

QoE driven CDN resource allocation approach: literature review

Hanyu Li

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1 The method that is being used now by industry

The most commonly used method is to randomly assign new users to currently available CDN(Content Delivery Networks), usually according to the hashed id of users. Apparently, this kind of round robin approach gives rise to a set of problems. For example, the CDN dynamics are neglected. Furthermore, the QoE(Quality of Experience) of users are affected by various factors not only by QoS(Quality of Service).

2 State of art works

2.1 Prediction based

2.1.1 confounding factors(2013)[1]

It aims to develop a predictive model of engagement that accounts for the complex relationship between QoS and engagement, the interdependencies between quality metrics(e.g., buffering, join time), and the confounding factors(e.g., device, genre) that impact different aspects of this learning. The dataset has 40 million video viewing sessions collected over 3 months spanning two popular video content providers in US. The model inputs are

quality metrics and confounding factors, and it will output the prediction of the video engagement(QoE).

Its main observation is that decision tree is expressive enough for the quality metrics, while not for confounding factors. Thus they captured several most important confounding factors and proposed a predictive model where a decision tree is trained for every combination of confounding factors.

Its accuracy on *** testbed is

Its pros and cons are

2.1.2 user mapping strategies(2016)[2]

Zhu et al. proposed a prediction model considering QoS metrics and the preference on videos of users. Afterwards they came up with a heuristic CDN mapping strategy. The input when testtime is the video requests consist of (user, video), and a hyperparameter K which is the number of users they adjust in every CDN allocation process. The output will be the mapping of (user, CDN).

They used a simple but effective method to model the user preference: the cosine similarity between videos based on the categorical vector, and users based on weighted historical sum of videos vectors. Then they feed the QoS factors and this preference factor into a decision tree to get the predicted QoE. The mapping strategy is also straightforward. They simulate the assignment of users randomly and pick K users who have the largest QoE improvement and change their CDN in reality.

Its accuracy on *** testbed is

One of the disadvantages is that we can not change CDN for existing users frequently in live streaming scenarios, which is not compatible with the optimization part of this strategy.

2.1.3 CFA(2016)[3]

It aims to capture the complex relationships between session features and video quality. Furthermore, it tries to address the needs for fresh updates. Also being a predictive model, CFA takes features of sessions under

prediction as input, and outputs their assigned CDNs based on the prediction of QoE on each CDN.

Its main observation is that a few critical features is able to determine the QoE for a video session. Thus they proposed the prediction model which is consisted of a critical feature learner and a quality estimator based on the sessions with the same critical features in a period of time. They also observed that critical features will remain for a relatively long period of time. Therefore CFA only updates the critical feature when triggered(e.g., when the performance drop to a certain threshold). The quality estimator on the other hand is updated every ten seconds.

Its accuracy on *** testbed is

The QoE metric used to evaluate the model is a simple weighted sum of several QoS metrics, which is homogeneous for users, so there is still space to alter the assignment of CDN to achieve better QoE by considering user heterogeneity.

2.1.4 k-NN VCP(2019)[4]

This system monitors all CDN performance and selects the most performing one when a new video request is received. The VCP takes QoE feedbacks of old users and ISP(Internet Service Provider) from all users as inputs and output the assigned CDN for old users with bad QoE and new users.

The authors performed a k-NN regression on the prediction of QoE by dividing users into groups regarding CDN and ISP and the mean of the QoE. When a new user comes in, the CDN ranker ranks the candidate CDN based on the QoE prediction and selects the best.

Its accuracy on *** testbed is

The existing users before the assignment will be affected by new users, and if their QoE declines they will be new users as well. Thus the greedy assignment for each user is not perfect.

2.1.5 crowdsourced live streaming(2019)[5]

This approach aims to minimize access delay and video stall costs by carefully choosing which edge server to allocate the broadcast video and how to migrate between servers. Input: session features. Output: prediction of the video quality.

The predictive part will predict the number of viewers expected near each cloud site. Based on the predicted results, the optimization part will allocate live video replicas across the geo-distributed cloud sites near the viewers proximity by integral programming.

Its accuracy on *** testbed is

Its pros and cons are

2.1.6 E2E(2019)[6]

E2E is the first resource allocation system that embraces user heterogeneity to allocate server-side resources in a QoE-aware manner. It is still a prediction based system, consisting of the prediction of QoE and the optimization of the total QoE. Like its predecessors, the input is the requests and the outputs are the assignment.

They made simple assumptions on the prediction part where the QoE is a single variable function of the sum of client and server side delay because they used database request as an example. However, considering the user heterogeneity means that the optimizing step will be much more difficult because they can not simply choose the best CDN or database for every user in a random order. On contrast, they have to take all current users into consideration. They managed to transform the complicated and coupled problem into two steps, and solved them separately.

Its accuracy on *** testbed is

The prediction part can be modified to a more expressive model to fit in the video session scenario.

2.2 E2 based

2.2.1 pytheas(2017)[7]

The authors believe that data-driven QoE optimization should instead be cast as a real-time exploration and exploitation(E2) process rather than as a prediction problem. The inputs include historical measurements and the measurements of the requested session. The output will be the decision.

They argue that the methods based on prediction suffer from the prediction bias and slow reaction. Thus they proposed pytheas which formulates measurement collection(exploration) and decision making(exploitation) as a joint process with real-time QoE measurements using E2 process. They group the sessions based on the factors on which their QoE and best decisions depend, and run discounted UCB(Upper Confidence Bound) algorithm on each group.

Its accuracy on *** testbed is

Its pros and cons are

3 User heterogeneity: a new way to improve QoE

4 How we mitigate those drawbacks

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