

# Global Optimization for Display Ad

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## Abstract

Online display advertisement has been examined by numerous studies. Most online display ad systems take the greedy approach, namely they display, for each user, the set of ads that match best with the user's interests. One shortcoming of the greedy approach is that it does not take into account the budget limitation of each advertiser. As a result, we often observed that some ads are popular and match with the interests of millions of users; but due to the budget restriction, these ads can only be presented by a limited times, leading to a suboptimal performance.

To make our point clear, let's consider a simple case where we only have two advertisers (i.e. A and B), and two users (i.e. a and b). We assume that both advertisers have only a budget of one display. We further assume that user a is interested in both ads even though he is more interested in ad A, while user b is only interested in ad A. Now, if we take the greedy approach, we will always present ad A to user a; as a result, if user a comes before user b, we will have no appropriate ad to be displayed for user b. On the other hand, if we can take into account the budget limitation of both advertisers, a better approach is to present ad B to user a and ad A to user b. This simple example motivates us to develop the global optimization approach for online display advertisement that explicitly

take into account the budget limitation of advertisers when deciding the ad presentation for individual users.

The key idea of the proposed approach is to compute a user-ad assignment matrix that maximizes the number of clicks under the constraint of ad budgets from individual advertisers. The main computational challenge is the size of variable to be optimized: since the number of users and advertisements involved in our system are 1 billion and ten thousands, respectively, we need to estimate a matrix of billions times ten thousands. We address this challenge by converting the original optimization problem into its dual problem, in which the number of variables is reduced to only ten thousands. A distributed computing algorithm, based on the Nesterov's method and map-reduce framework, was developed to efficiently solve the related optimization problem. We have observed that, the proposed algorithm significantly improves the effectiveness of ad presentation compared to the greedy algorithm.

## Categories and Subject Descriptors

H.4.0 Information Systems, INFORMATION SYSTEMS  
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**Keyword:** online advertisement

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