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Mention we will not cover format pricing and format pricing in this talk.

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# Part 1: Background

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#### Auction recap

We run a generalized second price auction (GSP)

- We auction off each position separately
- Each candidate gets a score, called Long Term Value or LTV
- For each position, we rank ads according to LTV (LTV must be > 0)
- We then pick the top to show in that position
- We move on to the next position and repeat, until we either run out of space or candidates

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#### Second Pricing

Winner pays minimum price needed to beat runner up

 $LTV_w = LTV_{ru}$ 

- 1. Equate LTV of winner to LTV of runner up
- 2. Solve for bid. Result is the costper-click (CPC)

In the equations:

- w: winner
- ru: Runner Up

 $bid \cdot pctr_w - \beta_w = bid_{ru} \cdot pctr_{ru} - \beta_{ru}$ 

$$did_{f} = \frac{bid_{ru} \cdot pctr_{ru} - \beta_{ru} + \beta_{w}}{pctr_{w}}$$

This becomes the CPC

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#### **Reserve Pricing**

Where there is no competition (i.e. no runner up) winner pays the "blindness reserve"

$$LTV_w = 0$$

- 1. Equate LTV of winner to 0 2. Solve for bid. Result is the
  - reserve cost-per-click (CPC)

 $bid \cdot pctr_w - \beta_w = 0$ 

In the equations:

- w: winner .
- ru: Runner Up ۰

This becomes the CPC  $\longrightarrow bid = \frac{\beta_w}{pctr_w}$ 

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## **Efficiency Loss**

Today in our auction, selection, ranking and pricing are all tied together

→ Changing the mechanism to affect one, has ramifications on the others

In particular, pricing changes often lead to worse allocations

→ This is referred to as efficiency loss



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### **Auction Pricing Mechanisms**

What are auction pricing mechanisms designed to do?

- Specifically designed to extract value from advertisers
  - Advertisers derive value from the clicks we deliver to them
  - Are we pricing them adequately for the value they receive?
- Designed to minimize efficiency loss
  - A simple proxy to efficiency loss is click loss
  - Since we're paid for clicks, we don't want to disproportionately lose them in the process
- Designed to minimize adverse response from advertisers
  - Is pricing too aggressive compared to value?
  - Are certain advertisers at risk of withdrawing from the auction?

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### **Auction Pricing Mechanisms**

What are they **not** designed to do?

- Not designed to increase clicks
  - We're actually happy when we *minimize* the click loss
- Not designed to focus on the user
  - We resort to allocation mechanisms for this, e.g. Kumamon (go/kumamon-design)

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## Source of Efficiency Loss

Pricing mechanisms often have side effects which lead to efficiency loss. Some example are:

- Click Loss. Can happen one of two ways:
  - Reranking: Higher pCTR ads are forced down the rank
  - Impression Loss: You can't get clicks on ads that don't show!
- Adverse Advertiser Response
  - Advertiser lower bids, change targeting, or downright leave the auction

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But we have an auction designed to set prices... why do we need more?

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## When Vanilla pricing may no be sufficient

Second Pricing works great most of the time, but there are failure scenarios

- Weak or lack of Auction Pressure
  - When no competition is present, or when competition is of inferior quality
- Reserve pricing
  - Reserve prices are generally lower than their second price counterparts

We need a way to extract value more directly

→ We need pricing mechanisms with pricing knobs

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## Canonical example: Squashing

How it works?

- Compress dynamic range of pCTRs in a given auction
- Achieved by moving all candidate pCTRs in the direction of the max pCTR in that auction
- Effectively simulates auction pressure



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### Logs Analysis

- Tail Impact: What fraction of cost (or gains) come from adgroups whose CPCs are larger than a certain fraction
  - Weighted by cost: Provides a measure of *risk*
  - Weighted by gains: Provides a measure of stickiness
- **Top Division Impact**: For our top divisions, what does the CPC impact look like?
- MH-CPC: controls for advertiser mix

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#### Comparison of Tail Impacts of various mechanisms

Threshold	Potiron	Kabocha (full)	Momiji	GammaYello w (full)	Sapporo (full)
12.5%	4%	3.5%	13.4%	4%	1.54%
25.0%	2%	1.2%	0.57%	2%	0.92%

Risk: % of Ad Groups with CPC change > Threshold (spend weighted)

Stickiness: % of Ad Groups with CPC change > Threshold (gains weighted)

Threshold	Potiron	Kabocha (full)	Morniji	GammaYello w (full)	Sapporo (full)
12.5%	31%	20%	21%	45%	90%
25.0%	18%	5%	1%	31%	85%

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## Understanding response: Advertiser Experiments

- Partition query space so as to maximize advertiser's interactions (i.e. discover micro markets)
- 2. Randomly partition the space into treatment and control
- 3. Apply treatment for several weeks
- Run inference models to predict, as a function of dose, what the response under a launch would look like



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# Handling contributions over time: Holistic Pricing effort

- Teams across AQ create value and move prices around
- Lower risk when we move prices along with value
- Developing tools to track, monitor the state of our system over time
  - Excess CPC rule of thumb
- Tune prices, safely, to
  - Ensure good value sharing between advertisers / google
  - Stay in touch with the additional value created over time
  - o Limit risk



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# Part 2: Recent Innovations

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# Fine Grained Squashing

**Project Potiron** 



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#### Motivation

Now that we know efficiency loss is a natural outcome of any pricing mechanism, how do we go about minimizing it?

- Can we identify, in a *robust* way, pockets of auctions that are more (or less) susceptible to efficiency loss?
  - > Turn down the pricing knob for auctions that are more susceptible
  - > Turn up the pricing knob for auctions that are *less* susceptible



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# Combatting Efficiency Loss: QSpace Squashing (aka Fine Grained)

QSpace is an AQ-wide service that clusters queries into ~23M clusters

- Could we fine tune squashing at that level?
  - Large fraction of spend lies in clusters that have a large fraction of auctions pCTR ranked
  - Opportunity for fine tuning it at that level



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### A teaser of what's to come...

The team is actively developing several pricing mechanisms

#### Stateful Pricing:

- > Borrow headroom from one auction to use in other auctions
- > Preliminary live experiments show a 8:1 Revenue-Efficiency Tradeoffs
- > Many infrastructure considerations

#### Probabilistic Click Pricing

- > Randomly drop ads to achieve desired click-cost curve properties
- > A possible replacement for format pricing
- Fractional Formats
  - > Probabilistically show incremental formats that are unsold due to low bids

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# Questions?

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