

# Measurement and Analysis of OSN Ad Auctions

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# Motivation

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Online advertising networks are **everywhere**

Google earned over **\$50** billion in advertising in **2013**



How is online advertising implemented?

Through **Auctions!**

Advertisers pick **keywords, search terms** and bid on ads

Advertising networks **select** the winning bidders and **present** ads to users

Two ways to pay

**CPM**: Cost Per Mille, the cost of 1,000 ad impressions

**CPC**: Cost Per Click

# Motivation

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The new OSN-based ad services became **popular**

Facebook had over **\$7.8** billion in advertising in **2013**

**Ask** users to fill in their information



**Significant** data about the users

Personal information (demographics, interests, educational history, relationship status, etc)

Identities of friends

User activity



Target **users** directly (not keywords, or search terms)

**Atlas** to serve ads on **non-OSN sites**

across **multiple devices**

# What has been studied?

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## Web-search-based advertising networks

"**Estimated prices**" from Google's Traffic Estimator Tool [Manage.Sci.'11]

Analytical models to **predict** the clicks, prices, CTR [WWW'14]

**New models** for conducting online auctions [EC'12]

## User Value

**Influential** users in OSNs [EC'12]

The contribution of users to advertising revenue is **skewed** [IMC'13]

**65%** of ad categories received by users are targeting **interests** [HotNets'13]

## Unfortunately

**Little academic study** of the OSN-based ad networks

OSNs have released **little data** about their advertising markets



# This paper

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## Goal

Develop techniques to **measure and understand** OSN ad markets

Bring **visibility** to OSN ad markets, focusing on **Facebook**

Research problem **meaningful** for advertisers, users, and other researchers

## Assumption

No current **tool** to measure Facebook ad market

No **visibility** to Facebook internal system (as external researchers)

# Outline

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~~Motivation~~

Exploring suggested bid mechanism

How are suggested bids calculated?

Exploring user value

# Facebook advertising

**AUDIENCE** [Help: Choose Your Audience](#)

**Locations** ⓘ United States  
**All United States**  
Add a country, state/province, city or ZIP

**Age** ⓘ 13 ▾ - No max ▾


**Gender** ⓘ All **Men** Women

**Languages** ⓘ Enter a language...  
**More Demographics** ▾

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**Interests** ⓘ Search interests | [Suggestions](#) | [Browse](#)

**Audience Definition**



Your audience selection is fairly broad.

Potential Reach: 82,000,000 people

**Your ad targets people:**

- Who live in United States
- Who are male

**Suggested Bid**

**\$0.04–\$1.23** USD

# Facebook's targeting parameters

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<b>Basic Fields</b>	<b>Parameters/Examples</b>
<i>Location</i>	Country, State, City, Postal code
<i>Gender</i>	Male, Female, All
<i>Age</i>	Range (from 13–65)
<i>Precise Interest</i>	Travel, Science, Music, ...
<i>Broad Category</i>	Cooking, Gardening, iPhone 5, ...
<i>Interested In</i>	Male, Female, All
<i>Relationship Status</i>	All, Single, In a relationship, Married, Engaged, Not specified
<i>Language</i>	English, Spanish, French, ...
<i>Education</i>	Anyone, In high school, In College, College Grad
<i>Workplaces</i>	Google, Facebook, AT&T, ...

## Notes

Target any combination of these parameters

Required to specify at least one country



# Facebook advertising

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# Methodology

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What are suggested bids?

Facebook undocumented feature

*"The suggested bid range you see when creating your ads is based on the bids that are **currently winning the ad auction** for the users you've chosen to target."*

How to collect suggested bids in scale?

Programmatically send **HTTP GET** requests to the Facebook Ad Creation URL

## Query:

```
https://graph.facebook.com/reachestimate?targeting_spec=
{"countries":["US"],"age_min":21,"age_max":30,genders=[1]}
&currency=USD&accountId=XXX&access_token=XXXX
```

## Response:

```
{"data": {"users":62984500,"bid_estimations":
[{"location":3,"cpc_min":54,"cpc_median":82,"cpc_max":144,
"cpm_min":3,"cpm_median":14,"cpm_max":83}]}}
```

# Suggested bid data

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## Example Dataset

1,000 suggested bids

Each of the 204 countries that Facebook supports

Queries were roughly spaced 35 milliseconds apart

U.S.: 159M; New Zealand: 2.2M; Antigua and Barbuda: 29K users

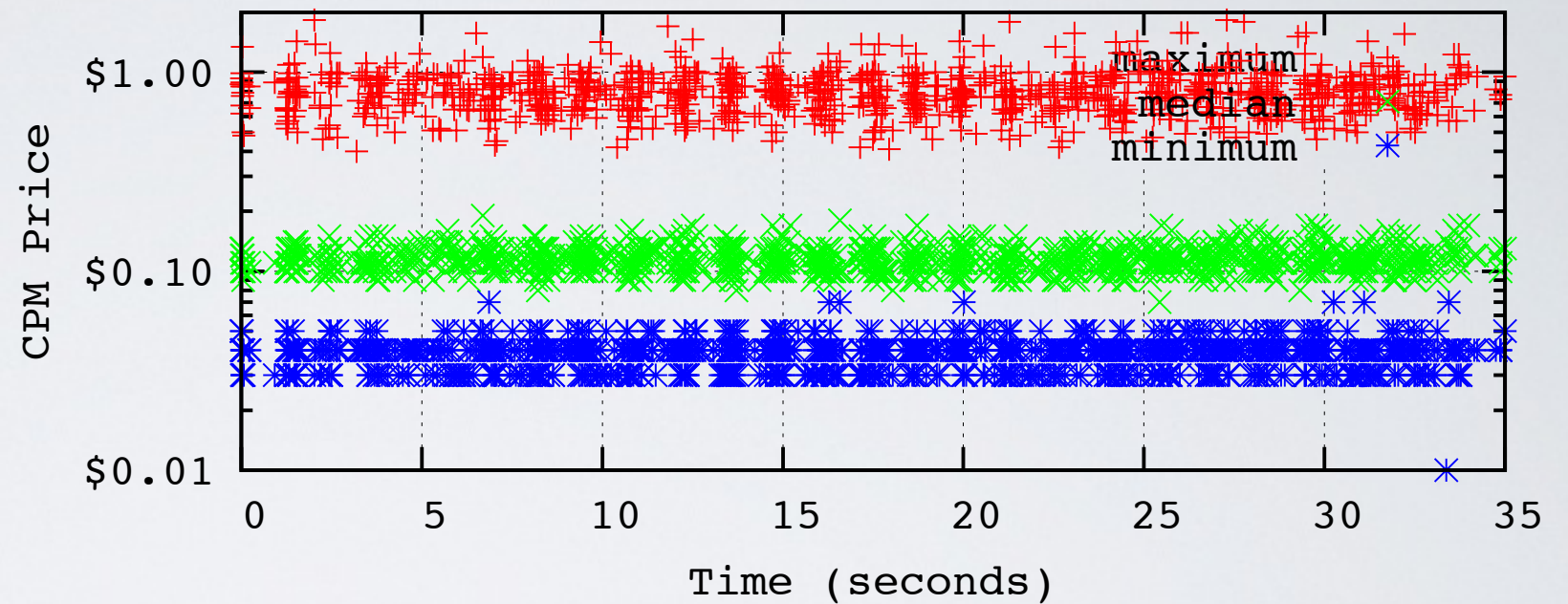
## CPM ad prices

reasoning about CPC requires knowing an advertiser's CTR

CTR (click-through rate): the fraction of impressions that result in a click

# Suggested bid observations

## 1 Skewed distribution



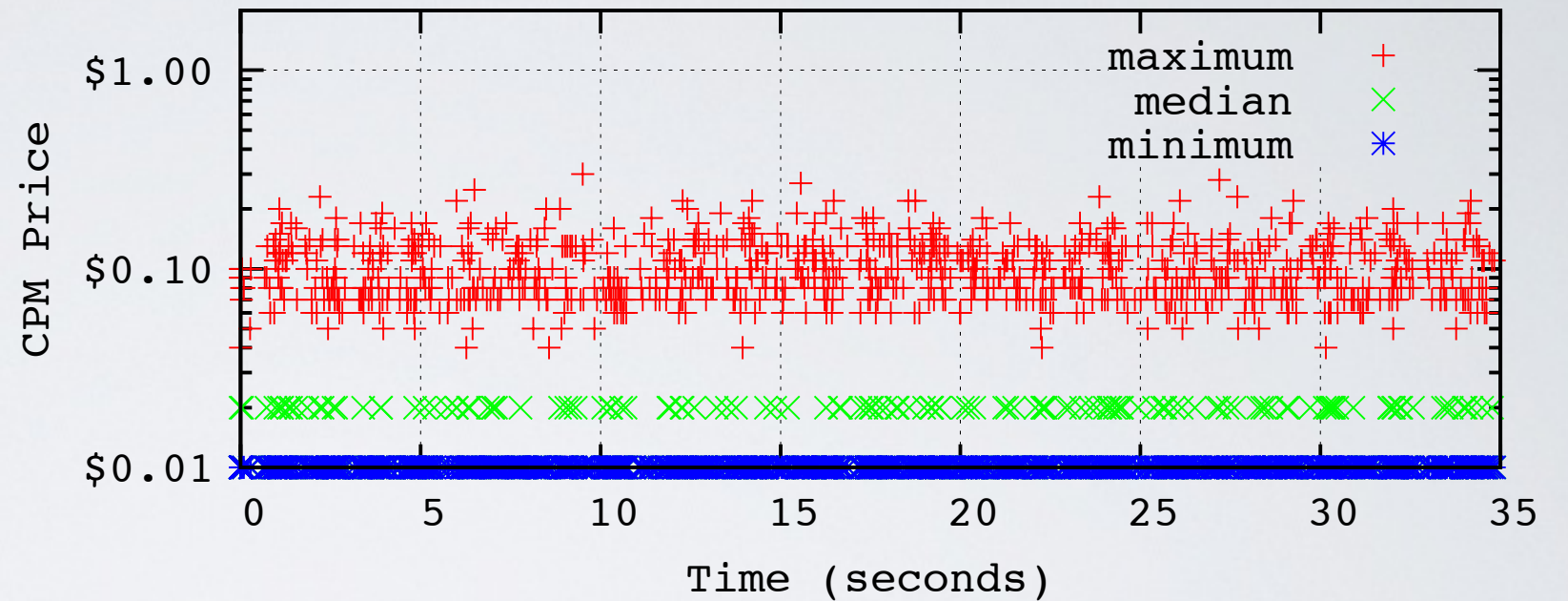
United States (159,115,060 users)



# Suggested bid observations

1 **Skewed** distribution

2 Significant **variance**



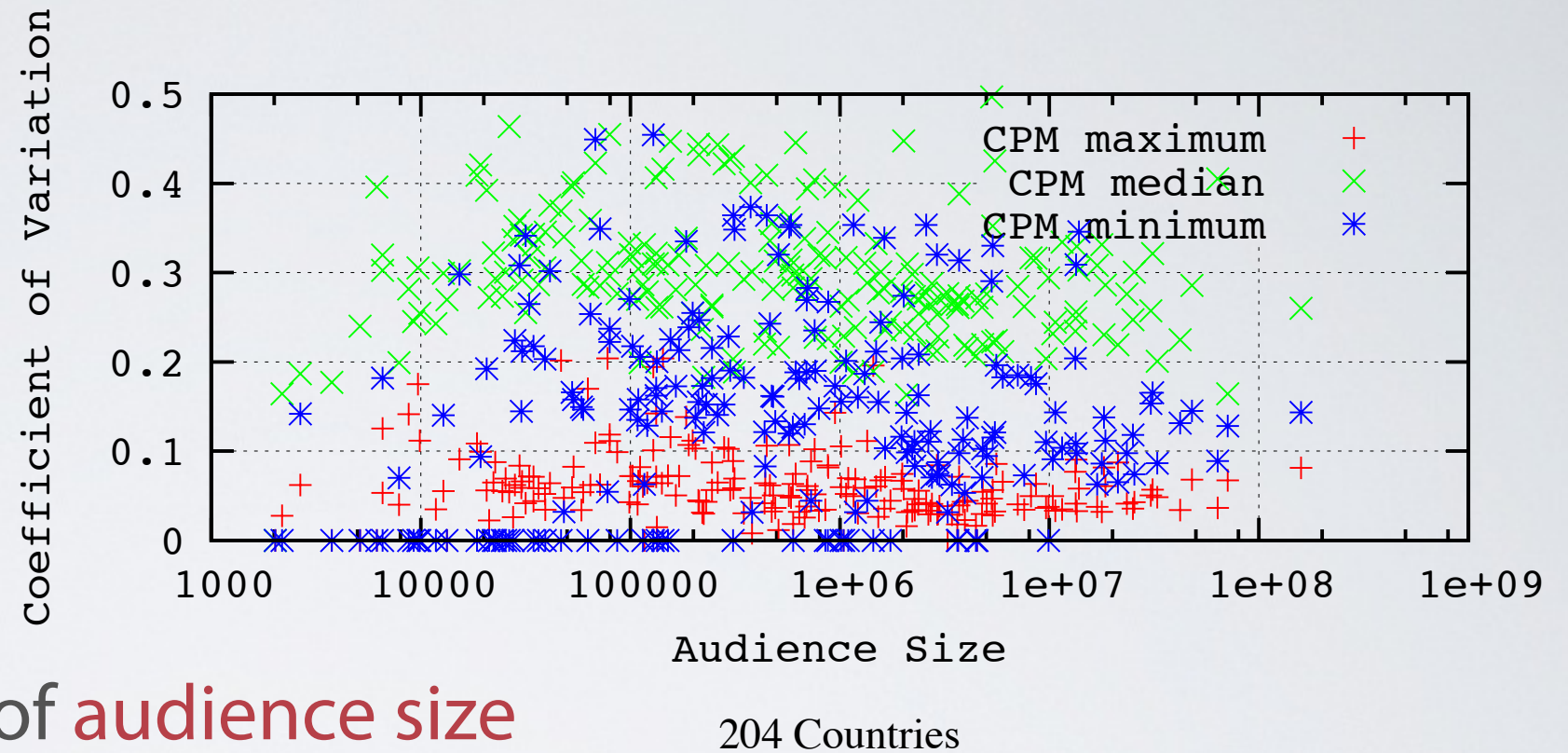
Antigua and Barbuda (29,580 users)

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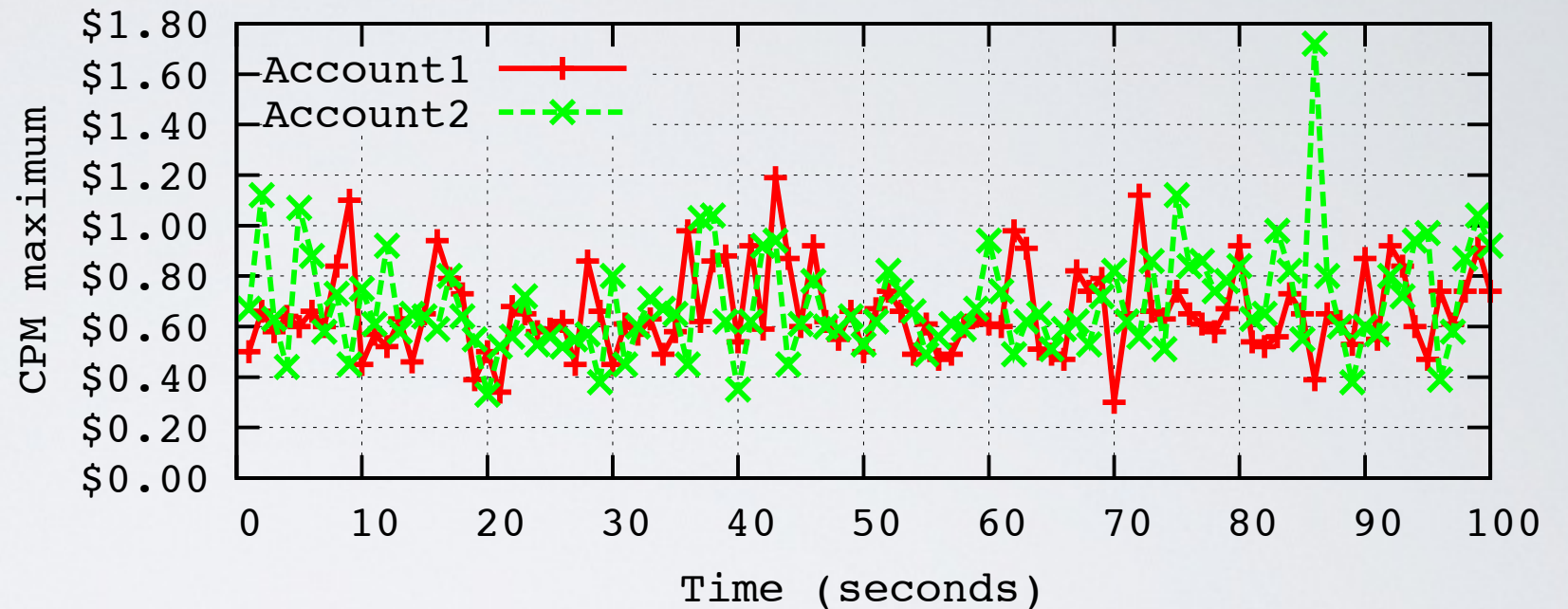
3 Variance independent of **audience size**



# Suggested bid observations

1 **Skewed** distribution

2 Significant **variance**



3 Variance independent of **audience size** United States (159,115,060 users)

4 Variance across **accounts**



# Suggested bid observations

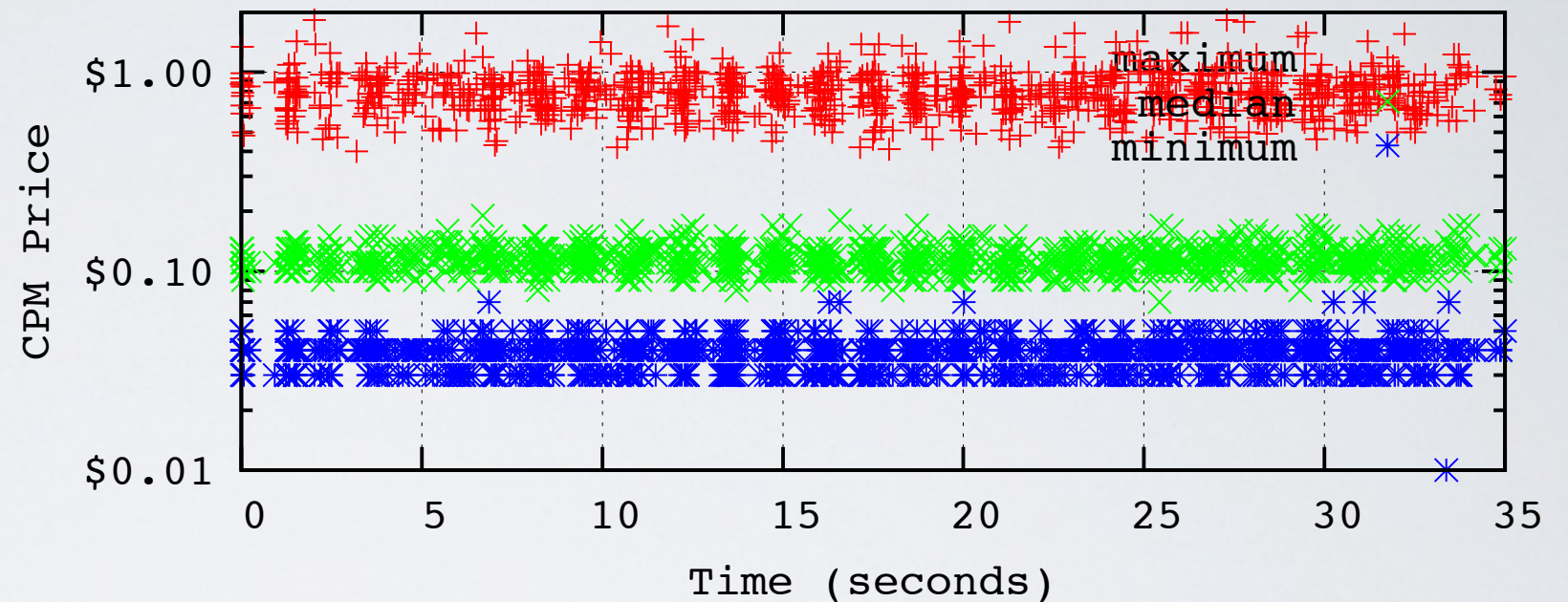
1 **Skewed** distribution

2 Significant **variance**

3 Variance independent of **audience size** United States (159,115,060 users)

4 Variance across **accounts**

5 **Non-persistence** of min or max





# Outline

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How are suggested bids calculated?

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# Reverse-engineering suggested bids

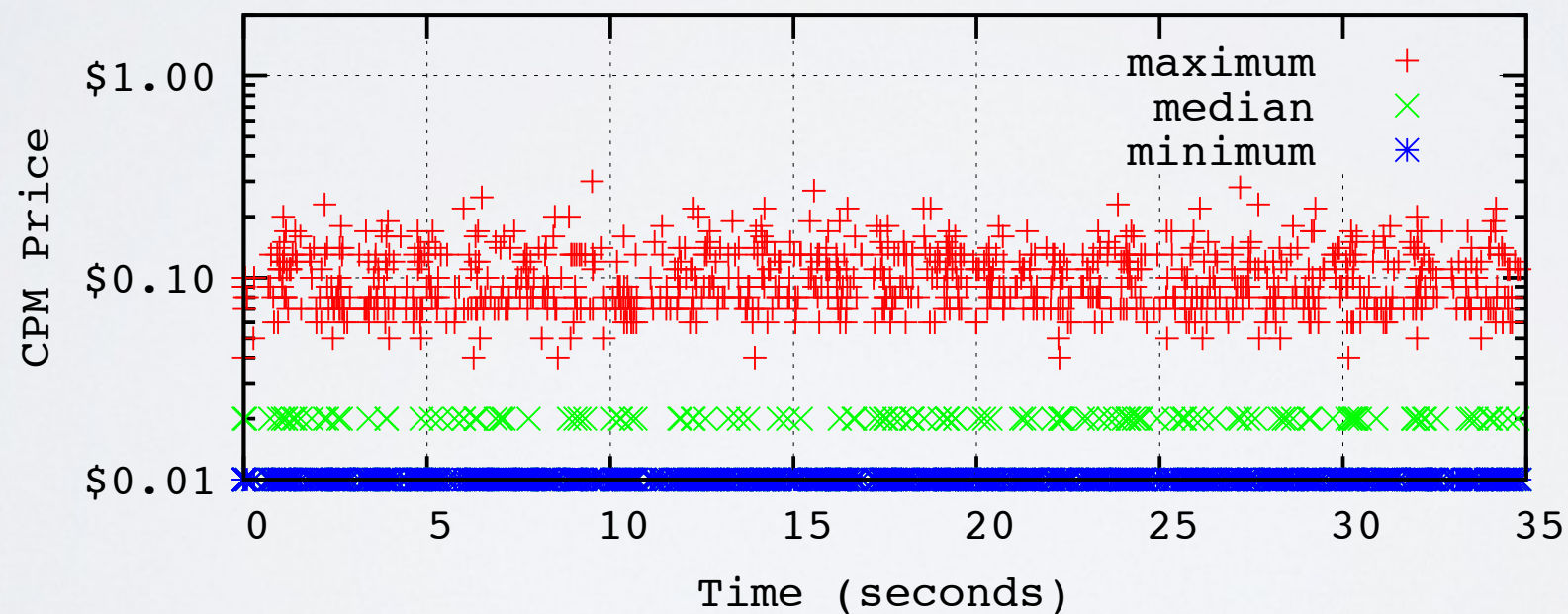
Goal:

The suggested bid algorithm is a **black box**

Look for the most reasonable explanation

Hypothesis 1: Winning bids change rapidly

Derived from the most-recent-k winning bids for the target users



Antigua and Barbuda (29,580 users)

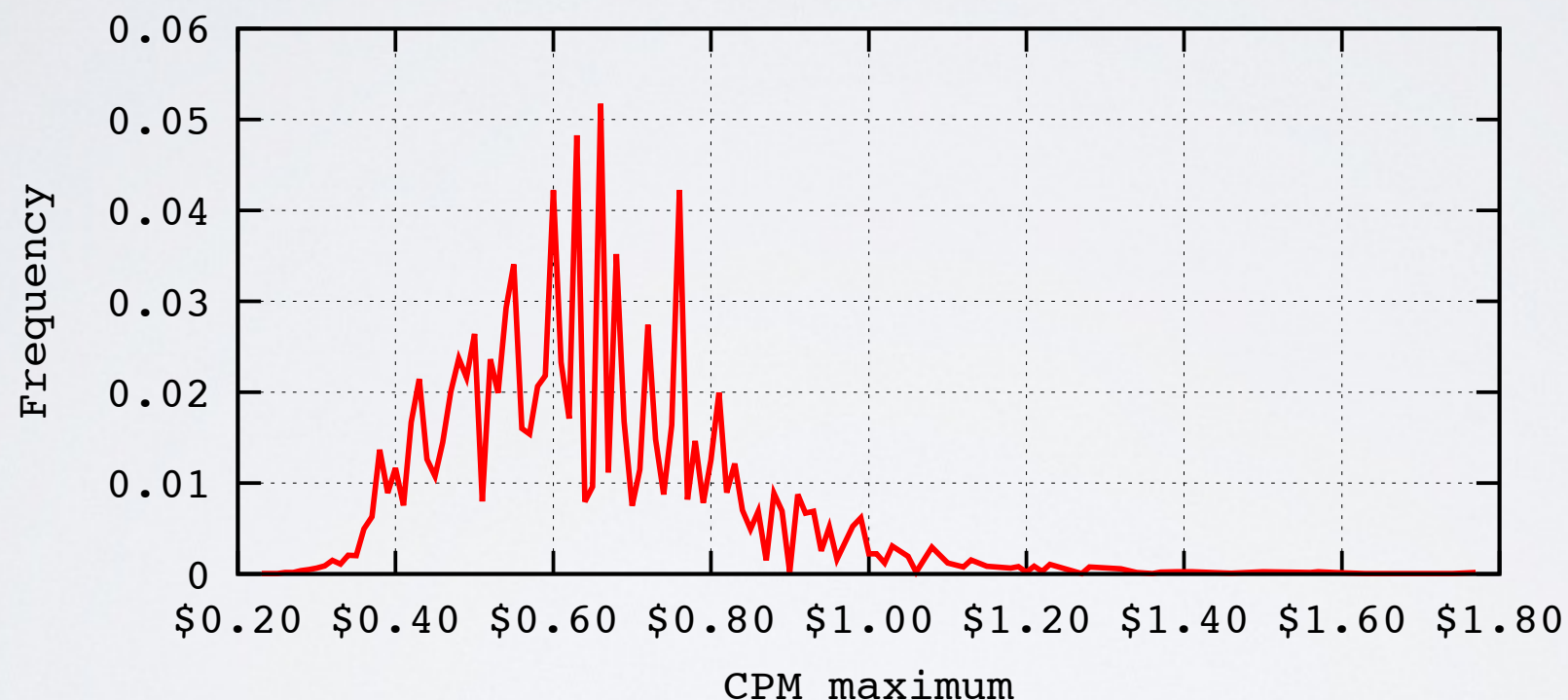
**Not true:** significant variance observed on very short timescales

# Reverse-engineering suggested bids

## Hypothesis 2: Adding random noise

In order to obfuscate the true value

Statistical tests: if the data matched a number of common **statistical distributions** (Uniform random, Gaussian, Cauchy, Log-Normal or Logistic)



Example probability distribution function of CPM max values for 20,000 suggested bids.  
Fails statistical tests.

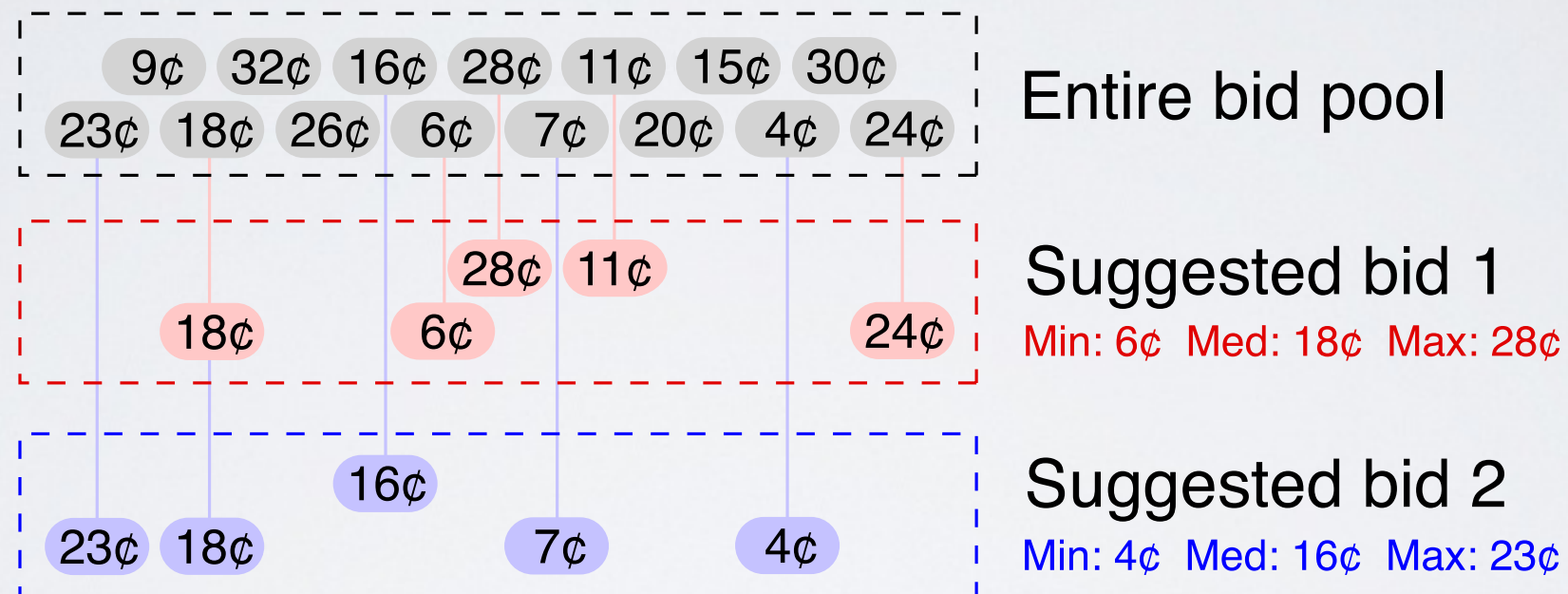
**Not true:** poor fit for all distributions, with a p-value of less than  $10^{-16}$

# Reverse-engineering suggested bids

## Hypothesis 3: Sampling winning bids

Sampling from the recent-k winning bids

Reporting the min, median, and max of the sample



**Logical** mechanism for calculating suggested bids

**Consistent** with all the five properties of suggested bids

**Suggested bid is most likely sampled from the recent-k winning bids**



# How real auctions affect suggested bids?

## Changes to the market

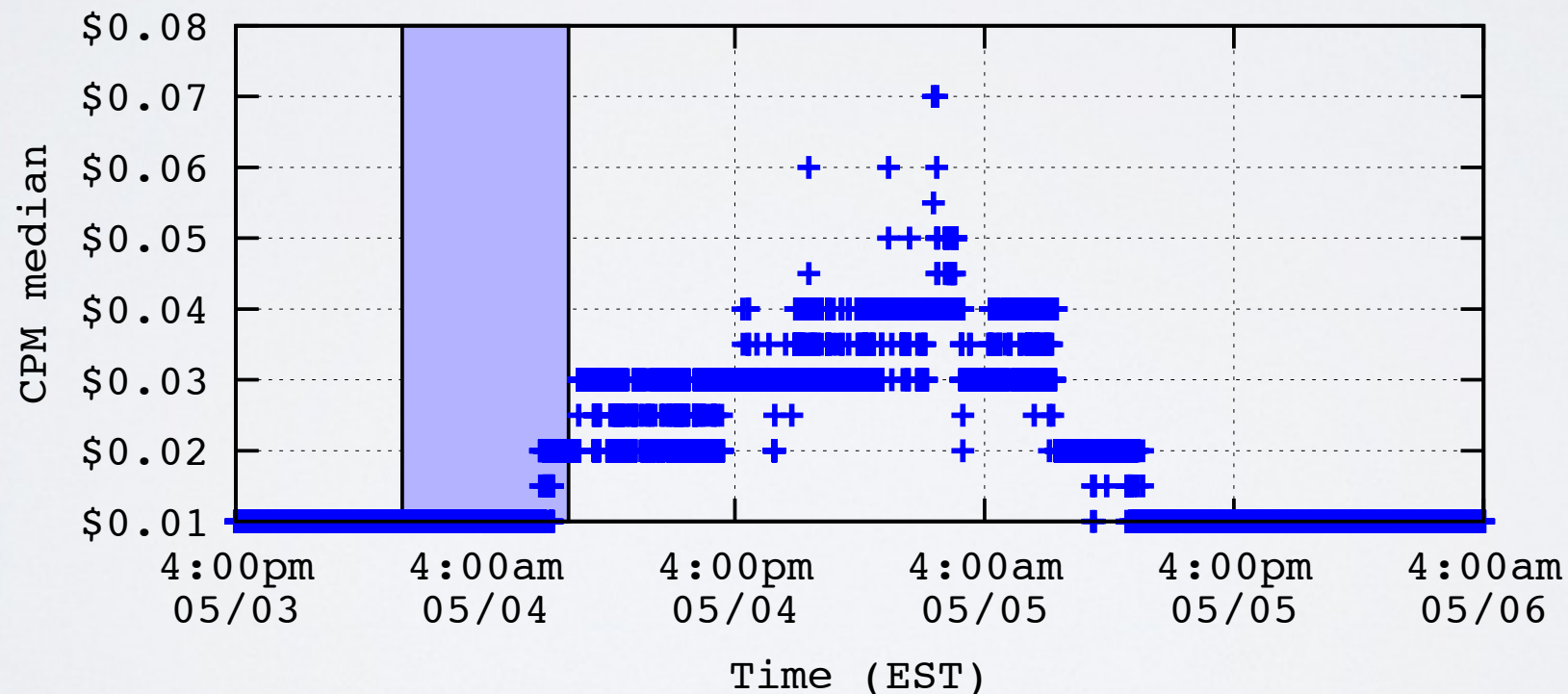
Actively participate in the advertising market

See how quickly we can affect the ad market

Chose a **small** country (Seychelles, 26K users) with **low** suggested CPM

Bid a higher CPM (**\$1.00**) than the suggested CPM max (**\$0.16**) from 3 accounts

Ran campaigns concurrently for **8 hours**



Changes to the ad market are reflected in the suggested bids.

# How suggested bids correlate with revenue?

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## Comparison with Facebook's revenue

The ground truth: **Facebook's SEC filings**

Average Revenue Per User (ARPU) at the granularity of regions

**Aggregate** our CPM median data into the same regions

Region	Facebook ARPU		Suggested Bid Scaled
	Raw	Scaled	
US, Canada	\$3.50	1.00	1.00
Europe	\$1.60	0.45	0.42
Asia	\$0.64	0.18	0.30
Rest of World	\$0.50	0.14	0.15

## Notes

Rank the regions in **the same order**

Europe and Rest of the World regions at approximately **the same ratios**

**The suggested bid data at least correlates with the distribution of Facebook's revenue.**

# How researchers use suggested bids

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Suggested bid data is most likely calculated by **sampling from the recent winning bids** for the target users.

## Multiple samples

Extract the **overall** min, median, and max from the collated samples

## Convergence

How **many samples** to collate together?

We use 25 collated suggested bids

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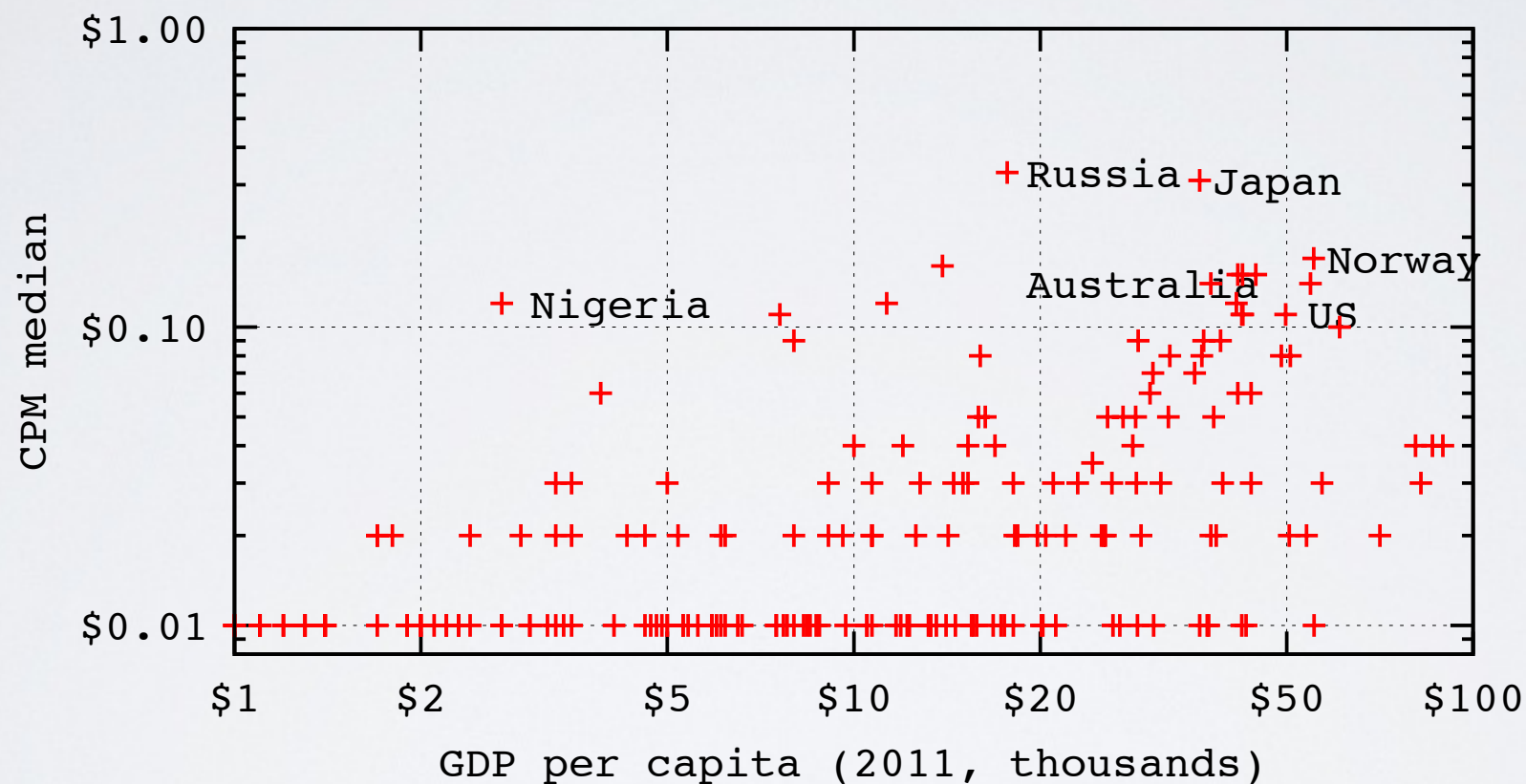


# Location

How the location influences the ad auction winning bids?

**GDP** (Gross Domestic Product) per capita for **204 countries**

The output of a country's economy per person



Note

Observed a correlation of **0.37** between the GDP per capita and CPM values

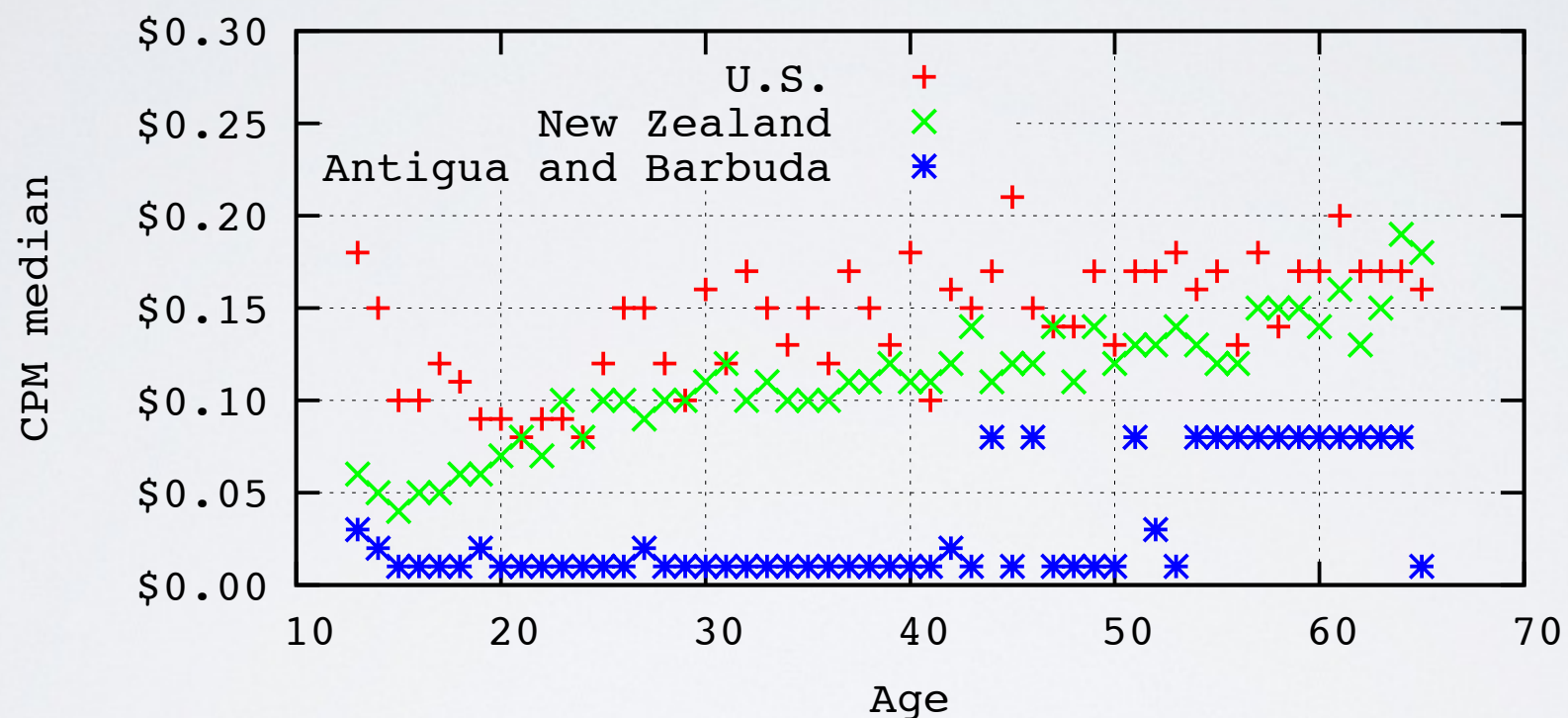
**Dramatic differences in ad auction prices across different countries**

# Age

How is CPM median price correlated with user age?

Select the same three countries (U.S., NZ, AG)

The smallest age is 13, while targeting age 65 encompasses all users 65 and over



## Notes

For U.S. and NZ, as age increases, the CPM median price increase as well

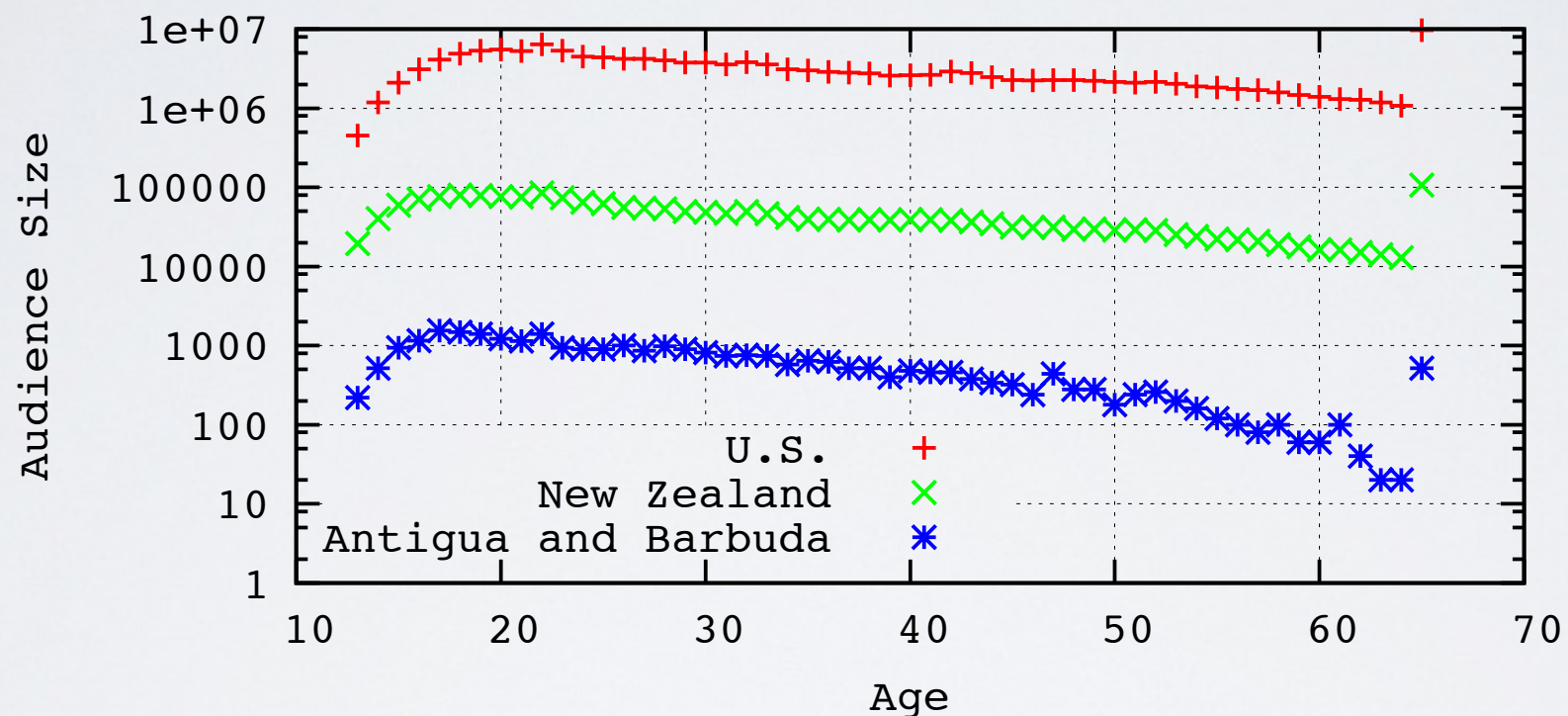
Less clear trend for AG

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Less clear trend for AG

Less differences in ad auction prices across different ages

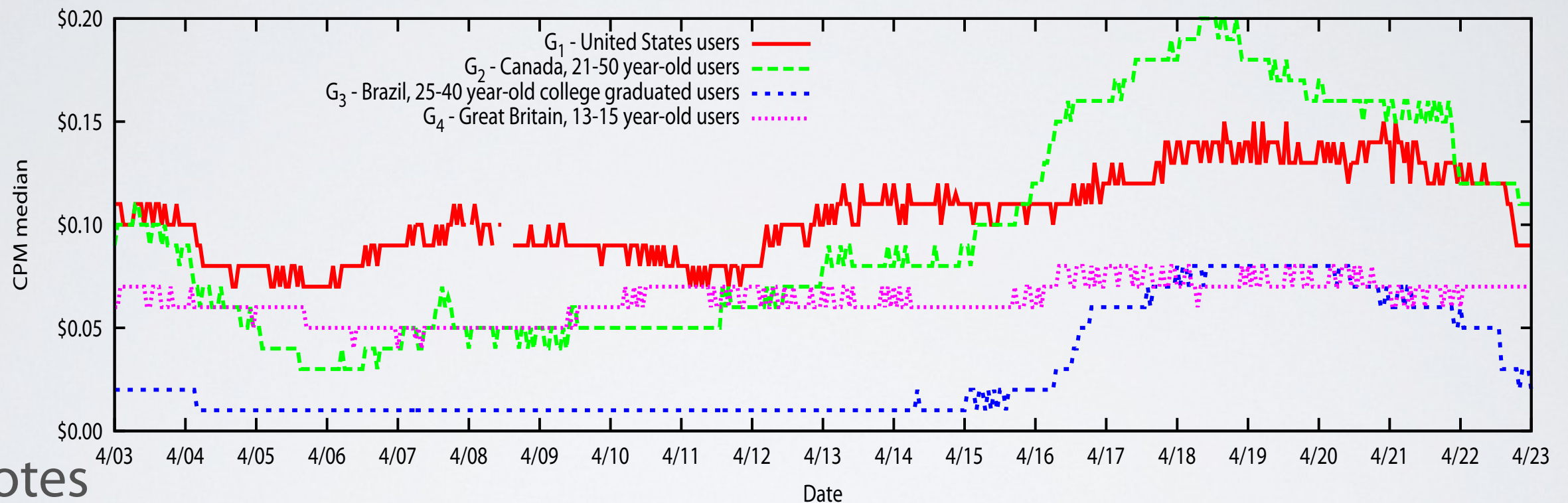


# Price stability

How **stable** are the prices for different target demographics **over time**?

Select four different sets of targeting parameters

Retrieve 25 suggested bids each hour for a period of 3 weeks (Apr. 3~23, 2013)



## Notes

G1 shows a periodic increase per week

G2 and G3 shows a multi-day increase starting on 04/16

G4 does not vary much over the study period

**Significant long-term dynamics present in Facebook's ad auctions.**



# Summary

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Identify the **suggested bid** mechanism to measure Facebook ad market

Validate and show how researchers can **use** the suggested bid data

Analyze how **different users** contribute to Facebook's revenue

**Dramatic differences** in ad auction prices across different locations, interest

Significant **long-term** dynamics present in Facebook's ad network

# Questions?

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Our suggested bid collection code and collected data available at  
<http://osn-ads.ccs.neu.edu>