Display Advertising

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thanks: Andrei Broder, Vanja Josifovski

Introduction

Web search
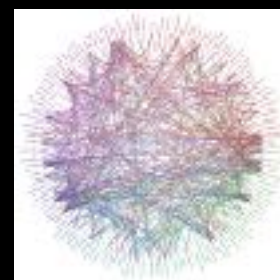

Game Theory

Auctions

Contextual Ads

Display Ads

Behavioral targeting

Recommender systems

Privacy

Networks

Emerging areas

Final Presentations

old standards

Banners and Buttons

468 x 60 IMU – (Full Banner)	40k	:15
234 x 60 IMU – (Half Banner)	30k	:15
88 x 31 IMU – (Micro Bar)	10k	:15
120 x 90 IMU – (Button 1)	20k	:15
120 x 60 IMU – (Button 2)	20k	:15
120 x 240 IMU – (Vertical Banner)	30k	:15
125 x 125 IMU – (Square Button)	30k	:15
728 x 90 IMU – (Leaderboard)	40k	:15

with the large number of display sizes, things are not so simple anymore

new standards

DISPLAY ADVERTISING CREATIVE FORMAT GUIDELINES:
QUICK REFERENCE GUIDE

iab.

CREATIVE UNIT NAME	INITIAL DIMENSIONS (WXH IN PIXELS)	MAXIMUM EXPANDED DIMENSIONS (WXH IN PIXELS)	MAX INITIAL FILE LOAD SIZE (SEE NOTE 2 BELOW)	HOST-INITIATED SUBLOAD (SEE NOTE 3 BELOW)	ANIMATION/VIDEO GUIDELINES (SEE VIDEO NOTES BELOW)	Z-INDEX RANGE	UNIT-SPECIFIC NOTES (SEE GENERAL AD REQUIREMENTS BELOW)
Billboard	970x250	Initiates in expanded dimensions Please see style guide for details	200 KB	1 MB	Minimum 24 fps for video 30 sec max length (unlimited user-initiated) 2.2 MB additional file size allowed for host-initiated video Unlimited file size for user-initiated video or animation	0 - 4,999	This ad unit collapses to "Show Ad" text with icon (or 88x31 image), or "Show Ad" text/icon with residual branding in 62x88 px or 196x31 px image. Example & Style Guide: www.iab.com/risingstars Publishers: Please see note 6 below.
Filmstrip	300x600 viewable with scrolling ad size of 300x3000 Please see style guide for details	Expansion not allowed for this unit	200 KB	300 KB	Minimum 24 fps for video 15 sec max length (unlimited user-initiated) 1.1 MB additional file size allowed for host-initiated video Unlimited file size for user-initiated video	0 - 4,999	This ad uses a 300x600 viewable window in which a 5-segment ad of total size 300x3000 scrolls Modular design may require added user control. Example & Style Guide: www.iab.com/risingstars Publishers: Please see note 6 below.

Brand advertising
   Goal: create a distinct favorable image
   Mostly display

why banner?

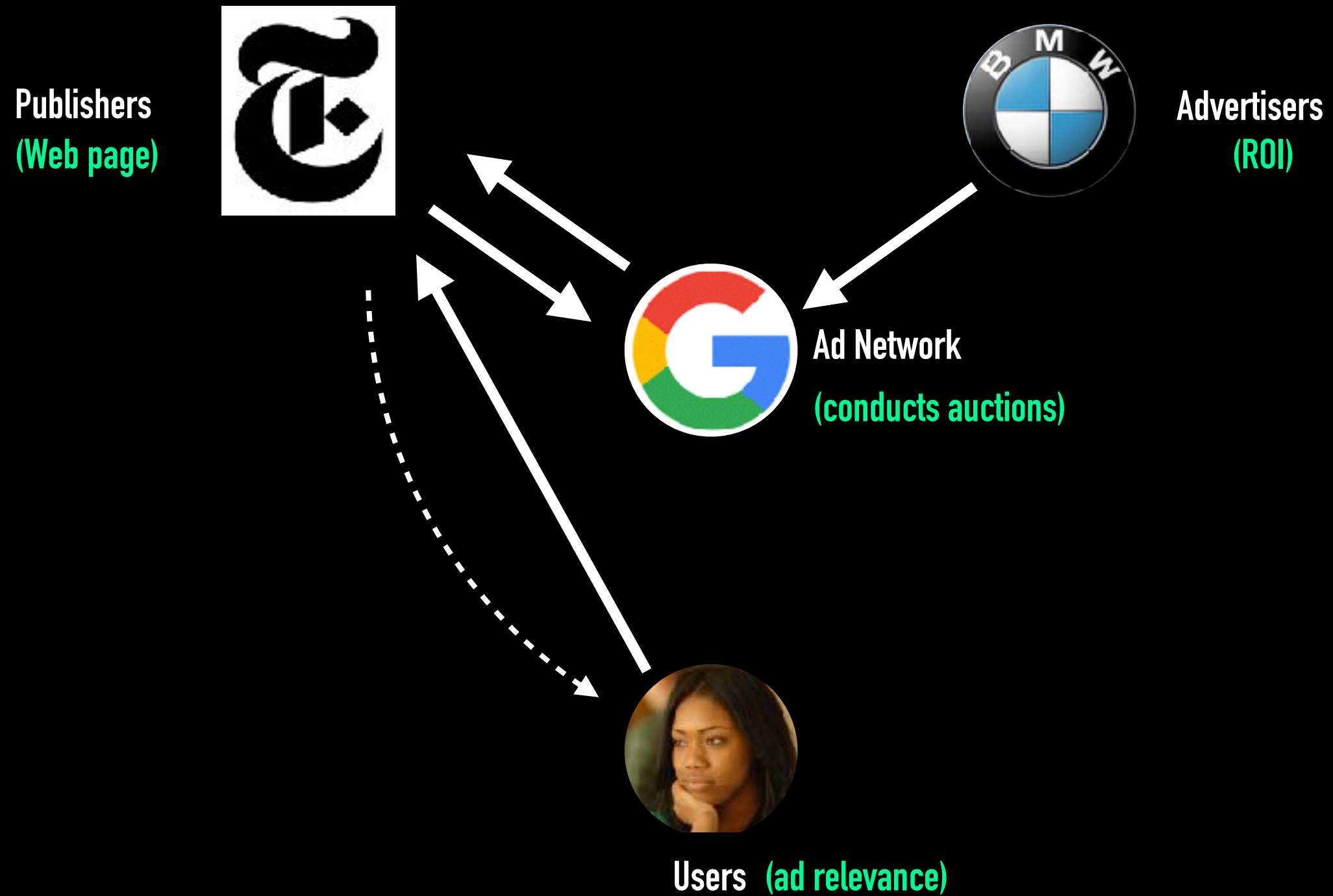oldest form of digital advertising!

Direct marketing
   Goal: a "direct response": buy,
   subscribe, vote, donate, etc, now
   or soon
   Majority via paid search but
   display catching up

Net US Digital Display Ad Revenues, by Company, 2016-2020

billions, % change and % of total

	2016	2017	2018	2019	2020
Facebook	**$12.24**	**$17.42**	**$22.87**	**$27.57**	**$32.58**
—% change	50.9%	42.4%	31.2%	20.6%	18.2%
—% of total	34.5%	38.1%	39.8%	40.6%	40.8%
Google	**$4.83**	**$6.03**	**$6.86**	**$7.95**	**$9.14**
—% change	14.8%	24.8%	13.7%	15.9%	15.0%
—% of total	13.6%	13.2%	11.9%	11.7%	11.4%
Oath	**$1.06**	**$2.39**	**$2.46**	**$2.51**	**$2.57**
—% change	6.0%	126.6%	2.6%	2.4%	2.1%
—% of total	3.0%	5.2%	4.3%	3.7%	3.2%
Twitter	**$1.36**	**$1.17**	**$1.15**	**$1.21**	**$1.26**
—% change	6.4%	-13.6%	-1.9%	5.5%	3.8%
—% of total	3.8%	2.6%	2.0%	1.8%	1.6%
Microsoft (LinkedIn)	**$0.46**	**$0.53**	**$0.70**	**$0.79**	**$0.88**
—% change	-	14.7%	32.2%	13.7%	11.6%
—% of total	1.3%	1.1%	1.2%	1.2%	1.1%
Snapchat	**$0.30**	**$0.56**	**$0.66**	**$0.92**	**$1.21**
—% change	444.9%	85.6%	18.7%	39.0%	31.1%
—% of total	0.8%	1.2%	1.2%	1.4%	1.5%
Hulu	**$0.31**	**$0.35**	**$0.40**	**$0.46**	**$0.52**
—% change	15.9%	13.0%	15.5%	15.0%	13.3%
—% of total	0.9%	0.8%	0.7%	0.7%	0.7%
Roku	**$0.06**	**$0.12**	**$0.26**	**$0.43**	**$0.63**
—% change	-	117.0%	109.9%	66.7%	46.2%
—% of total	0.2%	0.3%	0.5%	0.6%	0.8%
IAC	**$0.05**	**$0.06**	**$0.06**	**$0.07**	**$0.08**
—% change	5.1%	19.0%	5.1%	17.2%	14.7%
—% of total	0.1%	0.1%	0.1%	0.1%	0.1%
Yahoo	**$1.26**	-	-	-	-
—% change	-0.5%	-	-	-	-
—% of total	3.6%	-	-	-	-

Publishers
(Web page)

Advertisers
(ROI)

Ad Network
(conducts auctions)

Users (ad relevance)

Contract booked based on targeting attributes.

Hundreds of dimensions available: user dimensions (age, gender, interests, ...), page dimensions (content category, type, ...), context dimensions (location, mobile/PC, ...)

Example: Male, 25–40, Interested in Sports, Travel Enthusiast, ..., Sports Page, NFL, NBA, ..., California, iPhone, ...

guaranteed delivery

Each contract has a duration and a desired number of impressions
Publishers guarantee the desired number of user visits many months in advance
Advertisers pay for ads delivered to user visits
Publishers are responsible for any shortfall in the guaranteed user visits

non-guaranteed delivery

Impressions sold at auction in (approximately) real-time

Early January: Yahoo! sales person receives an RFP (Request for Proposal) from BMW Motors

Mid January: Yahoo! confirms and guarantees order with BMW

   Target: Males in California visiting Yahoo! Sports

   Duration: October 1-29

   Quantity: 25 million user visits (impressions)

   Price: $6.25 CPM (Cost Per Mille = 1000 user visits)

7 Oct, 4:02 PM: Male from CA visits Sports page

27 Oct, 4:02.5 PM: Sports page shown with the BMW ad

30 Nov 2017: BMW pays for delivered ads, Yahoo! incurs penalties/make-goods for shortfall

the life of an ad

Currently, GD commands premium prices
Advertisers may have timed reach goals
    E.g. GM knows will launch a new model
    targeted to single, young, males in Nov.
    2019..
In general: quality of inventory (page views)
given to GD contracts is better than non-
guaranteed
    Quality of a page is really about the users!

why GD?

Advertiser can buy the ad space
    in advance (1-24 months) as GD
        Pay a premium
        Get premium inventory
        Many targeting attributes
    on the spot market (at the time of page view) as NGD

advertisers view

Same advertiser might buy both GD and NGD
Goal: maximize ROI (e.g. cost per conversion,
cost per lead, etc)

Some impressions clearly more valuable than others — price should somehow be determined by supply and demand
  More competition for "females, 30–50, high income" than for "teenager, high-school drop-outs"
  More competition for "finance" than for "horoscopes"

publishers view

Publishers sell impressions

Must decide whether to sell GD contracts in advance (at what price?) or spot market online (NGD)
Wants to maximize revenue but also not make their users (readers) unhappy by excessive/intrusive advertisers

1. Forecast supply and demand
2. Forecast NGD pricing
3. Admission control & pricing

    Advertiser wants: 100m impressions in May 2019 on
    ESPN sports
    Should we accept the contract? Can we meet the
    guarantee? What price should we charge? How are
    other contracts impacted?

} sell time

GD components

4. Optimal allocation of impressions to active contracts
    Objective function?
    Can not re-run after every impression:
    Need short term delivery plans
5. Ad serving

} delivery time

components 1–4 are interrelated

demand depends on allocation quality

Assume we know the future supply in perfect detail
Assume that we have a well defined "impression quality"
metric

Admissions control

To decide whether to accept a contract or not need to

1. Figure out of all contracts agreed to plus
   new contracts that can be satisfied

   Some old contracts might now be
   under-delivered
   The quality assigned to some
   contracts might decline

2. Figure out the expected revenue with/
   without the contract

3. Figure out the price

Need to solve an
optimal allocation
problem!

Publishers need to effectively price guarantee contracts that are sold months in advance

Over-pricing → reduced sales → reduced revenue

Under-pricing → reduced revenue

detour: pricing GD contracts

The price needs to be available for any targeting combination since advertisers can target any combination

Many trillions of possible combinations

Up to tens of billions of user visits per day

The price needs to be produced in 100s of milliseconds to satisfy interactive queries/bookings

Note: Price used as starting point for negotiation by the sales team

Maximize a stated objective
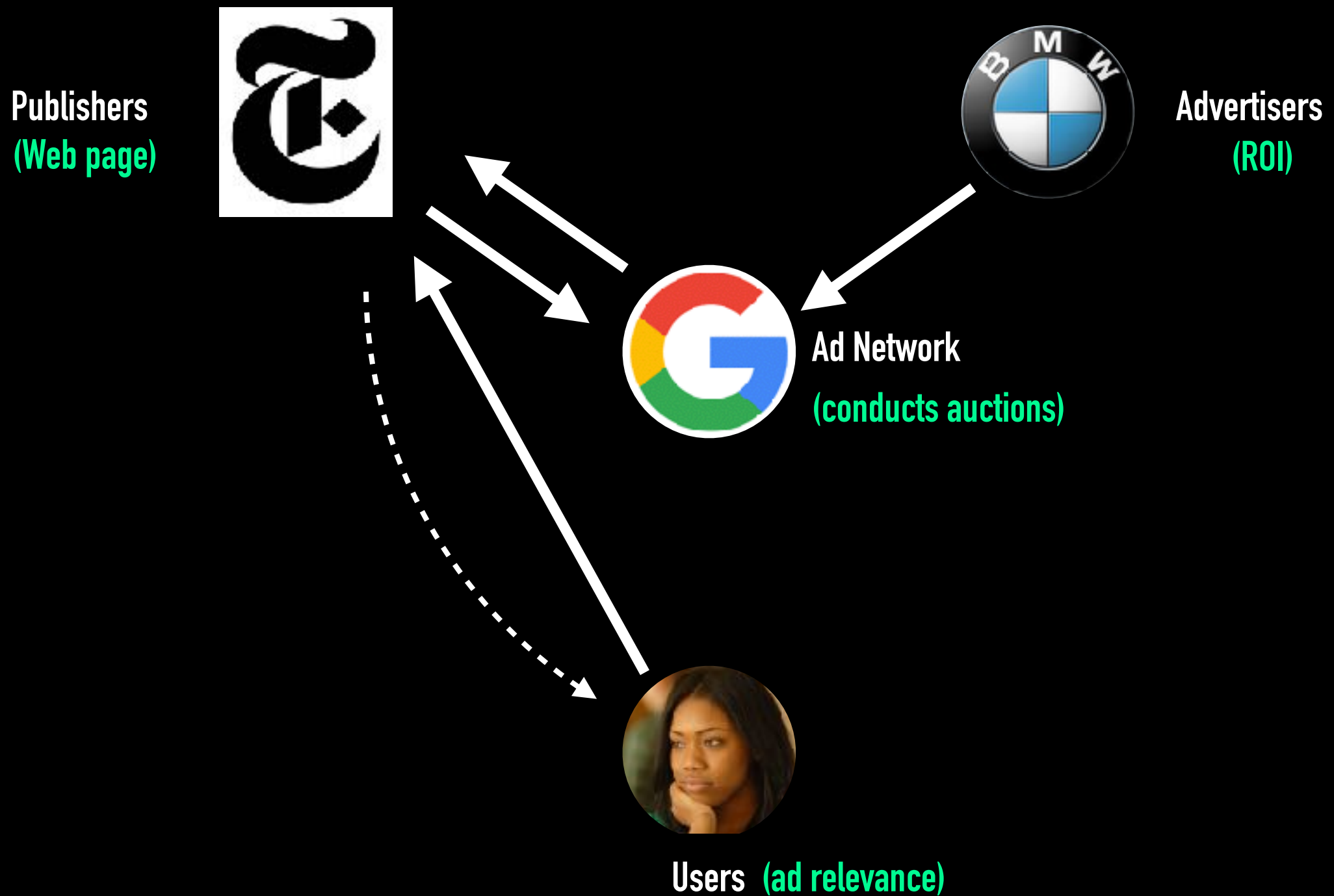function subject to:
    Supply constraints
    Demand constraints

optimal allocation

What objective?
    Value of the remaining
    inventory? (Good for
    publisher)
    Maximize quality? (Good for
    advertiser)

Publishers
(Web page)

Advertisers
(ROI)

Ad Network
(conducts auctions)

Users (ad relevance)

Need to balance utilities: publisher, advertiser, user, & network!

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Subjective and fuzzy
Examples
Female, 25–34
Male, CA Bay Area, finance interest
Male, US, auto interests
Based on both (semi) reliable and soft data: registration data, previous activity, inferred demograph
Usually only a "best commercial effort" promise

Really about the user
    Demographics
    Context

What determines page view quality?

Ultimately about the user's receptiveness to the ad and/or
propensity to (eventually) buy what the advertiser wants to sell
    Remember: interesting ads are better for both users and
    advertisers

Examples:
    Female, 25–34
    Male, CA Bay Area, finance interest
    Male, US, auto interests
Based on both (semi) reliable and soft data:
registration data, previous activity, inferred
demographics
Usually only a "best commercial effort"
promise

subjective and fuzzy

Contract says: Male, US, auto interests
  What should be supplied to satisfy this contract?
  Is it OK to supply 100% 15 year-old males,
  daydreams about cars, weekly allowances $25 ?
  Advertiser probably wants/expects a
  representative sample of car-buying US male
  population

Wide variation of quality

unless the targeting is very precise

Lack of representativeness leads to
  loss of advertisers' trusts in targeting →
  lower price ("cat in the bag")
  mis-formulation of targets→inefficient
  market

what about discrimination?

At serving time:
Should we sell the current opportunity on the spot market or use it to satisfy one of the contracts?

Advertisers may prefer
9 a.m. viewers over 1 a.m. viewers
New York viewers over Bangalore viewers
Certain users, depending on the advertisers private info

what about the spot market?

Remember: Spot market prices vary!
Spot market prices for the targeted slot (Male, US, auto interests) depends on supply/demand for the given slot

Spot market for the target slot depends on the entire market; so the price is highly variable, but reflects "true value"

Suboptimal

Deliver first all impressions
to the contract
Only after the contract met,
sell in spot market

publisher strategy #1

Assume publisher has just one GD contract

Bad for the publisher because
the GD pageviews may fetch lot
more money on the spot than
the contract value

publisher strategy #2

Put up every pageview on auction (as a seller)
Also place a bid on it for the contract (as a buyer)
Value determined by probability and penalty of not fulfilling the contract

what could go wrong here?

Unfair to the GD contract

All impressions delivered are of low value (e.g. 2 a.m. viewers); wrong set of viewers; basically, viewers nobody wanted! (Winners' curse!)

publisher strategy #3

If target is 30 million, place the smallest constant bid in each round so that exactly 30 million pageviews are won

All excess inventory will be sold to someone else (not the GD contract) at a higher price.

$p =$ **price (winning bid)**

$f(p) =$ **highest bid is drawn i.i.d from f**

$s =$ **total supply of impressions**

$d =$ **demand (i.e. GD volume) for the constract**

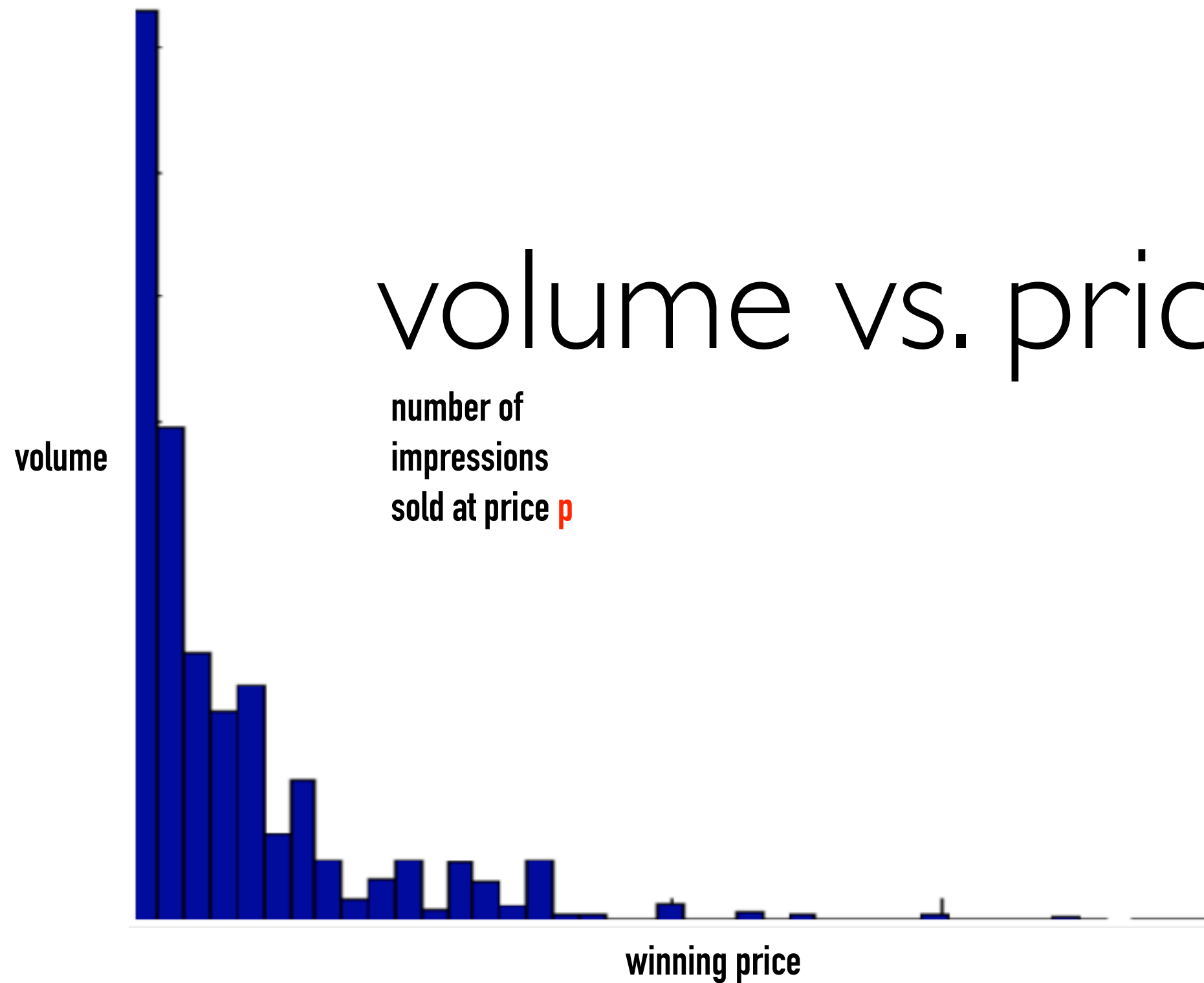$t =$ **target spend per impression (budget)**

problem setting

**Assume the publisher knows the distribution
of the external winning bid on the spot market**

$\dfrac{d}{s}$ **is the fraction of the total supply that needs to be delivered to the (unique!) contract**
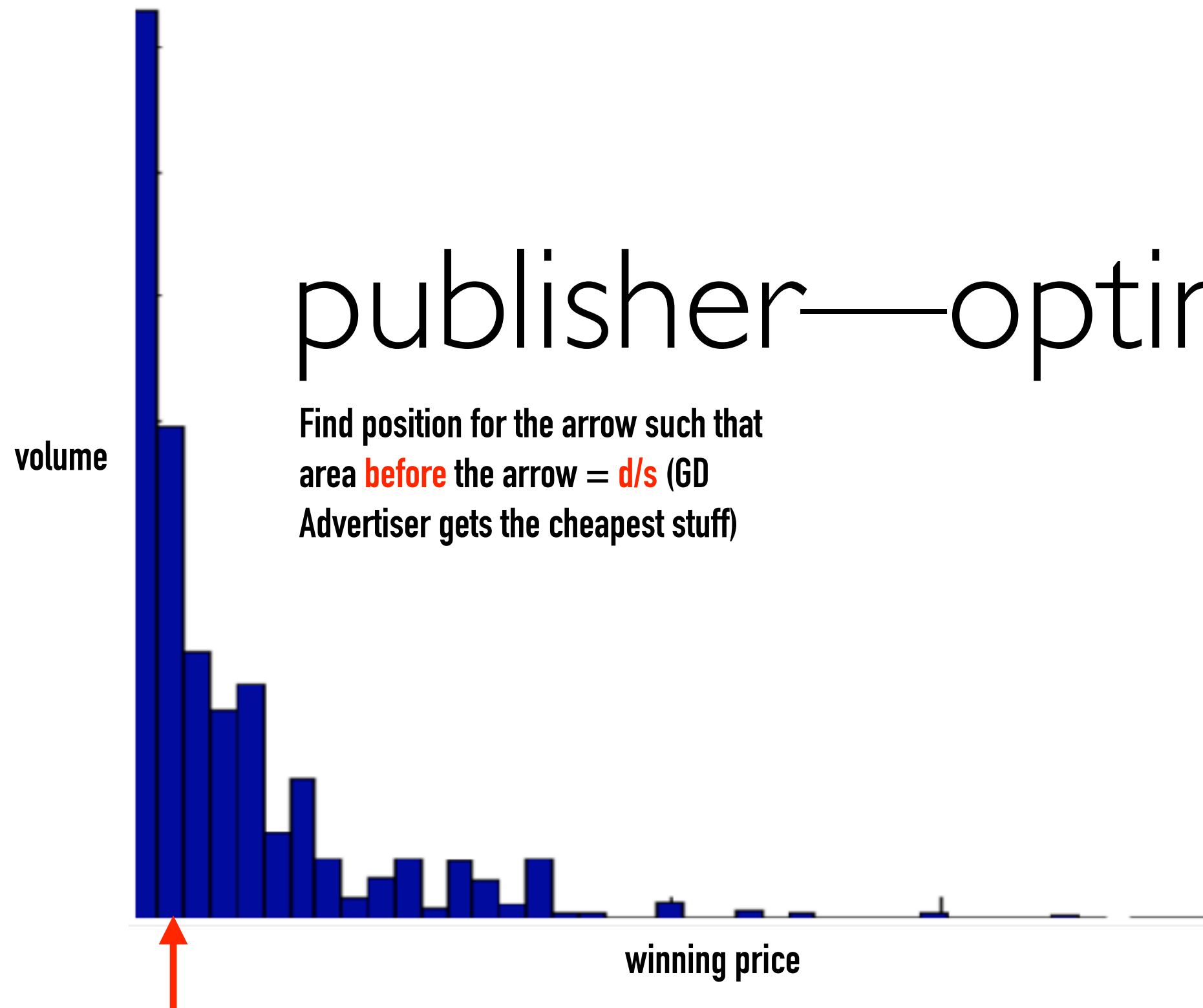
Arpita Ghosh, Preston McAfee, Kishore Papineni, and Sergei Vassilvitskii. **Bidding for representative allocations for display advertising.** In Stefano Leonardi, editor, Internet and Network Economics, pages 208–219, Berlin, Heidelberg, 2009. Springer Berlin Heidelberg.
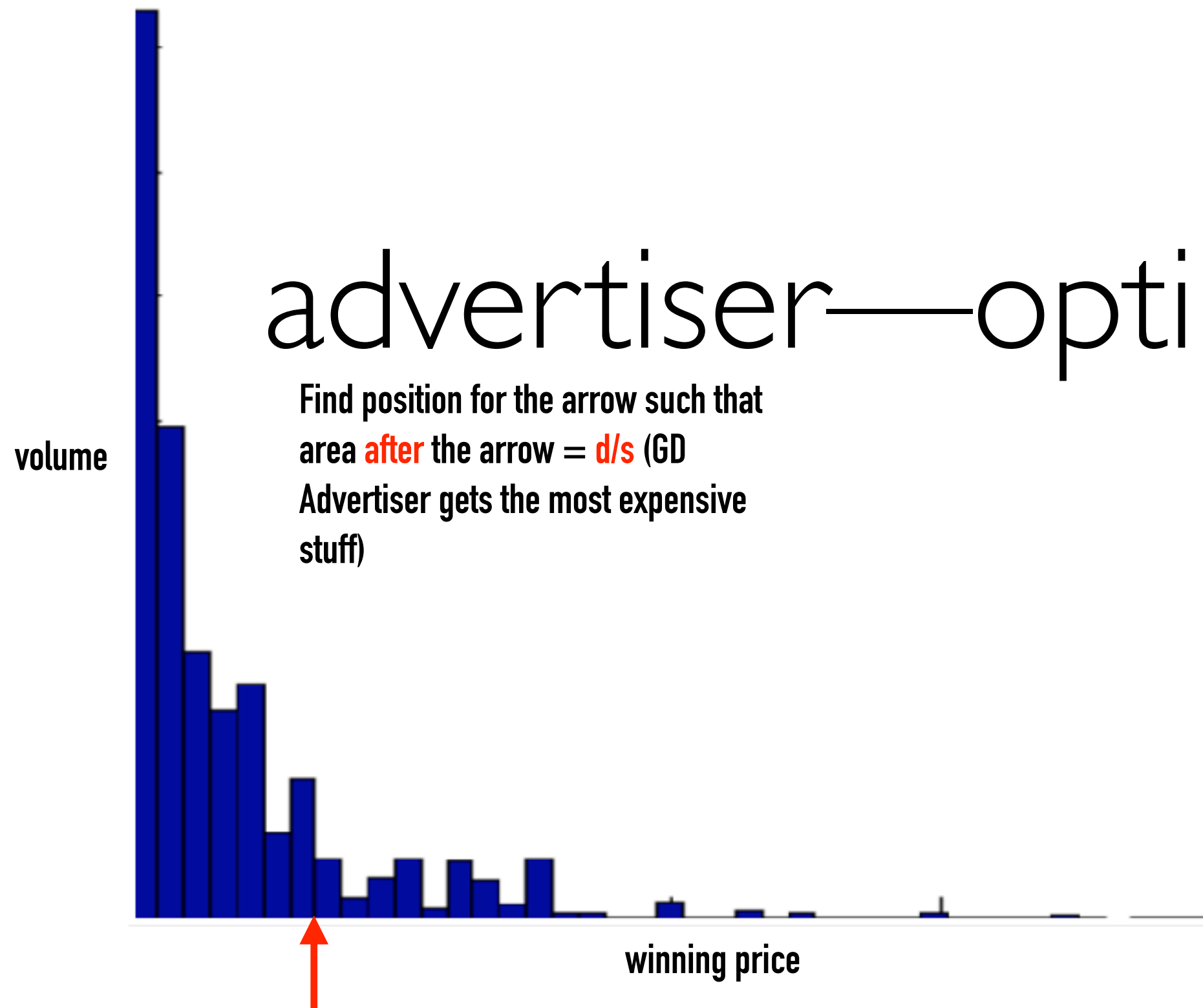
volume vs. price

number of impressions sold at price p

volume

winning price

how should we set the GD price?

publisher—optimal

Find position for the arrow such that area before the arrow = d/s (GD Advertiser gets the cheapest stuff)

volume

winning price

advertiser—optimal

volume

Find position for the arrow such that area after the arrow = d/s (GD Advertiser gets the most expensive stuff)

winning price

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Allocate to the contract inventory at various prices proportional to the supply
   Example: Suppose 2/3 of the supply sells for $1 and 1/3 sells for $2 and we needs 30M impressions

a compromise

GD contract should get 20 million impressions that sell for $1 and 10 million that sell for $2

what is an issue here?

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Of the supply selling at every price, give d/s fraction to the GD contract.

an alternative view

Then, price distribution in GD mirrors the intrinsic distribution in the total supply.

Our objective function must penalize deviation from this ideal

$$\frac{a(p)}{s}$$

fractional GD
allocation at
price p

allocation a(p)

allocation to GD at price p

$$s \times f(p)dp$$

impressions available at price p

allocation a(p)

allocation to GD at price p

$$\frac{a(p)}{s} \times s \times f(p)dp = a(p) \times f(p)dp$$

fractional allocation

impressions available

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ideal case

$$\frac{a(p)}{s} = \frac{d}{s}$$

allocation a(p)

allocation at price **p**

$$\int_0^\infty a(p)f(p)dp = d$$

a constraint

demand

probability of
winning bid at
price **p**

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if

$$\frac{a(p)}{s} = \frac{d}{s}$$

the constraints are satisfied

constraints on a(p) #1

$$0 \leq a(p) \leq s$$

$$\int_0^\infty a(p)f(p)dp = d$$

Integrals are Lebesgue; a(p) is not assumed to be continuous

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constraints on a(p) #2

$$\int_0^\infty pa(p)f(p)dp \leq t \times d$$

total contract expense

average budget
per impression

u is a utility function that measures the divergence between the allocation a(**p**)/**s** and the ideal distribution **d**/**s**.

$$\inf_a \int_0^\infty u(a(p), d)f(p)dp$$

objective function

$$0 \leq a(p) \leq s$$

$$\int_0^\infty a(p)f(p)dp = d$$

$$\int_0^\infty pa(p)f(p)dp \leq td$$

possible distance

$$\int_0^\infty a(x)\log\frac{a(x)}{b(x}dx$$

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$$\inf_a \int_0^\infty a(p) \log \frac{a(p)}{d} f(p) dp$$

KL optimization problem

$$0 \le a(p) \le s$$

$$\int_0^\infty a(p)f(p)dp = d$$

$$\int_0^\infty p a(p)f(p)dp \le td$$

How can we implement the
optimal allocation $a(p)$ in
the auction environment?

bidding strategy

We have to bid randomly!
   Bidding the same amount each
   round is suboptimal (except when
   the budget is tightest)

Recall a(p)/s is the fraction of supply available at price p that should be won for GD

Let H(x) be the GD bid distribution (cdf)

enter the auction with probability $1 - H(0)$

draw bid from distribution H

stochastic bidding (overview)

Given a price p in the NGD side, what fraction of the supply will be won for GD?

$$P(\text{GD bid } > p) = 1 - H(p)$$

define $H(p)$ via $\dfrac{a(p)}{s} = 1 - H(p)$

↑

a(p) needs to be monotone non-increasing!

display ads—summary

Complex optimization problem—a lot more math than you might suspect

Need to have solutions for:
1. Forecast supply, demand, NGD pricing
2. Admission control
3. Pricing
4. Optimal allocation of impressions to contracts
5. Ad serving

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