

2018 EE448, Big Data Mining, Lecture 12

# Real-Time Bidding & Behavioral Targeting

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<http://wnzhang.net/teaching/ee448/index.html>

# Content of This Course

- Real-time bidding based display advertising
- User tracking and profiling
- Real-time bidding strategies
- Fraud detection

# Display Advertising

The New York Times

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## Exxon Mobil Investigated in New York Over Possible Lies on Climate

By JUSTIN GILLIS and CLIFFORD KRAUSS  
3:30 PM ET

The sweeping inquiry, by the state attorney general, focuses on whether the oil company lied to the public and investors over the risks of climate change.

250 Comments



T. Fallon/Bloomberg, via Getty Images

An Exxon Mobil refinery in Los Angeles, Calif. The New York attorney general is investigating the oil and gas company.

## European Union Predicts Economic Gains From Influx of Migrants

By JAMES KANTER  
12:10 PM ET

Officials forecast that the three million arrivals expected by 2017 would provide a net gain of perhaps a quarter of 1 percent by that year to the European economy.



### INSIGHT & ANALYSIS

#### COMMON SENSE

Dewey Jury's Deadlock Exposes a System's Flaws

By JAMES B. STEWART  
3:06 PM ET

One reason for the mistrial in the Dewey & LeBoeuf criminal case may have been the requirement for a unanimous decision.



### LATEST NEWS

- |            |   |
|------------|---|
| 5:01 PM ET | 'Grand Theft Auto' Maker Take-Two's Revenue Nearly Triples      |
| 5:00 PM ET | United Airlines CEO to Return in Early 2016 After Heart Attack  |
| 4:57 PM ET | NY Attorney General Investigating Exxon Over Climate Statements |

### MARKETS »

At close 11/05/2015

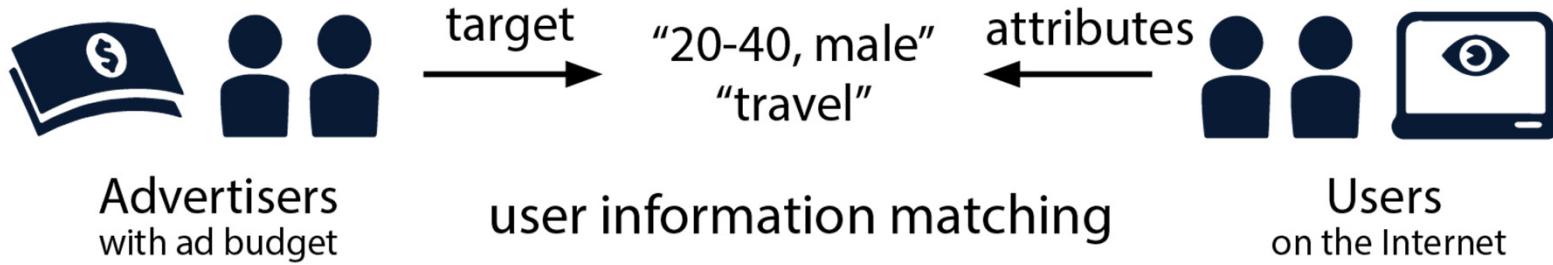
 BACKBASE

Backbase a Leader in the Forrester Wave for Omni-Channel Digital Banking

Read the Report

<http://www.nytimes.com/>

# Display Advertising



- Advertiser targets a segment of users
  - No matter what the user is searching or reading
  - Intermediary matches users and ads by user information

# Internet Advertising Frontier: Real-Time Bidding (RTB) based Display Advertising

## What is Real-Time Bidding?

- Every online **ad view** can be evaluated, bought, and sold, all **individually**, and all **instantaneously**.
- Instead of buying keywords or a bundle of ad views, advertisers are now **buying users** directly.
- **Behavioral targeting**: it is possible now to **track** user actions resulted from an online campaign, advertising optimization becomes more resembling to that of the financial market trading and tends to be driven by the marketing profit and return-on-investment (ROI).

# An Example of RTB

Suppose a student regularly reads articles on [emarketer.com](http://emarketer.com)

**eMarketer.**

Research Topics   Products   Why eMarketer   Customer Stories   Articles

## Advertisers Continue Rapid Adoption of Programmatic Buying

By 2017, advertisers will spend more than \$9 billion on RTB

Nov 26, 2013

Share   Print   Email

Advertisers are spending more than expected on real-time bidding, which is expected to account for a significant share of all display ad spending in the US billions, % change and % of total digital display ad spending

Year	RTB digital display ad spending (billions)	% change
2012	\$1.92	13.0%
2013	\$3.37	19.0%
2014	\$4.66	22.0%
2015	\$6.15	31.9%
2016	\$7.83	25.0%
2017	\$9.03	27.4%

eMarketer projects RTB digital display ad spending in the US will account for 29.0% of total US digital display ad spending by 2017, or \$9.03 billion. In 2013, it will account for 19.0%, or \$3.37 billion. These estimates are revised slightly upward from our previous forecast in August

Note: Includes all display formats served to all devices  
Source: eMarketer, Dec 2013  
166097   www.emarketer.com

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Content-related ads

# An Example of RTB

He recently checked the London hotels

Booking.com

Browse by destination theme Shopping Fine Dining Culture Sightseeing Monuments Relaxation

home — uk 16,378 properties — greater london 1,824 properties — london 1,574 properties — search results London, 2 adults, 11 nights (Jul 14 - Jul 25) Change dates (In fact, no login is required)

**Search**

Destination/Hotel Name:

Distance: 16 miles

Check-in Date: Mon 14 July 2014

Check-out Date: Fri 25 July 2014

I don't have specific dates yet

Guests: 2 Adults (1 room)

**Search**

**48% reserved**

London is a top choice with fellow travelers on your selected dates (48% reserved).  
Tip: Prices might be higher than normal, so try searching with different dates if possible.

[Try previous week](#) Jul 7 - Jul 18    [Try next week](#) Jul 21 - Aug 1

**930 out of 1857 properties are available in and around London**

Showing 1 – 15

Sort by: Recommended Stars Location Price Review Score

**Park Plaza Victoria London** ★★★★  1736 reviews  
Central London, Westminster, London •  Nearby stop

Very good 8.5  
Score from 1137 reviews

There are 13 people looking at this hotel.  
Latest booking: 1 hour ago

Superior Double Room  
7 more room types

Price for 11 nights £2,353.65

**Book now**

**Central Park Hotel** ★★★  1993 reviews

6.6

We have 5 rooms left!

Filter by:

# An Example of RTB

## Relevant ads on facebook.com

Search for people, places and things

Weinan | Home

Family  
UCL  
SJTU 16  
UCL 20+  
Shanghai Jiao Ton... 16  
London, United Ki... 20+  
University College... 20+  
Close Friends  
Intern,Beijing,Microso...  
GROUPS  
Microsoft Research C...  
Create group  
INTERESTS  
Pages and Public Fig...  
PAGES  
Like Pages 1  
Pages feed 9  
Create a Page...  
DEVELOPER

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Bingkai Lin 43 mutual friends **Add Friend**

Zhaomeng Peng 10 mutual friends **Add Friend**

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# An Example of RTB

Even on supervisor's homepage!  
(User targeting dominates the context)

**DR. JUN WANG**  
Computer Science, UCL

About Me Contact Publications Teaching Research Team Prospective Students Type text to search here...

## CIKM2013 Tutorial: Real-Time Bidding: A New Frontier of Computational Advertising Research

July 30th, 2013 Comments of

Online advertising is now one of the fastest advancing areas in IT industry. In display and mobile advertising, the most significant development in recent years is the growth of Real-Time Bidding (RTB), which allows selling and buying online display advertising in real-time one ad impression at a time. Since then, RTB has fundamentally changed the landscape of the digital media market by scaling the buying process across a large number of available inventories. It also encourages behaviour (re-)targeting, and makes a significant shift toward buying focused on user data, rather than contextual data. A report from IDC shows that in 2011, global RTB based display ad spend increased by 237% compared to 2010, with the U.S.'s \$2.2 billion RTB display spend leading the way. The market share of RTB-based spending of all display ad spending will grow from 10% in 2011 to 27% in 2016, and its share of all indirect spending will grow from 28% to 78%.

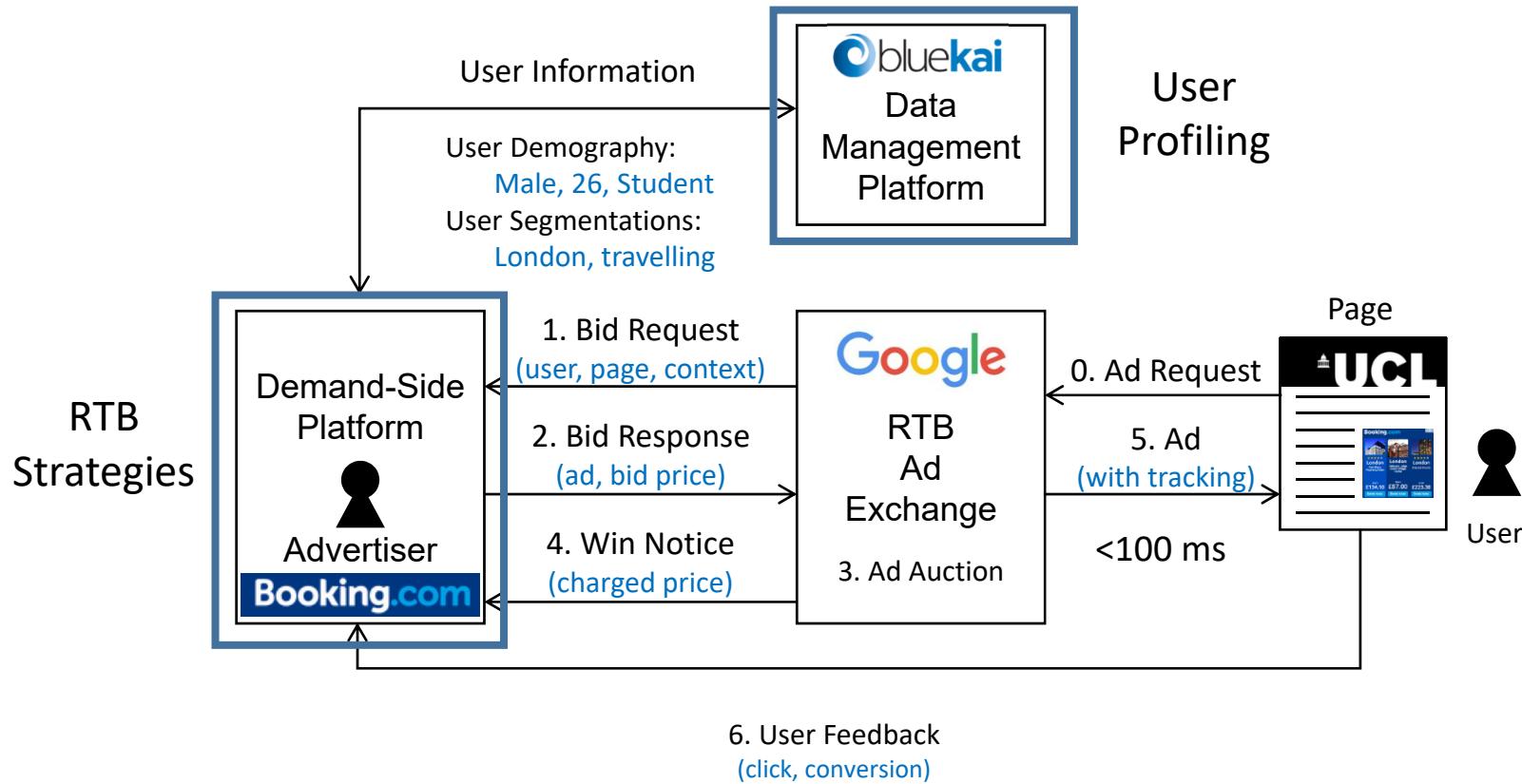
Scientifically, the further demand for automation, integration and optimization in RTB brings

"Relevant" Ads or not?

**Booking.com**

★★★★★ London Park Plaza Victoria London From £134.10 Book now	★★★★★ London Palmers Lodge Swiss Cottage Hostel From £87.00 Book now	★★★★★ London Thistle Hotel From £223.38 Book now
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# RTB Display Advertising Mechanism



- Buying ads via real-time bidding (RTB), 10 billion per day
- A real big data battlefield

# RTB: A Big Data Battle Field

- The daily volume of RTB platforms and the comparison with finance institutes

	DSP/Exchange	Daily Traffic
Advertising	iPinYou, China	18 billion impressions
	YOYI, China	5 billion impressions
	Fikisu, US	32 billion impressions
Finance	New York Stock Exchange	12 billion shares
	Shanghai Stock Exchange	14 billion shares

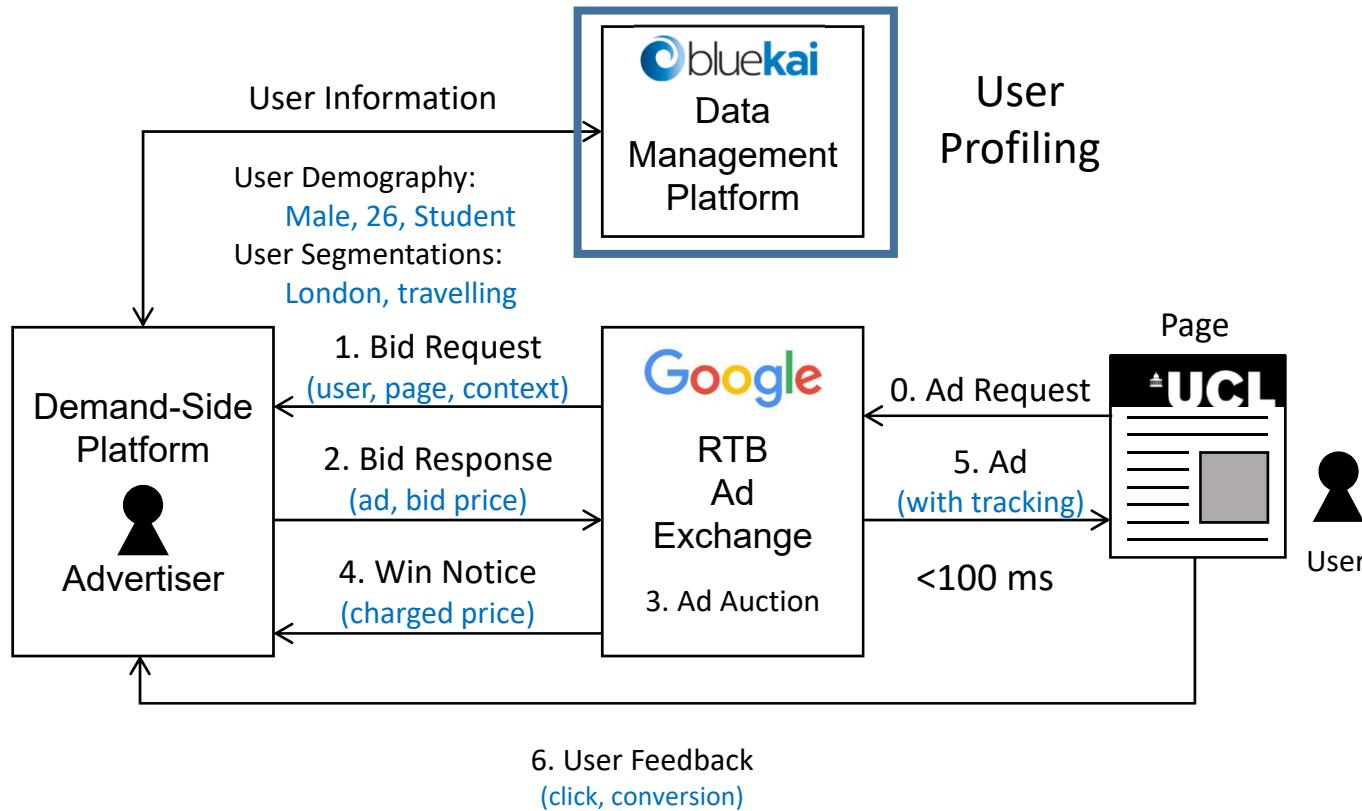
	Query per Second
Turn DSP	1.6 million
Google	40,000 search

It is fair to say that the transaction volume from display advertising has already surpassed that of the financial market

# Content of This Course

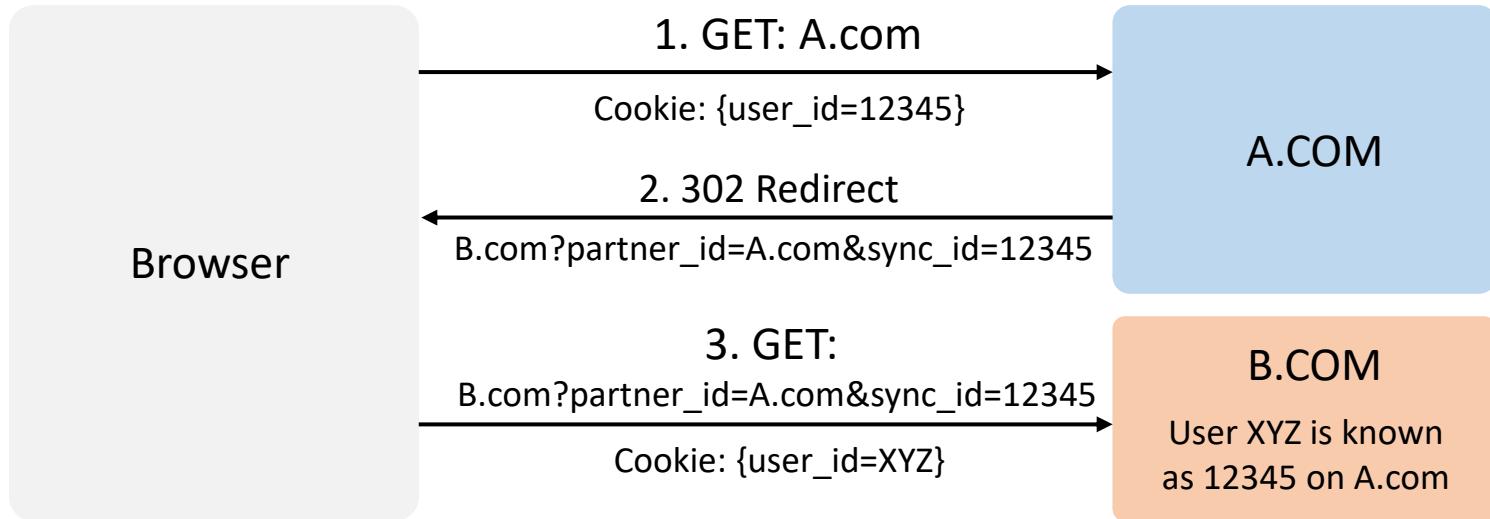
- Real-time bidding based display advertising
- User tracking and profiling
- Real-time bidding strategies
- Fraud detection

# DMP: Data Management Platform



- DMP is a data warehouse that stores, merges, and sorts, and labels it out in a way that's useful for marketers, publishers and other businesses.

# Cookie Sync: Merging Audience Data

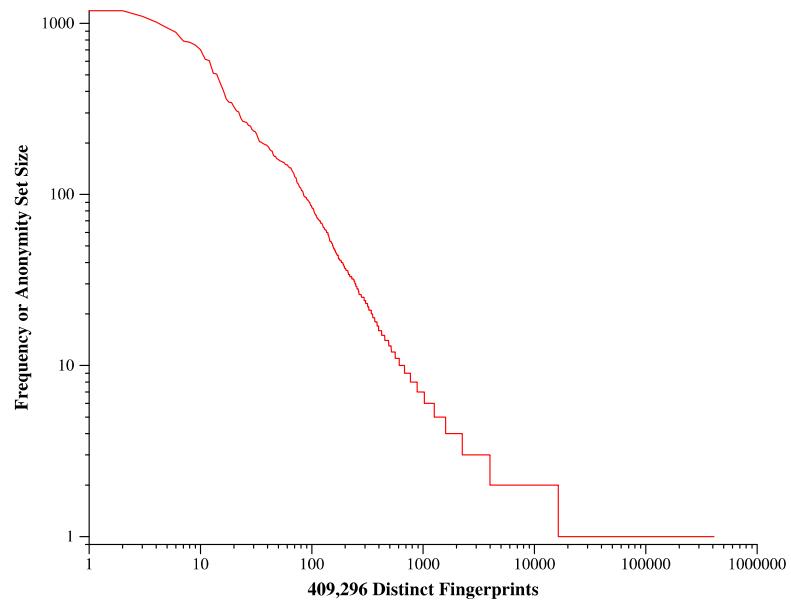


When a user visits a site (e.g. ABC.com) including A.com as a third-party tracker.

- (1) The browser makes a request to A.com, and included in this request is the tracking cookie set by A.com.
- (2) A.com retrieves its tracking ID from the cookie, and redirects the browser to B.com, encoding the tracking ID into the URL.
- (3) The browser then makes a request to B.com, which includes the full URL A.com redirected to as well as B.com's tracking cookie.
- (4) B.com can then link its ID for the user to A.com's ID for the user2

# Browser Fingerprinting

- A **device fingerprint** or **browser fingerprint** is information collected about the remote computing device for the purpose of identifying the user.
- Fingerprints can be used to **fully or partially identify individual users** or devices even when cookies are turned off.



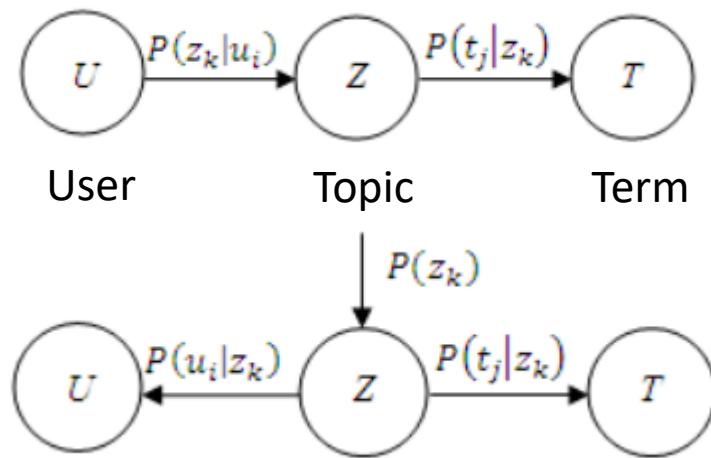
94.2% of browsers with Flash or Java were unique in a study

Eckersley, Peter. "How unique is your web browser?." Privacy Enhancing Technologies. Springer Berlin Heidelberg, 2010.

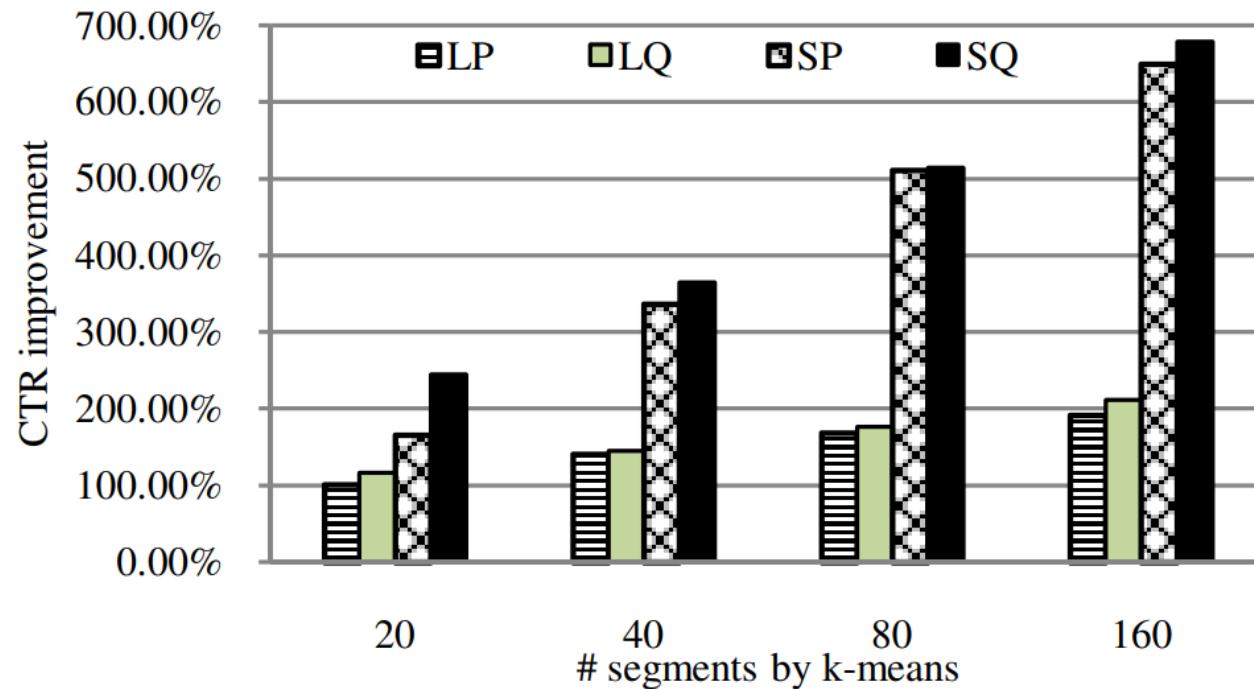
Acar, Gunes, et al. "The web never forgets: Persistent tracking mechanisms in the wild." Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security. ACM, 2014.

# User Segmentation and Behavioral Targeting

- Behavioral targeting helps online advertising
- From user – documents to user – topics
  - Latent Semantic Analysis / Latent Dirichlet Allocation



# User Segmentation and Behavioral Targeting

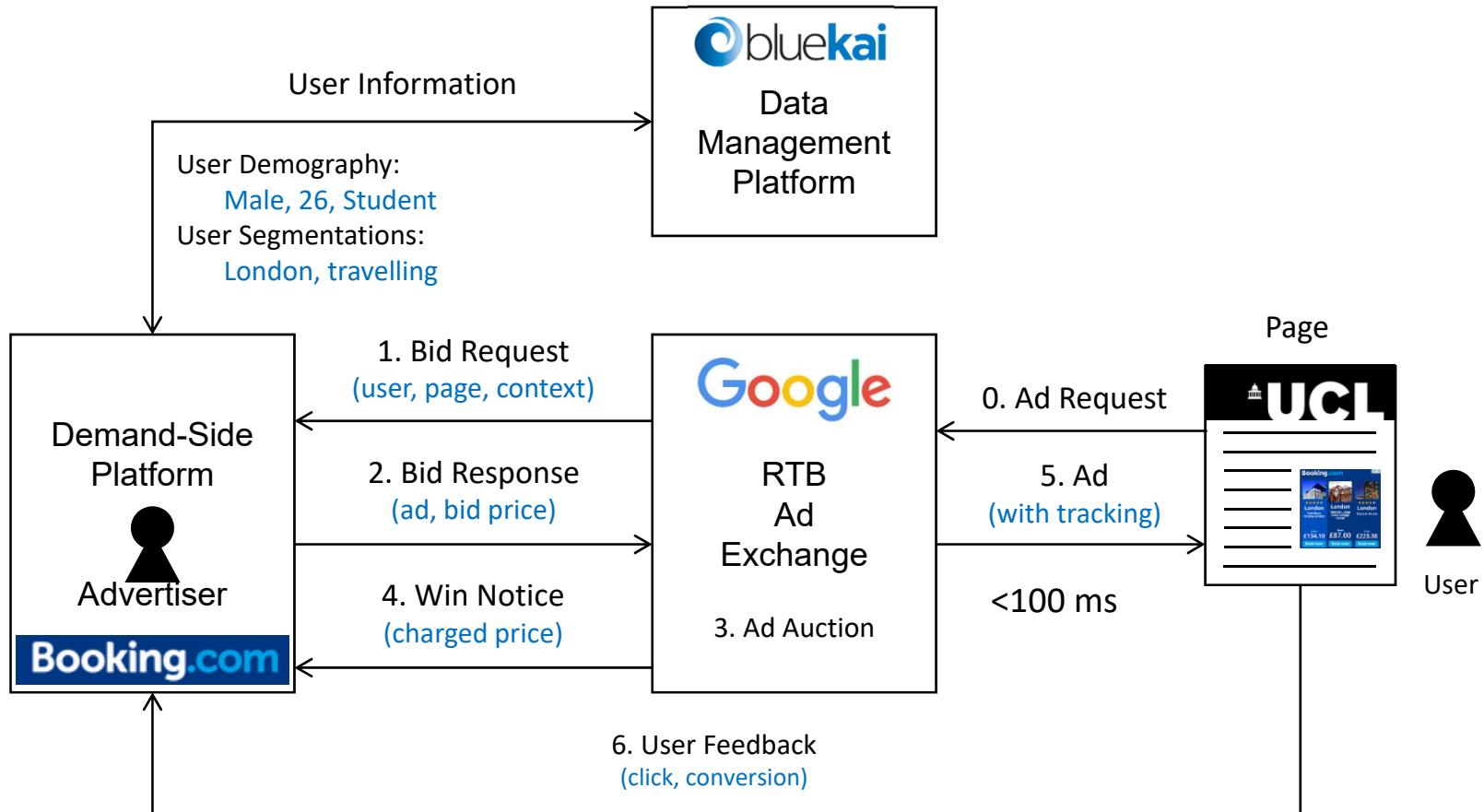


- LP: using Long term 7-day user behavior and representing the user behavior by Page-views;
- LQ: using Long term 7-day user behavior and representing the user behavior by Query terms;
- SP: using Short term 1-day user behavior and representing user behavior by Page-views;
- SQ: using Short term 1-day user behavior and representing user behavior by Query terms.

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- Real-time bidding based display advertising
- User tracking and profiling
- Real-time bidding strategies
- Fraud detection

# RTB Display Advertising Mechanism



- Buying ads via real-time bidding (RTB), 10B per day

# Data of Learning to Bid

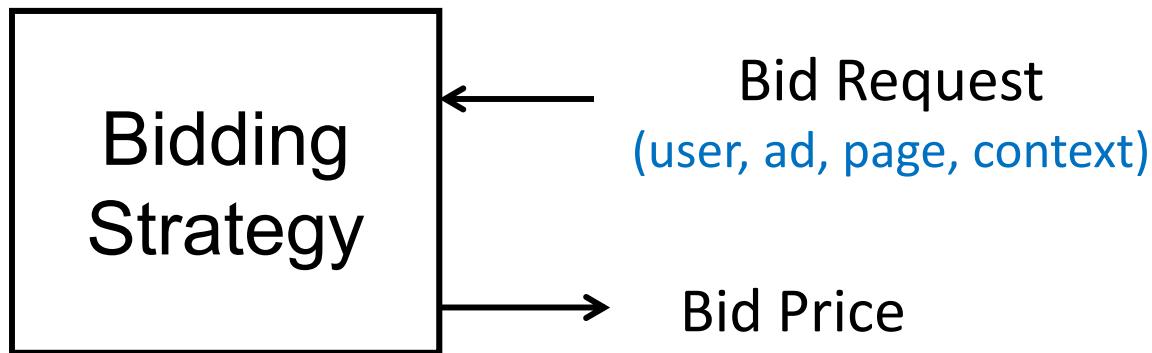
- Data

( $\mathbf{x}, t$ )	$b$	$w$	$c$	$y$
(up, 1500×20, Shanghai, 0)	5	1	4	1
(down, 1200×25, Paris, 1)	4	1	3	0
(left, 20×1000, Los Angeles, 2)	3	0	×	×
(right, 35×600, London, 3)	0	0	×	×

- Bid request features: High dimensional sparse binary vector
- Bid: Non-negative real or integer value
- Win: Boolean
- Cost: Non-negative real or integer value
- Feedback: Binary

# Problem Definition of Learning to Bid

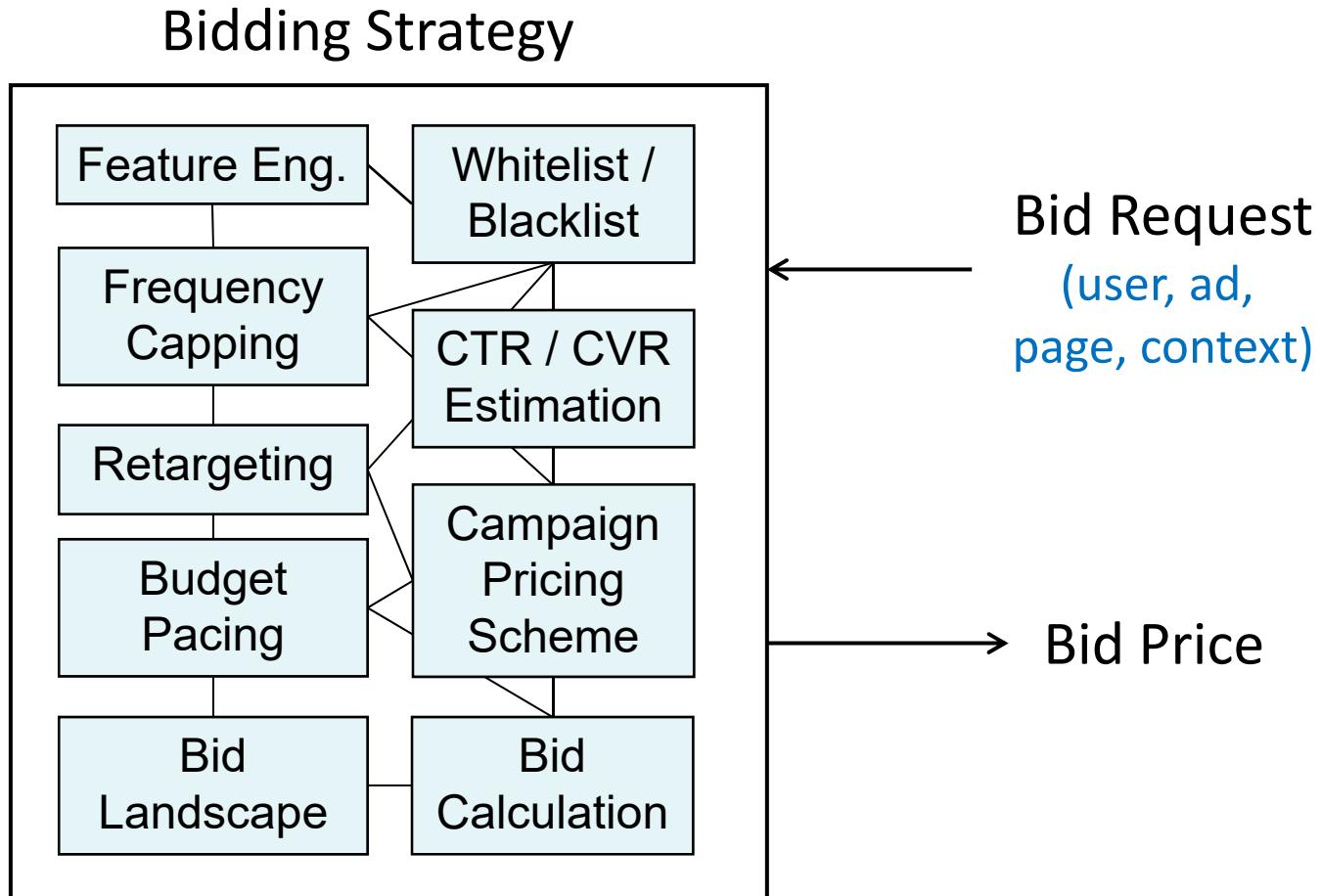
- How much to bid for each bid request?
  - Find an optimal bidding function  $b(x)$



- Bid to optimize the KPI with budget constraint

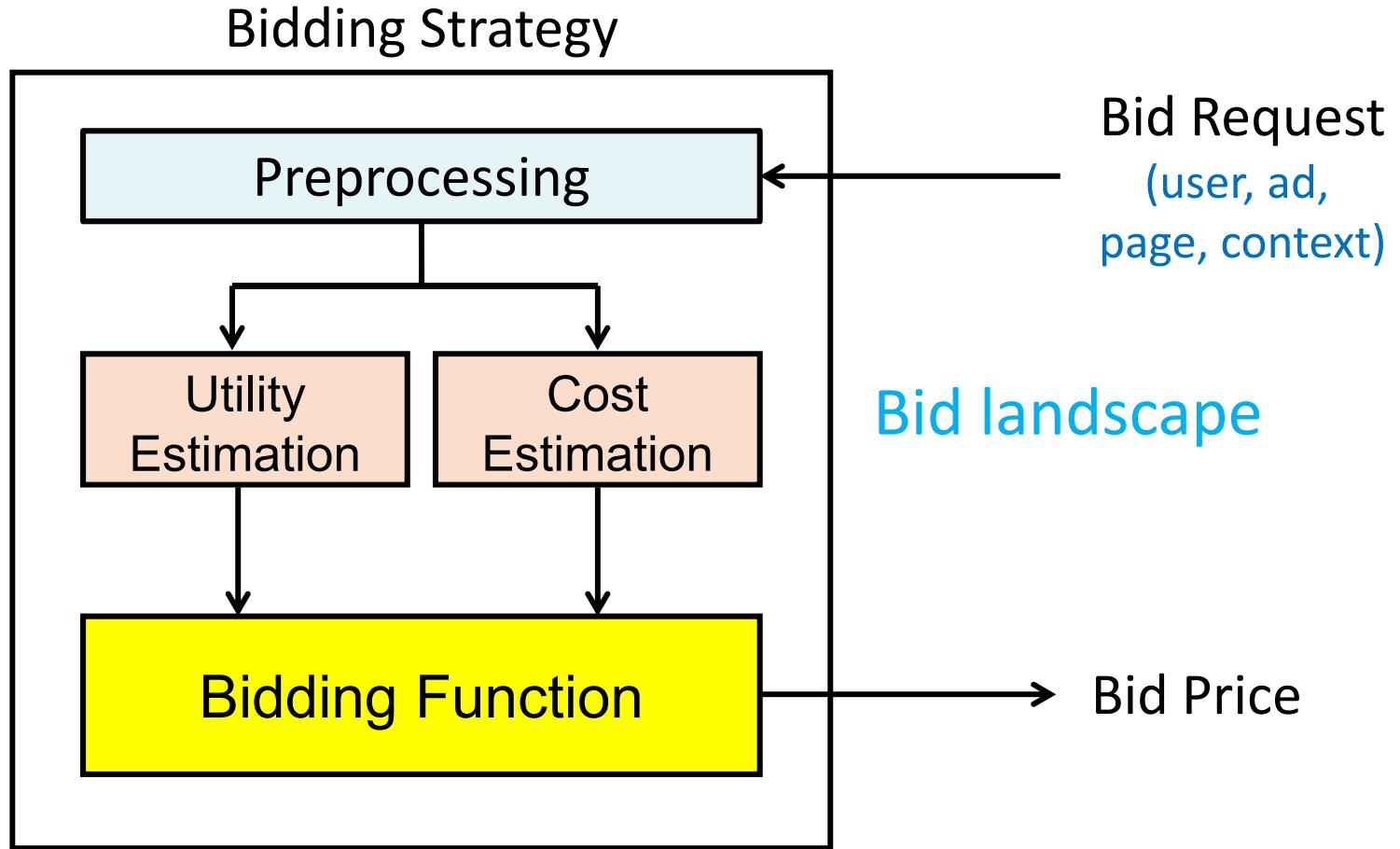
$$\begin{array}{ll} \max_{\text{bidding strategy}} & \text{KPI} \\ \text{subject to} & \text{cost} \leq \text{budget} \end{array}$$

# Bidding Strategy in Practice

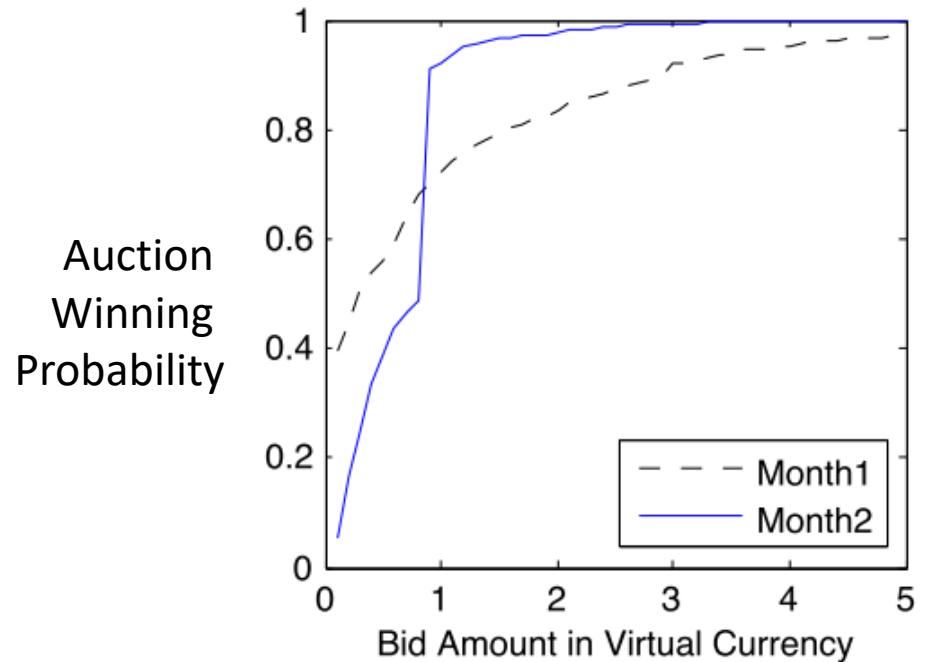
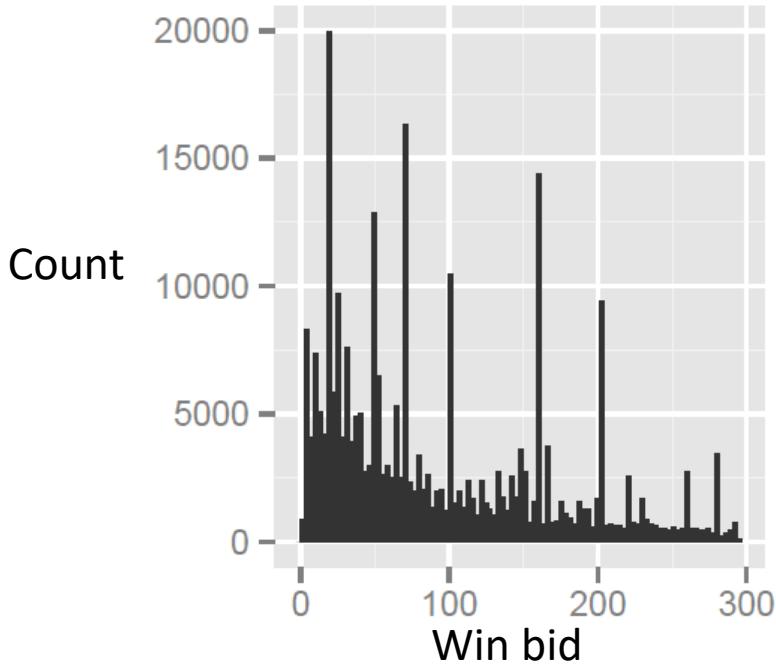


# Bidding Strategy in Practice: A Quantitative Perspective

CTR,  
CVR,  
revenue



# Bid Landscape Forecasting



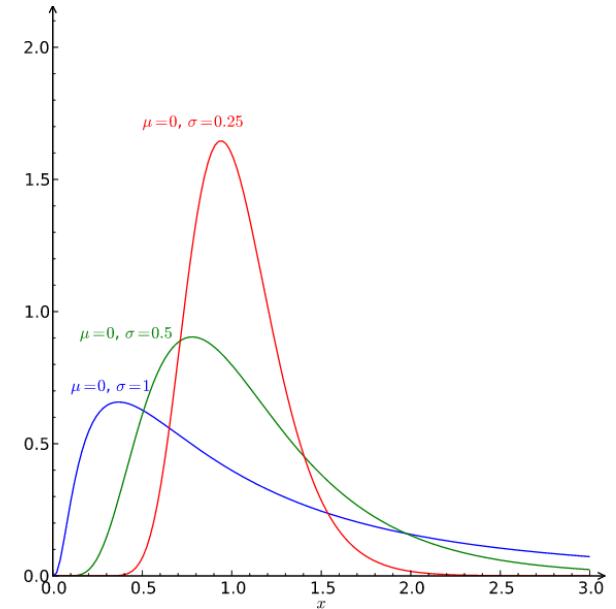
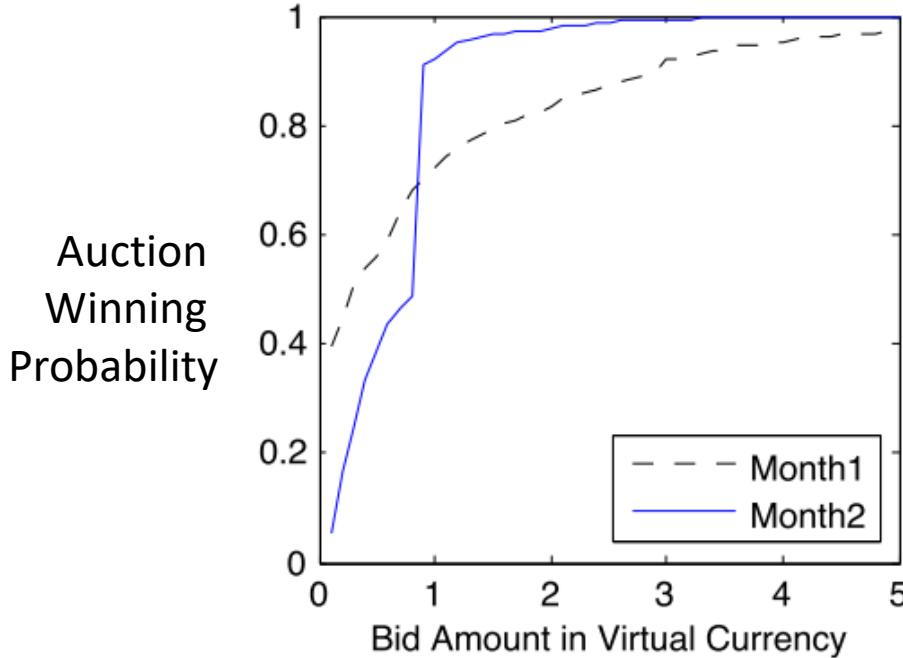
Win probability:

$$w(b) = \int_{z=0}^b p(z) dz$$

Expected cost:

$$c(b) = \frac{\int_{z=0}^b z p(z) dz}{\int_{z=0}^b p(z) dz}$$

# Bid Landscape Forecasting



- Log-Normal Distribution

$$f_s(x; \mu, \sigma) = \frac{1}{x\sigma\sqrt{2\pi}} e^{\frac{-(\ln x - \mu)^2}{2\sigma^2}}, x > 0$$

# Data Bias Problem for Bid Landscape

$$w(b) = \int_{z=0}^b p(z) dz$$

- If we directly count the probability from observed market prices

$$w_o(b_x) = \frac{\sum_{(\mathbf{x}', y, z) \in D} \delta(z < b_x)}{|D|}$$

- The estimation is unbiased since the observed market prices is always lower than the historic bid
- Counterfactual case: example of WW2 planes

# Survival Model for Bid Landscape

- Kaplan-Meier Product-Limit method

$$l(b_{\mathbf{x}}) = \prod_{b_j < b_{\mathbf{x}}} \frac{n_j - d_j}{n_j} \quad w(b_{\mathbf{x}}) = 1 - \prod_{b_j < b_{\mathbf{x}}} \frac{n_j - d_j}{n_j}$$

$b_i$	$w_i$	$z_i$
2	win	1
3	win	2
2	lose	✗
3	win	1
3	lose	✗
4	lose	✗
4	win	3
1	lose	✗

$b_j$	$n_j$	$d_j$	$\frac{n_j - d_j}{n_j}$	$w(b_j)$	$w_o(b_j)$
1	8	0	1	$1 - 1 = 0$	0
2	7	2	$\frac{5}{7}$	$1 - \frac{5}{7} = \frac{2}{7}$	$\frac{2}{4}$
3	4	1	$\frac{3}{4}$	$1 - \frac{5}{7} \frac{3}{4} = \frac{13}{28}$	$\frac{3}{4}$
4	2	1	$\frac{1}{2}$	$1 - \frac{5}{7} \frac{3}{4} \frac{1}{2} = \frac{41}{56}$	$\frac{4}{4}$

# Survival Model for Bid Landscape

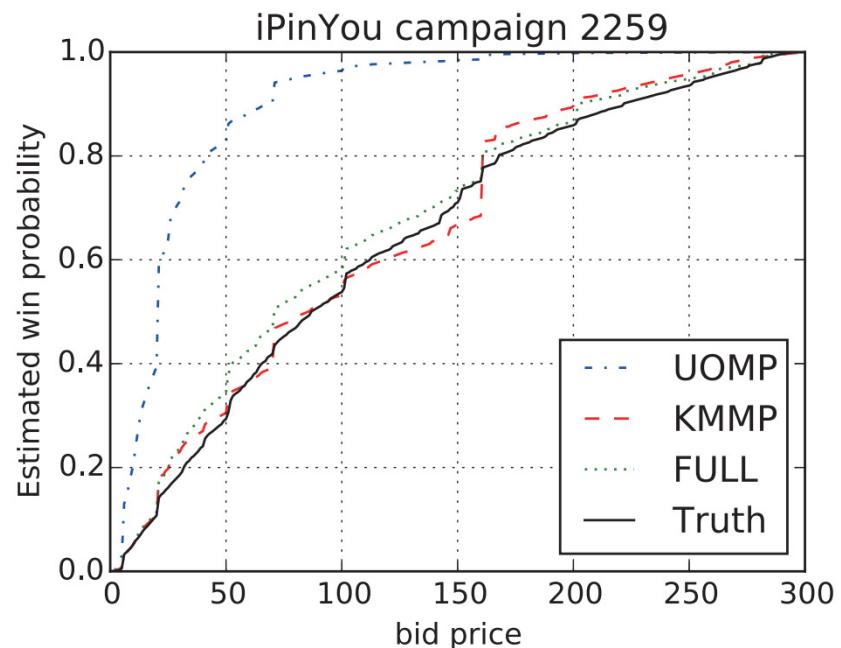
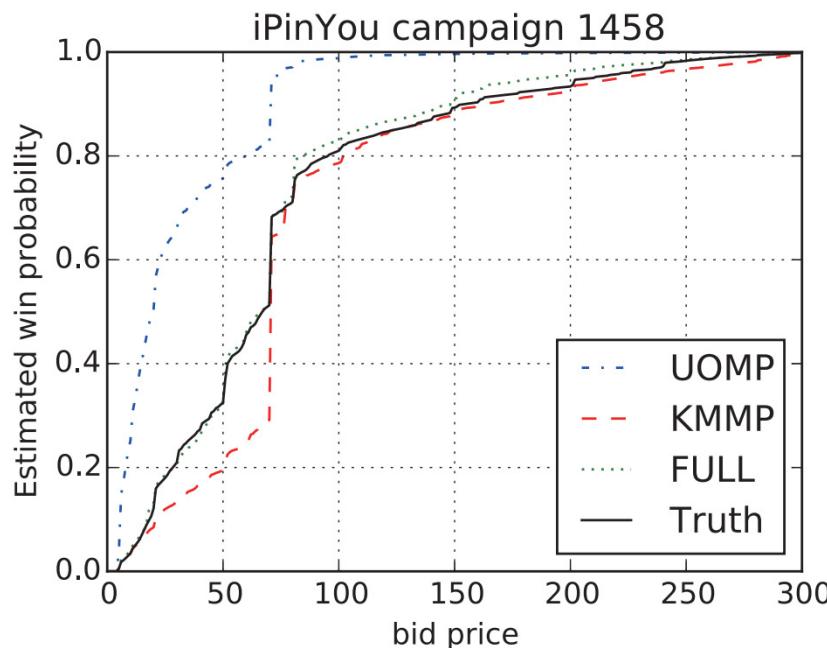
- Kaplan-Meier Product-Limit method

$$w_o(b_{\mathbf{x}}) = \frac{\sum_{(\mathbf{x}', y, z) \in D} \delta(z < b_{\mathbf{x}})}{|D|}$$

UOMP

$$w(b_{\mathbf{x}}) = 1 - \prod_{b_j < b_{\mathbf{x}}} \frac{n_j - d_j}{n_j}$$

KMMP



# Bid Landscape Forecasting

- Price Prediction via Linear Regression

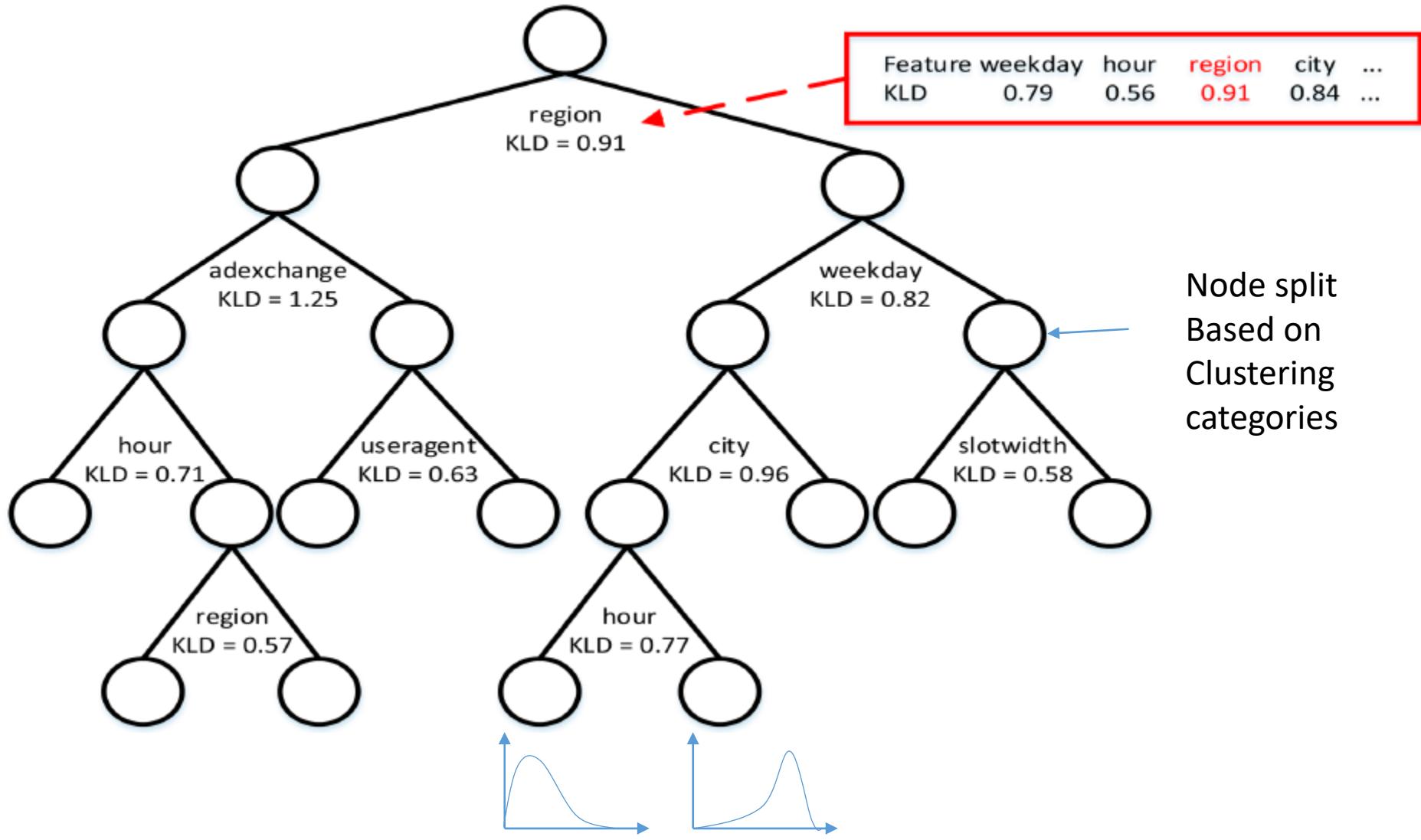
$$z = \boldsymbol{\beta}^T \mathbf{x} + \epsilon \quad \max_{\boldsymbol{\beta}} \sum_{i \in W} \log \phi\left(\frac{z_i - \boldsymbol{\beta}^T \mathbf{x}_i}{\sigma}\right)$$

- Modelling censored data in lost bid requests

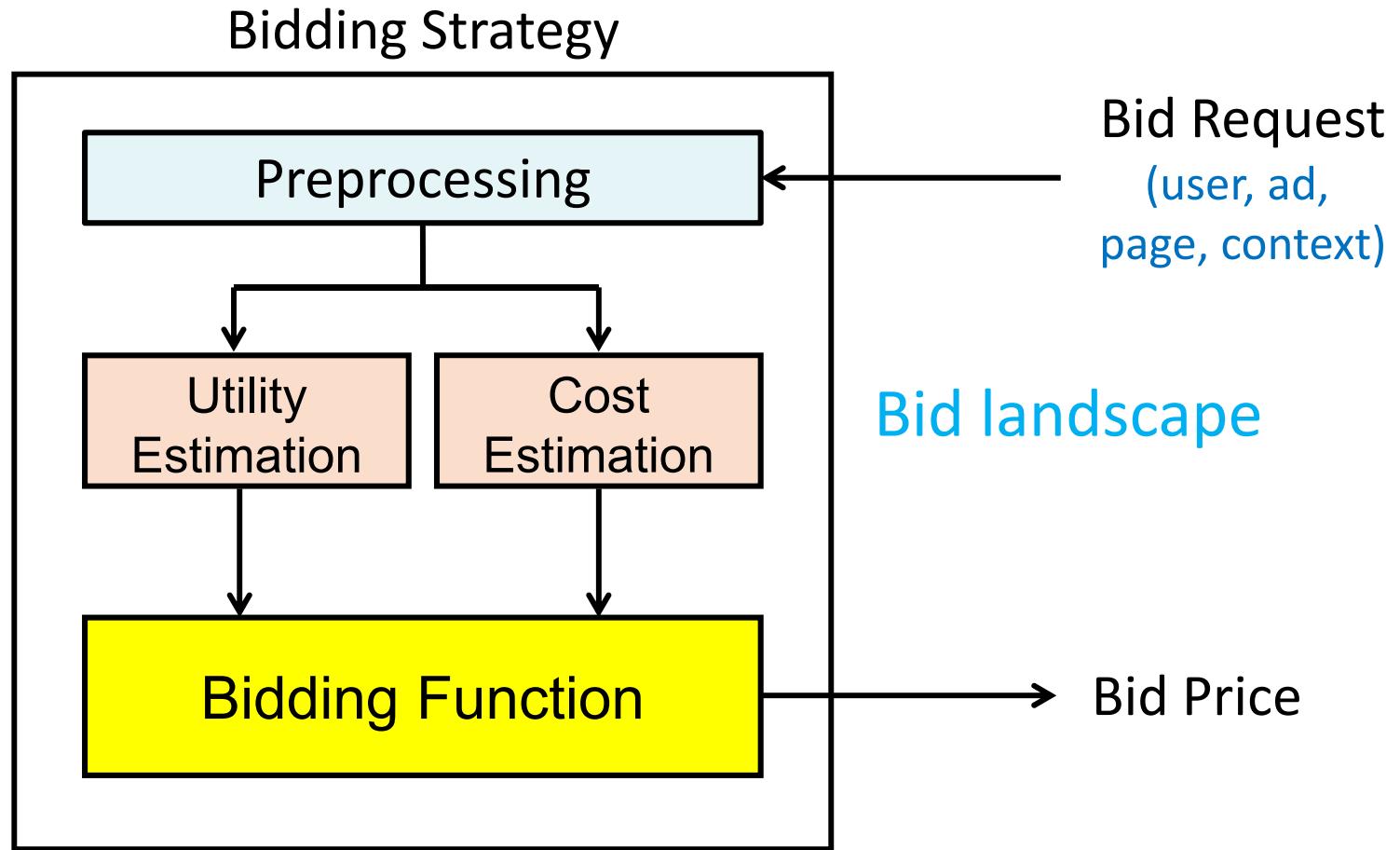
$$P(b_i < z_i) = \Phi\left(\frac{\boldsymbol{\beta}^T \mathbf{x}_i - b_i}{\sigma}\right)$$

$$\max_{\boldsymbol{\beta}} \sum_{i \in W} \log \phi\left(\frac{z_i - \boldsymbol{\beta}^T \mathbf{x}_i}{\sigma}\right) + \sum_{i \in L} \log \Phi\left(\frac{\boldsymbol{\beta}^T \mathbf{x}_i - b_i}{\sigma}\right)$$

# Survival Tree Models

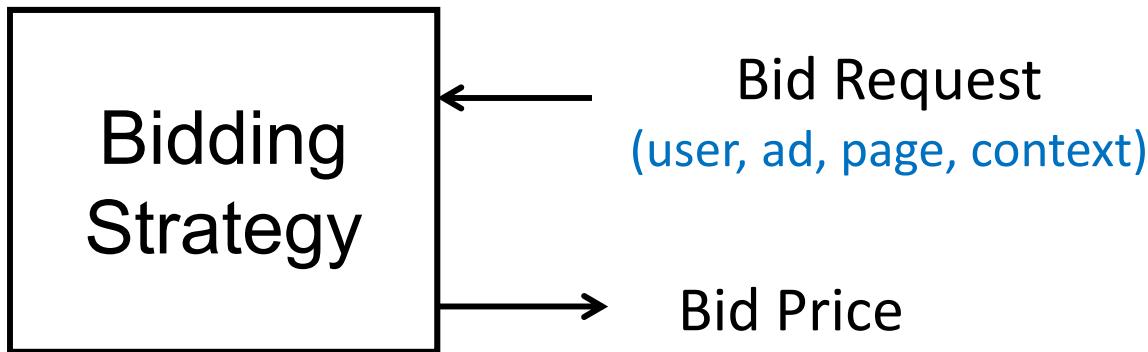


# Bidding Strategy in Practice: A Quantitative Perspective



# Bidding Strategies

- How much to bid for each bid request?



- Bid to optimize the KPI with budget constraint

$$\begin{aligned} & \max_{\text{bidding strategy}} && \text{KPI} \\ & \text{subject to} && \text{cost} \leq \text{budget} \end{aligned}$$

# Classic Second Price Auctions

- Single item, second price (i.e. pay market price)

Reward given a bid:  $R(b) = \int_0^b (r - z)p(z)dz$

Optimal bid:  $b^* = \max_b R(b)$

$$\frac{\partial R(b)}{\partial b} = (r - b)p(b)$$

$$\frac{\partial R(b)}{\partial b} = 0 \Rightarrow b^* = r \quad \text{Bid true value}$$

# Truth-telling Bidding Strategies

- Truthful bidding in second-price auction
  - Bid the true value of the impression
  - Impression true value =  $\begin{cases} \text{Value of click, if clicked} \\ 0, \text{ if not clicked} \end{cases}$
  - Averaged impression value = value of click \* CTR
  - Truth-telling bidding:

$$\text{bid} = r_{\text{conv}} \times \text{CVR} \quad \text{or} \quad \text{bid} = r_{\text{click}} \times \text{CTR}$$

# Truth-telling Bidding Strategies

$$\text{bid} = r_{\text{conv}} \times \text{CVR} \quad \text{or} \quad \text{bid} = r_{\text{click}} \times \text{CTR}$$

- Pros
  - Theoretic soundness
  - Easy implementation (very widely used)
- Cons
  - Not considering the constraints of
    - Campaign lifetime auction volume
    - Campaign budget
  - Case 1: \$1000 budget, 1 auction
  - Case 2: \$1 budget, 1000 auctions

# Non-truthful Linear Bidding

- Non-truthful linear bidding

$$\text{bid} = \text{base\_bid} \times \frac{\text{predicted\_CTR}}{\text{base\_CTR}}$$

- Tune base\_bid parameter to maximize KPI
- Bid landscape, campaign volume and budget indirectly considered

$$\begin{array}{ll} \max_{\text{bidding strategy}} & \text{KPI} \\ \text{subject to} & \text{cost} \leq \text{budget} \end{array}$$

# ORTB Bidding Strategies

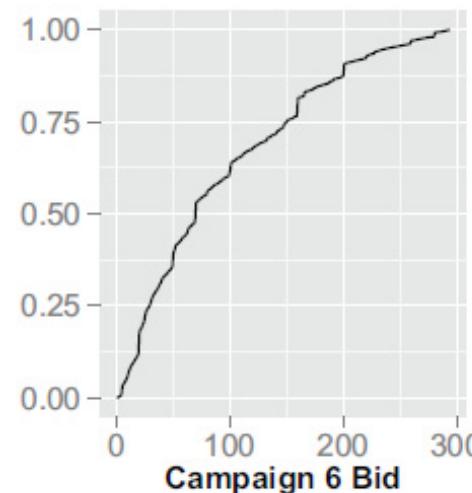
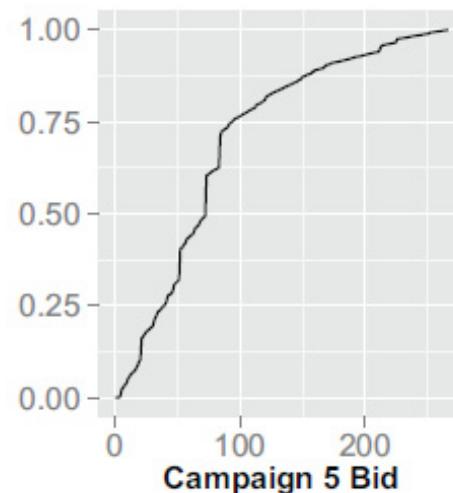
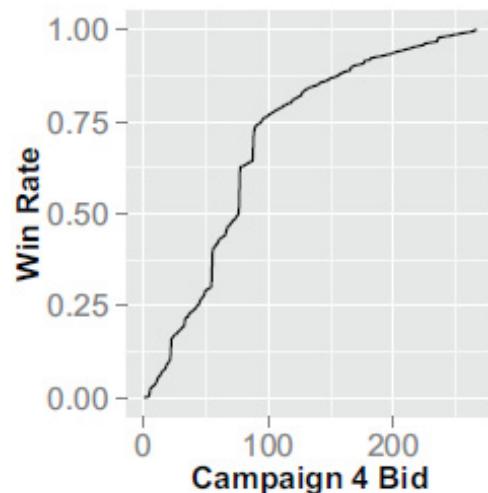
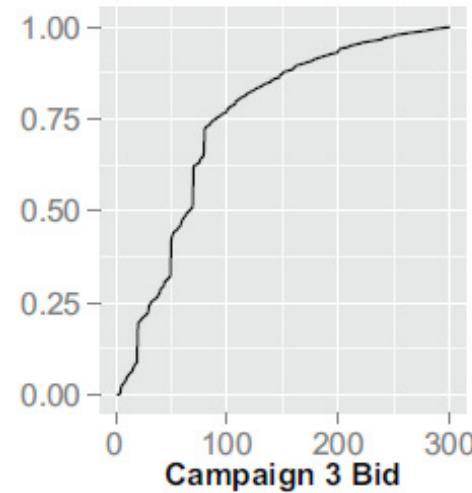
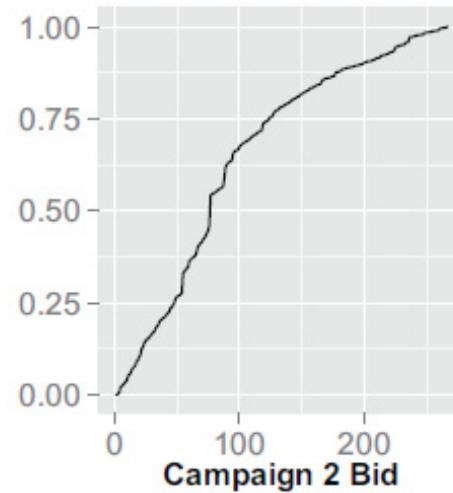
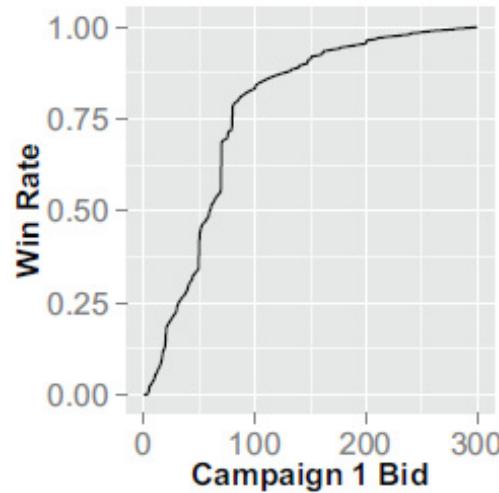
- Direct functional optimisation

- Solution: Calculus of variations

$$\mathcal{L}(b(\theta), \lambda) = \int_{\theta} \theta w(b(\theta)) p_{\theta}(\theta) d\theta - \lambda \int_{\theta} b(\theta) w(b(\theta)) p_{\theta}(\theta) d\theta + \frac{\lambda B}{N_T}$$

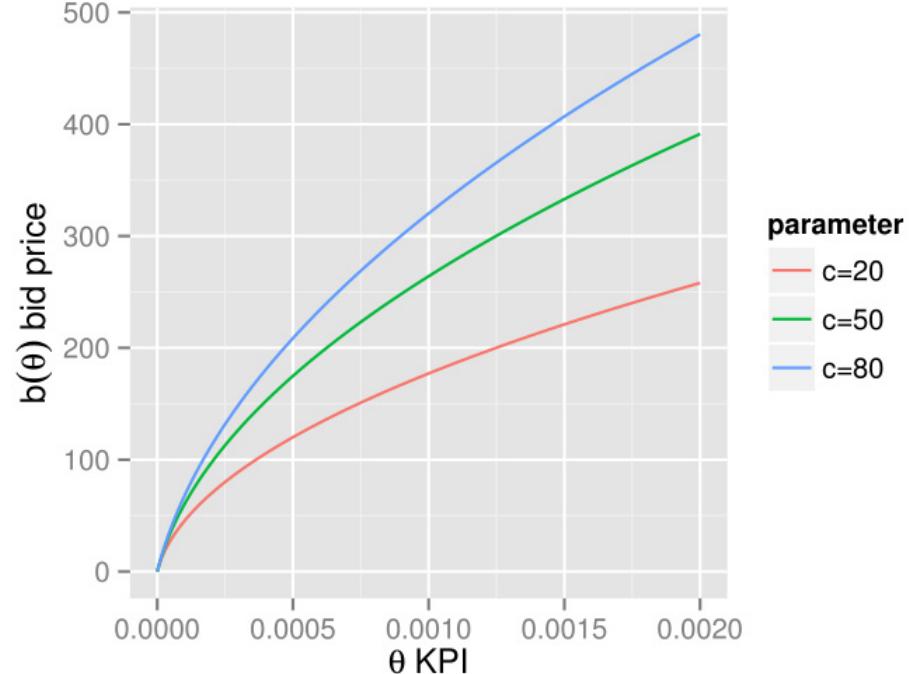
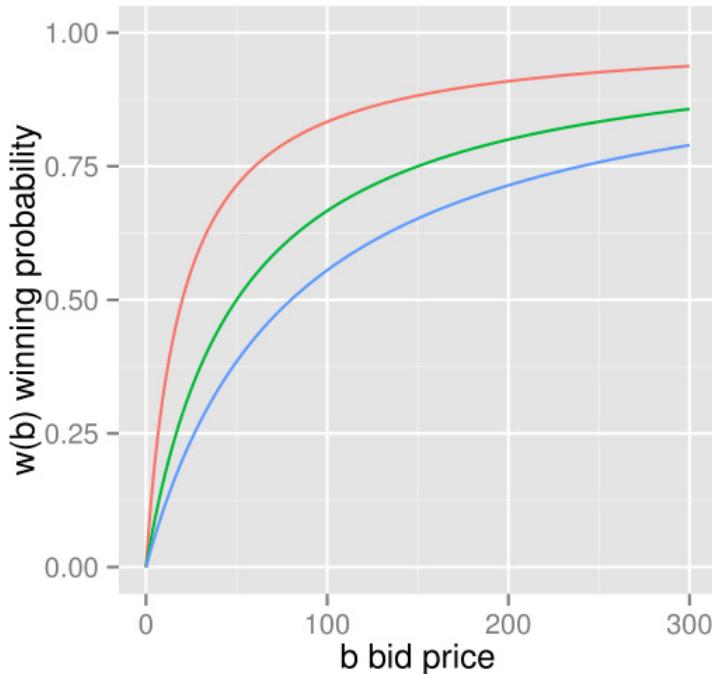
$\frac{\partial \mathcal{L}(b(\theta), \lambda)}{\partial b(\theta)} = 0 \quad \rightarrow \quad \boxed{\lambda w(b(\theta)) = [\theta - \lambda b(\theta)] \frac{\partial w(b(\theta))}{\partial b(\theta)}}$

# Bid Landscape: $w(\text{bid})$



# Optimal Bidding Strategy Solution

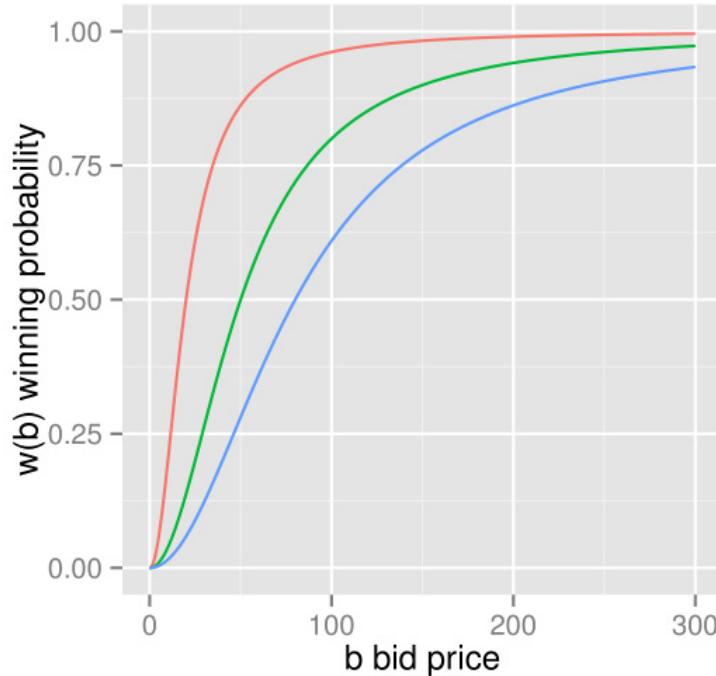
$$\lambda w(b(\theta)) = [\theta - \lambda b(\theta)] \frac{\partial w(b(\theta))}{\partial b(\theta)}$$



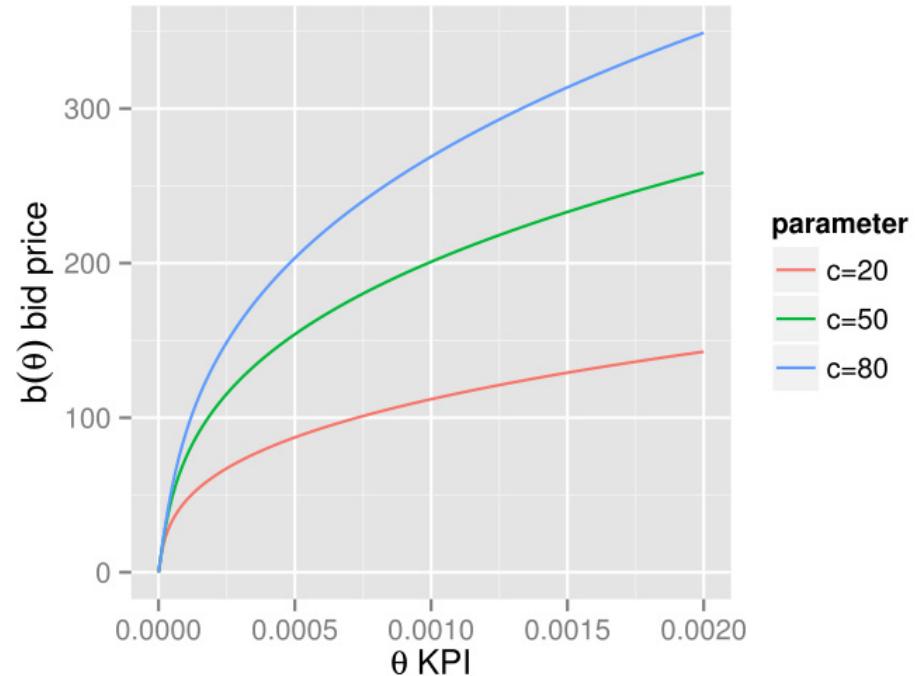
$$w(b(\theta)) = \frac{b(\theta)}{c + b(\theta)} \rightarrow b_{\text{ORTB1}}(\theta) = \sqrt{\frac{c}{\lambda} \theta + c^2} - c$$

# Optimal Bidding Strategy Solution

$$\lambda w(b(\theta)) = [\theta - \lambda b(\theta)] \frac{\partial w(b(\theta))}{\partial b(\theta)}$$



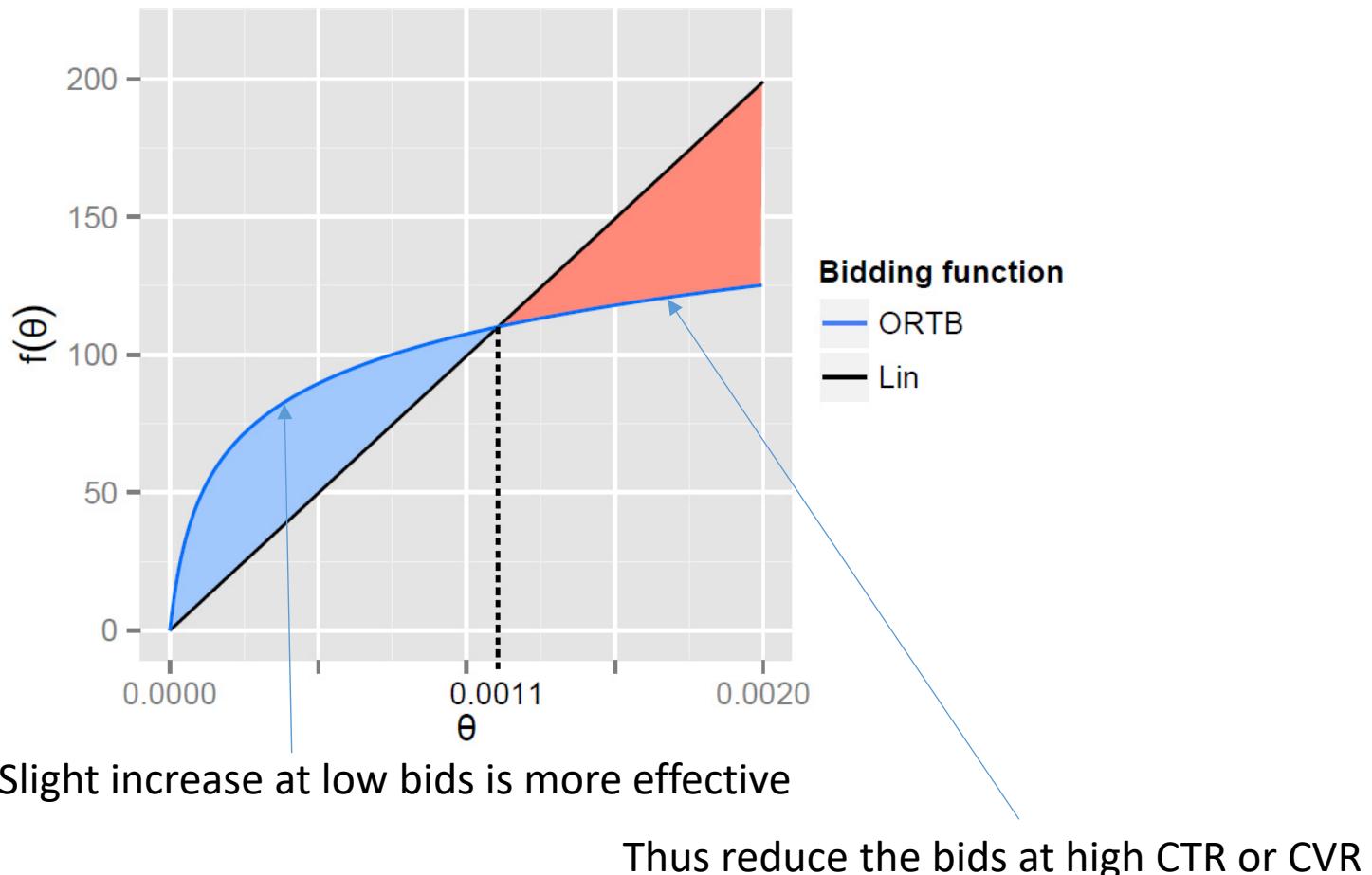
(a) Winning function 2.



(b) Bidding function 2.

$$w(b(\theta)) = \frac{b^2(\theta)}{c^2 + b^2(\theta)} \rightarrow b_{\text{ORTB2}}(\theta) = c \cdot \left[ \left( \frac{\theta + \sqrt{c^2 \lambda^2 + \theta^2}}{c \lambda} \right)^{\frac{1}{3}} - \left( \frac{c \lambda}{\theta + \sqrt{c^2 \lambda^2 + \theta^2}} \right)^{\frac{1}{3}} \right]$$

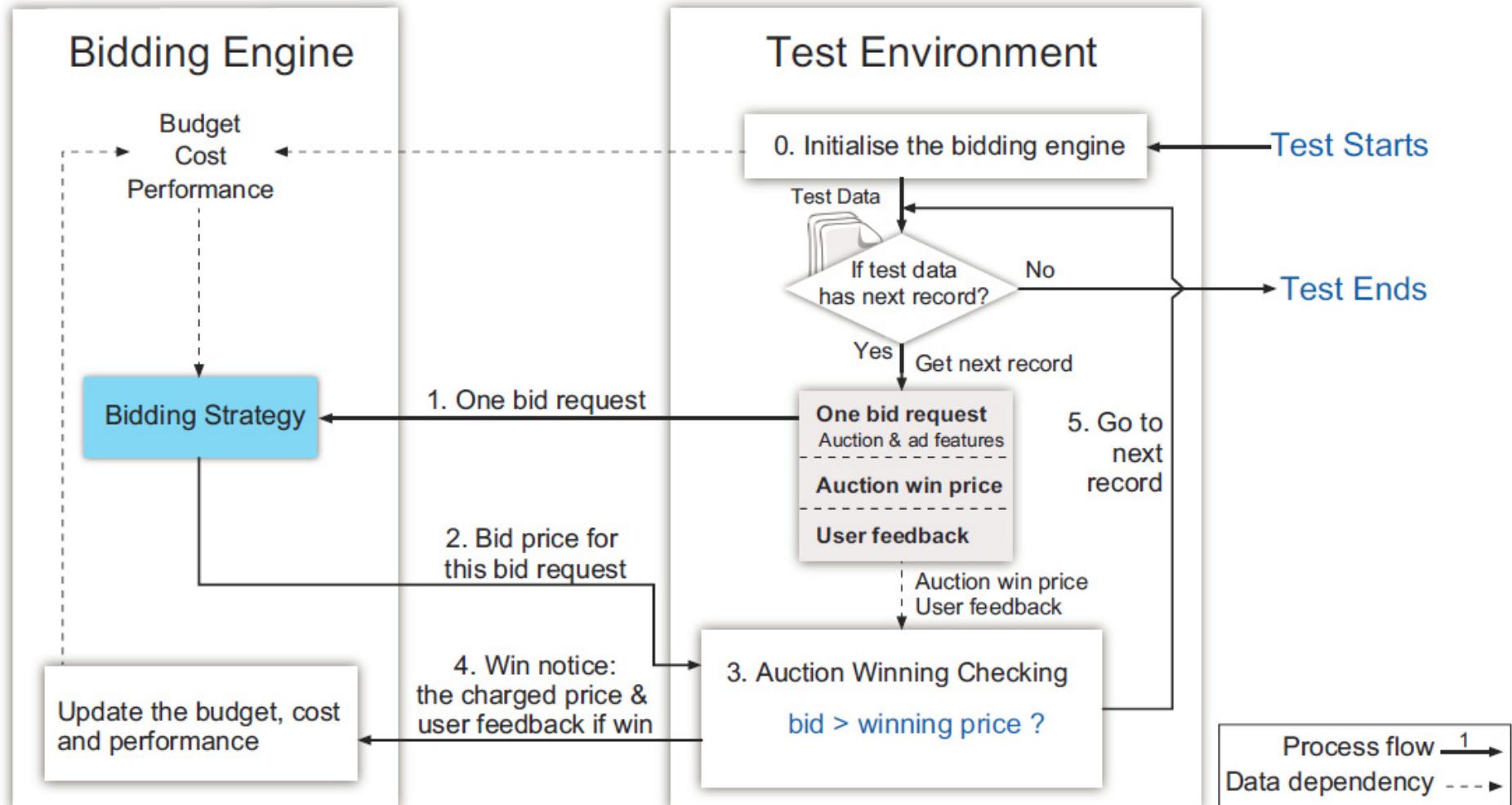
# Optimal Bidding Strategy: the Analysis



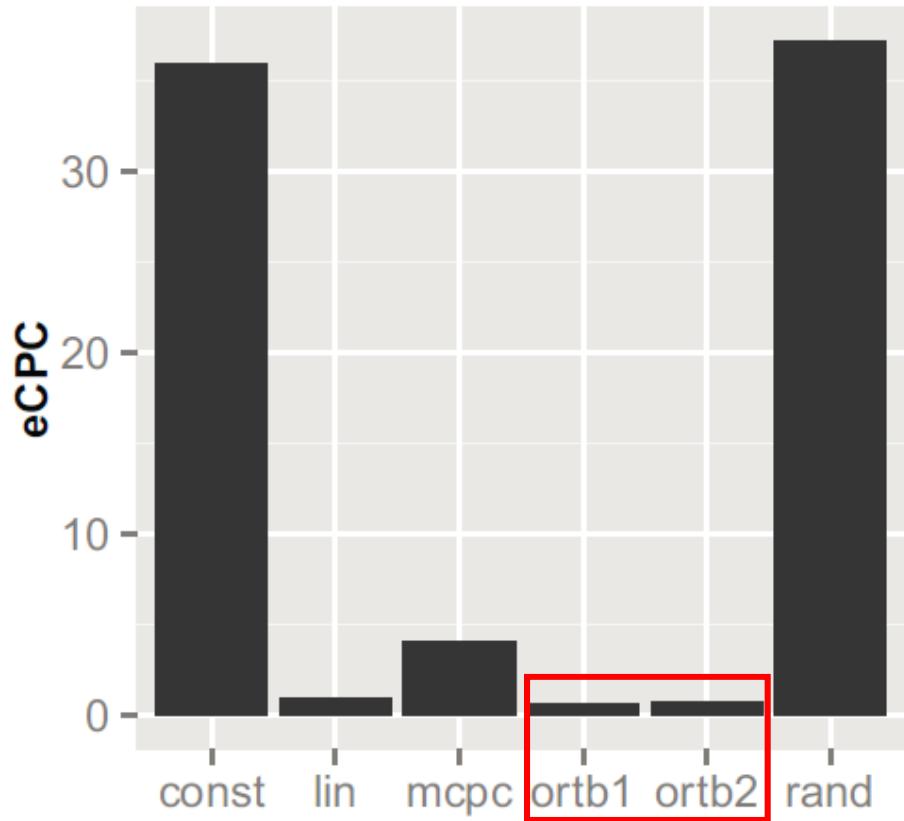
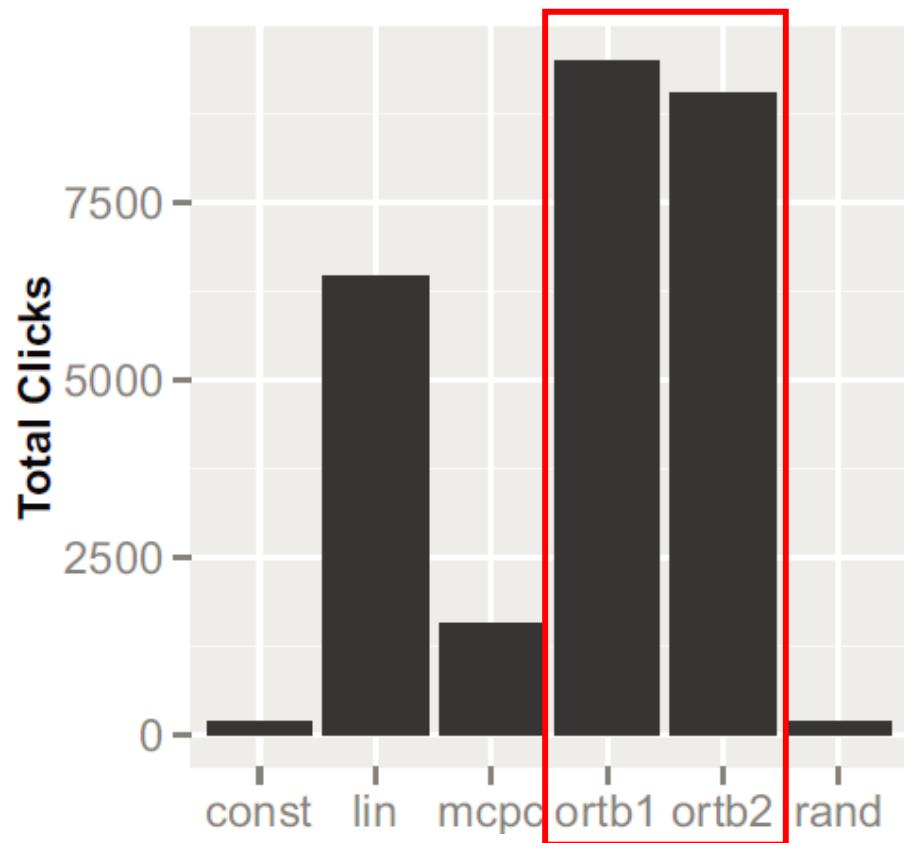
# Experiment

- We used iPinYou's dataset
  - 1-<http://data.computational-advertising.org>
  - 9 Campaigns, 15M impressions, 11K clicks, 935 conversions
- Evaluated bidding strategies
  - Const: Constant
  - Rand: Random
  - McpC: Bidding based on advertiser's given max eCPC [Chen et al. 2011]
  - Lin: Linear to pCTR [Perlich et al. 2012]
  - ORTB1, ORTB2: Optimal bidding strategies with two forms of winning rate functions

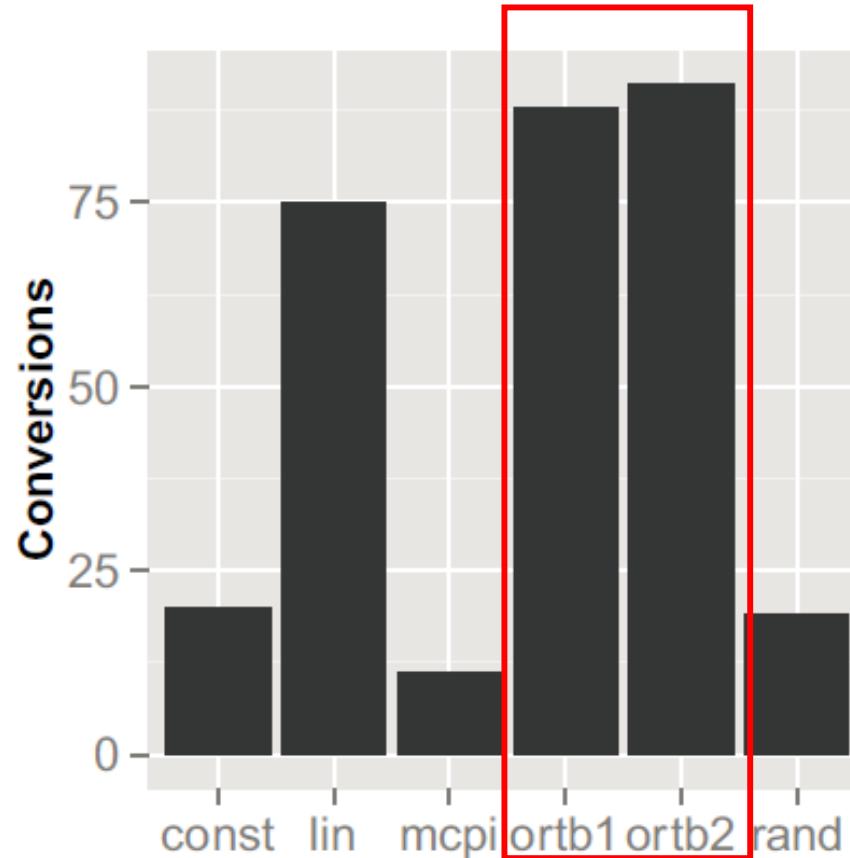
# Offline Test Evaluation Flow



# Overall performance: Optimizing Clicks



# Overall performance – Optimizing Conversions



# Unbiased Optimization

- Bid optimization on ‘true’ distribution

$$\arg \max_{b(\cdot)} T \int_{\mathbf{x}} f(\mathbf{x}) w(b(f(\mathbf{x}))) p_x(\mathbf{x}) d\mathbf{x}$$

$$\text{subject to } T \int_{\mathbf{x}} b(f(\mathbf{x})) w(b(f(\mathbf{x}))) p_x(\mathbf{x}) d\mathbf{x} = B$$

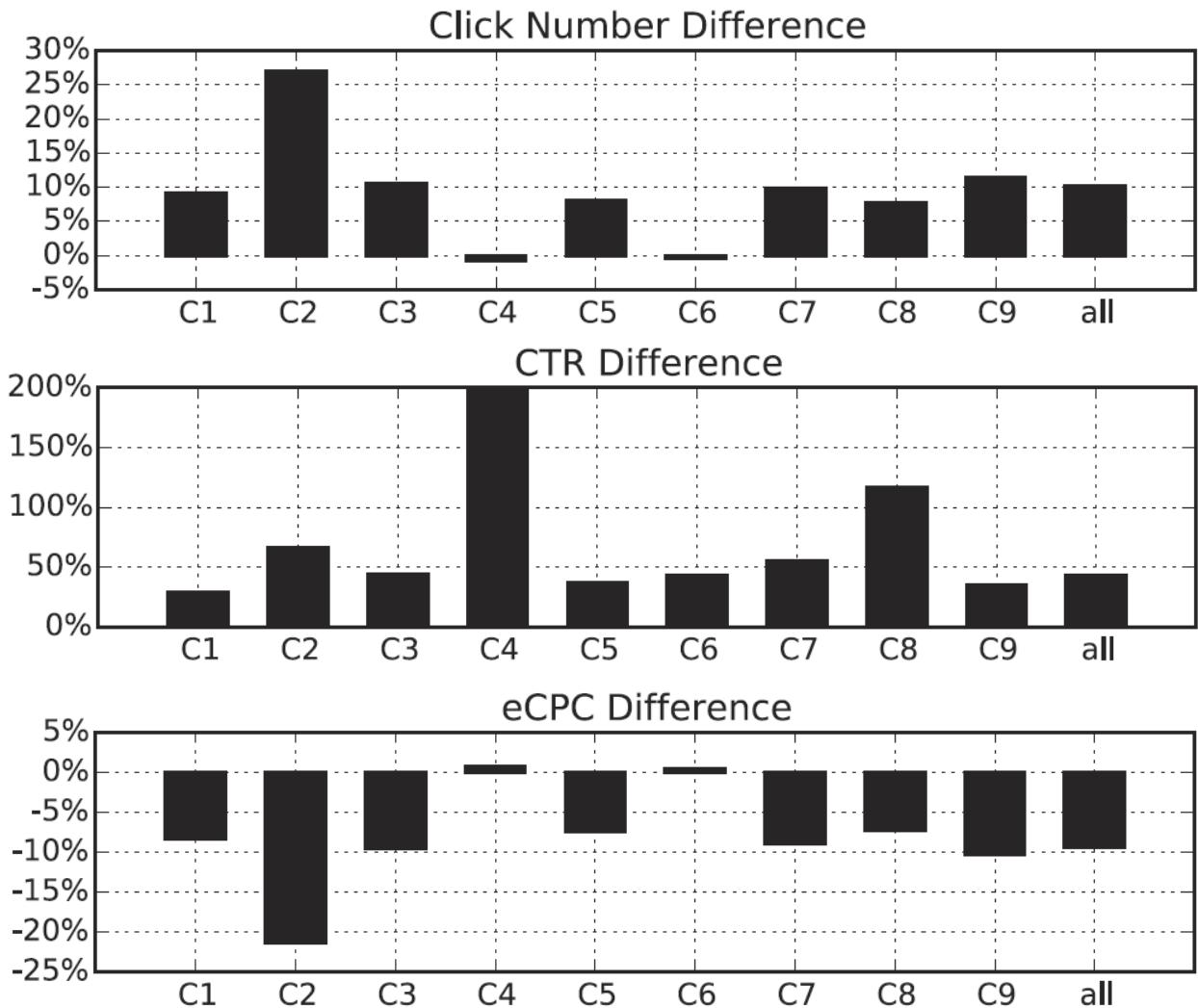
- Unbiased bid optimization on biased distribution

$$\arg \max_{b(\cdot)} T \int_{\mathbf{x}} f(\mathbf{x}) w(b(f(\mathbf{x}))) \frac{q_x(\mathbf{x})}{w(b_{\mathbf{x}})} d\mathbf{x}$$

$$\text{subject to } T \int_{\mathbf{x}} b(f(\mathbf{x})) w(b(f(\mathbf{x}))) \frac{q_x(\mathbf{x})}{w(b_{\mathbf{x}})} d\mathbf{x} = B$$

# Unbiased Bid Optimization

A/B Testing  
on Yahoo!  
DSP.



# Content of This Course

- Real-time bidding based display advertising
- User tracking and profiling
- Real-time bidding strategies
- Fraud detection

# Fraud

- Reported by Interactive Advertising Bureau's (IAB) in 2015
- Ad fraud is costing the U.S. marketing and media industry an estimated \$8.2 billion each year
- \$4.6 billion, or 56%, of the cost to “invalid traffic”, of which 70% is performance based, e.g., CPC and CPA, and 30% is CPM based.

# An Display Ad Example

How do you know the user is a human or a robot?

## 大陆



### 河南省公安厅彻查“封丘36人入警35人身份不合规”

中封丘县公安局的36名受训人员，35人是公安局内部的文职或临时人员，与“民警必须具备公务员身份”的国家规定不符，引发该局内部

- 上海至成都沿江高铁提上日程 串联长江沿线22城市
- 2016号歼-20原型机曝光 已滑行测试(图)
- 日媒：中国或派万吨海警船巡钓鱼岛 打消耗战
- 外媒：中国开始研制隐身武装直升机 预计2020年交付
- 习近平关于中美关系的十个判断
- 住建部黑臭水沟整治工作指南：9成百姓满意才能达标
- 陕西：职校“校长”让女学生陪酒 学校被撤除
- 揭秘“团团伙伙”的武钢漩涡和落马高管

## 国际



### 巴塞罗那200万人游行 呼吁加泰罗尼亚独立(图)

- 李炜光：收税是不公平的恶？
- 许章润：超级大国没有纯粹内政
- 刘昀献：国外政党联系群众的路径研究

## 时局观



民革中央副主席：中共从未否定国民党抗战作用

- 施芝鸿：文革基础上搞改革致一个时期市场官场乱象
- 朱维群回应争议：尊重民族差异而不强化
- 伊协副会长：穆斯林不应因宗教功修忽视社会责任

## 领袖圈



奥巴马54岁啦，当7年总统人苍老了头发也白了



海绵城市 未来之城

水危机：青岛告急

探访中国绿化博览会

帝都吸引华人首富

凤凰房产 诚邀加盟

谈华山论剑与中国精神

黑龙江创新驱动三步棋

《印记》之江城夜未眠

办公环境搜查令

圈层生活尽在凤凰会

## 精彩视频

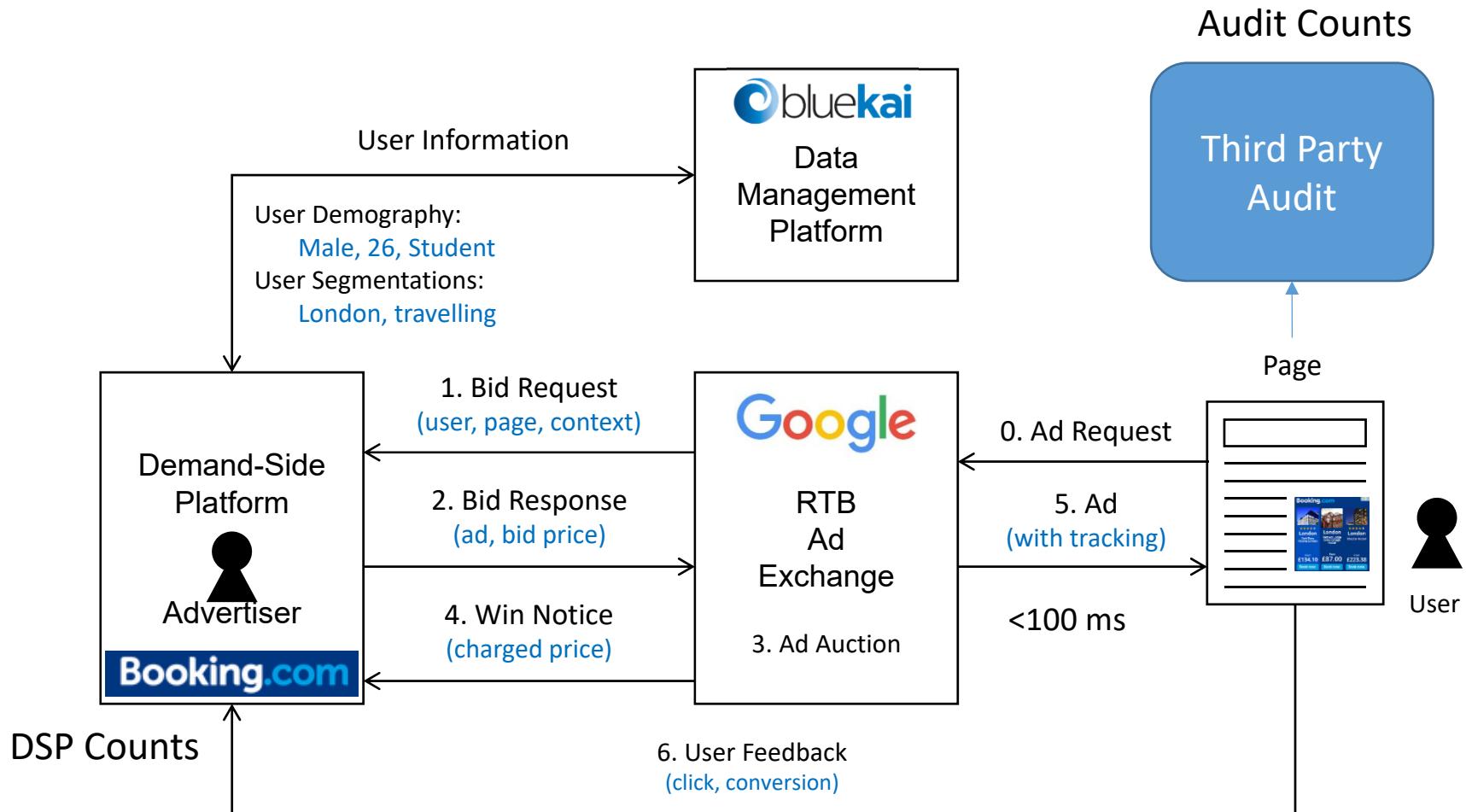


菲媒曝菲律宾军演针对中国 直指南海生命线

播放数：2602282

凤凰联播台

# Leverage Third Party to Audit



- Typically, the counts of the DSP and Audit should be close
  - Say  $\pm 5\%$

# A Good Story of Fraud Fighters

- <http://www.rtbchina.com/inside-google-s-secret-war-ad-fraud.html>



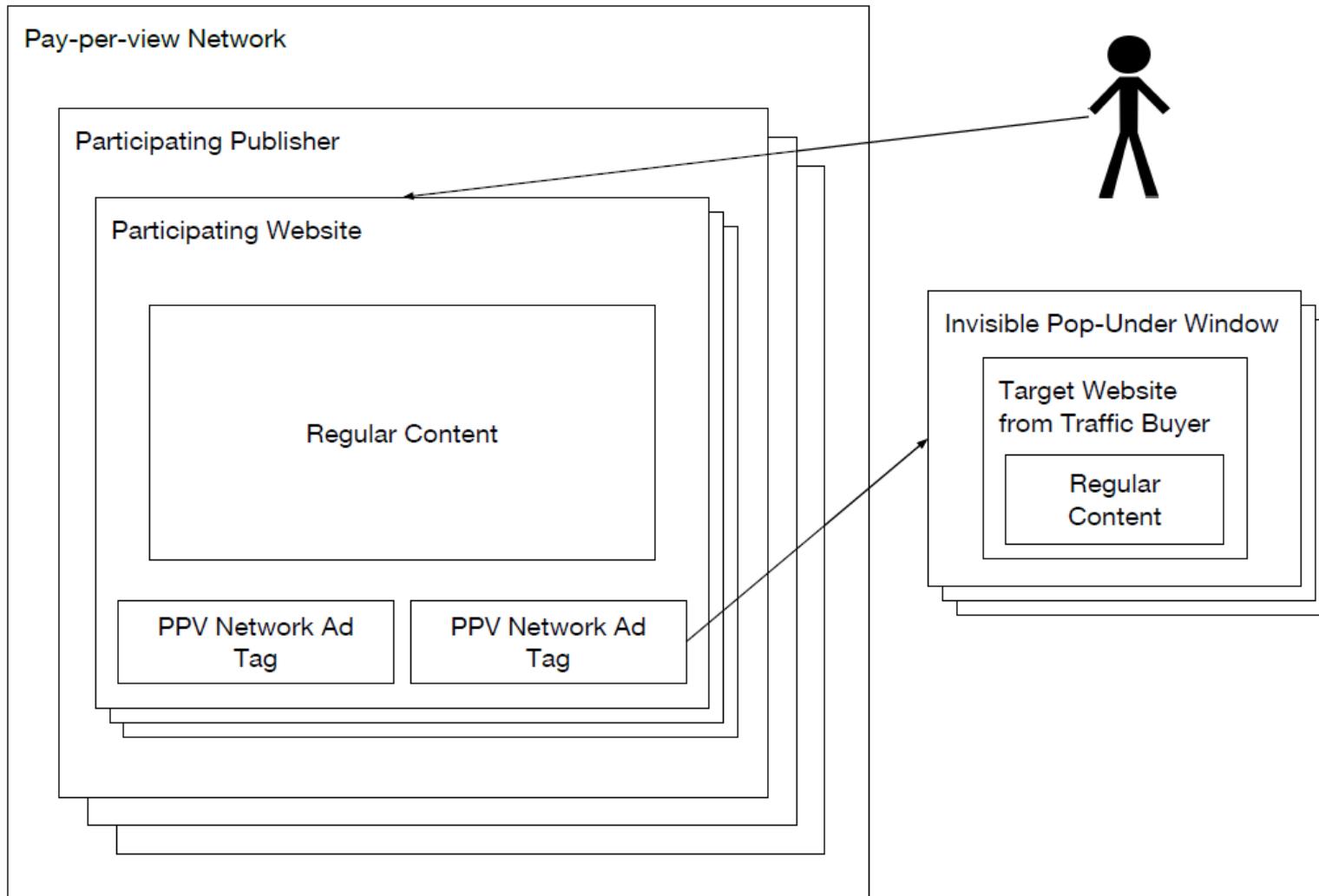
# Ad Fraud Types

- Impression fraud
  - where the fraudster generates fake bid requests, sells them in ad exchanges, and gets paid when advertisers buy them to get impressions
- Click fraud
  - where the fraudster generates fake clicks after loading an ad
- Conversion fraud
  - where the fraudster completes some actions, e.g., filling out a form, downloading and installing an app, after loading an ad

# Ad Fraud Sources

- Publisher driven: pay-per-view network
- User/robot driven: botnet

# Pay-Per-View (PPV) Networks



# Possible Methods to Avoid PPV for Advertisers

- Viewport size check: valid impressions will not be displayed in a 0x0 viewport, which is invisible to users
- A referrer blacklist, which checks if the traffic is from the PPV networks
- A publisher blacklist, which avoids buying traffic from publishers who participate in the PPV networks

# Botnets

- Botnets are usually built with compromised end users' computers.
  - These computers are installed with one or multiple software packages, which run autonomously and automatically.
  - Adware

# Adware Examples

The screenshot shows a web browser window displaying the PCrisk.com website. The main content area features several sections about different types of adware:

- Online Video Promoter Adware**: Describes how the adware tracks internet browsing activity and collects information like IP addresses, websites visited, search queries, and pages viewed.
- iShopper Ads**: Mentions that iShopper collects diverse software.
- YTDownloader Adware**: Notes that YTDownloader is potentially unwanted software.
- Threat Finder Ransomware**: Warns that Threat Finder ransomware encrypts files.
- UnknownFile Adware**: Describes UnknownFile as a file manager application.
- 1Player Adware**: Mentions 1Player as a media player application.

On the right side of the page, there is a sidebar titled "New Removal Guides" which lists the same items as the main content area. A large orange arrow points from the "About Our S" text in the Online Video Promoter section towards the "New Removal Guides" sidebar. Another orange arrow points from the "Adware" tag under the YTDownloader entry towards the Threat Finder Ransomware entry. The top right corner of the browser window contains a large advertisement for "Call for Great Tech Support" with a toll-free number (1-855-565-3218) and a photo of a smiling customer service representative.

# A Few Ways to Detecting Botnets

- Signature based detection, which extracts software / network package signature from known botnet activities
- Anomaly detection of traffic
- DNS based detection, which focuses on analyzing DNS traffic which is generated by communication of bots and the controller
- **Mining based detection**, which uses Machine Learning techniques to cluster or classify botnet traffic

# Data Mining based Fraud Detection

- As fraud detection is usually an unsupervised learning problem and it is difficult to capture the ground-truth
- Fully unsupervised learning
  - Detect the fraud based on the revealed web structures and human heuristics
- Semi-supervised learning
  - Detect the fraud by training a predictor based on a very small labeled data and large unlabeled data

# Ad Fraud Detection with Co-visit Networks

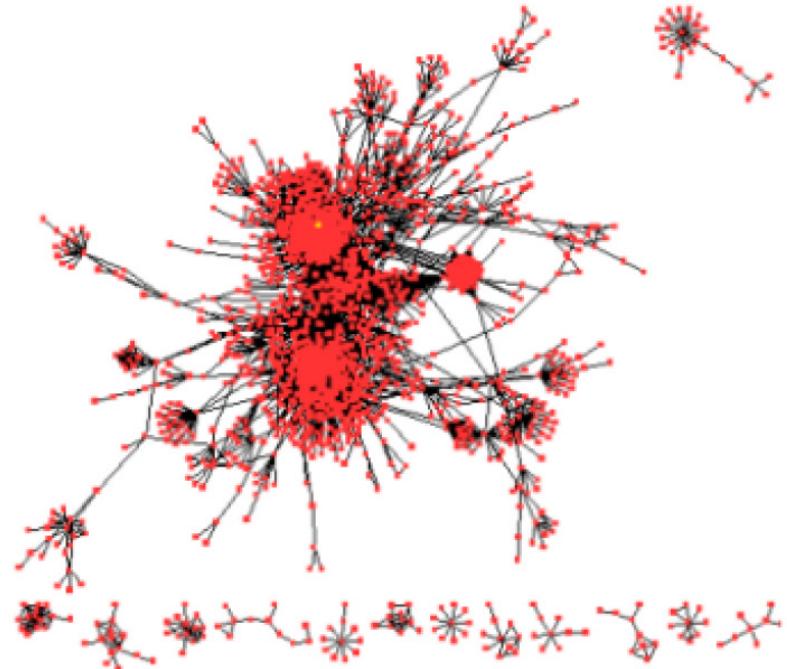
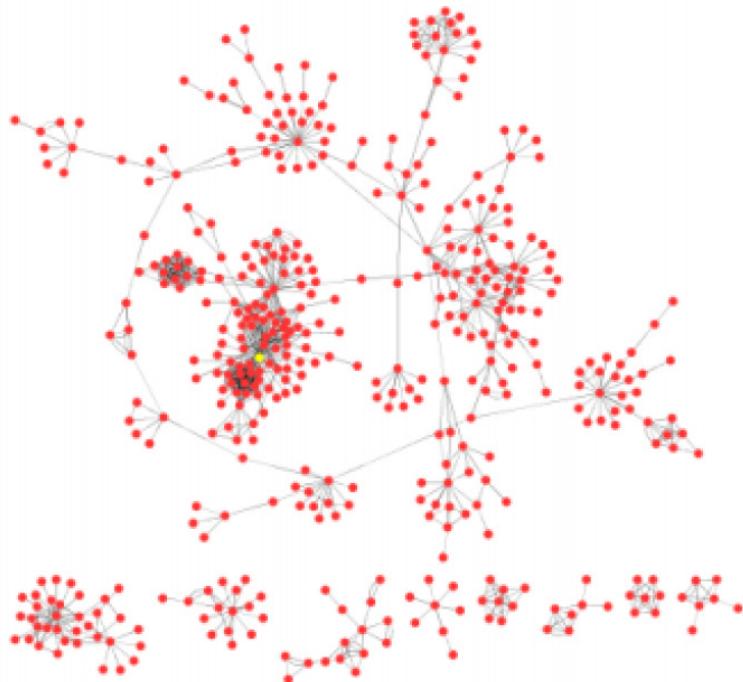
- Define a bipartite graph between users (browsers) and websites

$$G = \langle B, W, E \rangle$$

- $B$ : users
- $W$ : websites
- $E$ : the edge indicating whether the user has visit the website over a specified time period
- The co-visit network is based on  $G$

$$G_W^n = \langle V_W \subseteq W, E = (x, y) : x, y \in W, [\Gamma_G(x) \cap \Gamma_G(y)] / \Gamma_G(x) \geq n \rangle$$

# Co-Visit Network Examples



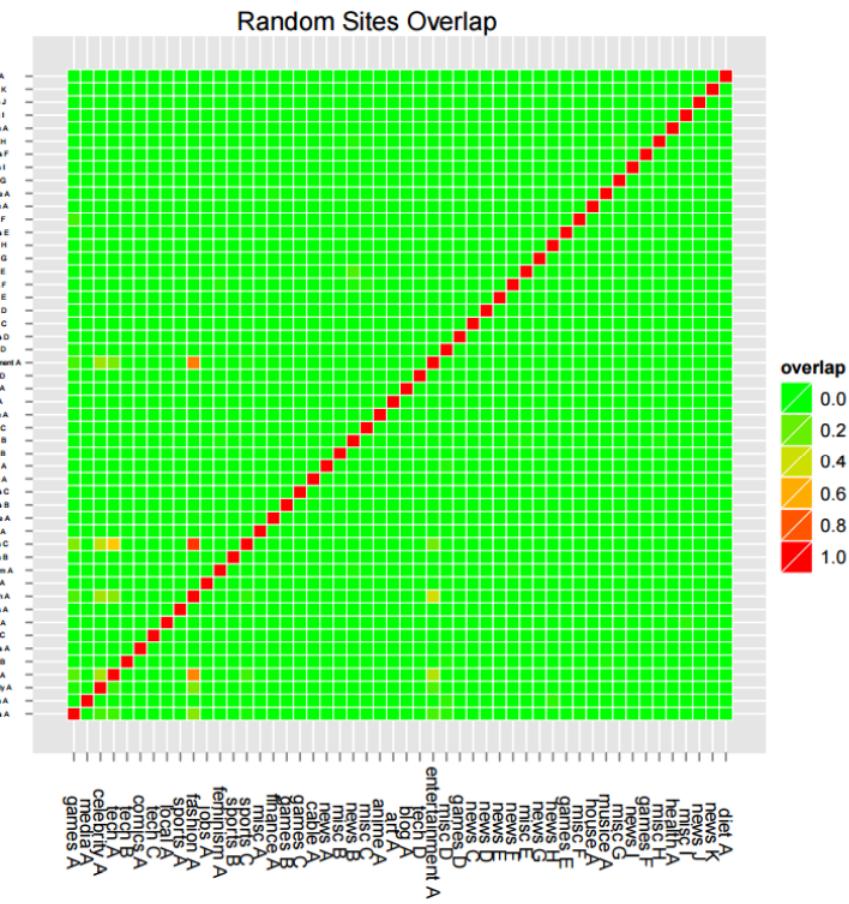
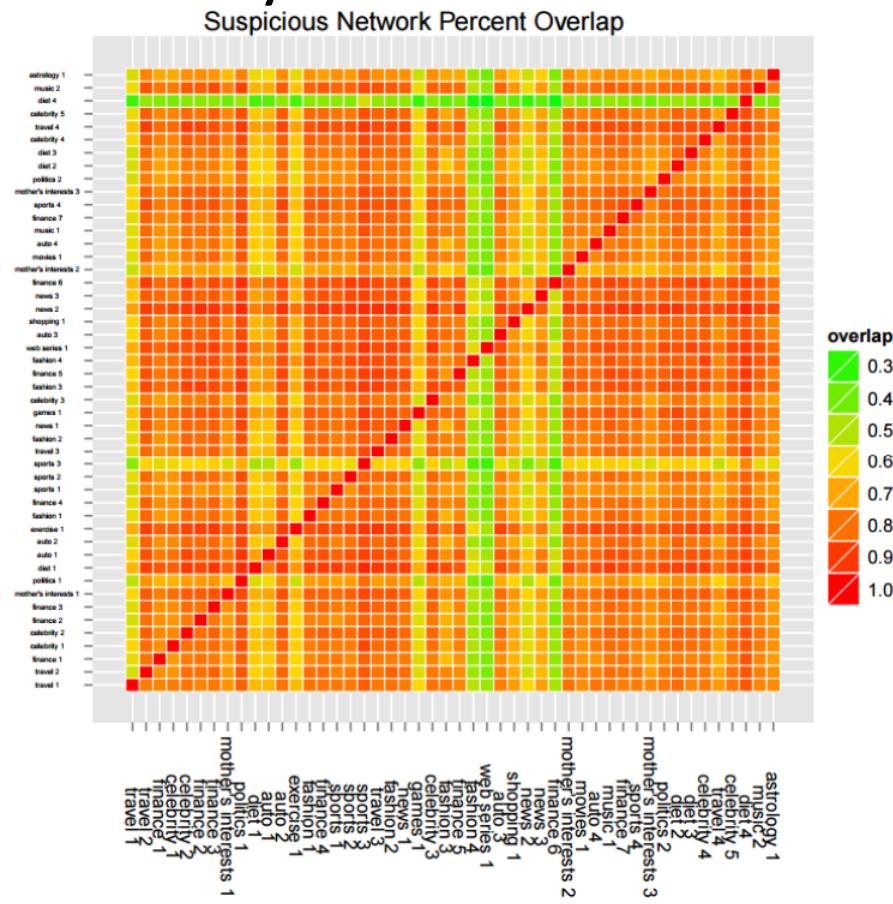
- The co-visit networks of Dec 2010 (left) and Dec 2011 (right) reported by Stitelman et al. [2013].

# Co-Visit Network for Fraud Detection

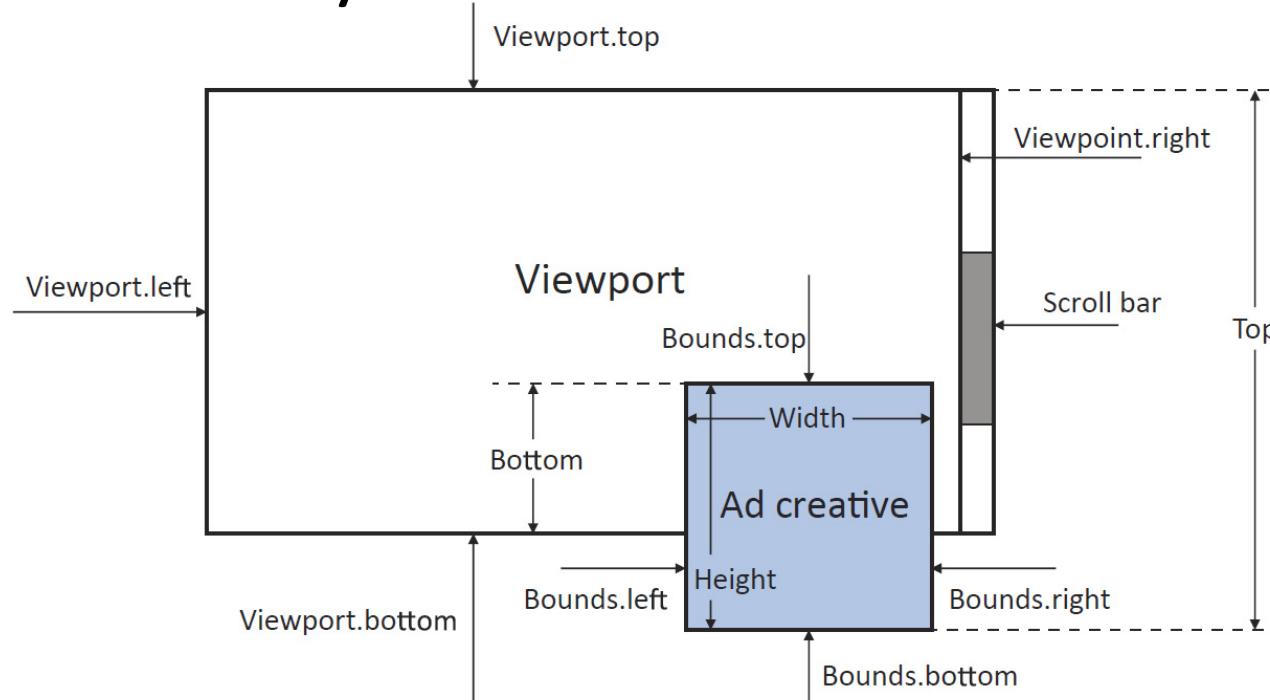
- Intuition: two websites' user overlap is normally very small
  - High dimensional random vectors are almost vertical (i.e. with cosine close to 0)

# Co-Visit Network for Fraud Detection

- Intuition: two websites' user overlap is normally very small



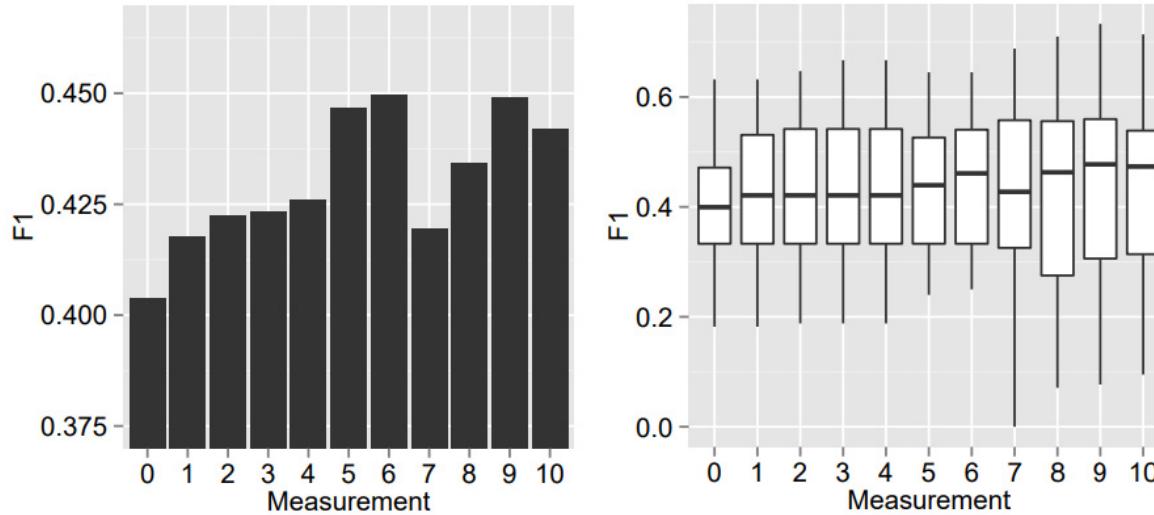
# Viewability Methods



We developed a javascript to tracking each user's behavior on browsing a displayed ad

- Pixel percentage tracking: The displayed pixel percentage for rectangle ad creative in the viewport
- Exposure time tracking: The exposure time is associated with a pixel percentage threshold.

# Viewability Methods



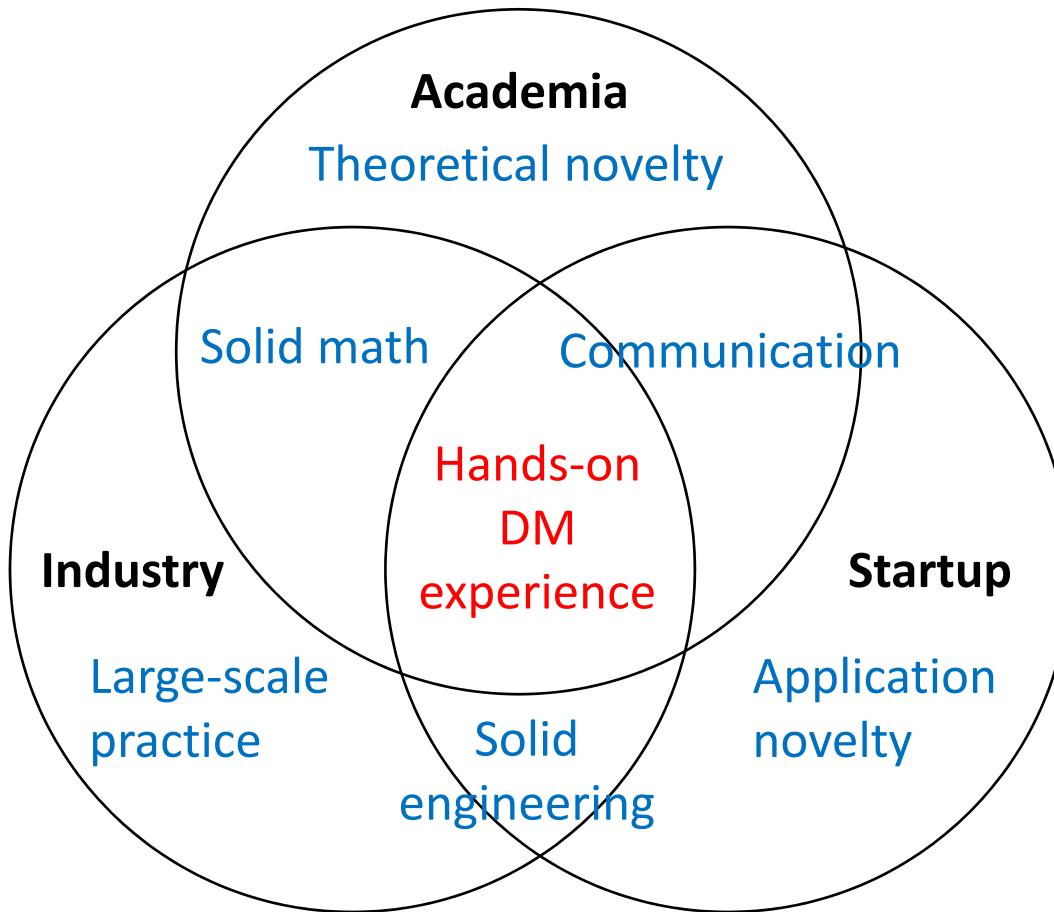
meas.	pixel	time	meas.	pixel	time	meas.	pixel	time
0	0%	0	4	100%	(0,2)	8	50%	[4,+)
1	0%	(0,2)	5	50%	[2,4)	9	75%	[4,+)
2	50%	(0,2)	6	75%	[2,4)	10	100%	[4,+)
3	75%	(0,2)	7	100%	[2,4)			

- Results: (pixel  $\geq 75\%$ , time  $\geq 2s$ ) provided the highest average F1 score and median F1 score

# Summary of EE448

- 1. Data Mining Intro
- 2. Fundamentals of Data
- 3. Basic DM Algorithms
- 4. Supervised Learning 1
- 5. Supervised Learning 2
- 6. Supervised Learning 3
- 7. Supervised Learning 4
- 8. Unsupervised Learning
- 9. Search Engines
- 10. Ranking Information Items
- 11. Recommender Systems
- 12. Computational Ads
- 13. Behavioral Targeting
- 14. Poster Session

# We focus on hands-on DM



- Get familiar with various data mining applications.
- Play with the data and get your hands dirty!

# Thank You!

Weinan Zhang, Ph.D.  
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Dept. of Computer Science & Engineering  
Shanghai Jiao Tong University