



GOOGLE ADWORDS

Optimizing Online Advertising

15.071x – The Analytics Edge

Google Inc.

- Provides products and services related to the Internet
 - Mission: “... to organize the world’s information and make it universally accessible and useful.”
- Most widely known for its search engine (www.google.com)
 - User enters a query; Google returns links to websites that best fit query



History of Google



- 1996 – Sergei Brin and Larry Page, graduate students at Stanford, working on a research project
 - How to measure importance of any webpage using links on the internet
- 1998 – Incorporated Google as a company and received first funding; database of 60 million webpages
- 2004 – Initial Public Offering
- 2007 – Google acquires YouTube and other companies
- 2013 – **More than 1 billion unique monthly visitors**

Google's Business Model



- Google search engine is free to use, so how does Google make money?
- Answer: **online advertising**

Example of Sponsored Ads

The screenshot shows a Google search results page for the query "nine inch nails tickets". The browser's address bar shows the URL "https://www.google.com/#q=nine+inch+nails+tickets". The search bar contains the text "nine inch nails tickets". Below the search bar, there are navigation tabs for "Web", "Images", "Maps", "Shopping", "More", and "Search tools". The search results are displayed in two columns. The left column contains several sponsored advertisements, each with a title, a URL, and a brief description. The right column contains a vertical list of sponsored advertisements, each with a title, a URL, and a brief description. The advertisements are for various ticketing services and offer discounts and special deals.

Ads related to **nine inch nails tickets**

Tickets at StubHub - Sports, Concert, & Theater Tickets
www.stubhub.com/
The Only FanProtect Guarantee.
The first choice for ticket bargains – [SportsBusiness Daily](#)
StubHub has 1,901 followers on Google+
Concert Tickets - Deals In Your Area - Buy Tickets, Earn Rewards - Sell Tickets

40% Nine Inch Nails Tix - Prices Slashed for a Limited-Time
www.goodseattickets.com/Nine-Inch-Nails ★★★★★ 62 seller reviews
Don't Miss out. Buy **Tickets** today.
Good Seat Tickets has 441 followers on Google+
Compare Us - Get \$15 Coupon - 40% Discount

30% Off 9 Inch Nails Tix - Event Happening Soon?
www.bargainseatsonline.com/ ★★★★★ 46 seller reviews
Save Up To 30% On Select **Tickets**. Buy Now!

nine inch nails Tickets - Ticketmaster
www.ticketmaster.com > All Tickets > Music Tickets > Alternative Rock
Buy **nine inch nails tickets** from the official Ticketmaster.com site. Find nine inch nails tour schedule, concert details, reviews and photos.

NIN Tour
tour.nin.com/
Nine Inch Nails. ... DATE, CITY, VENUE, PUBLIC **TICKETS**. 03.06.2014, Sydney, Australia, Entertainment Centre w/ Queens Of The Stone Age & Brody Dalle ...
[Tickets - Signin - Nin.com presale ticketing fan - Sign up for a nin.com account](#)

Ads

50% Off Nine Inch Nails
nineinchnails.pricesavertickets.com/
Up To \$75 Off Use Code SAVENOW
Nobody Beats **Nine Inch Nails Ticket**

Event Tickets Cheap
www.ticketliquidator.com/
★★★★★ 131 seller reviews
Concerts, Sports & Theatre **Tickets**.
Compare Prices. Save 15% or More.

Nine Inch Nails Tickets
www.tickets.toget.com/
Get Great **Ticket** Selection & Prices
on **Nine Inch Nails** Concerts

Nine Inch Nails Tickets
nin.eventticketsexpress.com/
1 (866) 702 9901
Low Low Prices On All Event **Tickets**
30-40% Less Than The Competition!

Nine Inch Nails Concert
www.amazon.com/dvd
★★★★★ 367 reviews for amazon.com
Save up to 35% on top sellers.
Free Shipping on Qualified Orders.

Google Advertising - AdWords




- Why do companies advertise on Google?
 - Google receives heavy traffic
 - Search pages are formatted in a very clean way
 - Companies can choose which types of queries their ads will be displayed for; better targeting
- 97% of Google's revenues come from AdWords

How does Advertising on Google work?



1. Advertisers place bids for different queries in an auction
2. Based on bids and *quality score* (fit of advertiser and ad to the queries), Google decides price-per-click of each advertiser and each query
3. Google then decides how often to display each ad for each query

Price-per-click (PPC)



- For each query, Google decides each advertiser's **price-per-click (PPC)**
 - How much advertiser pays Google when user clicks ad for that query
- Each advertiser also specifies a **budget**
 - Each time user clicks on advertiser's ad, budget is depleted by PPC amount

Example of price-per-click



| Advertiser | Query 1 ("4G LTE") | Query 2 ("largest LTE") | Query 3 ("best LTE network") |
|------------|-----------------------|----------------------------|---------------------------------|
| AT&T | \$5 | \$5 | \$20 |
| T-Mobile | \$10 | \$5 | \$20 |
| Verizon | \$5 | \$20 | \$25 |



| Advertiser | Budget |
|------------|--------|
| AT&T | \$170 |
| T-Mobile | \$100 |
| Verizon | \$160 |



-T-Mobile- **verizon**

\$100

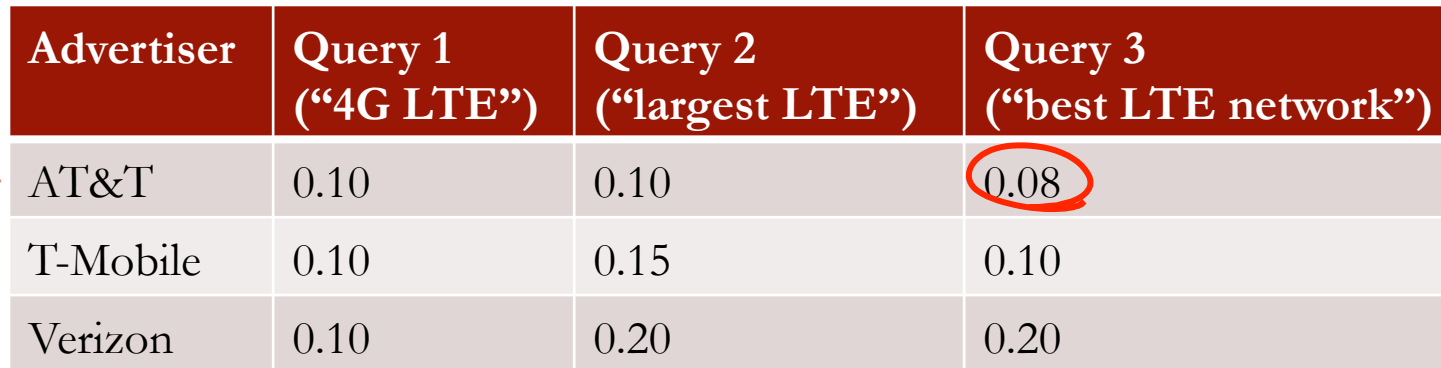
$$5 \times \$10 = \underline{\$50}$$

Click-through Rate (CTR)



- Advertiser only pays Google if the user *clicks* on the ad
- The probability that a user clicks on an advertiser's ad is the **click-through rate (CTR)**
 - Can also think of as “clicks per user”

Example of click-through rate



| Advertiser | Query 1 ("4G LTE") | Query 2 ("largest LTE") | Query 3 ("best LTE network") |
|------------|-----------------------|----------------------------|---------------------------------|
| AT&T | 0.10 | 0.10 | 0.08 |
| T-Mobile | 0.10 | 0.15 | 0.10 |
| Verizon | 0.10 | 0.20 | 0.20 |

$$50 \text{ users} \times 0.08 = 4 \text{ users}$$

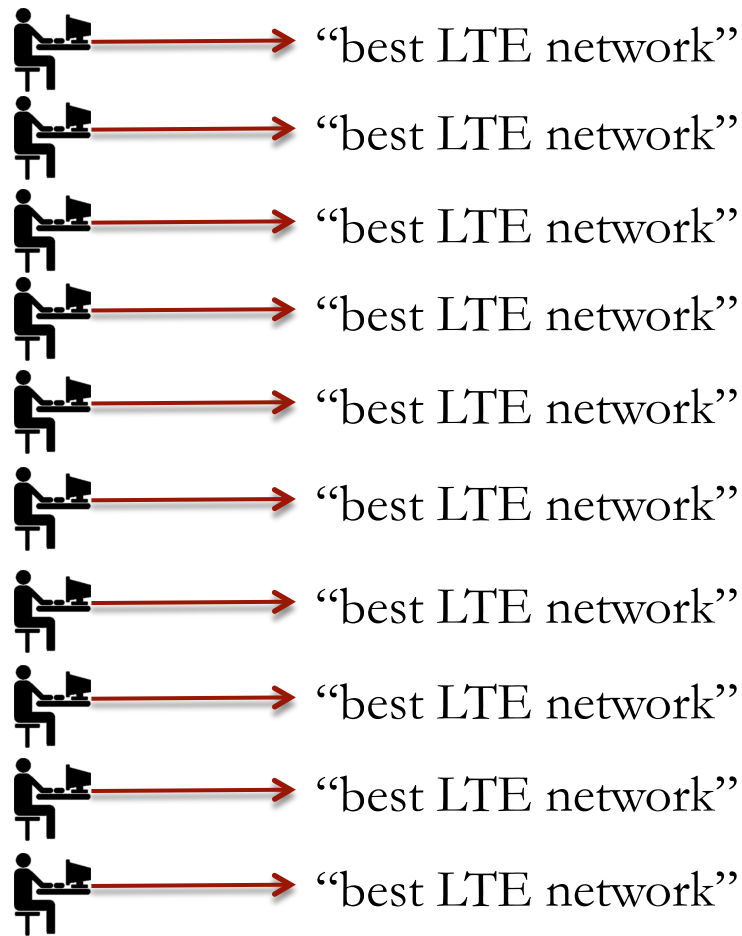
$$100 \text{ users} \times 0.08 = 8 \text{ users}$$

Average Price Per Display



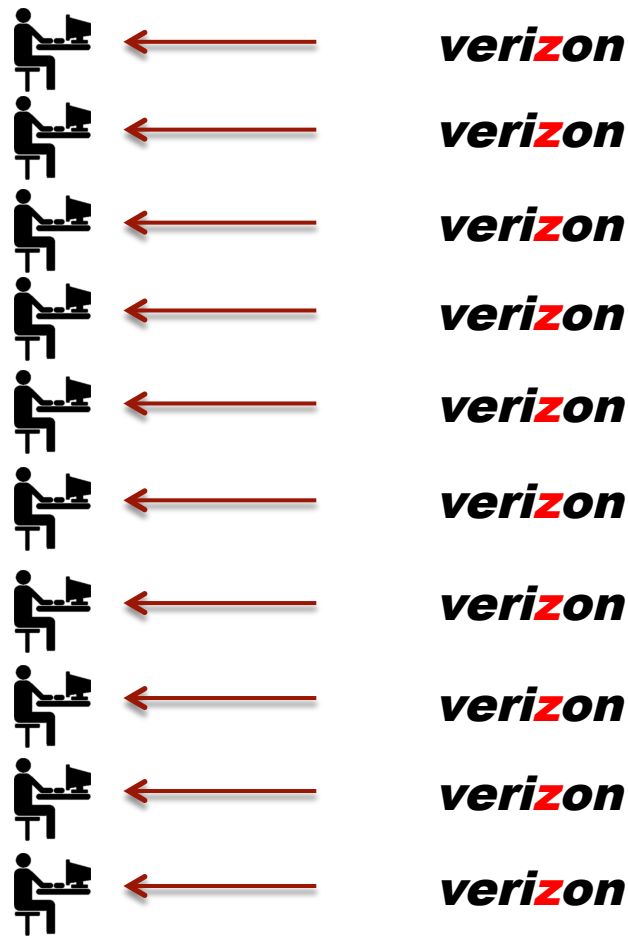
- Average amount that an advertiser pays each time its ad is shown is **PPC x CTR**

How average price per display works



Suppose 10 users
search for
“best LTE network”

How average price per display works



Google decides
to display
Verizon's ad

verizon

How average price per display works



verizon

verizon

verizon

verizon

verizon

verizon



verizon

verizon

verizon

verizon

CTR of Verizon
and “best LTE
network” is 0.2,
so only 2 users click
on the ad

How average price per display works



verizon

Verizon pays PPC
for each user:



verizon

2 clicks
× \$25 per click
= \$50

How average price per display works



verizon

Verizon pays on
average per user/
display:

\$50

÷ 10 displays

= \$5 per display



verizon

How average price per display works



verizon

This is exactly the
PPC multiplied
by the CTR:

verizon

\$25 per click
× 0.20 clicks per user
= \$5 per user/display

Average price per display for example

| Advertiser | Query 1 PPC ("4G LTE") | Query 2 PPC ("largest LTE") | Query 3 PPC ("best LTE network") |
|------------|---------------------------|--------------------------------|-------------------------------------|
| AT&T | \$5 | \$5 | \$20 |
| T-Mobile | \$10 | \$5 | \$20 |
| Verizon | \$5 | \$20 | \$25 |

| Advertiser | Query 1 CTR ("4G LTE") | Query 2 CTR ("largest LTE") | Query 3 CTR ("best LTE network") |
|------------|---------------------------|--------------------------------|-------------------------------------|
| AT&T | 0.10 | 0.10 | 0.08 |
| T-Mobile | 0.10 | 0.15 | 0.10 |
| Verizon | 0.10 | 0.20 | 0.20 |

Average price per display for example

| Advertiser | Query 1 APPD ("4G LTE") | Query 2 APPD ("largest LTE") | Query 3 APPD ("best LTE network") |
|------------|----------------------------|---------------------------------|--------------------------------------|
| AT&T | \$0.50 | \$0.50 | \$1.60 |
| T-Mobile | \$1.00 | \$0.75 | \$2.00 |
| Verizon | \$0.50 | \$4.00 | \$5.00 |

Query estimates



- Google does not control how many times a query will be requested – driven by users!
- For each query, Google has estimate of number of times query will be requested over a given day

Example of query estimates


| Query | Est. # of Requests |
|--------------------|--------------------|
| “4G LTE” | 140 |
| “largest LTE” | 80 |
| “best LTE network” | 80 |

Google's problem



- **How many times to display each ad for each query to maximize revenue**

Google's problem



- Objective:
 - Maximize revenue
- Decision:
 - For each advertiser and query, number of times ad will be displayed for that query
- Constraints:
 - Average amount paid by each advertiser cannot exceed budget
 - Total ads for given query cannot exceed estimated number of requests for that query

Problem data

| Advertiser | Avg. \$ / Query 1 Ad Display | Avg. \$ / Query 2 Ad Display | Avg. \$ / Query 3 Ad Display |
|------------|---------------------------------|---------------------------------|---------------------------------|
| AT&T | \$0.50 | \$0.50 | \$1.60 |
| T-Mobile | \$1.00 | \$0.75 | \$2.00 |
| Verizon | \$0.50 | \$4.00 | \$5.00 |

| Advertiser | Budget |
|------------|--------|
| AT&T | \$170 |
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| Query | Est. # of Requests |
|-------------------------|--------------------|
| Q1 (“4G LTE”) | 140 |
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| Q3 (“best LTE network”) | 80 |

Modeling the problem

- Decision variables:

$$x_{A1} \quad x_{A2} \quad x_{A3} \quad x_{T1} \quad x_{T2} \quad x_{T3} \quad x_{V1} \quad x_{V2} \quad x_{V3}$$

- Revenue to Google under ad strategy:

$$0.50 x_{A1} + 0.50 x_{A2} + 1.60 x_{A3} + 1.00 x_{T1} + \dots + 5.00 x_{V3}$$

- Amount advertiser AT&T pays in ad strategy:

$$0.50 x_{A1} + 0.50 x_{A2} + 1.60 x_{A3} \leq 170$$

- Number of times ad strategy uses query 2:

$$x_{A2} + x_{T2} + x_{V2} \leq 80$$

Let's do it in LibreOffice



Extensions to the problem



- Slates/positions
- Personalization
- Other issues
 - Estimating CTRs
 - How should advertisers bid?

Slates/positions

- Search result page has space for more than one ad
- **Slate:** combination of ads
- Many possible slates: which ones to display?

$X_{\text{advertiser, query}}$

X_{AI} X_{TI} X_{VI}

$X_{\text{slate, query}}$

X_{ATI} X_{AVI} X_{TVI}

X_{TAI} X_{VAI} X_{VTI}

↑↑

Personalization

- In addition to the query, Google can use other information to decide which ad to display:
 - IP address/geographic location
 - Previous Google searches/browser activity on Google
- How do we account for this?

$X_{\text{advertiser, query}}$

$X_{A|P_1}$

$X_{\text{advertiser, query, user profile}}$

$P_1 \quad P_2 \quad P_3$

AdWords at Google's scale



- We studied a small instance of the ad allocation problem
 - 3 bidders, 3 queries
- We saw how an optimization solution increases revenue by 16% over “common-sense” solution
- In reality, problem is *much* larger
 - Hundreds to thousands of bidders, over \$40 billion
 - Gains from optimization at this scale become *enormous*