

Ads and Auctions



Motivation

- Ads are the business model behind most of the web
- Google sponsored links, Facebook, Snapchat, Instagram, YouTube, etc



Google

Search

google lava lamp

About 654,000 results (0.32 seconds)

Cool Lava Lamps
www.google-store.com/Lavalamp
Google lava lamp in different colors. Buy one today!

Ad - Why this ad

Google Lava Lamp - Google Store
www.google-store.com/product_info.php?products_id=52
The essential design element in any Google cube, there's just something we love about Lava Lamps. Maybe because they ooze gooey coolness. The Google ...

Fun - Google Store
www.google-store.com/index.php?cPath=25
Products 1 - 23 of 23 – Google Lava Lamp · Google Blinky Pin · Recycled Google ...
Bendy Pencils Pack of 4. Price: £2.40 Chrome Beanbag Lounger ...
Filling - *High Carriage Cost* Price: £12.87 Flashing Bouncy Ball Price: £3.10

Selling ads the old-fashioned way

Before the Web:

- Newspaper ads sold by the column-inch
 - Bigger ads cost more
 - Different sections cost different \$
- TV ads sold by the minute
 - Different shows and different time of day cost different \$
 - Upfront season – a few months before fall when new shows are announced and advertisers can buy air time

Selling ads on the Web

Before the Web:

- Content known in advance
- Advertisers purchased newspaper space / air time well in advance

With the Web:

- Content not known in advance
- Ads are sold “just in time”
 - E.g., before every search on Google!
- Use automated *auctions* to select the ad and price

Pay per click

Before the Web:

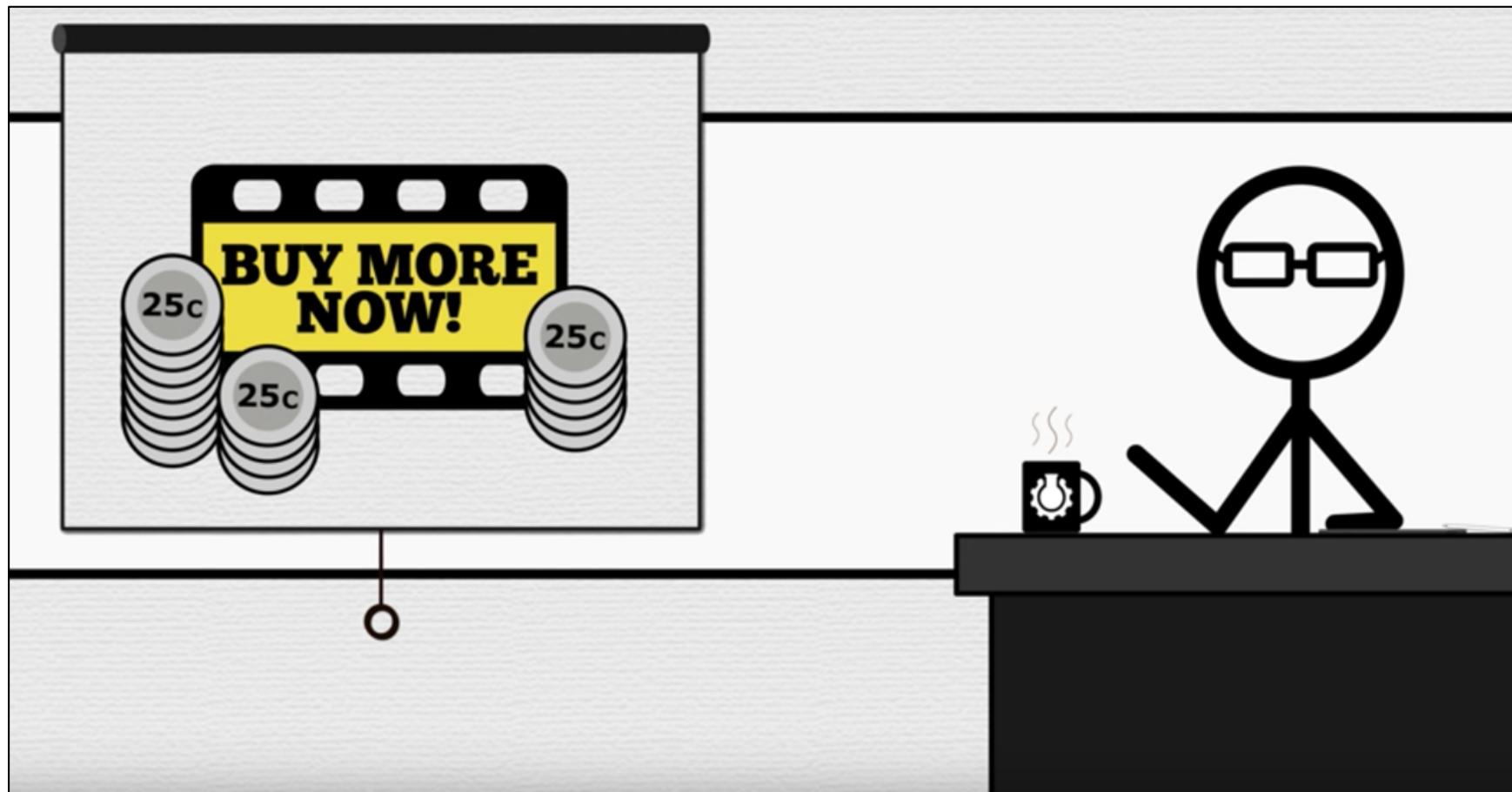
- Approximate the number of people you reach
- Number of newspaper subscribers, TV viewers, etc.

With the Web:

- Measure audience more accurately
- Record when a user clicks on the ad
- *Pay per click*

YouTube ads in action

- <https://www.youtube.com/watch?v=KW0eUrUiyo>



Agenda

- **Auctions in the real world**
- Auction types and terminology
- Auction mathematical analysis
- Auctions for selling ads

Real world auctions in action

- <https://www.youtube.com/watch?v=ACKT5jWJHTI>
- Cattle auction in Kansas
- Bidding on the price in dollars per 100lb live weight



Real world auction observations

- In a cattle auction
 - Lots of participants
 - Who need to find a price
 - With no central (price) control
- The same with the web
- Auctions work for both

Real world auction observations

- Expensive to run an auction and get the attention of multiple potential buyers in a short window
- Used for
 - Commodities, livestock
 - Art, antiques, rare items
- Auctions become much cheaper to run online
 - Particularly if there is no human in loop

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Auction mechanisms

- There are lots of different kinds of auctions, which favor different outcomes
- Sometimes called *mechanism design*, creating an auction system can be highly mathematical
- Players (called *agents*) in an auction have different motives and strategies
- Tightly related to game theory

The players

- Players (AKA *agents*)
 - A *seller*
 - A set of *bidders*
- There's also a *thing* to sell
- Assume that *bidders* each know their valuation of the thing
 - A bidder will pay the valuation if necessary
 - Would like to pay less, if possible
 - Is this realistic?

The players: who knows what

- *Seller* does not know the *bidders'* valuations of the *thing*
- *Bidders* do not know each others' valuations
- Despite being self-interested and private, players must somehow find a price

Many kinds of auctions

- *Open auction*: everybody sees the bids
 - Ascending-price ("English" auction)
 - Descending-price ("Dutch" auction)
- *Sealed-bid auction*: bids are secret
 - First-price
 - Second-price (AKA "Vickrey" auction)

English auctions

- Open, ascending price
- Price goes up and up, until one bidder left
- This is the kind of art auction that James Bond attends in the movies
- Also used in cattle sales
- Best-known type



Dutch auctions

- Open, descending price
- Price goes down from high level, until someone agrees
- Used in Dutch flower auctions



Dutch auctions

- Flower Auction FloraHolland
- https://www.youtube.com/watch?v=Slf_XNroXS8&t=177



Sealed bid auctions

- Sealed-bid, first-price
 - Everyone bids silently, at once
 - Highest bid wins, and pays bid price
- Sealed-bid, second-price ("Vickrey")
 - Everyone bids silently, at once
 - Highest bid wins, pays 2nd-place price

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Analysis

- Open, ascending-price (English)
 - What is the bidder's likely strategy?
 - Who wins? What does the winner pay?
- Sealed-bid second-price auction (Vickrey)
 - What is the bidder's likely strategy?
 - Who wins? What does the winner pay?

Analysis

- Open, ascending-price (English)
 - What is the bidder's likely strategy?
 - Bidder stays in until price is higher than bidder's value
 - Who wins? What does the winner pay?
- Sealed-bid second-price auction (Vickrey)
 - What is the bidder's likely strategy?
 - Bidder bids true value
 - Who wins? What does the winner pay?
- In both cases, winner is the bidder with highest value, pays 2nd-highest value
 - Technically, English auction winner pays 2nd-highest + minimum bid increment, assuming optimal strategy

Sealed-bid, second-price analysis

- Sealed-Bid, 2nd-Price auctions (Vickrey)
- How much should you bid?
- True value? More? Less?

Sealed-bid, second-price analysis

- Bidding **your true value** is always best
- v_i = i's value for the object
 b_i = i's bid for the object
- Payoff to bidder is:
 - $v_i - \max(b_k)$ if $b_i > \max(b_k)$
 - 0 otherwise
- If $b_i > v_i$, bidder would pay more than they value it (with negative payoff)
- If $b_i < v_i$, bidder may fail to obtain object (0 payoff)
- Thus, best strategy is $b_i = v_i$

Sealed-bid, second-price analysis

- Moral of the story:
- In sealed-bid second-price auction, your bid does not directly impact what price you pay
- It determines *whether you get to pay*
- Same with an open/ascending ("English") auction, assuming you follow the optimal strategy
- Sometimes said that 2nd-price auction bidders are "truthful"

Proxy bidding

- Open auction
- 1st-place bidder pays 2nd-place price
- Halfway between Vickrey and English
- Used by Ebay



Proxy bidding example

- Sam the seller lists a backpack for sale on eBay with a minimum starting bid of \$1 and a 5 day duration



Proxy bidding example



Day 1

**Current (public) bid: n/a; Minimum next bid: \$1;
Max: n/a.**

- The first bid is from Jack, who bids \$10 even though the minimum is \$1. Since there are no other bidders, eBay bids the minimum of \$1 on Jack's behalf and changes the minimum for any new bids to \$1.25—the current bid of \$1 plus the increment of \$0.25.

Proxy bidding example



Day 2

Current bid: \$1; Minimum next bid: \$1.25; Max: Jack, up to \$10.

- The second bid is from Jill, who bids \$1.25. Because Jack's \$10 maximum was higher, eBay immediately bids \$1.50 on Jack's behalf (\$1.25 plus one increment) and resets the minimum to \$1.75 (\$1.50 plus one increment).

Proxy bidding example



Day 3

- Current bid: \$1.50; Minimum next bid: \$1.75; Max: Jack, up to \$10.
- Jill tries again, bidding \$1.75. Jack's maximum is still higher, so eBay immediately bids on his behalf again and adjusts the minimum accordingly.

Proxy bidding example



Day 4

- **Current bid: \$2; Minimum next bid: \$2.25; Max: Jack, up to \$10.**
- Frustrated, Jill tries a fourth time, bidding \$16.50. This is higher than Jack's maximum, so eBay sets the current bid to \$10.50 (Jack's maximum plus one increment). Jill is now the high bidder and eBay is bidding automatically on her behalf.

Proxy bidding example

Day 5

- Current bid: \$10.50; Minimum next bid: \$11; Max: Jill, up to \$16.50.
- During the final moments of the auction, a new bidder named Tim bids the minimum of \$11. eBay automatically bids on Jill's behalf, outbidding Tim by one increment at \$11.50.



Proxy bidding example



End

- **Winning bid: \$11.50; Winner: Jill.**
- The auction ends after exactly five days. Jill is the highest bidder and wins, *not* for \$16.50 (her maximum bid), but for \$11.50 (one increment higher than her nearest competitor's bid).

Sniping

- Some people on Ebay use software to "snipe" auctions
 - At an appointed time immediately before time runs out, the software raises the sniper's bid substantially
 - Why does this seem ridiculous?
 - Why might people do it?
- What does this do to the Proxy Bidding auction?

Sniping

- Some people on Ebay use software to "snipe" auctions
 - At an appointed time immediately before time runs out, the software raises the sniper's bid substantially
 - Why does this seem ridiculous?
 - Why might people do it?
- Sniping effectively turns a Proxy Bidding auction into a Vickrey Auction, because it "seals" bids

Sealed-bid, first-price analysis

- Sealed-Bid, 1st-Price Analysis
- What is the bidder's likely strategy?

Sealed-bid, first-price analysis

- Sealed-Bid, 1st-Price Analysis
- What is the bidder's likely strategy?
- Because the bid determines the price, bidding the true value may lead to overpayment
 - Bidders tend to underbid in a first-price auction

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Pay-per-click (PPC) auctions

- Auctions determine which ads you see

The screenshot shows a Google search results page for the query "insurance". The search bar at the top contains "insurance". Below the search bar are navigation links for "All", "News", "Maps", "Images", "Books", "More", and "Search tools". A message indicates "About 1,100,000,000 results (0.87 seconds)". The first result is an advertisement for Progressive Car Insurance, featuring a blue link to "Progressive Car Insurance - Named #1 Car Insurance Website" and a green "Ad" label. It includes a sub-link "www.progressive.com/" and text "Get A Free Online Quote Now." with options for "Auto Quote", "Boat Quote", "Renters Quote", and "Motorcycle Quote". The second result is another advertisement for Michigan Auto Insurance, linking to "Michigan Auto Insurance - Protecting You & Your Family - insure.com" with a green "Ad" label. It includes a sub-link "autoinsurance.insure.com/Quotes/Michigan" and text "Find Peace of Mind With MI Auto Insurance. Let Us Do the Worrying For You.", "Save on Average \$540 · Quotes in 5 Mins. or Less · Live Reps to Assist · Personalized Rates", "Insurance coverage: Car Insurance, Auto / Home Bundles, Multiple Discounts", and "Best Michigan Rates · Health Insurance · Home Insurance · Minimum or Full Coverage". The third result is an advertisement for Need Health or Life Insurance, linking to "Need Health or Life Insurance? - Senior, Medicare, & Individual" with a green "Ad" label. It includes a sub-link "www.iagmi.com/" and text "Insurance Acceptance Group - Servicing Southeast Michigan. Call (844) Policy-8", "Life Insurance · Medical Insurance", and "About Us · Services".

Most expensive ad words, 2016

| # | Keyword | Category |
|--------------|---|--------------|
| #1 | \$935.71 best mesothelioma lawyer | LEGAL |
| #2-25 | | |
| \$425.70 | dallas truck accident lawyer | LEGAL |
| \$411.04 | truck accident lawyer houston | LEGAL |
| \$393.79 | louisville car accident lawyer | LEGAL |
| \$388.84 | houston 18 wheeler accident lawyer | LEGAL |
| \$381.65 | san diego water damage | WATER DAMAGE |
| \$377.70 | are personal injury settlements taxable | LEGAL |
| \$361.34 | baltimore auto accident lawyer | LEGAL |
| \$358.11 | accident lawyer sacramento | LEGAL |
| \$358.03 | car accident lawyer phoenix | LEGAL |
| \$350.42 | car accident lawyers los angeles | LEGAL |
| \$348.78 | phoenix accident lawyer | LEGAL |
| \$344.25 | business phone service providers in my area | B2B |
| \$338.98 | san diego flood restoration | WATER DAMAGE |
| \$332.58 | los angeles car accident attorney | LEGAL |
| \$326.85 | mesothelioma compensation | LEGAL |
| \$326.76 | car accident lawyer in atlanta | LEGAL |
| \$319.36 | houston truck accident attorney | LEGAL |

Overture pay-per-click auctions

- Overture was the first company to do text search ads, even before Google!
 - Bought by Yahoo in 2003
- Bidders purchase "keywords"
 - Ads displayed in order, highest first
- If the user clicks the ad, high bidder pays bid price
 - User can click on many, or no, ads
- Bids are visible to other bidders
- **First-price, open auction**

Overture example

- Three parties bid on the keyword "eecs485"



\$1

\$2

\$3

Overture example

- R2D2 is pos #1
 - He bids \$3, pays \$3 upon user click
- Neytiri is pos #2
 - She bids \$2, pays \$2 upon user click
- ET is pos #3
 - He bids \$1, pays \$1 upon user click
- What should R2D2 do?

Overture example

- R2D2 is pos #1
 - He bids \$3, pays \$3 upon user click
- Neytiri is pos #2
 - She bids \$2, pays \$2 upon user click
- ET is pos #3
 - He bids \$1, pays \$1 upon user click
- What should R2D2 do?
- Decrease bid to \$2.01, and save \$0.99 per click

Overture example

- R2D2 is pos #1
 - He bids \$2.01, pays \$2.01 upon user click
- Neytiri is pos #2
 - She bids \$2, pays \$2 upon user click
- ET is pos #3
 - He bids \$1, pays \$1 upon user click
- What should Neytiri do?
- Increase bid to \$2.02: with just \$0.02 more per click, she can get first position!!

Overture example

- **Neytiri is pos #1**
 - She bids \$2.02, pays \$2.02 upon user click
- R2D2 is pos #2
 - He bids \$2.01, pays \$2.01 upon user click
- ET is pos #3
 - He bids \$1, pays \$1 upon user click
- What happens next?

Overture example

- It's advantageous to change your bid rapidly
 - Pay enough to be on top, but no more
- Has some bad social effects: lots of time/money spent on bidding

Google PPC (AdWords)

- A few critical differences:
- Sealed-bid, 2nd-price auction
- Allowed Ebay-style "auto bidding" but other bids are not revealed

Google AdWords example

- Neytiri is pos #1
 - She bids \$3.00, but pays \$2.01 upon click
- R2D2 is pos #2
 - He bids \$2.00, pays \$1.01 upon click
- ET is pos #3
 - He bids \$1, pays minimum
- Great! But...



Google AdWords example

- Unlike Overture, Google auction prices are kept secret. You don't know what other people bid.
- But you can guess. What if R2D2 changes his bid to \$2.75?

Google AdWords example

- Neytiri is pos #1
 - She bids \$3.00, but pays \$2.76 upon click.
 - Her cost increased due to R2D2!
- R2D2 is pos #2
 - He bids \$2.75, still pays \$1.01 upon click
- ET is pos #3
 - He bids \$1, pays minimum



Google AdWords example

- More differences:
 - Displayed ads ranked by combination of bid amount and ad-quality
 - How do PPC motives differ from Ebay's?
 - Click-through rates are highly dependent on the ad text
- Google was originally the "cheap competitor" to Overture, then overtook

Google AdWords caveats

- Google AdWords is not exactly a Vickrey (sealed 2nd-price) auction
 - Standard 2nd-price auctions sell one item
 - Google sells multiple items
 - It's a "Generalized Second Price" auction
 - Lacks some technical properties of Vickrey
- What if you want two items, but if you can't get them both, you want neither?
 - E.g., cotton candy machine + 32 tons of raw cotton candy

Summary

- Auctions are automated on the web
- Primarily used to sell ads
 - Sellers with ad platforms like Google, Facebook, etc.
 - Buyers who want to advertise
- Enable just-in-time ad sales customized to users