Pacing in the RTB Space

The State of Ad Tech Research

PAPERS

Budget Pacing for Targeted Online Advertisements at LinkedIn by Deepak Agarwal et al. KDD 2014.

Smart Pacing for Effective Online Ad Campaign Optimization by Jian Xu et al. KDD 2015.

Real Time Bid Optimization with Smooth Budget Delivery in Online Advertising by Kuang-Chih Lee, Ali Jalali, Ali Dasdan. ADKDD 2013.

From 0.5 Million to 2.5 Million: Efficiently Scaling up Real-Time Bidding by Jianqian Shen et al. ICDM 2015.

A BRIEF OVERVIEW

- **Why pacing is hard**
- **Pacing techniques**
  - Traffic vs KPI
  - Slow start; Early finish
- **Control Systems Engineering**
  - How to pace: probabilistic throttling vs bid modification
  - Naïve control system
  - Priority control system
- **Evaluation metrics**

CHALLENGES WITH PACING

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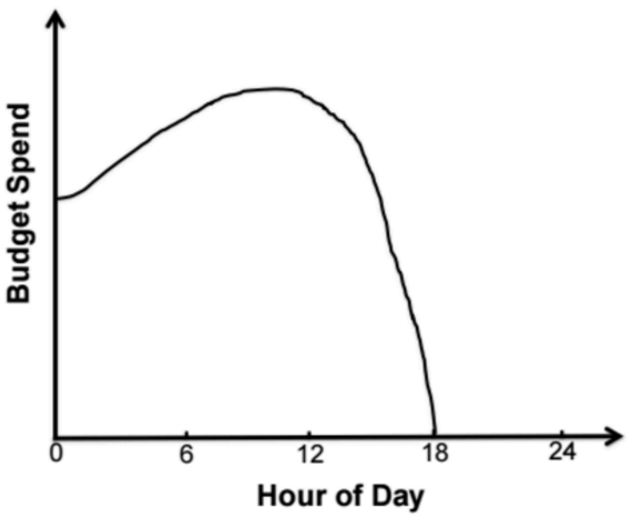
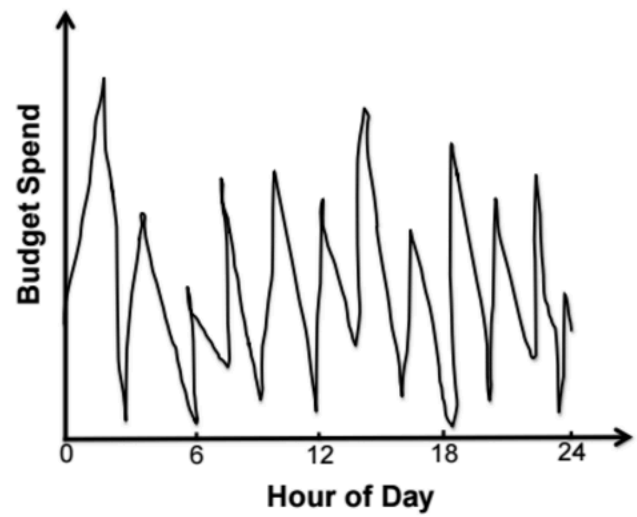
- Advertisers prefer campaign budgets to be spent smoothly
- Hard to execute in the real world



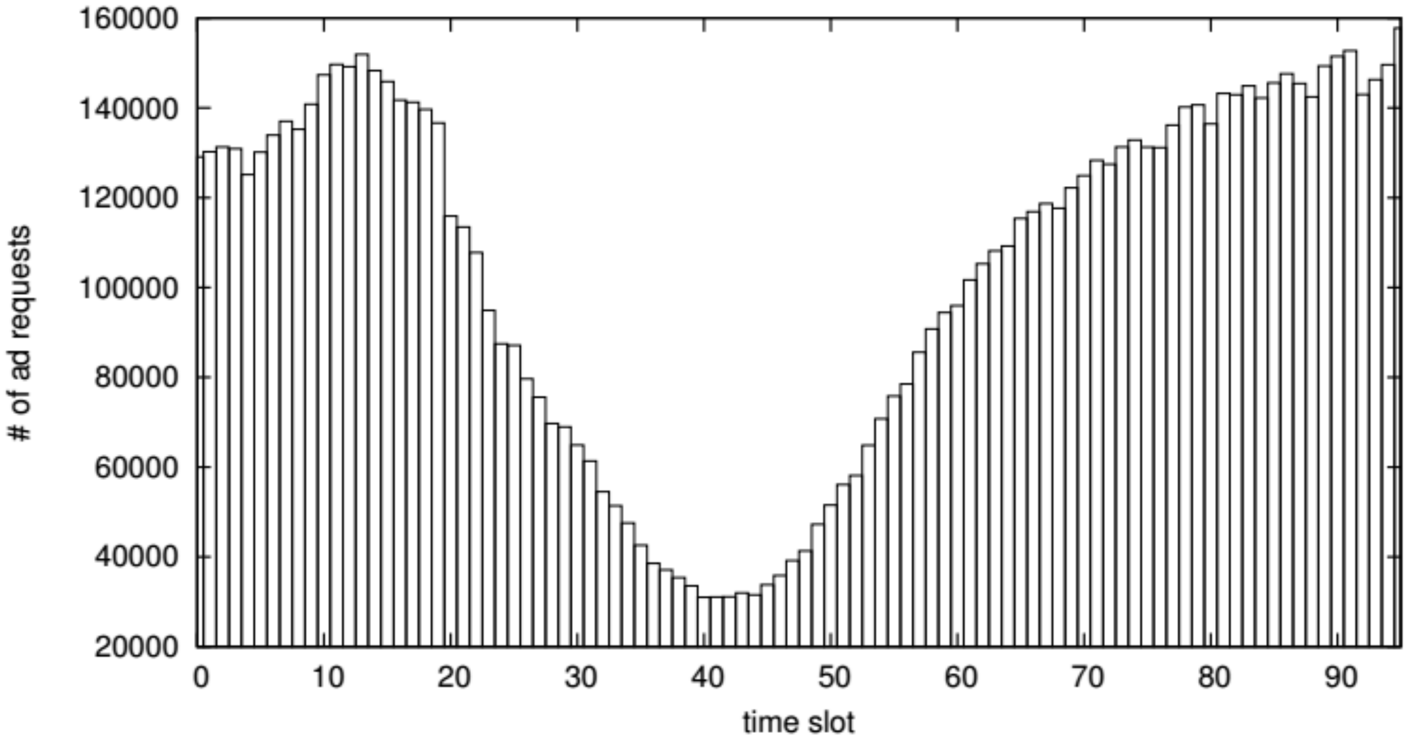
(a) Premature Stop



(b) Fluctuating Budget

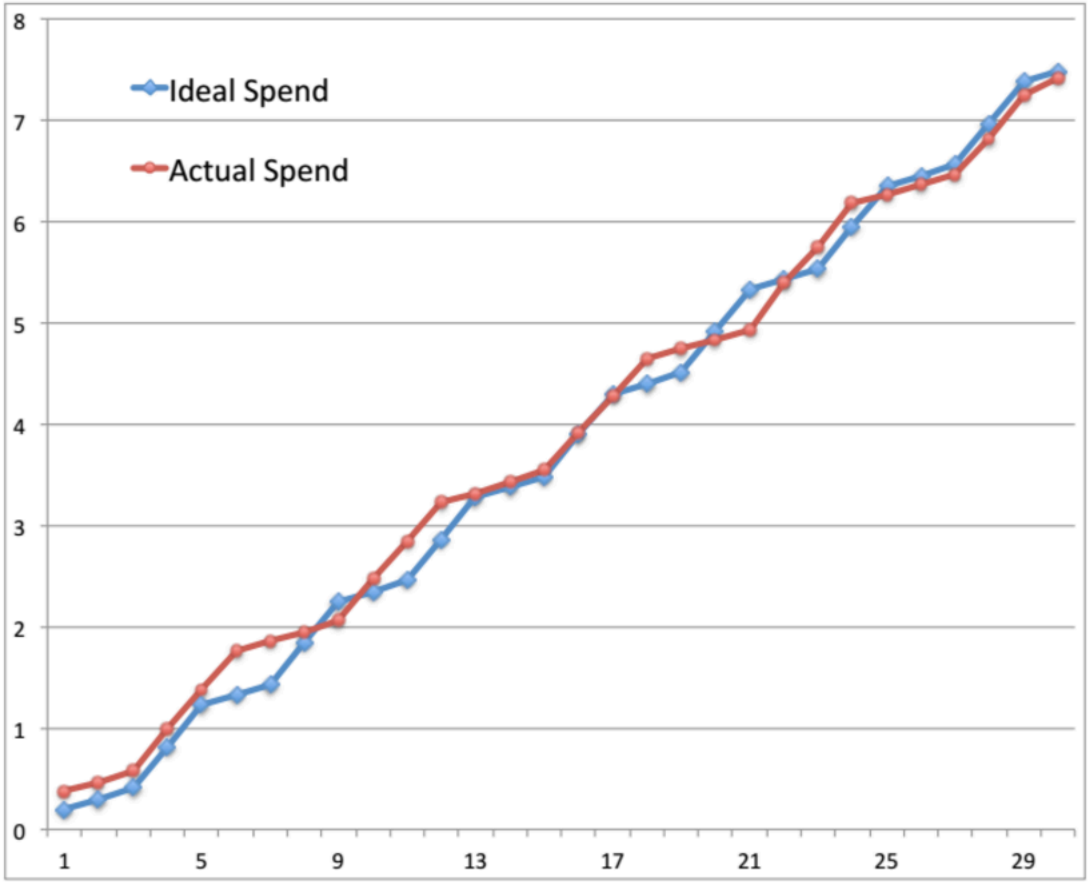
CHALLENGES WITH PACING

- Traffic is highly variable
- Even more erratic on a per campaign basis (i.e. site list, geo filter)



(a) Ad request distribution over time slots

CHALLENGES WITH PACING: IDEAL



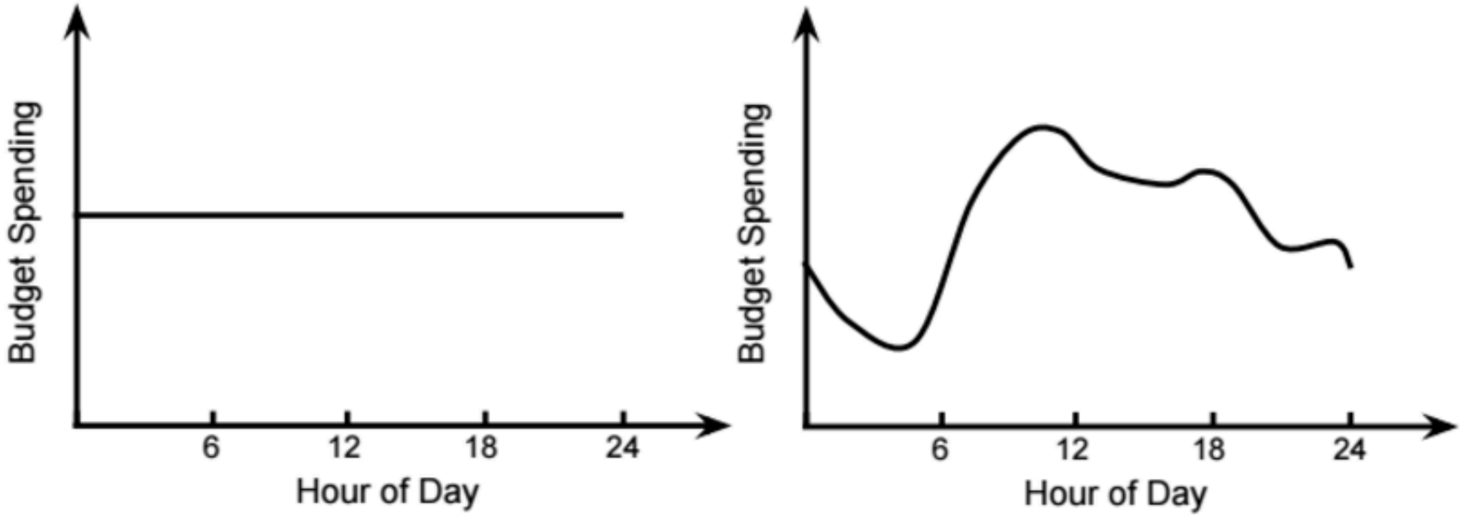
PACING TECHNIQUES

PACING TECHNIQUES: HOW DO WE PACE?

- Come up with a spend plan

$$\mathbf{B} = (B^{(1)}, ..., B^{(K)})$$

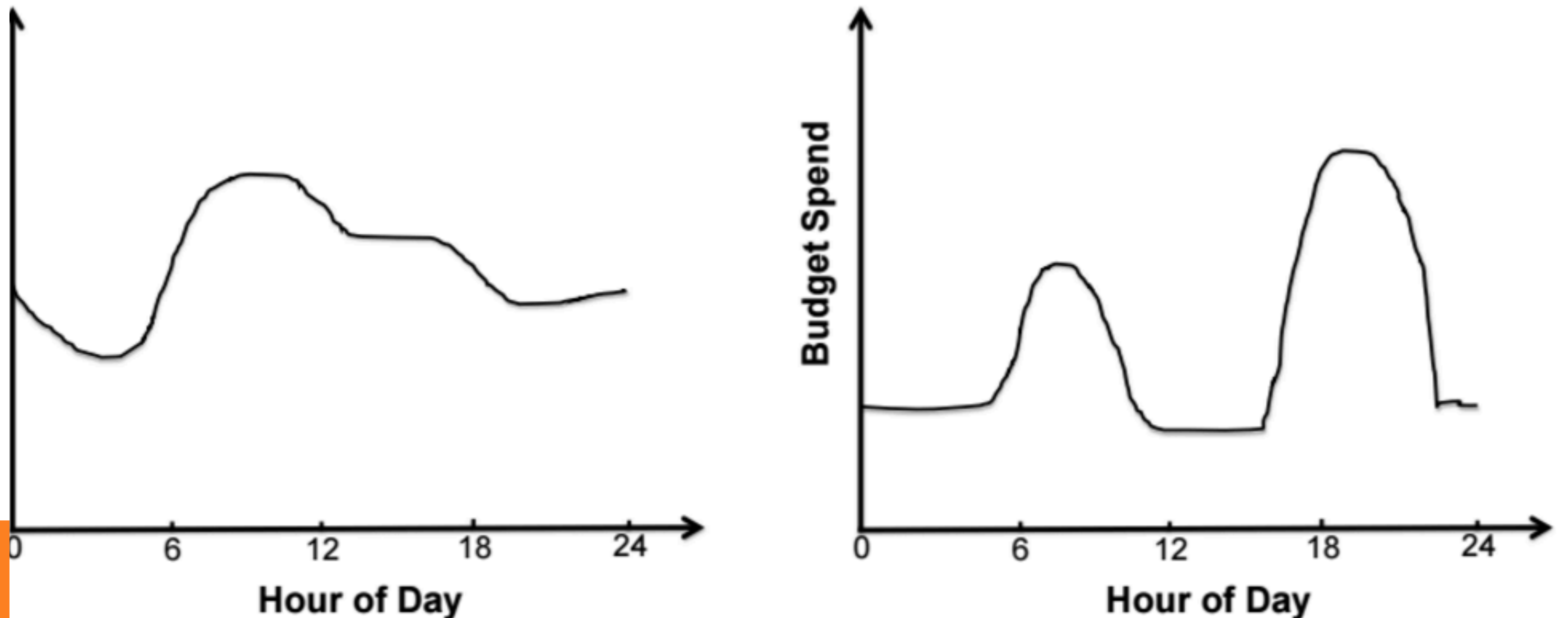
- Divide up day into time slots and allocate budget *B* per time slot



(a) Even pacing (b) Traffic based pacing

TRAFFIC VS KPI BASED PACING

- Traffic based pacing tries to control how many auctions a campaign sees
- KPI based pacing tries to get the cheapest KPIs (clicks, completions…etc.)



(d) Traffic Based Pacing

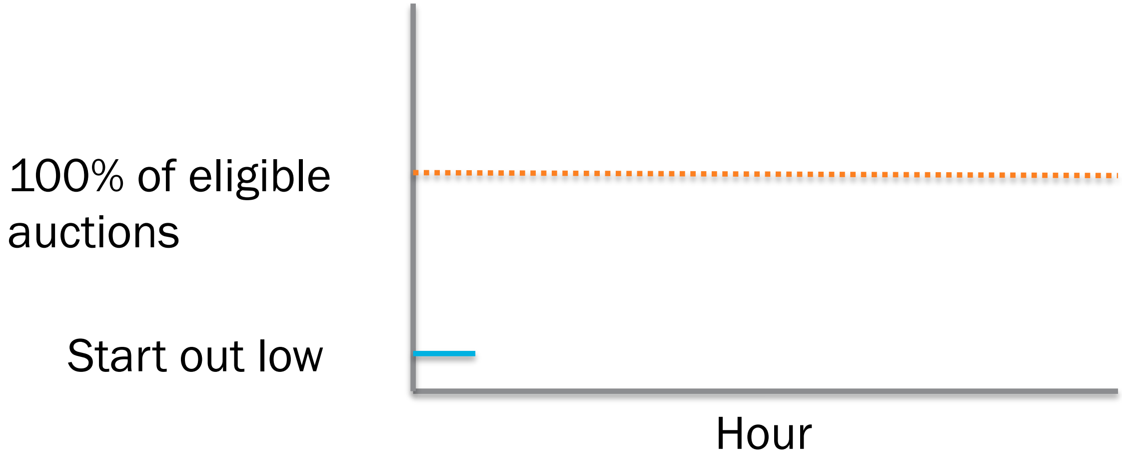
(e) Performance Based Pacing

COMBINING TRAFFIC AND KPI PATTERNS

- Allocate B(k) based on KPI patterns (e.g. a lot more clicks in the evening than morning)
  - Clicks are cheapest when there're an abundance of clicks
- Calculate pacing rates for each time slot based on traffic
  - Need to spend B(k)
  - Estimate how many auctions, N(k), an ad needs to see
  - Figure out the % of traffic to show the ad to get N(k) auctions

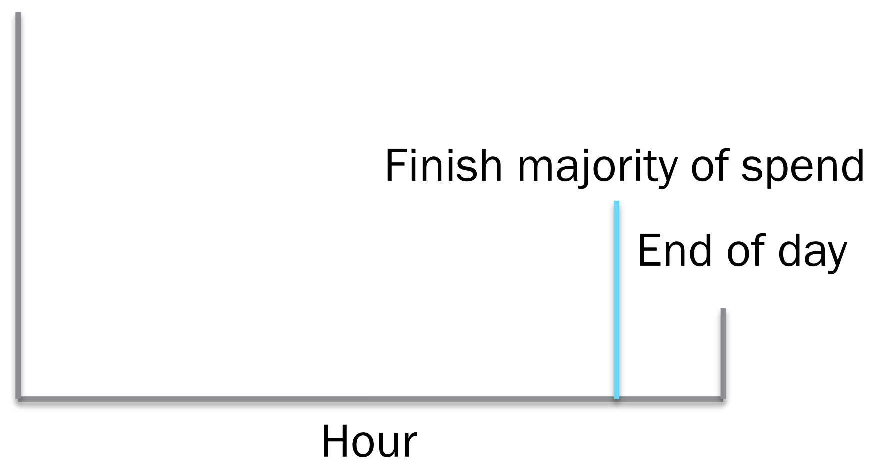
SLOW START

- Start out the day by being selective
- Prevents overspending / spending more than allocated
- Encourages optimizing for KPIs



FAST FINISH

- Finish spending budget a few hours before the 24 hour mark
- A DSP would rather overspend then underspend



CONTROL SYSTEMS

PROBABILISTIC THROTTLING VS BID MODIFICATION

- Want to spend exactly *B(k)* for time slot k
- There are 2 ways to control spending
- Probabilistic throttling
  - Show an ad an auction with ***p*** percent of the time
  - 0 means stop showing auctions to ad
  - 1 means show every auction to ad
- Bid modification
  - Assume each campaign bids ***c*** on each auction
  - Lower the bid to $\boldsymbol{\beta c}$, where $0 <= \beta <= 1$
  - Change $\boldsymbol{\beta}$ to control spending

PROBABILISTIC THROTTLING VS BID MODIFICATION

Advantages with probabilistic throttling:

1. Directly influences spend (*)
2. Bid modification must take account of business rules in the auction space such as the reserve price established by the publisher
3. Decouples pacing from bid evaluation

From this point on, we will use probabilistic throttling (*p,* the pacing rate) as the actuator in our controllers.

(*) Changing β for bid modification does not directly change spend, sincewin rate does not change linearly with bid multiplier

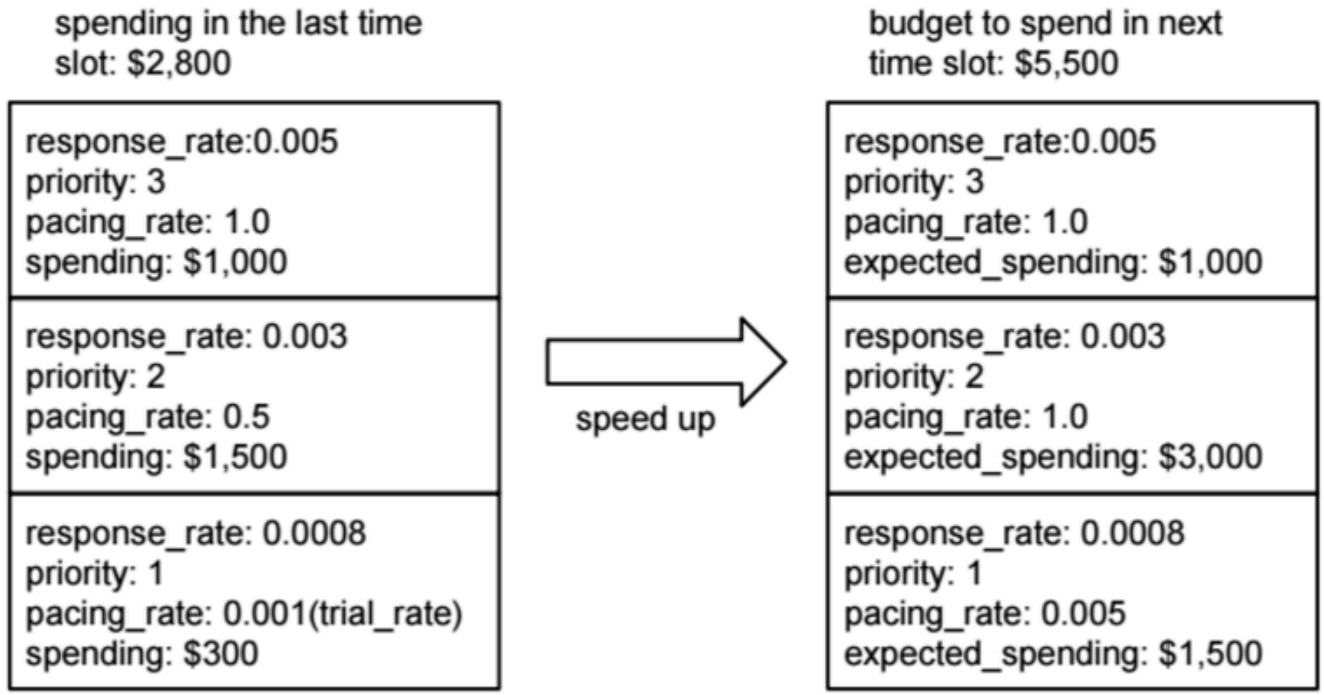
NAÏVE CONTROLLER

- LinkedIn uses a simple water wheel controller
- Start the day with $p = 0.1$
- Every 1 minute, update p:
  - If over pacing, $p = p * 1.1$
  - If under pacing, $p = p * 0.9$
- Problems:
  - Needs the system to update very often
  - p oscillates needlessly

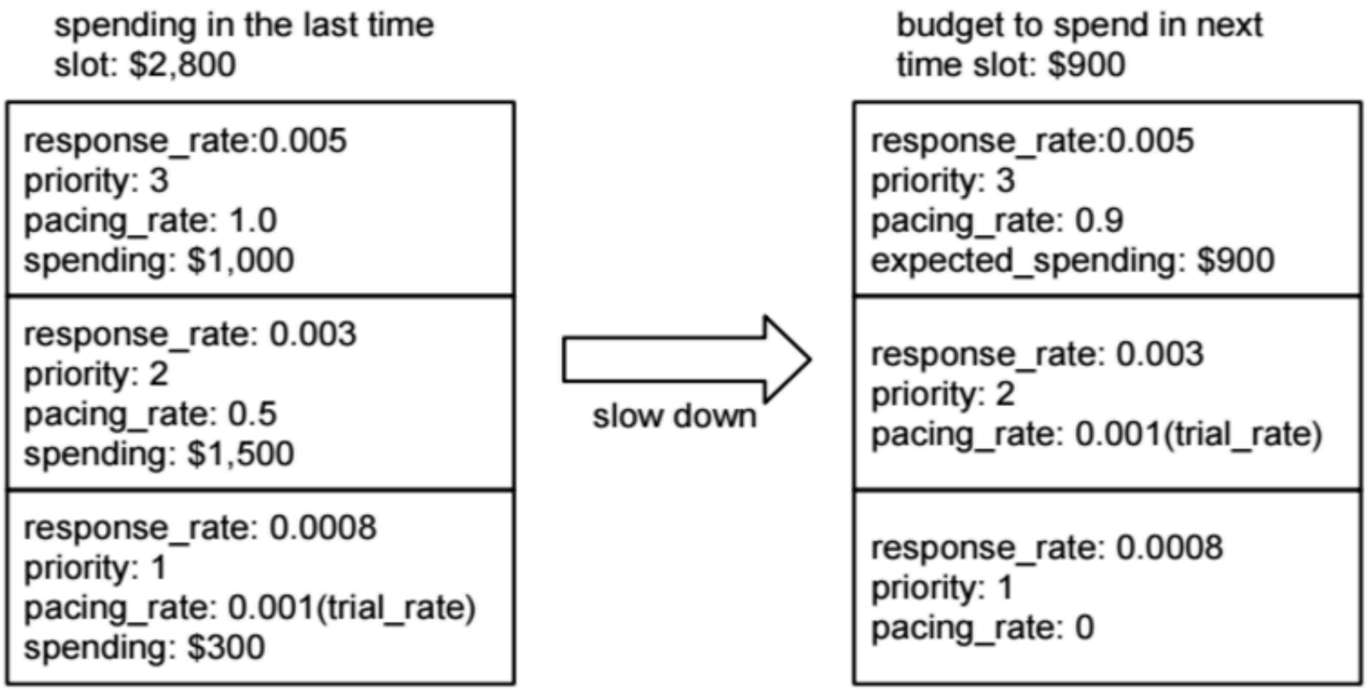
PRIORITY CONTROLLER

- Group similarly performing auctions together by KPI into layers
- Prioritize auctions that generate the best KPI (e.g. clicks)
- In time slot k, each layer is given a budget and a pacing rate *p*
- Rank layers by expected KPI (highest to lowest)
  - Layer 1, response rate: 0.002
  - Layer 2, response rate: 0.0002
  - Layer 3, response rate: 0.00002 …etc.
- If campaign is overspending, lower pacing rate from bottom up
- If campaign is under spending, raise pacing rate from top down

PRIORITY CONTROLLER



PRIORITY CONTROLLER



EVALUATION METRICS

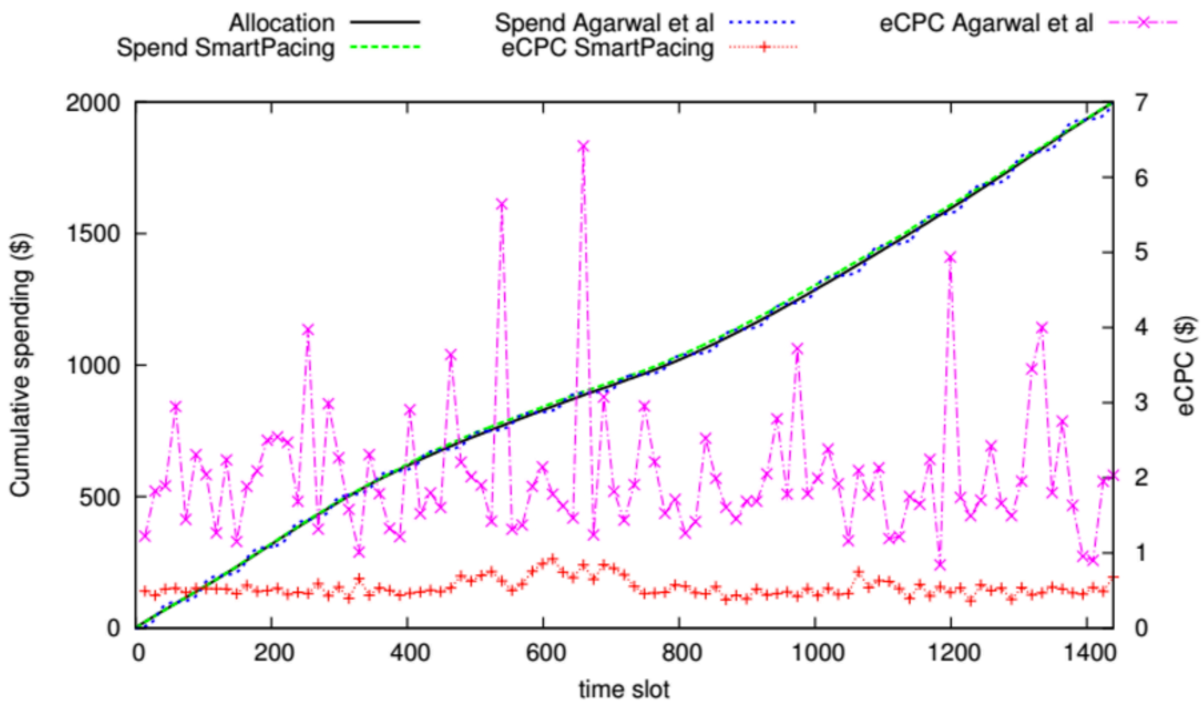
EVALUATION METRIC: RMSE

- Evaluate system by how closely it followed the budget
- RMSE penalizes large errors more than small errors
- B(k) is the spend plan, C(k) is the actual spend

$$\Omega(\mathbf{C}, \mathbf{B}) = \sqrt{\frac{1}{K} \sum_{t=1}^{K} (C^{(t)} - B^{(t)})^2}$$

EVALUATION METRIC: KPI

- If budget is allocated well, the eCPC of campaign will remain stable



(b) Actual spendings and eCPCs comparison (eCPC is calculated every 15 minutes to collect sufficient number of clicks)