Cost-Control in Display Advertising - Theory vs Practice

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Background

Marketing campaigns with budget and cost constraints (here, cpv): formulated as an optimization problem

Maximise {advertiser-utility} such that spend <= B and cpv <= C_{view}

Optimal bidding (at every request)

$$bid = (value_{pred} + C_{view} * \mu_t) / (1 + \lambda_t + \mu_t)$$

Online update (after every n requests)

$$\lambda_{t+1} = max(\lambda_t + \varepsilon_{spend} * (spend_t^{actual} - spend_t^{target}), 0)$$

$$\mu_{t+1} = max(\mu_t + \varepsilon_{cost} * x_i * (cpv_t^{actual} - C_{view}), 0)$$

Yuan Gao, Kaiyu Yang, Yuanlong Chen, Min Liu, and Noureddine El Karoui. AdKDD 2022. Bidding agent design in the linkedin ad marketplace.

Problem

The optimal bidding formula assumes optimal values for μ and λ.

- In offline optimization, this is possible
- In online optimization, they converge over time

For cost-constrained campaigns,

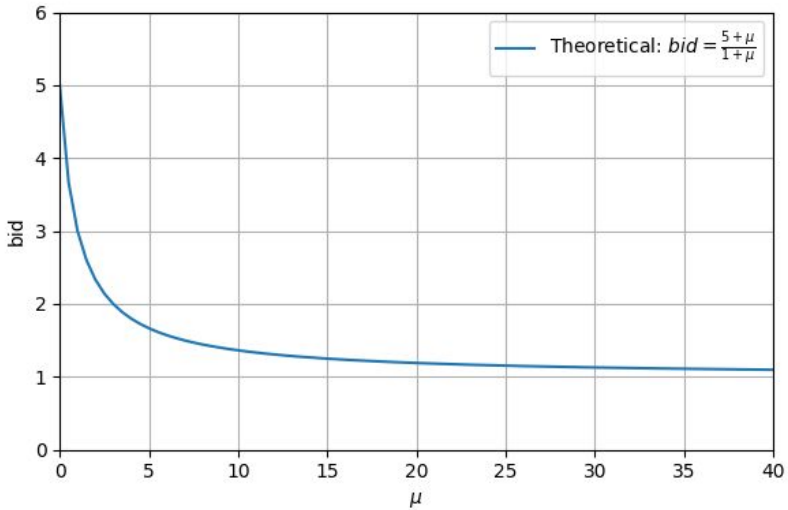
$$\lambda^{OPT}=0,\ \mu^{OPT}=\infty,\ bid^{OPT}=C_{view}$$

With optimal bidding formula, it can be shown:

$$bid_{avg} \geq C_{view}$$

Ineffective cost-control !

C_{view} = 1, E[value] = 5 * C_{view}



Proposed Solution

What if we introduced $C'_{view} = \beta * C_{view}$, $0 \leq \beta < 1$

✅ $bid \geq C'_{view}$, i.e. bid may drop below C_{view}, if it is necessary

❌ After cpv decreases to C_{view}, $\mu \rightarrow \infty$ and the bid keeps dropping towards C'_{view}

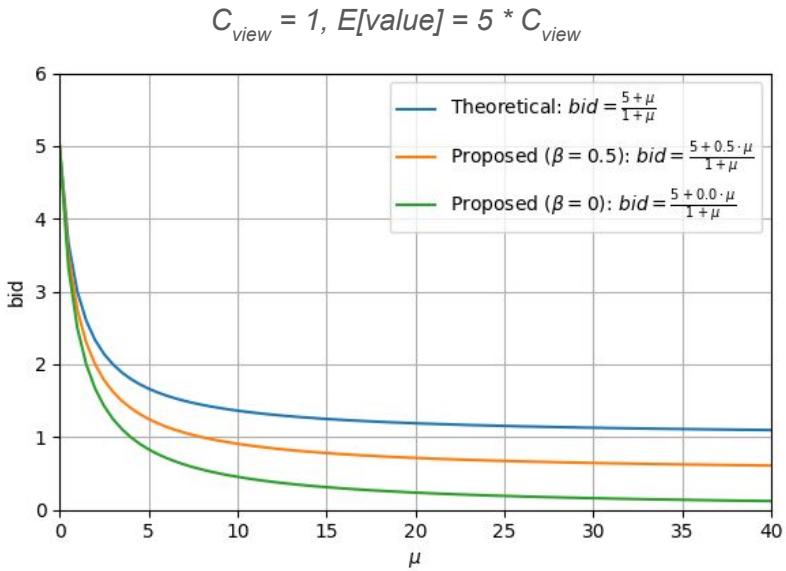
Proposed Solution

We propose taking the best of both worlds:

- Modify the bidding formula as if there is a discounted C'_{view}
- Don't modify the online update formula, i.e. compute it against C_{view} as before

New Bidding formula:

$$bid = (value_{pred} + \boldsymbol{\beta} * C_{view} * \mu_t) / (1 + \lambda_t + \mu_t)$$



Simulation on Synthetic Data

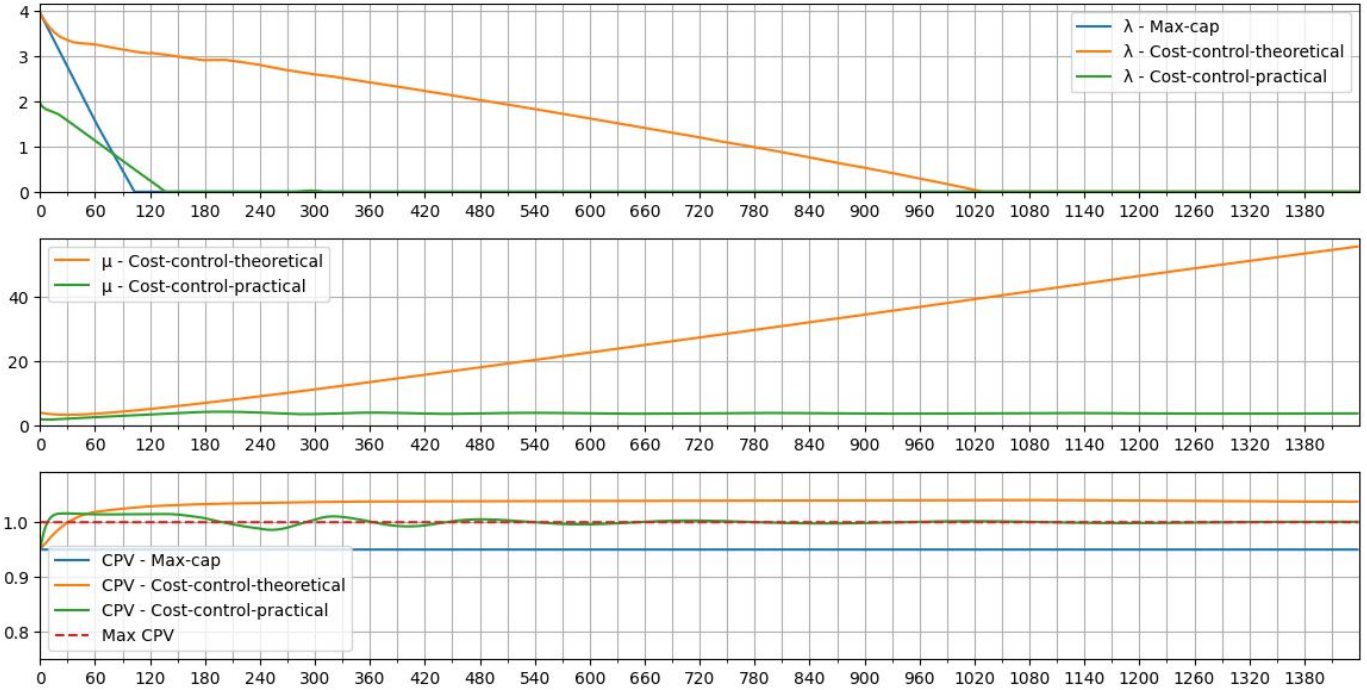
Cost is the active constraint (i.e. the budget is sufficiently high)

$C_{view} = 1, \beta = 0$

λ

μ

CPV



Large-scale Evaluation on Real-world Data

Tested on $O(10^3)$ campaigns

	#campaigns with cost violations	Uplift in advertiser utility over Max-cap
Max-cap	0%	-
Cost-control-theoretical	8.15%	+22.09%
Cost-control-practical, beta=0.8	4.12%	+22.60%
Cost-control-practical, beta=0.5	5.13%	+25.84%
Cost-control-practical, beta=0.2	5.21%	+17.49%
Cost-control-practical, beta=0.0	5.46%	+11.68%

Concluding Remarks

Summary

- New bidding formula that reduces cost violations by 50% (without hurting utility)

How to select β

- Depends on how close the prices are to the bids => property of the market itself
- High market competition => prices closely follow winning bids => lower beta (say, 0.5 - 0.8)
- Low market competition => prices are much lower than the winning bids => beta close to 1 (say, 0.9 - 0.95)

Future work

- Explore other ways to achieve cost-control and compare
- Attempt a theoretical justification