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Analysis of Mixed Strategies for 2p2 Streaming Systems with Buffering

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ABSTRACT
Several P2P based streaming systems were successfully deployed. In such systems, the basic streaming quality parameters that affect the user Quality of Experience (QoE) are Playback Continuity and Startup Delay. Several research conducted have revealed that buffer filling strategies used in these systems play a key role on the streaming quality. The popularly used strategies are the Rarest First (RF) and Greedy (Gr) strategies, however, studies have shown that RF strategy outperforms Gr strategy in terms of startup delay. In this paper, a problem of finding an optimal buffer filling strategy in form of mixed strategy was considered. The idea of the mixed strategy is to divide the buffer into two parts through demarcation point and apply one strategy to fill one part of the buffer and then the other strategy is applied to fill the other part of the buffer. Among the derived mixed strategies, an optimal was discovered which provides high probability of playback continuity with low startup delay.

Keywords: *P2P streaming, Rarest first, Greedy, Startup delay, Playback continuity*

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I. Introduction

Streaming is an enabling technology for providing multimedia data delivery among clients in various multimedia applications on the internet. With this technology, the client can playback the media content without waiting for the entire media file to arrive. Thus, streaming allows real-time transmission of multimedia over the net. Internet streaming media changed the web, as we know it changed it from a static text and graphic based medium into a multimedia experience populated by sound and moving pictures Begg,s J & Thede (2001).

The basic idea of video streaming is to split the video into parts, transmit this part in succession, and enable the receiver to decode and playback the video as these parts is received, without having to wait for the entire video to be delivered.

Video streaming over the internet is already part of our daily life. The engineering of video streaming from a server to a single client is well studied and understood. Thus, however, is not scalable to serve a large number of clients simultaneously.

A successful alternative to client-server~~ paradigui sinle ~~ the carly 2000s is the peer-to-peer (p2p) paradigm, where peers share their computational resources and bandwidth with other peers and communicate with each other directly for data sharing and exchange. The p2p paradigm is also part of the Device-to-device (D2D) communication which includes many ways to reduce load on networks, e.g, offloading.

Despite the fact that the first commercial p2p-based streaming systems were successfully deployed in 2010, this technology is still in demand. Applications related to the internet of things, such as social-aware p2p - video transmission, have added particular ~~mm~~ to research. Hsu and Tung in proposed a p2p-based streaming architecture for multimedia IOT devices and silva et al. is also proposed another p2p- based streaming systems, video stream is divided into portions of video data called video chunks, and the user streaming application is equipped with a buffer which serves as a temporary storage space for chunks in order to ensure smooth and interrupted playback.

The video playback process is divided into time slots, the length of each time slot correspond to the time required to playback one chunk. When a new peer joined a video session, it first begins by filling it's buffer, after down loading a reasonable number of chunks enough to be played back for some time; the chunks will start to move to the video player for playback.

The basic quality parameters that directly affect the user Quality of experience (QoE) in p2p streaming systems are playback continuity startup, startup delay and playback latency. However, the system's performance based on these parameters depends on some factors such as, the system's chunk down loading strategy, peer selection strategy, overlay construction, video coding and incentive scheme. Therefore, considering these factors, researchers have proposed several ideas to improve the performance of such systems. These ideas are either downloading strategy-based and incentive-based.

This paper aimed at analyzing the combined strategies (such as Rarest First (RF) and Greedy (Gr) strategy) in P2P streaming systems. With RF strategy, peers always tend to download a rare chunk (with few available copies) whereas with Gr strategy, peers tend to download a chunk with closest playback time (those chunks that are about to be played back). In results of the strategies analysis have shown that the probability of playback continuity (playback without pauses) is higher when RF strategy is used to download chunks than with Gr strategy, however, when RF strategy is used, the startup delay is high, unlike Gr strategy which provides a low startup delay. To achieve the set objects, an optimal buffer filling strategies in the form of combined strategy was discovered. The idea of combined strategy is to divide buffer with total of M+1 buffers positions into two parts via demarcation point x and apply one strategy to fill one part of the buffer and then the other strategy is applied to fill the other part of the buffer.

A playback model for p2p streaming systems

For the exchange of chunks, peers exchange buffer maps. Each buffer map contains information about the chunks a peer successfully downloaded, hence, ready for exchange. A peer can request a buffer map from any of its neighboring peers. i-peer obtained a buffer map from j-peer, it can download one or some of the chunks advertised in the j-peers buffer map. A peer could download chunks from one or more neighboring peers simultaneously. Different streaming systems have different chunk downloading strategies defined to dictate the right chunk to download especially when many chunks are available for download. The downloading strategies popularly used are Rarest First (RF) and Greedy (Gr) strategies. Further, consider a system with N peers and a single video server, which provides only one video stream to the peers and all peers watch and exchange among them only that single stream. The video playback process is divided into time slots the length of each time slot corresponds to the time required to playback one chunk.

Assume that each subscribed peer in the system has a buffer designed to accommodate M+1 chunks Buffer positions are numbered as follows: 0-buffer position (0-position) is designed only to store a fresh chunk, just produced by the server. Other buffer positions m, m = 1, ….., m – 1 are meant to store the recently downloaded chunks or the ones to be downloaded in the future time slots. The last buffer position M is to store the oldest chunk that will move to the playback in the next time slot.

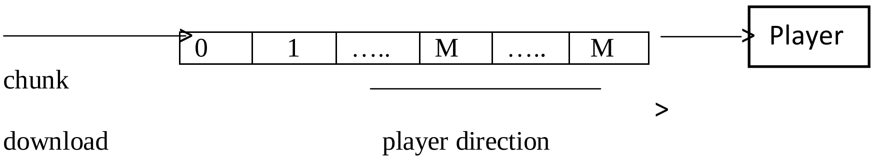


Fig. Playback buffer in p2p streaming system

At the beginning of each time slot, the server selects a peer at random and uploads to its O-position a freshly produced chunk for the current time slot. Any i-peer not selected by the server in the current time slot will perform the following actions.

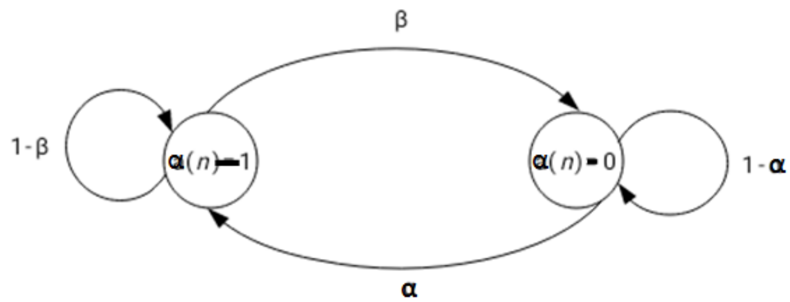
1. If there are empty positions in i-peers buffer, it will select at random another j- peer called a target peer from which it will try to download one of its missing chunks. If the target peer by chance has a more than one of the missing chunks, then the index of buffer positions to which i-peer can download chunk from the target peer is determined by the downloading strategy defined in the system. With RF strategy, i-peer will select and download the youngest chunk (with the longest playback deadline) among the missing chunks, while Gr strategy does the opposite, with Gr strategy, i-peer will select and download the oldest chunk (with the shortest playback deadline) among the missing chunks. I-peer will not download any chunk in the current time slot, IF:

- The target peer does not have any one of the missing chunks.
- All the position in i-peer's buffer are filled with the irrespective chunks.

Time slot ends with buffer content shift: chunk in M-position will exist the buffer and shift to the player for playback. Other chunks in other positions will shift one position ahead, towards the end of the buffer; hence 0-position be free to accommodate the fresh chunk to be produced by the server in the forthcoming time slot. Chunk in m-position will move to the player for playback after (M-m) time slots. Note that if peer; M-position is filled with a chunk during each time slot, then the peer will experience playback process without pause; this is what is called playback continuity.

Each peer at any moment can either be in online or offline state. Let a(n) be n-peer} online indicator, i.e, $\propto$ (n)=1, if the n-peer is online, otherwise $\propto(n) = 0$, for simplicity, assume that all peers join and leave the system with equal probabilities $\propto(n) = \propto$ and B(n) = B respectively, n = 1,…;N.

Analysis of combined strategies for p2p streaming systems



Let vector $x(n) = (x_0(n)= (x_0(n), x_1(n)\ldots. xm(n))$ be the state of n-peer's buffer, where $x_m(n)$ is the state of m-position in n-peer's buffer, i.e $x_m(n) = 1$ if n-peer's m-position is filled with a chunk, otherwise $xm(n) =0$, m-0, …., m; n = 1…., N.

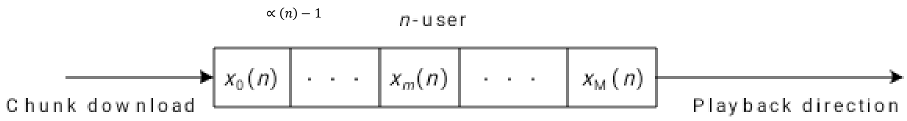


Fig 3. Buffer state of n-peer.

Denote by $p_1(n_1m)$ the probability that m-position in n-peer's buffer is occupied (also known as m-position occupancy probability) during each time slot; denoted also by v(n) the probability that buffer M-position of n-peer is filled with a chunk for playback at the end of each time slot. The probability V(n) depends on the downloading strategy used in the system. Therefore, the probability of playback continuity can be expressed by

$$V^{\delta}(n) = P_1(n_1 M)$$

Where δ is the strategy used in the system.
A recursive method for the computation of the probabilities $p_1(n_1m)$, m = 1, ….;

Mixed strategies

Since the strategies are two and the buffer is divided into two parts, there will be four possible mixed strategies, however, for the sake of brevity; this paper presents only the best two mixed strategies in terms of performance.

The idea of mixed strategy is to divide the buffer with the total M-positions into two parts via demarcation point x, x ∈ (0,…,M), and in part of the buffer a given strategy would be used to fill that part of the buffer, in the absence of chunks to download for that part of the buffer, then another strategy would be used to fill the other part of the buffer. In this paper its considered the two mixed strategies.

First, the rarest first strategy would be used for buffer m∈ (0,…,x), if there are no chunks available to download for these buffer positions, then Greedy would be applied to fill the rest of the buffer positions m∈ (x – 1,….;M), let's denote this mixed strategy RF|Gr, it can be noted that in this mixed strategy, Rarest first is marked out boldly, because it is the first strategy to be used. Secondly, the greedy strategy would be used for buffer positions m ∈ (x,….,m,) if there are no chunks to download for these buffer positions then Rarest first first strategy would be applied for the other buffer position m∈(0,…,x-1), lets denote this mixed strategy by RF|Gr, Greedy is marked out boldly, because it is the first strategy to be used in this mixed strategy in both of the mixed strategies the point x is the demarcation point.

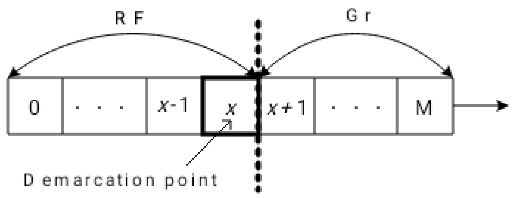


Fig 4. Mixedstrategy $RF|Gr_{0\cdots x\cdots M}$

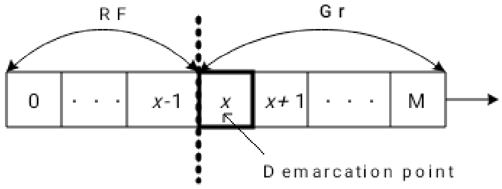


Fig 5. Mixed strategy $\underset{0\cdots x\cdots M}{RF|\mathbf{Gr}}$

Simulation Results

A simulation program was built based on the discrete model in order to analyze the effectiveness of the strategies and finally to find the optional buffer filling strategy in form of mixed strategy. To this end, let's first analyze a closed system, i.e a system where $\propto = 0$. The system and it's parameters.

Q = (N, M, X, $\propto = 0, \beta = 0, \delta \in (\underset{0\text{-x-m}}{RF}|\underset{0\text{-x-m}}{Gr})$)

For the closed system, the following problem would be solved

$M_a x\ V^{\delta}(x)$

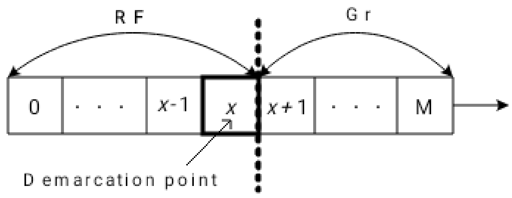
$0 \leq X \leq M$

$0 \leq V^{\delta}(x) \leq 1$

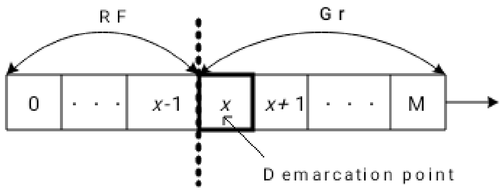
The search for the optimal demarcation points would be conducted using direct search method for a system with N = 100 peers and M = 40 buffer positions the results obtained have shown that for the defined mixed strategies $\underset{0...x...M}{RF|\ Gr}$ and $\underset{0..x...M}{RF|Gr}$ there are set of

Points x for which $V^{\delta} > V^{RF}$, $\delta \in \left\{ \underset{0....x...M}{RF|Gr}, \underset{0...x...M}{RF|Gr} \right\}$, where the maximum value of the probability of playback continuity

for mixed strategy $\underset{0...x\text{ - }M}{RF|\ Gr}$ is achieved at point $X^1 = 10$



a) Mixed strategy $\underset{0\cdots x\cdots M}{\mathbf{RF}|Gr}$



b) Mixed strategy $\underset{0\cdots x\cdots M}{RF|\mathbf{Gr}}$

Figure:Mixed strategies $\underset{0\cdots x\cdots M}{\mathbf{RF}|Gr}$ and $\underset{0\cdots x\cdots M}{RF|\mathbf{Gr}}$

Definition 1. For mixed strategy $RF|Gr_{0\cdots x\cdots M}$, if $M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h)) \neq \varnothing$ and $\{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{0,\cdots,x\} \neq \varnothing$, then

.

If $\{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{0,\cdots,x\} = \varnothing$ and

$$m_\delta(\mathbf{x}(n),\mathbf{x}(h)) = \min\{m : m \in \{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{0,\cdots,x\}\}$$

, then $\{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{x+1,\cdots,M\} \neq \varnothing$

. $m_\delta(\mathbf{x}(n),\mathbf{x}(h)) = \max\{m : m \in \{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{x+1,\cdots,M\}\}$

Definition 2. For mixed strategy $RF|Gr_{0\cdots x\cdots M}$, if $M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h)) \neq \varnothing$ and

$\{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{x,\cdots,M\} \neq \varnothing$, then

.

If $\{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{x,\cdots,M\} = \varnothing$ and $m_\delta(\mathbf{x}(n),\mathbf{x}(h)) = \max\{m : m \in \{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{x,\cdots,M\}\}$

, then $\{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{0,\cdots,x-1\} \neq \varnothing$

. $m_\delta(\mathbf{x}(n),\mathbf{x}(h)) = \min\{m : m \in \{M^0(\mathbf{x}(n)) \bigcap M^1(\mathbf{x}(h))\} \bigcap \{0,\cdots,x-1\}\}$

Definition 3. The demarcation point x of a mixed strategy with which the maximum of the probability of playback continuity is achieved is called the optimal demarcation point of that mixed strategy and is denoted by x^*, i.e.

, $\delta \in \{RF|Gr_{0\cdots x\cdots M}, RF|Gr_{0\cdots x\cdots M}\}$ $V^\delta(x^*) = \max V^\delta(x), 0 \leq x \leq M$ 4.8

Hence, the desired probability measures of the considered model obtained. Therefore, the proposed mixed strategy is the most favorable strategy, out of the two other strategies i.e. Rarest first and Greedy strategies.

II. Summary

In summary, the result shown that the Rarest First Strategy (RF) out performs Greedy strategy in terms of playback continuity and with Greedy strategy, the startup delay is shorter than that of Rarest First Strategy. Therefore, in the proposed work, we considered two mixed strategies. First, the Rarest first strategy would be used for buffer positions $m \in \{0,\cdots,x\}$, if there are no chunks available to download for these buffer positions, then Greedy would be applied to fill the rest of the buffer positions $m \in \{x-1,\cdots,M\}$.

III. Conclusion

In this paper, buffering strategies for p2p based streaming systems were studied. In order to maximize the probability of playback continuity and minimize startup delay, mixed strategies were designed and analyzed. For each of the considered mixed strategies, optimal demarcation points were found finally, among the derived mixed strategies, an optimal one which provides higher probability of playback continuity and low startup delay was discovered.

Recommendation for future work

The optimal demarcation points of the mixed strategies presented in this paper were discovered via direct search method, therefore in the future, a generalize optimization problem will be considered to enable the discovery of the optimal demarcation points for the mixed strategies for any given buffer and network size's.

Reference