Optimal Source Selection in P2P IPTV Based on Abandon Probability

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Problem

In peer-to-peer (P2P) IPTV, a new client selects one or more source peers that already receive the desired video stream and use their upstream connection to forward the video content. The importance of source selection becomes greater when multiple TV channels are available and the user tendency to browse increases the peer churn and negatively affects the overall performance [1, 2]. However, existing solutions focus on peers receiving several streams at the same time (a primary channel that is played-back to the user, and a number of secondary ones to serve the downstream peers)[3] that may be too expensive over a long period, or optimize the peer selection based on users channel switching patterns [4].

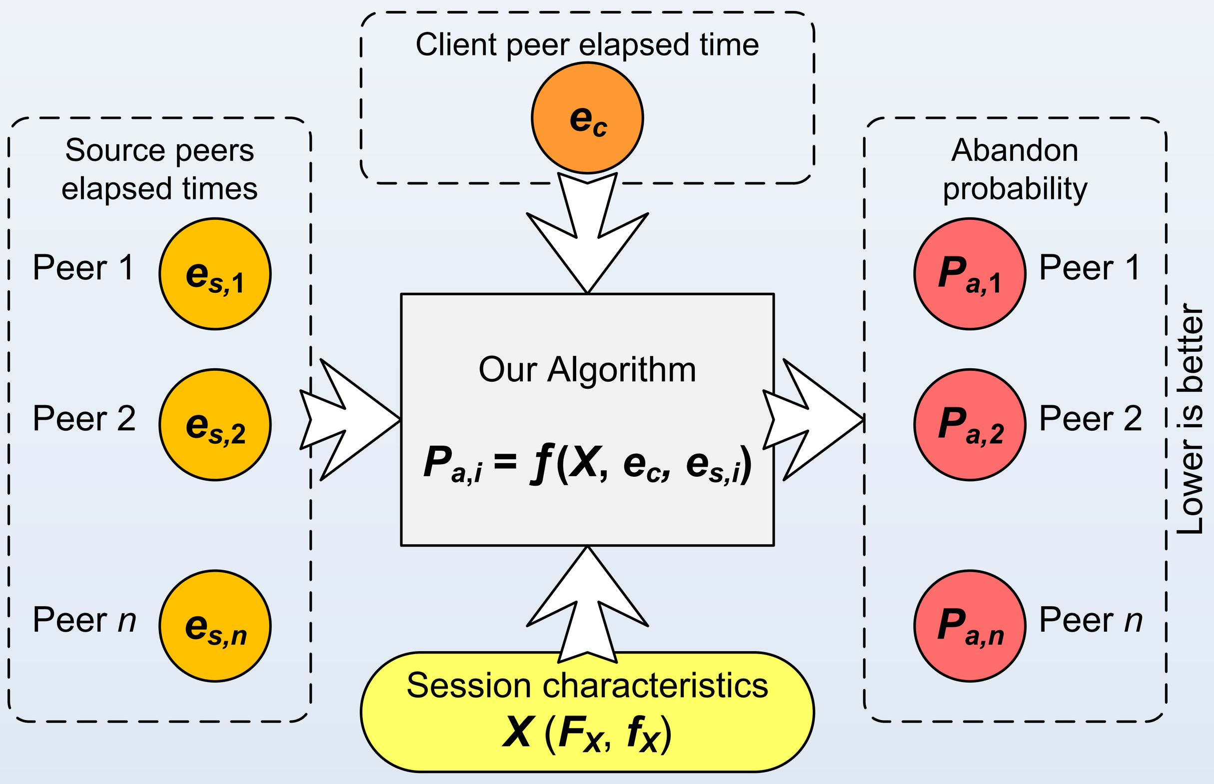
Method

We propose a simple algorithm executing at the client peer that examines:

- The channel session characteristics in the form of the probability distribution of the channel session time (X, F_X, f_X);
- The client peer characteristic in the form of its session elapsed time (e_c);
- The source peers characteristics in the form of their session elapsed times (e_s);

And calculates:

- The probability of each source *abandoning* the connecting peer during its session (P_a).



Selecting a source peer using abandon probability

The objective of our method is to reduce the peer churn determined by the channel changes and it can complement additional peer selection criteria such as bandwidth availability and future expected channel.

Channel Session Characteristics

Previous studies showed that a typical TV channel session has a duration with power-law probability distribution [5, 6]. Hence, we consider the *session time* as a random variable X, having a power-law probability distribution, described by the boundaries x_{min}, x_{max} and the exponent α. The probability density function and cumulative distribution function over $[x_{min}, x_{max}]$ are:

$$f_X(x) = \frac{1-\alpha}{x_{max}^{1-\alpha} - x_{min}^{1-\alpha}} x^{-\alpha}, \tag{1}$$

$$F_X(x) = \frac{x^{1-\alpha} - x_{min}^{1-\alpha}}{x_{max}^{1-\alpha} - x_{min}^{1-\alpha}}. \tag{2}$$

It is possible to calculate the probability of a certain *future lifetime* of the session depending on the already elapsed time, e. We introduce the channel future lifetime as a random variable Y conditioned by $\mathscr{E} = (X > e)$. The probability of the future lifetime being equal to a chosen value y is:

$$P\{Y = y|\mathscr{E}\} = P\{X = y + e|X > e\}. \tag{3}$$

We can write the cumulative distribution function of Y:

$$F_Y(y|\mathscr{E}) = P\{X \leq y + e|X > e\} = \frac{F_X(y+e) - F_X(e)}{1 - F_X(e)}. \tag{4}$$

The corresponding probability density function is obtained as the partial derivative with respect to y:

$$f_Y(y|\mathscr{E}) = \frac{f_X(y+e)}{1 - F_X(e)}. \tag{5}$$

Abandon Probability

The *abandon probability* (P_a) is the probability that the future lifetime of a client Y_c is greater than the future lifetime of its source peer Y_s, with session elapsed times for the source and client e_s and e_c.

If we introduce a random variable $Z = Y_s - Y_c$ as the difference between the future lifetime of the source and of the client, the abandon probability can be represented as:

$$P_a = P\{Z < 0\}. \tag{6}$$

Because Z is the difference between the two independent random variables Y_s and Y_c, its probability density function is:

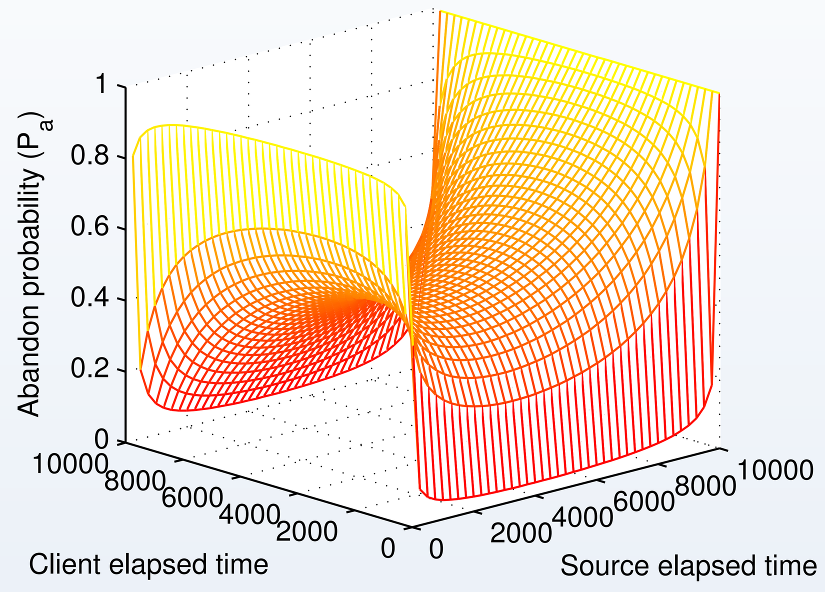
$$f_Z(z|\mathscr{E}_s\mathscr{E}_c) = \int_{-\infty}^{\infty} f_Y(x + z|\mathscr{E}_s) f_Y(x|\mathscr{E}_c)\, \mathrm{d}x, \tag{7}$$

where $\mathscr{E}_s$ and $\mathscr{E}_c$ are the elapsed time conditions for the source and for the client. Then, the abandon probability can be obtained as:

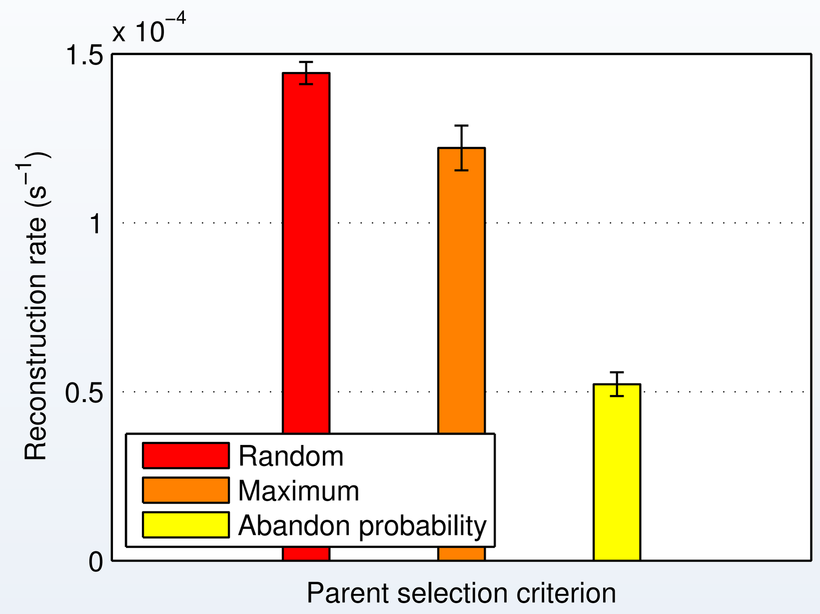
$$P_a = \int_{-\infty}^{0} f_Z(z|\mathscr{E}_s\mathscr{E}_c)\, \mathrm{d}z. \tag{8}$$

Experimental Evaluation

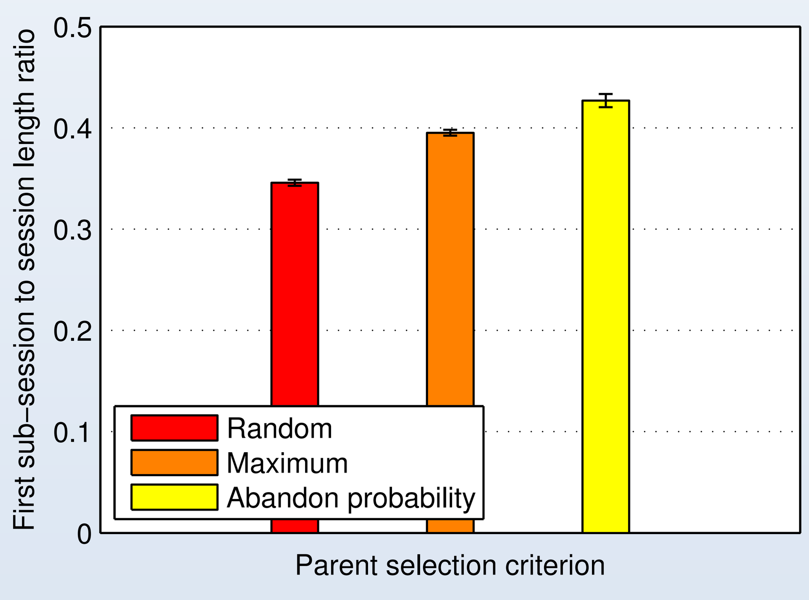
We use a P2P simulator to compare our algorithm against two classic choices for peer selection: *(i) random* selection, and *(ii)* peers having the *maximum* elapsed time.



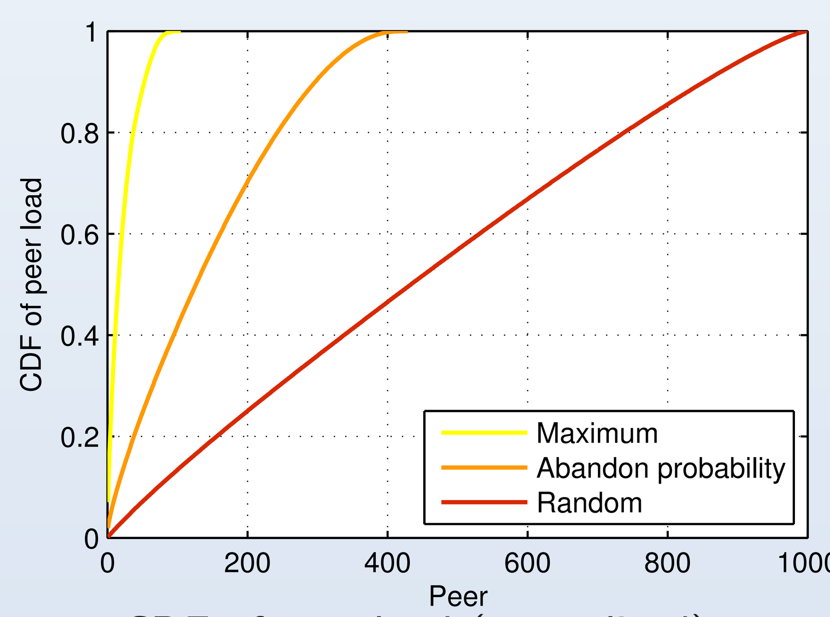
The abandon probability



Global peer reconstruction ratio



First sub-session to session length ratio



CDF of peer load (normalized)

References

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