Down-link speed results for scenario 2 (kbps).

K	NMPA max	NMPA min	MPA max	MPA min
2	41.2	33.5	54.4	45.9
4	38.0	28.5	46.4	34.1

Table 5. Statistical results of scenario 1.

K	File size (MB)	NMPA util.	MPA util.	Gain
2	21.75	22.5%	30.5%	8.1%
2	87	23.1%	28.9%	5.8%
4	21.75	23.2%	57.1%	33.9%
4	87	23.5%	55.8%	32.3%

Table 6. Statistical results of scenario 2.

S	File size (MB)	NMPA util.	MPA util.	Gain
0	21.75	22.5%	30.5%	8.1%
0	87	23.1%	28.9%	5.8%
0.25	21.75	20.1%	24.4%	4.3%
0.25	87	20.5%	24.3%	3.8%

proposed MPA method is better than that of the current non-MPA method. The statistical results of the above two scenarios are listed in Table 5 and Table 6.

From the statistical results of scenario 1 in Table 5, we see that, the variation in K value has no impact on the non-MPA method, but induces a visible impact on the MPA method. For instance, the improvement in the down-link bandwidth utilization is about 8.1% at $K = 2$, and it is up to 33% at $K = 4$, which proves that a large value of K could result in much better performance than a smaller one. Fig. 7 shows the comparison histogram related to Table 5, only in the case of small file size.

Similarly, for the statistic results of scenario 2 in Table 6, we also see that, the variation of S value has no impact on the non-MPA method but induces a visible impact on the MPA method. For instance, the improvement of the down-link bandwidth utilization is about 8.1% at $S = 0.00$, and it falls to 4.3% at $S = 0.25$, which proves that a smaller value of S could result in better performance than a larger one. Fig. 8 shows the comparison histogram related in Table 6.

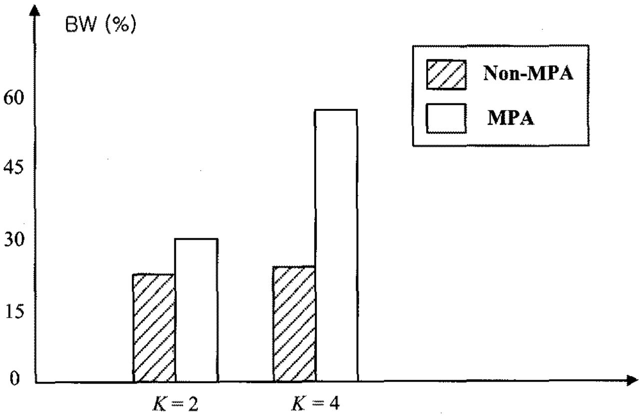


Fig. 7. Comparison histogram related to Table 5.

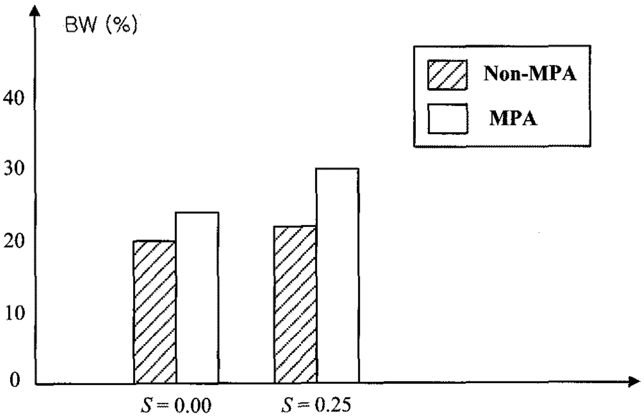


Fig. 8. Comparison histogram related to Table 6.

VI. CONCLUSION

This paper proposes a new fast P2P video transmission scheme in the asymmetrical speed channel environment. On the basis of the many-to-one concept, the proposed method uses a new MPA technique to enhance the utilization of down-link bandwidth. Further, an optimal peer assignment algorithm is also introduced in this paper, which aims to minimize the overall transmission time. Experimental results show that by using MPA method the down-link bandwidth utilization is significantly improved, and the overall transmission time is greatly saved.

We must note that, with the restriction on the external reality of the simulation environment, a group of simple simulation experiments has to be used for testing the proposed scheme. However, the proposed method is proved to be efficient. In future work, we plan to consider much more complex simulation conditions such as the dynamic aggregation scalability and intensity, larger scale network topology, etc.

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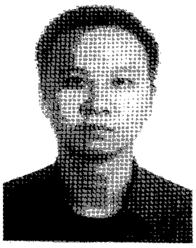

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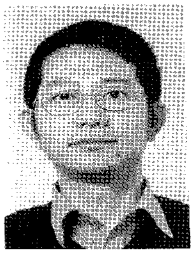

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