Exploring the Policy Selection of P2P VoD System-A Simulation based Research

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***Abstract*—The P2P-assisted video-on-demand (P2P VoD) service has achieved tremendous success among the Internet users. There are three core strategies in the P2P VoD system: the piece selection policy, the peer selection policy as well as the replica management policy. Different from the existing research works that only consider single policy optimization, we for the first time study the existing P2P VoD policies by using a simulation framework to understand the performance of different policy compositions. The simulation results indicate that when the bandwidth and storage resources are limited in the P2P VoD system, the composition of the sequential piece selection policy, the cascading peer selection policy and the proportional replica management policy has the best performance among all different policy compositions. However, when the bandwidth and storage resources are sufficient in the P2P VoD system, there will be little difference between different choices.**

***Keywords*-P2P VoD Streaming; Piece Selection Policy; Peer Selection Policy; Replica Management Policy**

I. INTRODUCTION

The peer-to-peer (P2P) technology has witnessed a great development in the past decade, and is widely used in the area of file sharing, audio and video streaming. Following the pace of Coolstreaming[1], the first practical P2P live media streaming system released in 2004, P2P VoD service has developed for several years, and there have been many P2P VoD system designed for the Internet users, such as PPLive[2], PPVA[3]. Apart from technical design discussions and system measurement work, there still exists some model analysis work on system strategies, such as [4].

The piece selection policy, the peer selection policy as well as the replica management policy are the core strategies of the P2P VoD system[2]. Although these policies have been studied in a great amount of P2P networks before, some fundamental questions are still unknown. In this paper, we are interested in the following questions:(1) *Which policy is more important among the three core strategies of the P2P VoD system?* (2) *Which policy composition will be the best choice for the P2P VoD system?* (3) *How will the bandwidth and storage resources impact the policies choice?* To answer these questions, similar to the design space analysis for the incentive mechanisms in [5], we build a simulation framework to simulate the P2P VoD system with different policies.

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II. P2P VOD POLICY SUMMARY

Many researchers have finished numerous works to study the P2P VoD policies, and proposed plenty of optimization policies to make the P2P VoD system work better. These works are summarized as shown in Table I. In Table I, 5 choices for piece selection policy, 3 ones for peer selection policy and 3 ones for replica management policy are included. It should be noted that we have not and do not intended to collect all the possible choices here since there are numerous optimization policies, and we just select the popular and simple ones here.

About the peer selection strategy, there are still some research works about how the peer fulfills the piece request directed to itself[6]. We suppose these policies can be switched to peer selection policies and get similar effects. Therefore, we concentrate on peer selection strategy in this paper. As for replica management policy, some researchers like [7] also proposed the active replica management policy which will make peers replicate the video files, even if the videos are not watched by these peers. In this paper, we just consider the passive replica management policy that only store the watched video files on their disk passively, in the view of the fact that the active replica management policy is complicated and also tends to be resisted by the users. The replica management policy can replace files in video granularity or piece granularity. Here we will research the policy with video granularity like PPVA[3]. The proportional replicas distribution strategy in Table I will replace videos according to the availability to demand ratio (ATD) [2] and keep videos replica count proportional to the number of watcher.

III. SIMULATION SETUP

In this section, we have built one simulation framework to compare the effect of different policy choices, as well as the performance of different policy compositions. Theoretical model, real system measurement and system simulation are usually used to analyze the performance of the P2P VoD system. However, theoretical model and real system measurement are not proper to research this topic. It is difficult to build a

TABLE I
P2P VoD SYSTEM POLICY SUMMARY

Policy	Approaches	Global Information Requirement	Implementation Difficulty	Evaluation
Piece Selection Policy	Rarest-First	No	Low	Real System
	Sequential	No	Low	Real System
	Probabilistic Method [8]	No	Medium	Simulation
	Window-based Method [9]	No	Medium	Simulation
	Segment Random [10]	No	Low	Simulation
Peer Selection Policy	Random	No	Low	Real System
	Cascading [11]	No	High	Simulation
	Least Loaded First [6]	Yes	High	Simulation
Replica Management Policy	Random	No	Low	Simulation
	LRU [2]	No	Low	Real System
	Proportional [2]	Yes	High	Real System

theoretical model to analyze the three core policies together. The real system measurement is not practical since it is impossible to implement these policies one by one and attract plenty of users to test these systems. Therefore, simulation work is the best choice for the preview research of this topic. Therefore, we build a simulation framework[1] to discuss the problem.

Similar to the design space analysis for the incentive mechanisms in [5], 5 kinds of piece selection policies, 3 kinds of peer selection policies, as well as 3 kinds of replica management policies listed in Table I are implemented in our simulation framework. In every round of simulation, the peers can choose different policies choices, and then combines the chosen policies as the peers' core strategies. Apart from the strategies, there are still some other factors that may influence on the performance of the P2P VoD system, such as, the network bandwidth and storage space of peers, the number of peers and videos. In our simulation, we also take these factors into consideration.

In our simulation, we assume that the network delay is 0 for simplicity[2]. The total simulation time is split into lots of time unit τ. We use t to represent time interval $[t\tau, (t+1)\tau]$, t=0,1,2..., and assume that the peers start requesting new pieces at $t\tau$ and finish downloading those pieces in one time unit τ. New peers will join the system at $t\tau, t = 0, 1, 2...$, and leave the system at $(t+1)\tau, t = 1, 2, 3....$ Assume that there are M videos in the P2P VoD system, and each video has P pieces while one piece's size is 1 with play time $t = \tau$. Hence, in the simulation, one piece will be downloaded or played in one time unit.

N peers, with some storage space filled with replicas, exist in the P2P system at the beginning of our simulation. New peers will join the P2P VoD system with possibility $R_j = 0.1$ in every round, and peers that have not finished watching its video will leave the system with possibility $R_l = 0.05$ in every round, while peers in the P2P VoD system that have finished watching one video will leave the system immediately or stay in the system for another video with possibility $R_f = 0.5$ and $1 - R_f$ respectively. New peers have no video replica on their disk and will request new video to watch from the beginning when they joins the system. Each peers' download and upload capacity is D and U respectively, and D and U are integral multiple of piece size. Therefore, peers can download at most D pieces in a time unit. The peers' sharing disk space is S which is the integral multiple of video size. In practical VoD system, most users will watch just a few popular videos [3]. In our simulation, we use Pareto principle[3] to simulate the video popularity, that is, peers will choose the selected 20% videos with 80% possibility while the other 20% possibility for the rest videos.

In our simulation, we use peers' delayed pieces count to indicate the performance of P2P VoD system. The delayed pieces count can reflect the play continuity of users. For piece k, we can calculate its required download completion time $t_r = t_s + k - s$, where t_s is the time that the peer starts watching video, and s is the piece that the peer starts watching. Besides, the download time t_d of piece k can be recorded in our simulation, then the downloading of piece k is delayed if $t_d < t_r$. The delayed piece count of a peer watching a video is the number of the delayed pieces in the process of watching the video. The peers' delayed piece count distribution is used as the metric of system performance.

To compare the performance of different policies and different policy compositions, 6 series of simulation are done by using different download, upload and storage capacity respectively, as Table II shows. In each series of simulation, there are 5*3*3=45 rounds simulation using different strategies.

The performance of different policy compositions under different network bandwidth and storage conditions is measured after 45 * 6 rounds of simulation, and we will analyze the simulation result in the next section.

IV. SIMULATION RESULT ANALYSIS

During our simulation, we first make two of the three core policies as fixed input, then compare the performance of different possible choices for the rest policy. Then, we compare the effect of different policy compositions under different circumstances. In the end, further discussion and comparison with other works are presented.

[1]The code of our simulation is shared at http://code.google.com/p/p2p-vod-simulation/

[2]In fact, network delay may have a mandatory influence in the peer connections, and could also influence the simulation results.

[3]http://en.wikipedia.org/wiki/Pareto_principle

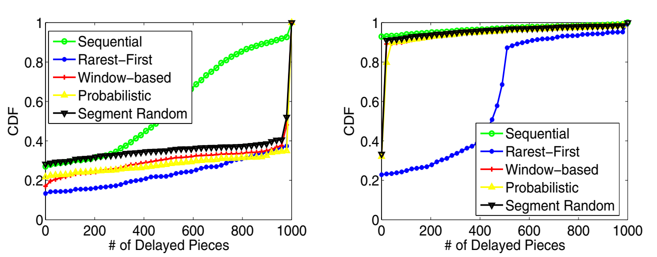
TABLE II
SIMULATION SCENARIOS SUMMARY

Scenarios	Download Capacity	Upload Capacity	Storage Capacity
Bandwidth limited scenario without extra replica space	1	1	1
Bandwidth limited scenario with limited replica space	1	1	2
Bandwidth limited scenario with sufficient replica space	1	1	4
Bandwidth sufficient scenario without extra replica space	2	2	1
Bandwidth sufficient scenario with limited replica space	2	2	2
Bandwidth sufficient scenario with sufficient replica space	2	2	4

A. *Different Single Policy Performance Comparison*

In this subsection, the performance of different piece selection policies, different peer selection policies and replica management policies in different scenarios are compared. In the simulation, we assume that the initial peer count $N = 1000$, the sharing video count $M = 100$ and the new peer join rate $R_j = 0.1$ in the P2P VoD system. When we look insight into one policy, the other two policies will just use the same policy as input.

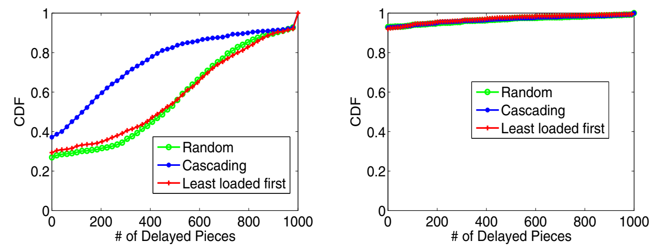
The delayed piece count distribution of peers with different piece selection policies in different scenarios is shown in Figure 1. It is obvious that the sequential policy will achieve the best play continuity with the least missed pieces under all circumstances. The rarest-first policy has the worst performance in all scenarios. As for the other three policies, their missed pieces count cumulative distribution lines lie between those of the sequential policy and the rarest-first policy. When the bandwidth resource is limited, the other three policies will have the performance similar to the rarest-first policy and be much worse than the sequential policy, but they will have the effect similar to the sequential policy when the bandwidth resource is sufficient in the P2P VoD system.



(a) Scenario with Limited Bandwidth and No Extra Storage (b) Scenario with Limited Bandwidth and Sufficient Storage

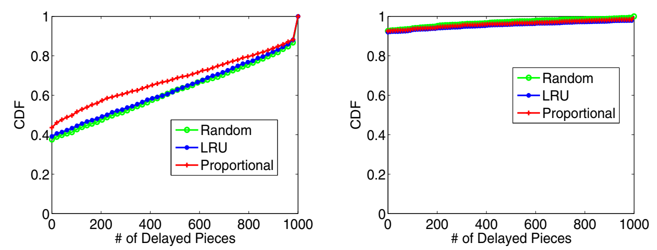
Fig. 1. Piece Selection Policy Performance Comparison

Figure 2 indicates that the performance of different peer selection policies do not have so many differences as that of different piece selection policies. When the bandwidth resource of the P2P VoD system is limited, the cascading peer selection policy will have better performance than the other policies, since the cascading peer selection policy will select peers by using scheduling algorithm to make the best use of peers' upload bandwidth. Similar to the peer selection policy, the simulation result in Figure 3 shows that the performance of different replica management policies will have similar effects when the bandwidth resource is sufficient. When the system's bandwidth resource is limited, the proportional replica management policy will have better performance than the random policy as well as the LRU policy.



(a) Scenario with Limited Bandwidth and No Extra Storage (b) Scenario with Sufficient Bandwidth and Sufficient Storage

Fig. 2. Peer Selection Policy Performance Comparison



(a) Scenario with Limited Bandwidth and Storage (b) Scenario with Limited Bandwidth and Sufficient Storage

Fig. 3. Replica Management Policy Performance Comparison

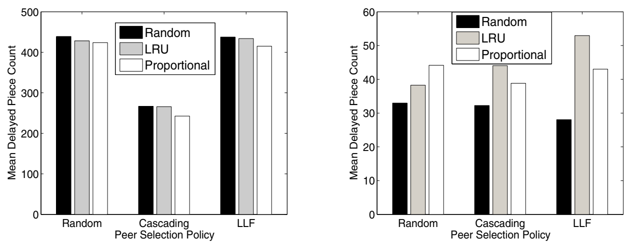
The single policy performance comparisons above all indicate that there is little difference among different policy choices if the bandwidth and storage resources are sufficient, and the performance difference will decrease as the resources grow. Therefore, if the network bandwidth and sharing disk space of peers are enough, the play continuity of peers will achieve the best effect even if we just use the simplest piece selection, peer selection and the replica management policies.

B. *Different Policy Composition Performance Comparison*

In this subsection, the performance of the P2P VoD system with different policy compositions will be simulated. Since the sequential policy is definitely the best choice for piece selection policy, therefore, we keep using sequential piece selection policy and change the peer selection and replica management policies. The performance of 3*3 compositions in total is measured in our simulation. Two scenarios are

TABLE III
SIMULATION SCENARIOS SUMMARY

P2P VoD System	**Piece Selection Policy**	**Peer Selection Policy**	**Replica Management Policy**
Our Results	Sequential	Cascading	Proportional
PPLive [2]	Sequential	Least Loaded First	Proportional (ATD)
PPVA [3]	Sequential	Least Loaded First	Proportional (ATD)
GridCast [7]	Sequential	Least Loaded First	Active Replication Algorithm



(a) Performance Comparison in Scenarios with Limited Resources (b) Performance Comparison in Scenarios with Sufficient Resources

Fig. 4. System Performance Comparison with Different Policy Composition

considered in the simulation, that is, resources limited scenario (D = 1, U = 1 and S = 2), and resources sufficient scenario (D = 2, U = 2 and S = 4).

The mean delayed pieces count of peers in the P2P VoD systems with different policy compositions are shown in Figure 4. The three set of bars in each subfigure of Figure 4 indicate the performance of different systems with different peer selection policy, while the three bars in each set show the performance of different systems with different replica management policy. Figure 4(a) shows the performance of different P2P VoD systems with different policy compositions when the resources are limited. It is obvious that the system with the cascading peer selection policy has much less mean delayed pieces count than the other two peer selection policies, and that the system with the cascading peer selection policy and the proportional replica management policy has the best performance. The simulation results in the scenario with sufficient resources are presented in Figure 4(b). There is little difference between different policy compositions when the resources are sufficient.

Therefore, the composition with cascading peer selection policy, the proportional replica management policy as well as the sequential piece selection policy have the best performance, which is consistent with the conclusion in the previous subsection.

C. Simulation Result Discussion

The simulation analysis shows that, the sequential piece selection policy, the cascading peer selection policy and the proportional replica management policy are the best choices for the P2P VoD system. We compare our simulation results with the existing system design work as shown in Table III.

It is obvious that our simulation results suggest the same piece selection policy as well as the replica management policy as PPLive [2], PPVA [3]. As for the peer selection policy, the practical P2P VoD systems usually use the least loaded first policy which will select the peers with the best connection, and this policy can work well in the practical Internet with heterogeneous bandwidth condition self-adaptively. However, the cascading peer selection policy can work well in bandwidth constraint condition through global or heuristic scheduling. Generally speaking, the comparison with the practical system design reflects the validity of our simulation results.

V. CONCLUSION

The piece selection policy, the peer selection policy and the replica management policy are the core strategies in the P2P VoD system. In this paper, we give evidence that the sequential piece selection policy, the cascading peer selection policy and the proportional replica management policy are the best choices when the bandwidth and storage resources are limited, and their composition also has the best performance. However, there are not many differences among different policy choices when the bandwidth and storage resources are sufficient.

We only compare the popular and easy-to-implement policies, but more possible policies should be researched in the future. Although the network condition is not taken into consideration in our simulation, these factors may lead to different results. Therefore, a more complicated and practical simulation is also one of our future works.

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