

Invited Talk in Nanjing Big Data Meetup

大数据，人工智能和互联网变现 和计算广告学 (Big data, AI and Computational Advertising)

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Computer Science, UCL (伦敦大学学院)

Co-founder, MediaGamma Ltd

Email: j.wang@cs.ucl.ac.uk

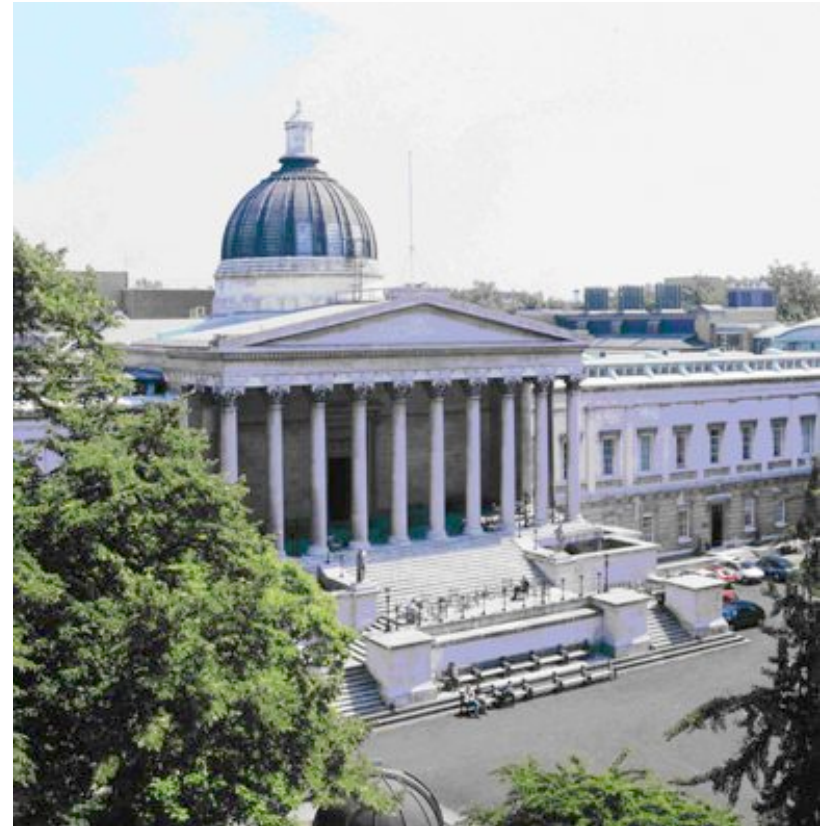
Wechat (微信): jw42338390



University College London

(伦敦大学学院)

- Regularly rank top-5 in UK
- UK REF2014
 - UCL Rank 2
 - Computer Science Rank 1
- 32 Nobel Laureates
 - e.g., Kuen Kao (高锟)
- Deepmind, acquired by Google \$400m



Who we are

- UCL Computational Advertising Lab
 - 5 PhDs and 1 Postdoc
 - Information retrieval and search
 - Personalisation, recommender systems and behavior targeting
 - Financial methods of display advertising
- MSc/Res Web Science and Big Data Analytics
- Start-up: MediaGamma Ltd
 - building the first automated Futures/Options exchange for display advertising
 - Combining AI/machine learning and financial methods



Big Data

- IBM data shows that consumers create about 2.5 quintillion bytes (十的十八次方) of data each day
- 90% of the data in the world today has been created in the last two years alone.

Big Data Revolution

- The revolution is
 - not about the quantity of data,
 - but about how we can now extract knowledge, insights, and make predictions with scalable computational and statistical methods.
- Computational power: Mapreduce/Spark/GPUs
- Data Science, Artificial Intelligence (AI) and Machine Learning have become a key basis of innovation

Break-through: Speech Translation

Scientists See Promise in Deep-Learning Programs

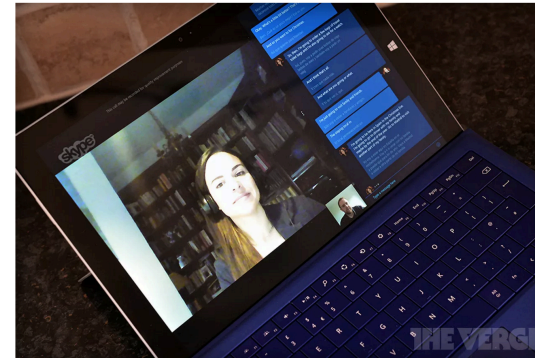
By JOHN MARKOFF NOV. 23, 2012



A voice recognition program translated a speech given by Richard F. Rashid, Microsoft's top scientist, into Mandarin Chinese. Hao Zhang/The New York Times

Skype's real-time translator now speaks French and German

By Tom Warren on June 18, 2015 05:12 am @tomwarren



THE LATEST HEADLINES



Netflix is doubling its number of original scripted shows next year



Google enables Safe Browsing by default on Chrome for Android



Japan's Akatsuki spacecraft is finally in orbit around Venus



Kickstarter projects have 'reasonable' 9 percent failure rate, study finds



We should mock IBM's terrible hair driver

Milestones on the path to Skype Translator

2014

December 15: Microsoft releases a preview version of Skype Translator for English and Spanish audiences.

- [Read more on the Skype blog](#)

November 12: Elementary school students in Tacoma, Washington, and Mexico City participate in the first Skype Mystery Call that uses a test version of Skype Translator.

Video: Skype Mystery Call

Skype Translator Preview



Skype users to get real-time language translating tool

<http://www.nytimes.com/2012/11/24/science/scientists-see-advances-in-deep-learning-a-part-of-artificial-intelligence.html>

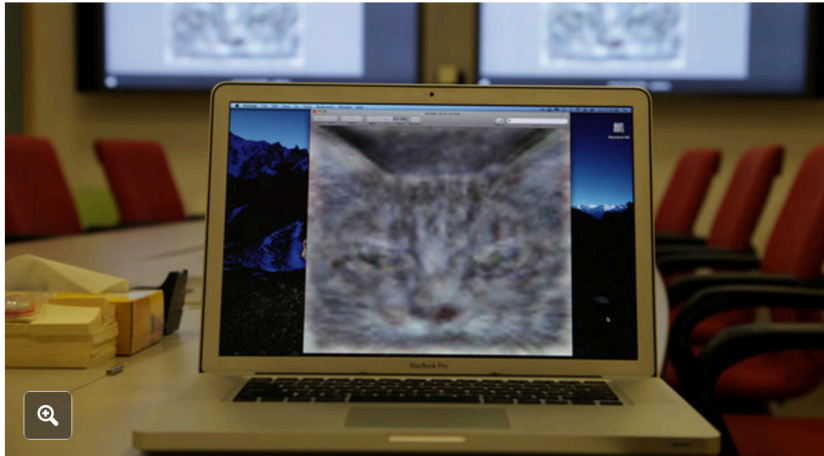
<http://research.microsoft.com/en-us/about/speech-to-speech-milestones.aspx>

Break-through: Computer Vision

TECHNOLOGY

How Many Computers to Identify a Cat? 16,000

By JOHN MARKOFF JUNE 25, 2012



An image of a cat that a neural network taught itself to recognize. Jim Wilson/The New York Times

MOUNTAIN VIEW, Calif. — Inside [Google's](#) secretive X laboratory, known for inventing self-driving cars and augmented reality glasses, a small group of researchers began working several years ago on a simulation of the human brain.

There Google scientists created one of the largest neural networks for machine learning by connecting 16,000 computer processors, which they turned loose on the Internet to learn on its own.

Presented with 10 million digital images found in YouTube videos, what did Google's brain do? What millions of humans do with YouTube: looked for cats.

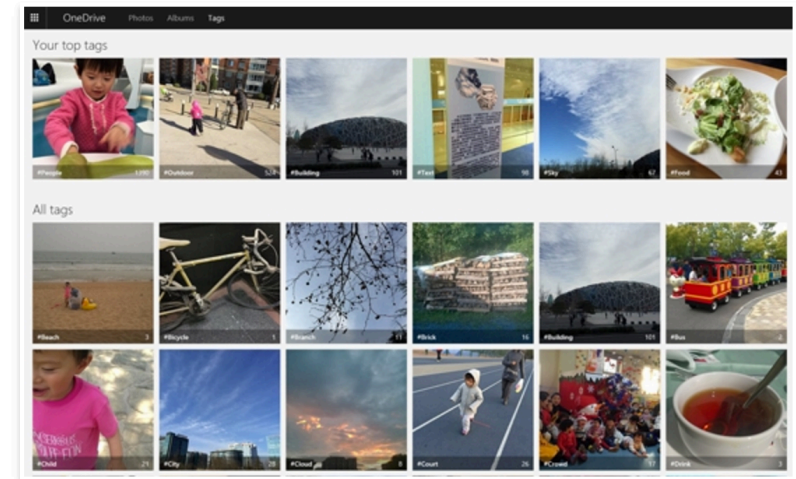
Microsoft Researchers' Algorithm Sets ImageNet Challenge Milestone

Inside Microsoft Research 10 Feb 2015 6:00 AM 1

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Posted by Richard Eckel



The race among computer scientists to build the world's most accurate **computer vision** system is more of a marathon than a sprint.

The race's new leader is a team of Microsoft researchers in Beijing, which this week published a paper in which they noted their computer vision system based on deep **convolutional neural networks** (CNNs) had for the first time eclipsed the abilities of people to classify objects defined in the ImageNet 1000 challenge.

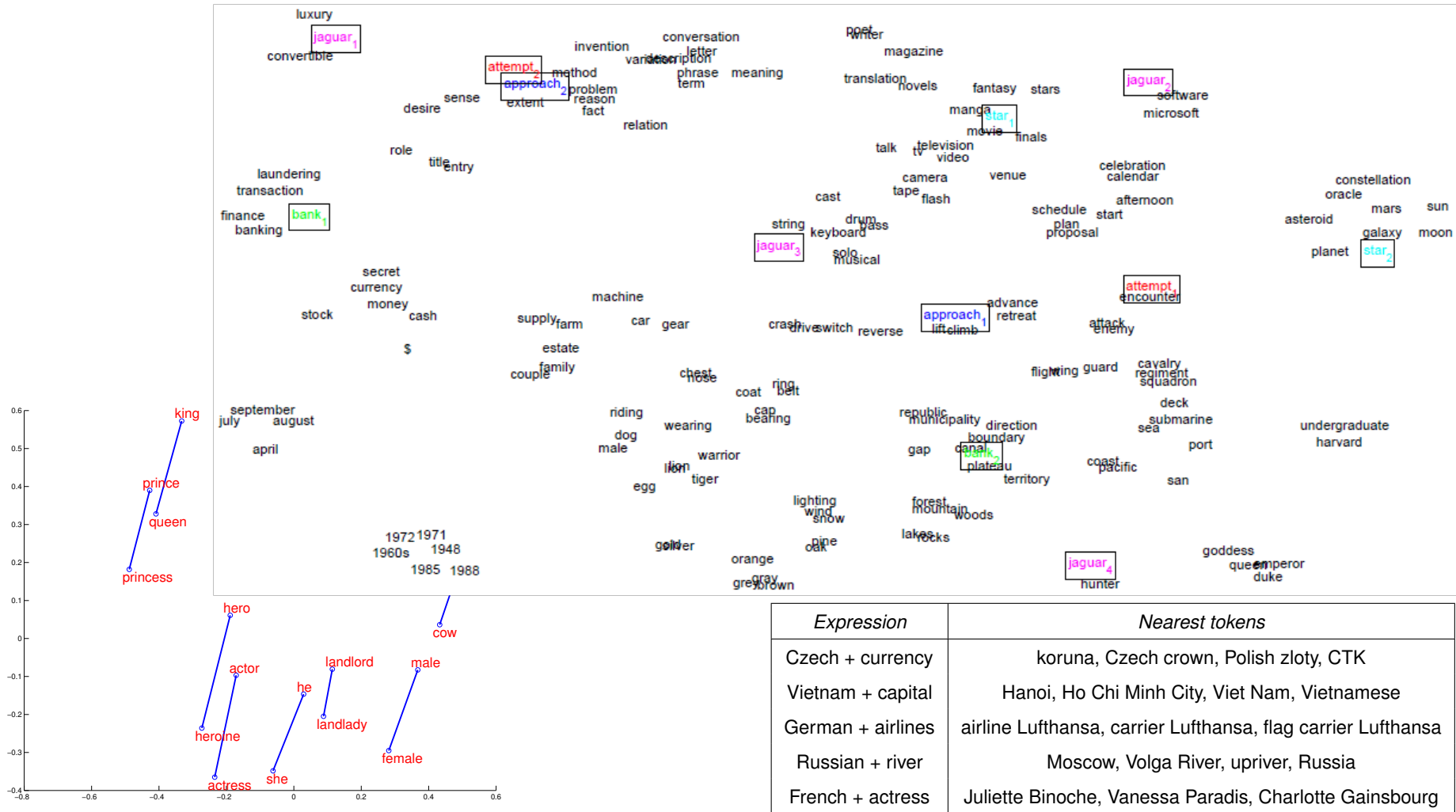
http://blogs.technet.com/b/inside_microsoft_research/archive/2015/02/10/microsoft-researchers-algorithm-sets-imagenet-challenge-milestone.aspx

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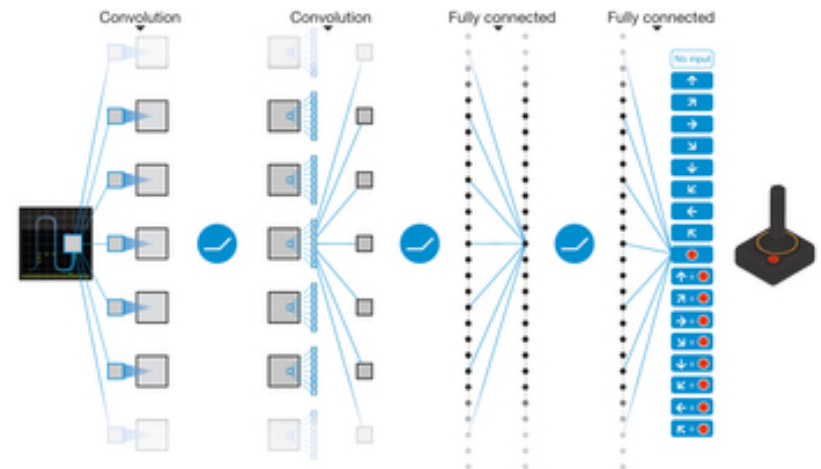
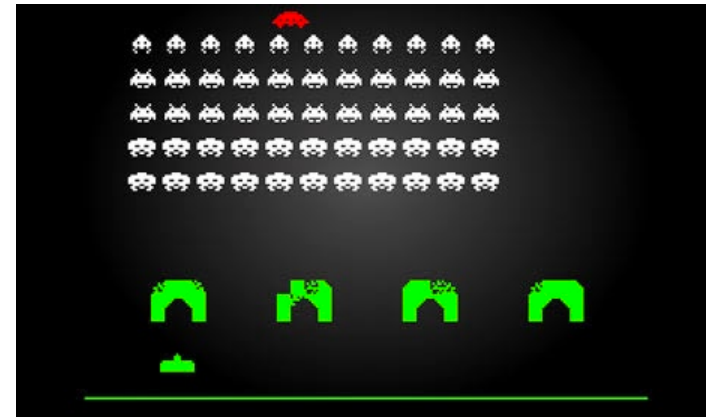
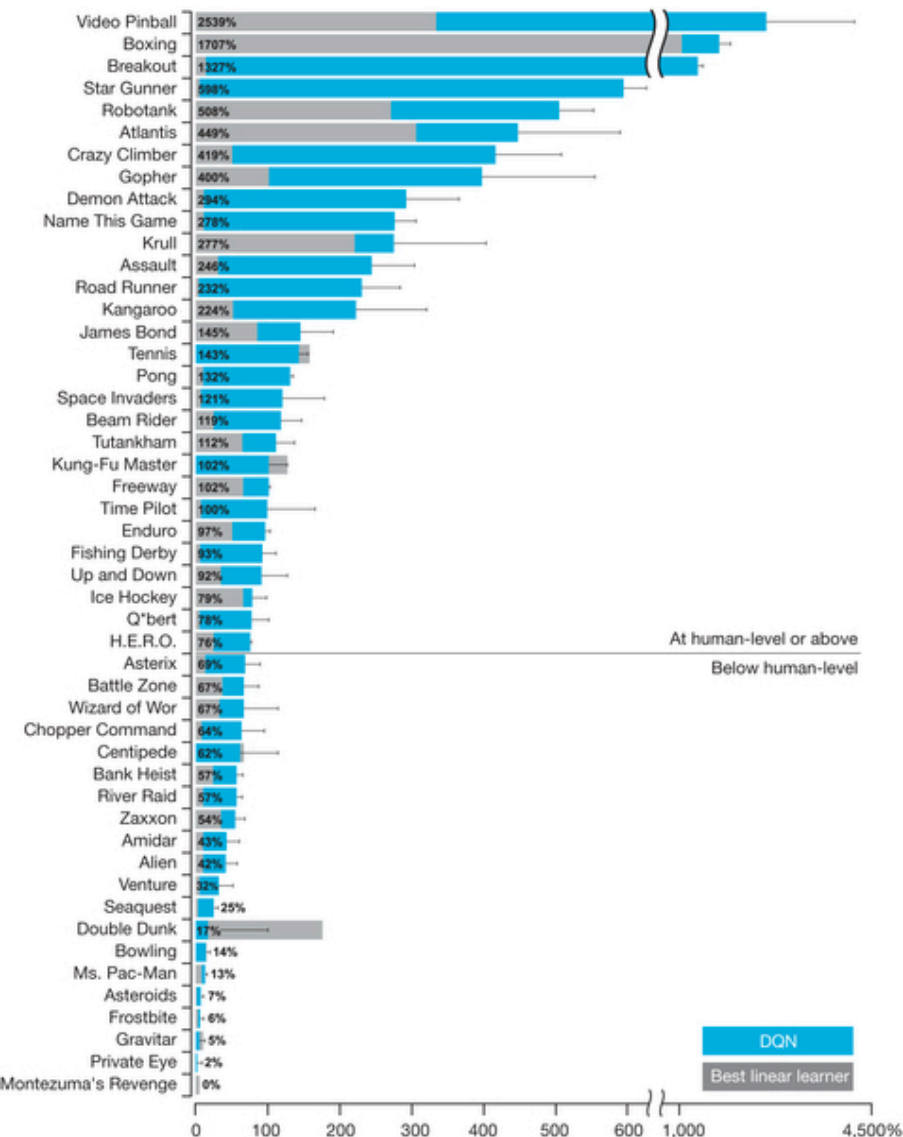
Talk at Nanjing Big Data Meetup

Break-through: Natural Language Processing

From bag of words to distributed representation of words



Break-through: Human-level Control



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Talk at Nanjing Big Data Meetup

<http://www.nature.com/nature/journal/v518/n7540/full/nature14236.html#videos>

Web Big Data (BAT)

- Baidu:
 - 531 million users
 - 500 million month active mobile search users (70 million daily)
- Alibaba
 - have 300million active users (mobile monthly active users 163 million)
 - 12.7 billion annual orders (Buyers 279 million and Sellers 8.5 million)
 - Alipay registered users: 300 million
- Tencent
 - Wechat has 438 million monthly active users
 - Qzone has 645 million monthly active users

Technologies behind content providers



Product search

Search results
- Maximize users'
satisfactions?

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¥79.00 销量: 3583

Clukbaby 运宝 特价包邮



¥58.00 销量: 4



Recommender Systems



Amazon Fire Phone, 32 GB (O2)
by Amazon
★★★★★ 106 customer reviews

4.1 out of 5 stars

5 star	<div><div></div></div>	53
4 star	<div><div></div></div>	28
3 star	<div><div></div></div>	12
2 star	<div><div></div></div>	7
1 star	<div><div></div></div>	6

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monthly tariff will be adjusted every year or
Index (RPI) rate of inflation announced in the preceding February.

Colour: **Black**



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Recommender systems

Customers Who Bought This Item Also Bought

amazon.co.uk
Prime



Sony DK48 Magnetic
Charging Dock for Z3/Z3
Compact

★★★★☆ (60)

£21.36



Sony SCR24 Style Up Cover
for Xperia Z3 - Copper

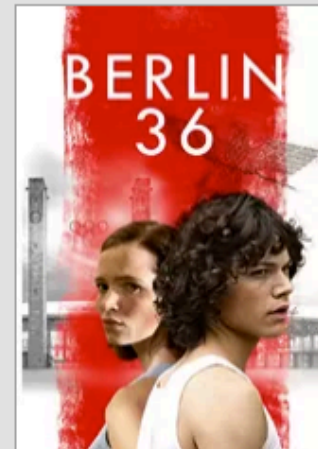


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不卡发
声音超小
送

¥49.90 7292人付款

包邮 岁末秒杀简爱婴儿理
发器超静音 宝宝理发防水儿童电

blackewite 浙江 杭州

¥79.00 销量: 3583

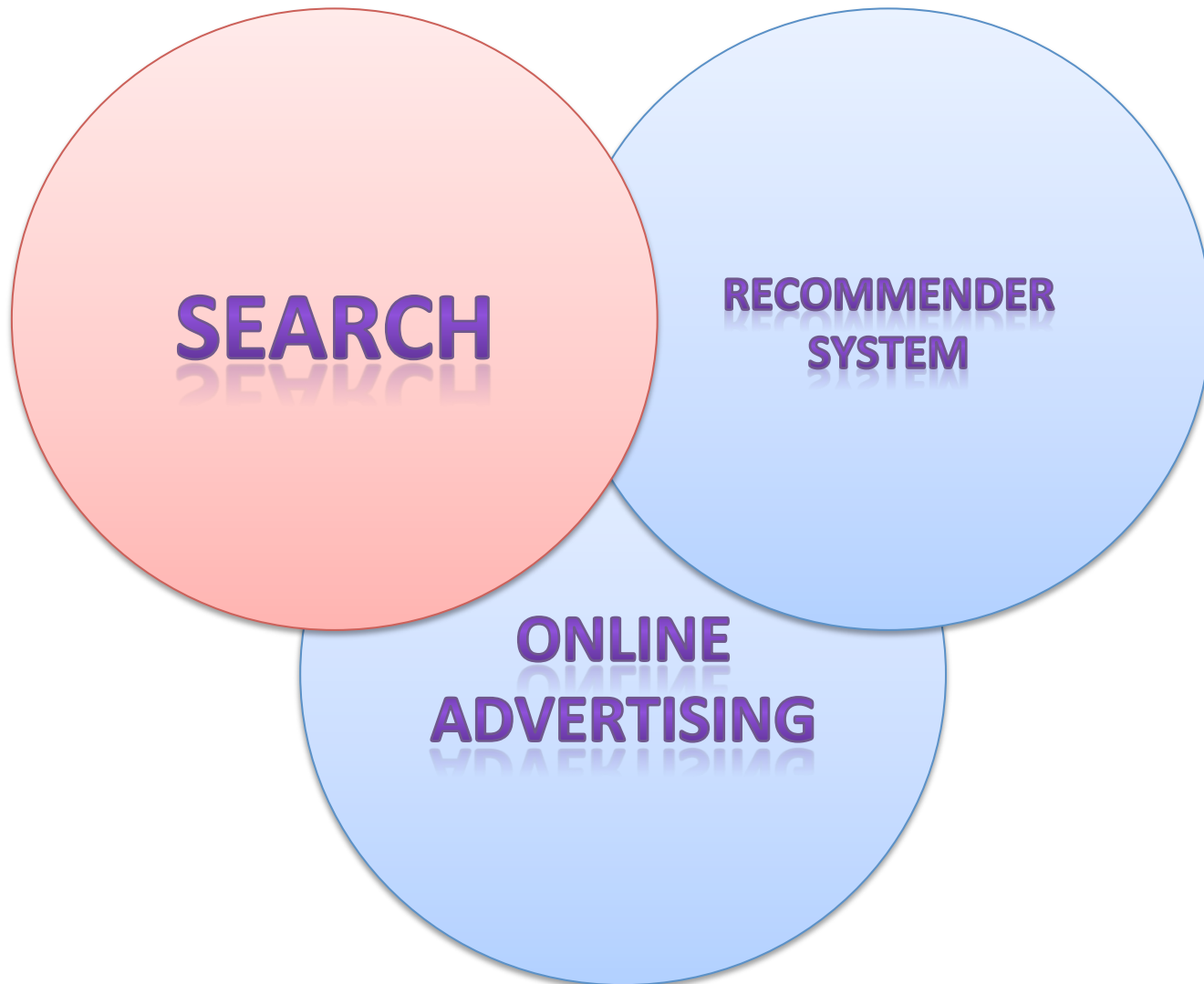
Clukbaby 运宝 特价包邮

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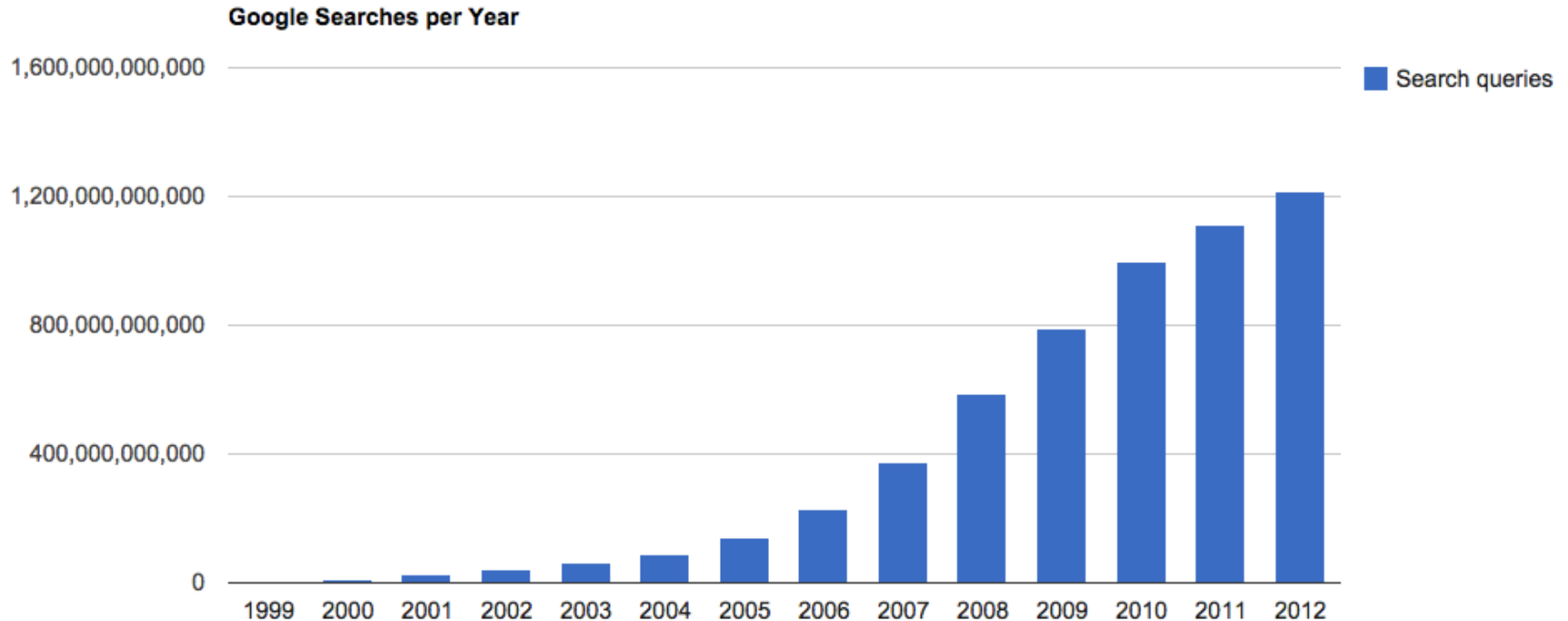
¥58.00 销量: 4



Real-time Services under Big Data

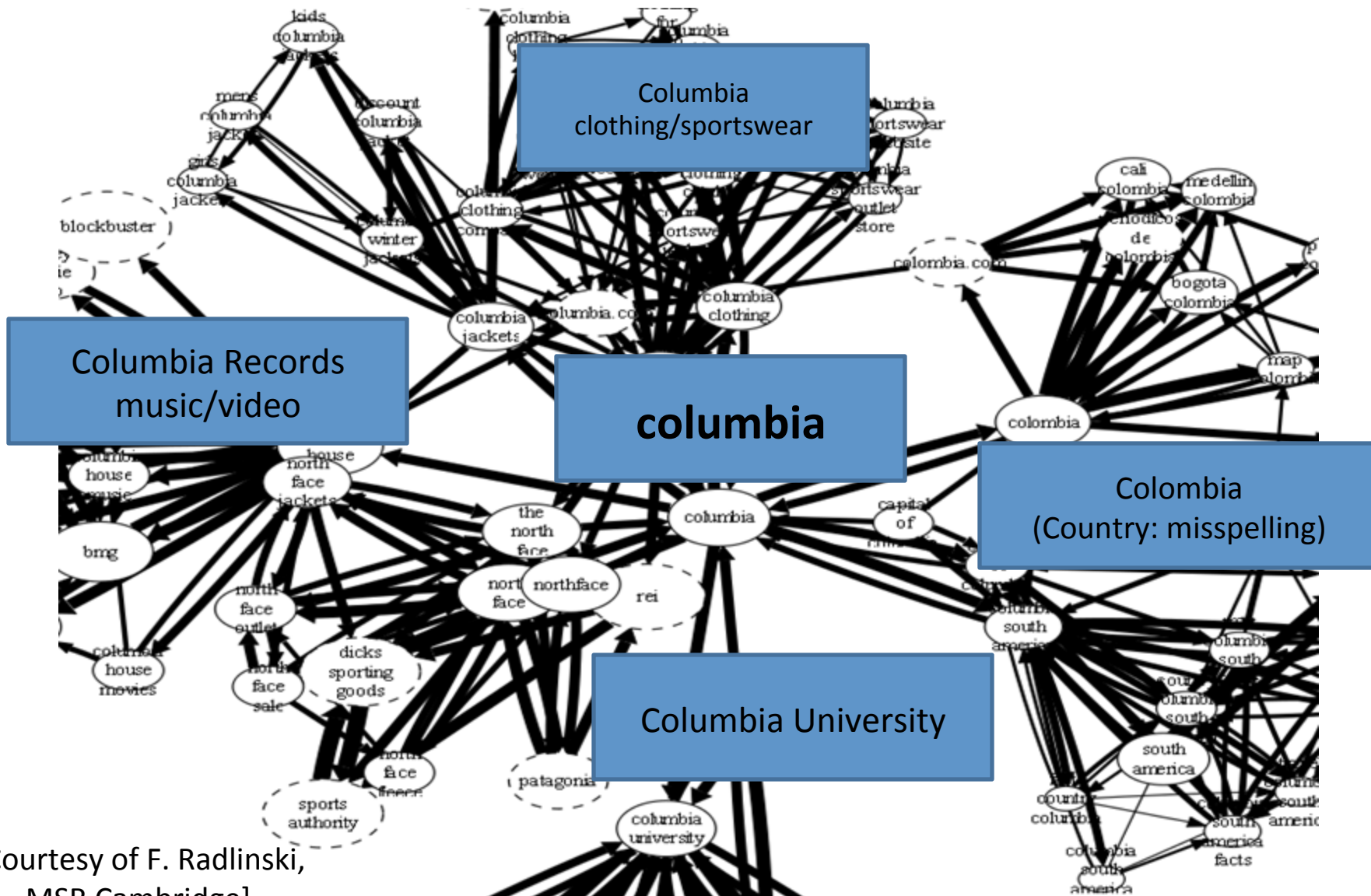


How big the search is?



Google now processes over **40,000 search queries every second** on average, which translates to **over 3.5 billion searches per day** and **1.2 trillion searches per year** worldwide.

Queries can have ambiguous intents



[Courtesy of F. Radlinski,
MSR Cambridge]

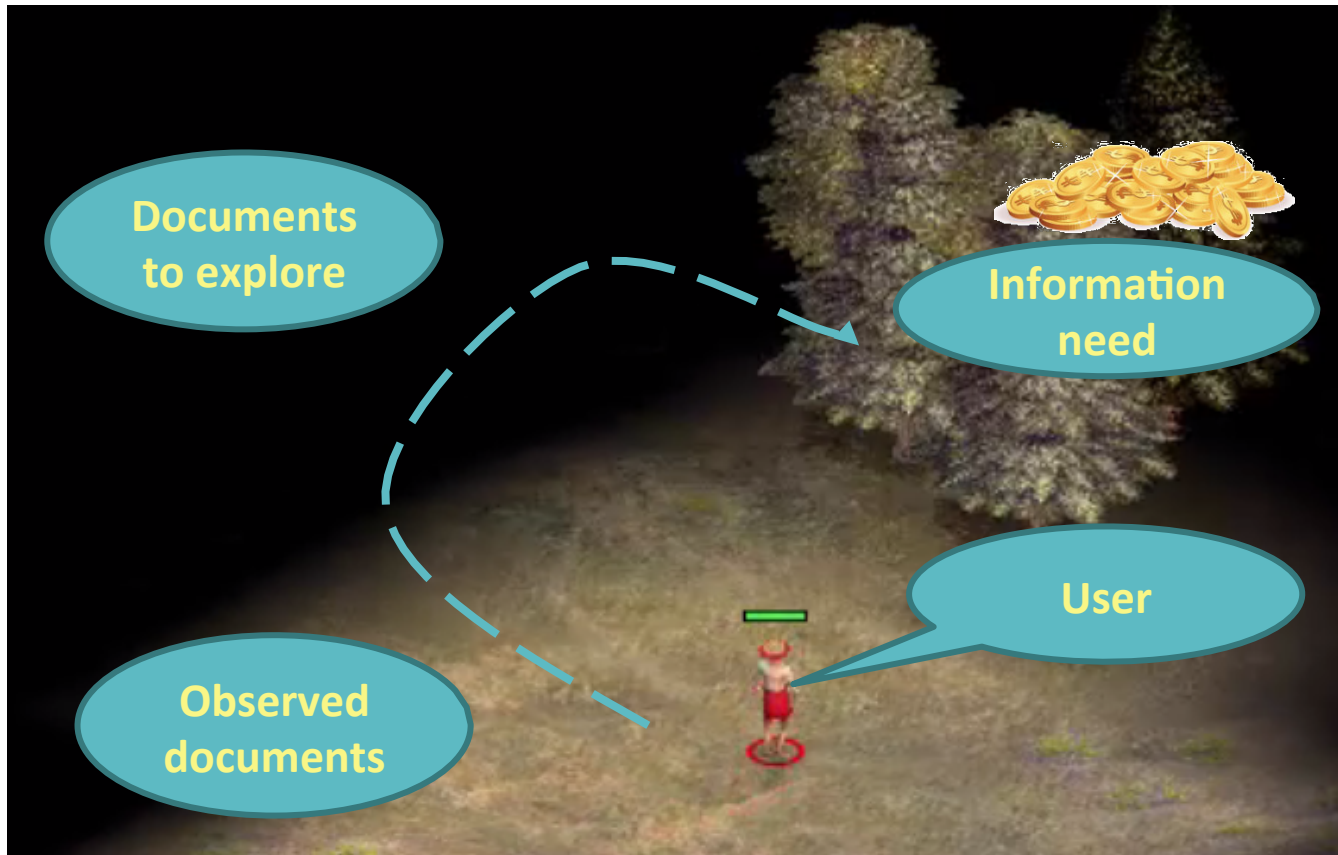
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Evolving IR

- Paradigm shifts in IR as new models emerge
- e.g. VSM → BM25 → Language Model
 - Different ways of defining relationship between query and document
- Static → Interactive → **Dynamic**
 - Evolution in **modeling** user interaction with search engine

Dynamic Information Retrieval



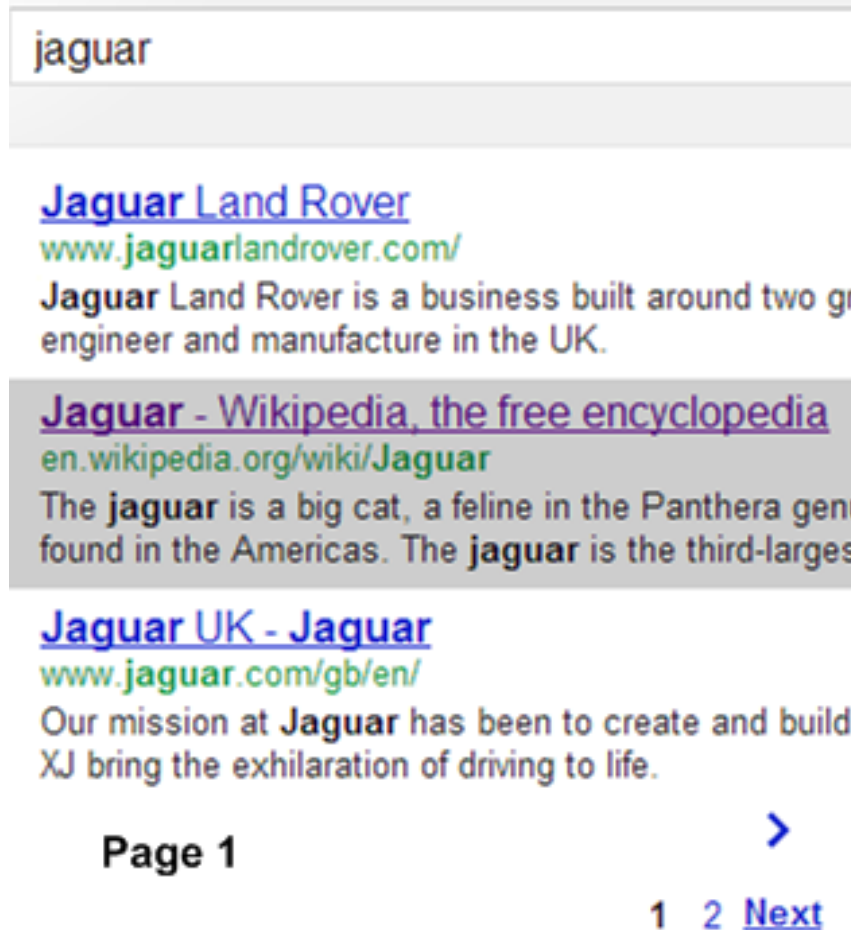
Devise a strategy for helping the user explore the information space in order to learn which documents are relevant and which aren't, and satisfy their information need.

Marc Sloan, Grace Yang, Jun Wang, Forthcoming book on Dynamic Information Retrieval, 2016

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Real-time Multi Page Search: relevance feedback revisit



exploratory relevance ranking

Personalised re-ranking

Real-time Multi Page Search: relevance feedback revisit

jaguar

Jaguar Land Rover

www.jaguarlandrover.com/

Jaguar Land Rover is a business built around two great engineering and manufacture in the UK.

Jaguar - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Jaguar

The **jaguar** is a big cat, a feline in the Panthera genus found in the Americas. The **jaguar** is the third-largest

Jaguar UK - Jaguar

www.jaguar.com/gb/en/

Our mission at **Jaguar** has been to create and build XJ bring the exhilaration of driving to life.

Page 1



Exploratory ranking

1 2 [Next](#)

Personalised re-ranking

Xiaoran Jin, Marc Sloan, and Jun Wang. Interactive Exploratory Search for Multi Page Search Results, www13

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Real-time Multi Page Search Example - States & Actions

State:
Relevance
of
document

jaguar

[Jaguar UK - Jaguar](#)

www.jaguar.com/gb/en ▾

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[Jaguar International - Home](#)

www.jaguar.com/gi/en ▾

Our mission at **Jaguar** has been to create and build beautiful fast cars. The XK, XF, and XJ bring the exhilaration of driving to life.

[Jaguar - Wikipedia, the free encyclopedia](#)

en.wikipedia.org/wiki/Panthera_onca ▾

[Etymology](#) · [Taxonomy and evolution](#) · [Biology and behavior](#) · [Ecology](#)

The **jaguar** is a big cat, a feline in the *Panthera* genus, and is the only *Panthera* species found in the Americas. The **jaguar** is the third-largest feline after the ...

[Jaguar Cars - Wikipedia, the free encyclopedia](#)

en.wikipedia.org/wiki/Jaguar_Cars ▾

[History](#) · [Current car models](#) · [R models](#) · [Future models](#) · [Previous models](#)

Jaguar Cars (pron.: /ˈdʒæɡjuːər/ JAG -ew-ər), since December 2012 officially incorporated as **Jaguar Land Rover Ltd**, is a British multinational car ...

[Jaguar](#)

www.agarman.dial.pipex.com/jaguar.htm ▾

The prey base of the **jaguar** is extensive, taking full advantage of the diversity and dense concentration of animal species found in the ...

Observation:
Clicks

1

[Next](#)

Belief: Multivariate
Guassian

Reward: DCG over 2
pages

jaguar

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used.jaguar.co.uk ▾

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www.stratstone.com/jaguar-cars.html ▾

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www.orangewheels.co.uk/new/jaguar.html ▾

New **Jaguar** UK Cars - Best Deals, Special Offers, **Jaguar** Finance and Cheapest Prices on Cheap New **Jaguar** Cars For Sale from Orangewheels.

[Jaguar / - Design/Designer Information - Design Museum London](#)

designmuseum.org/design/jaguar ▾

From the sleek XK120 two-seater and Mark 1 saloon to the sexy E-Type sports car, **JAGUAR** designed and built many of the best-loved British cars of the mid-20th ...

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2

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Action:
Ranking of
documents

Real-time Multi Page Search Example

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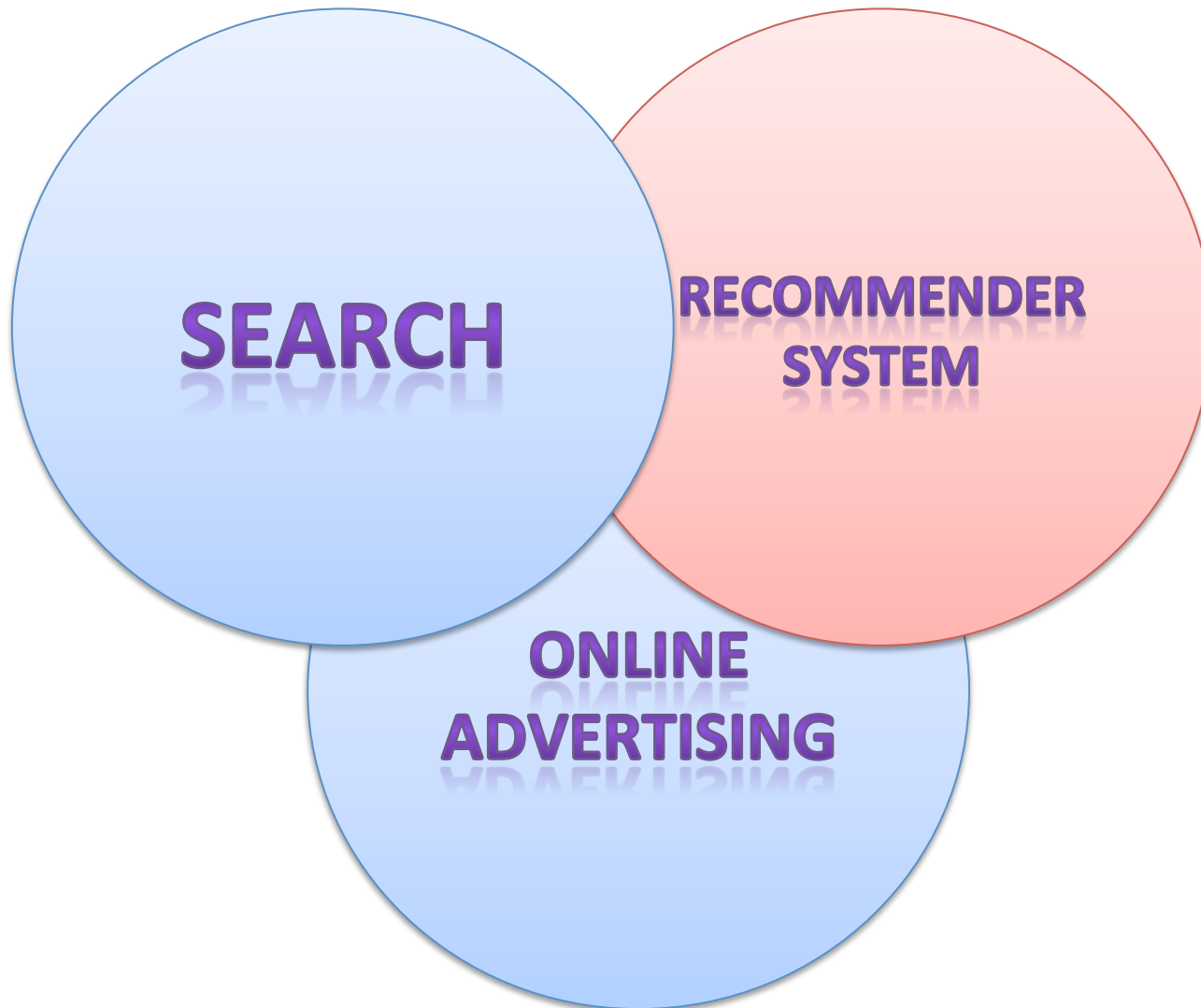
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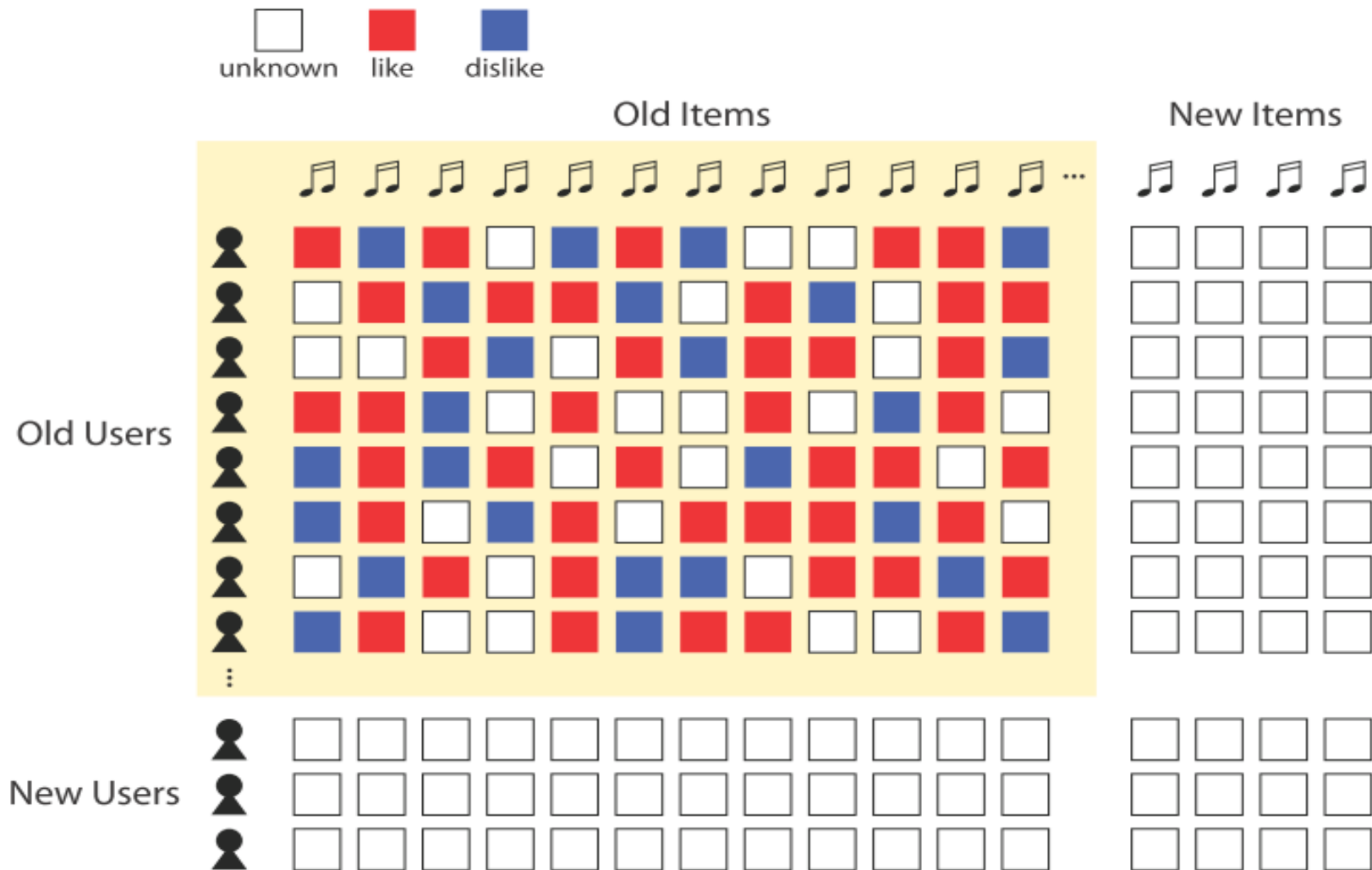
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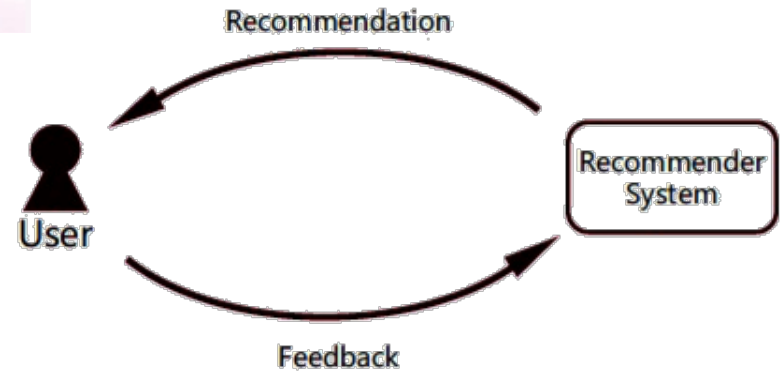
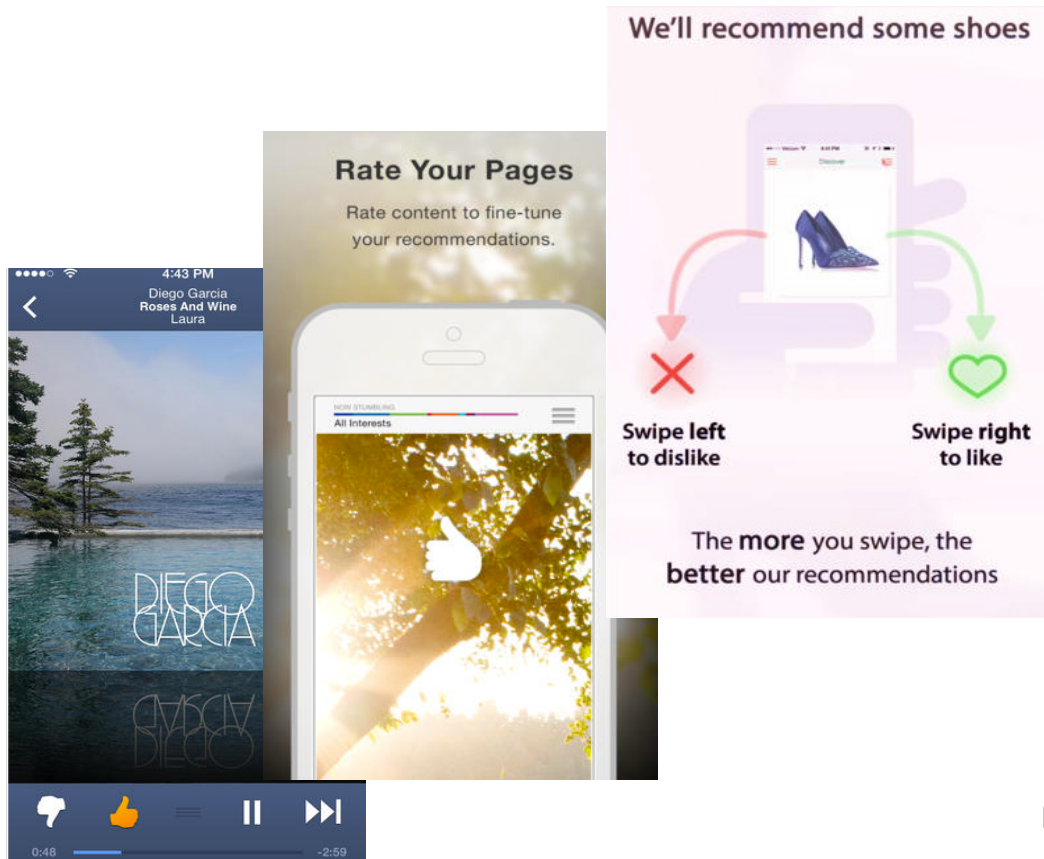
Real-time Services under Big Data



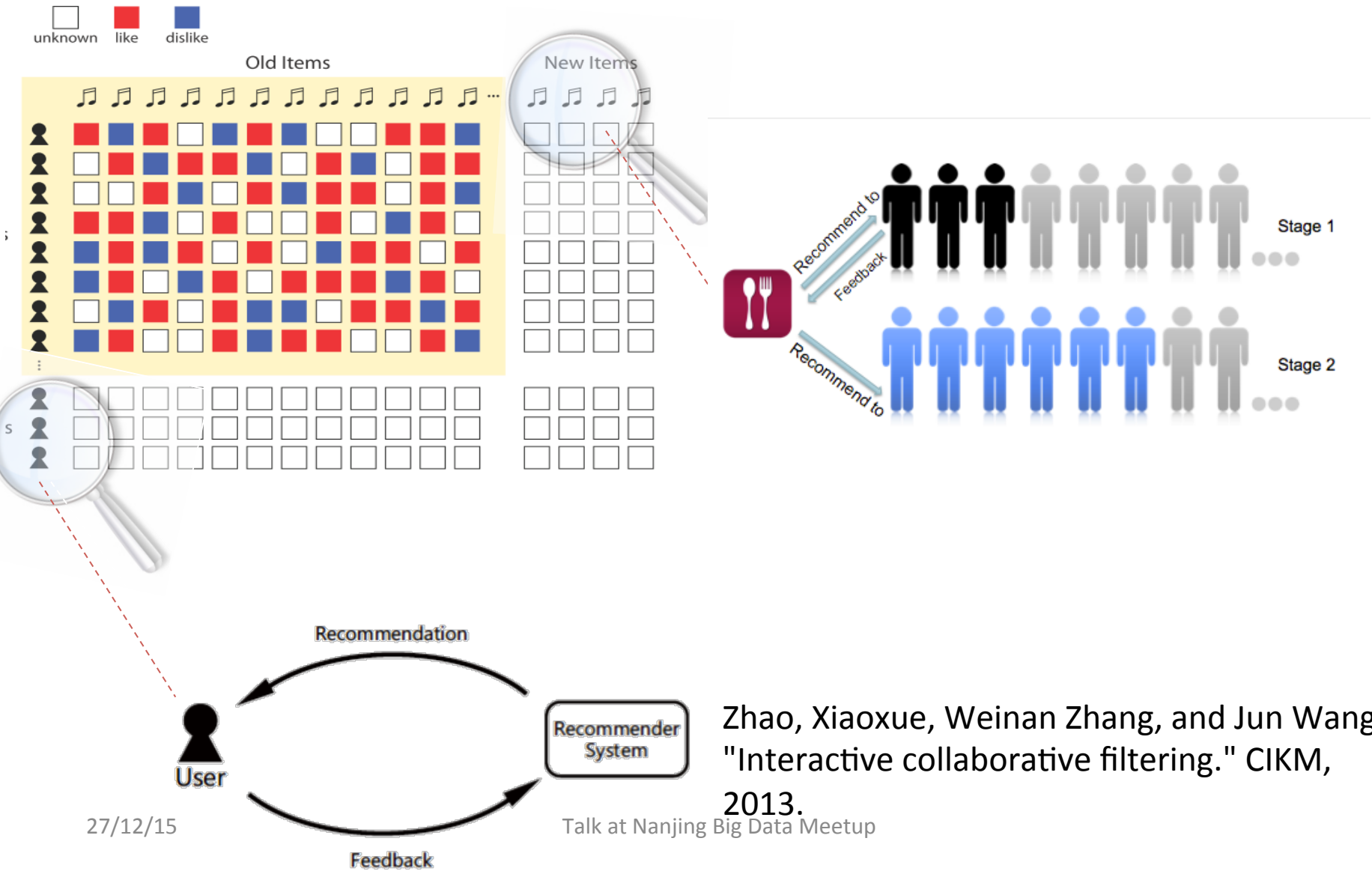
Cold-start problem in recommender systems



Interactive Recommender Systems

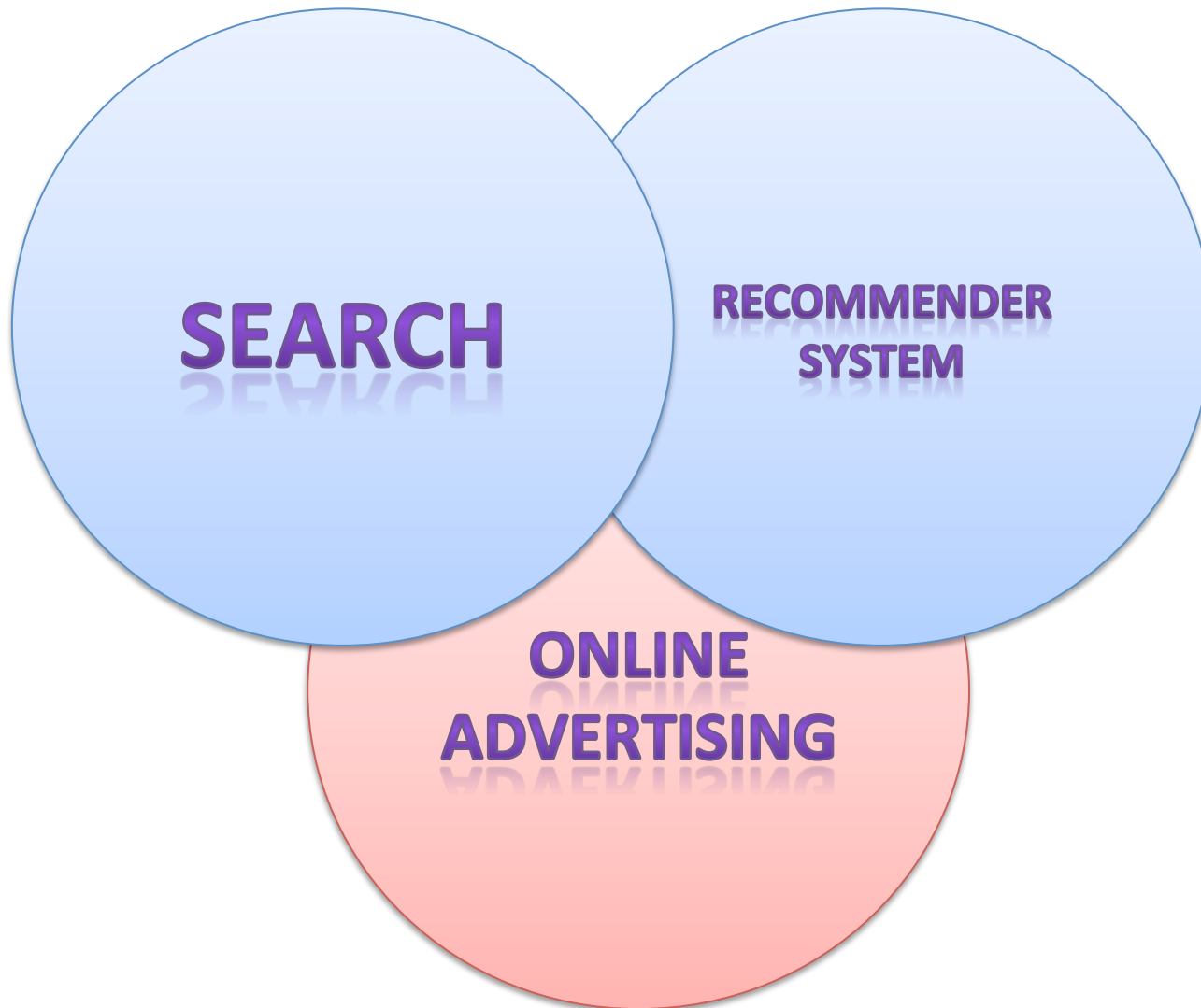


Possible Solutions



Zhao, Xiaoxue, Weinan Zhang, and Jun Wang. "Interactive collaborative filtering." CIKM, 2013.

Real-time Services under Big Data



How big Display Advertising is?

- Each day, around **400 billion RTB impressions** are bought globally:
 - about **100x** the number of shares traded daily on the The New York Stock Exchange.
- The Global Real-Time Bidding (RTB) market is forecast to GROW at **41.18%** CAGR (Compound annual growth rate) during 2014-2019
- Programmatic advertising spending: estimated \$61 bn in 2017

Contextual ads: relevant to the webpage content

The New York Times
Monday, March 15, 2010

Times Topics

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TIMES TOPICS > SUBJECTS > I > IPAD

iPad



Jim Wilson/The New York Times

Updated Jan. 27, 2010

The iPad is Apple's new tablet computer.

Steven P. Jobs positioned the iPad as a device that sits between the laptop and the smart phone - and which does certain things better than both of them, like browsing the Internet. The iPad was enormous anticipation. Media companies hoped for them to charge for new content.

The iPad's features and specifications, once the stuff of Internet myth, are now sharply in focus: The half-inch thick, 1.5-pound device will feature a

Bits

Three Reasons Why the iPad WILL Kill Amazon's Kindle
January 27, 2010 7:05pm

Three Reasons Why the iPad WON'T Kill Amazon's Kindle
January 27, 2010 5:57pm

David Pogue's First Look at the Apple iPad
January 27, 2010 4:05pm

[More posts about the iPad»](#)

Headlines Around the Web


What's This?

INDUSTRY STANDARD
MARCH 10, 2010
Mac user groups and iPod accessories

SILICON ALLEY INSIDER
MARCH 10, 2010
Bill Gates Loses Forbes' 'World's Richest' Title To Carlos Slim (MSFT, NYT, AMX)

GEAR LIVE
MARCH 10, 2010
Adobe answers Steve Jobs and his thoughts on Flash on iPad and iPhone

Photos



Ads by Google

what's this?

BlackBerry® Curve™ 8900
The Thinnest & Lightest Full-QWERTY BlackBerry Smartphone Available.
www.BlackBerry.com/Curve

Tablet PC's
Mobile Tablet PC Solutions. Digitizer, Touch and Rugged Devices
www.camtechsystems.co.uk

Win an Amazing New iPad

Ads:
Tablet PCs,
mobile phone
etc.

Content: iPad

Real-time Advertising: Selling ad slot per impression targeted to the user

veb4.cs.ucl.ac.uk/staff/jun.wang/blog/

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CIKM2013 Tutorial: Real-Time Bidding: A New Frontier of Computational Advertising Research

July 30th, 2013 Comments off Edit

Online advertising is now one of the fastest advancing areas in IT industry. In display and mobile advertising, the most significant development in recent years is the growth of Real-Time Bidding (RTB), which allows selling and buying online display advertising in real-time one ad impression at a time. Since then, RTB has fundamentally changed the landscape of the digital media market by scaling the buying process across a large number of available inventories. It also encourages behaviour (re-)targeting, and makes a significant shift toward buying focused on user data, rather than contextual data. A report from IDC shows that in 2011, global RTB based display ad spend increased by 237% compared to 2010, with the U.S.'s \$2.2 billion RTB display spend leading the way. The market share of RTB-based spending of all display ad spending will grow from 10% in 2011 to 27% in 2016, and its share of all indirect spending will grow from 28% to 78%.

Scientifically, the further demand for automation, integration and optimization in RTB brings new research opportunities in the CIKM fields. For instance, the much enhanced flexibility of allowing advertisers and agencies to maximize impact of budgets by more optimised buys based on their own or 3rd party (user) data makes the online advertising market a step closer to the financial markets, where unification and interconnection are strongly promoted. The unification and interconnections across webpages, advertisers, and users require significant research on knowledge management, data mining, information retrieval, behaviour targeting and their links to game theory, economics and optimization.






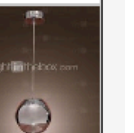
Despite its rapid growth and huge potential, many aspects of RTB remain unknown to the research community for a variety of reasons. In this tutorial, teamed up with presenters from both the industry and academia, we aim to bring the insightful knowledge from the real-world systems, to bridge the gaps between industry and academia, and to provide an overview of the fundamental infrastructure, algorithms, and technical and research challenges of the new frontier

RSS

twitter Loading tweets...

"Relevant" Ads or not?

Lightinthebox.com

		
€280.49	€119.62	€53.62
		
€218.62	€210.37	AS69.89

Real-time Advertising: Selling ad slot per impression targeted to the user

DR. JUN WANG
Computer Science, UCL

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CIKM2013 Tutorial: Real-Time Bidding: A New Frontier of Computational Advertising Research

July 30th, 2013


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Relevant Ads or not?

Booking.com




★★★★★
London
Park Plaza
Victoria London

From
£134.10
Book now



★★★★★
London
Palmers Lodge
Swiss Cottage
Hostel

From
£87.00
Book now



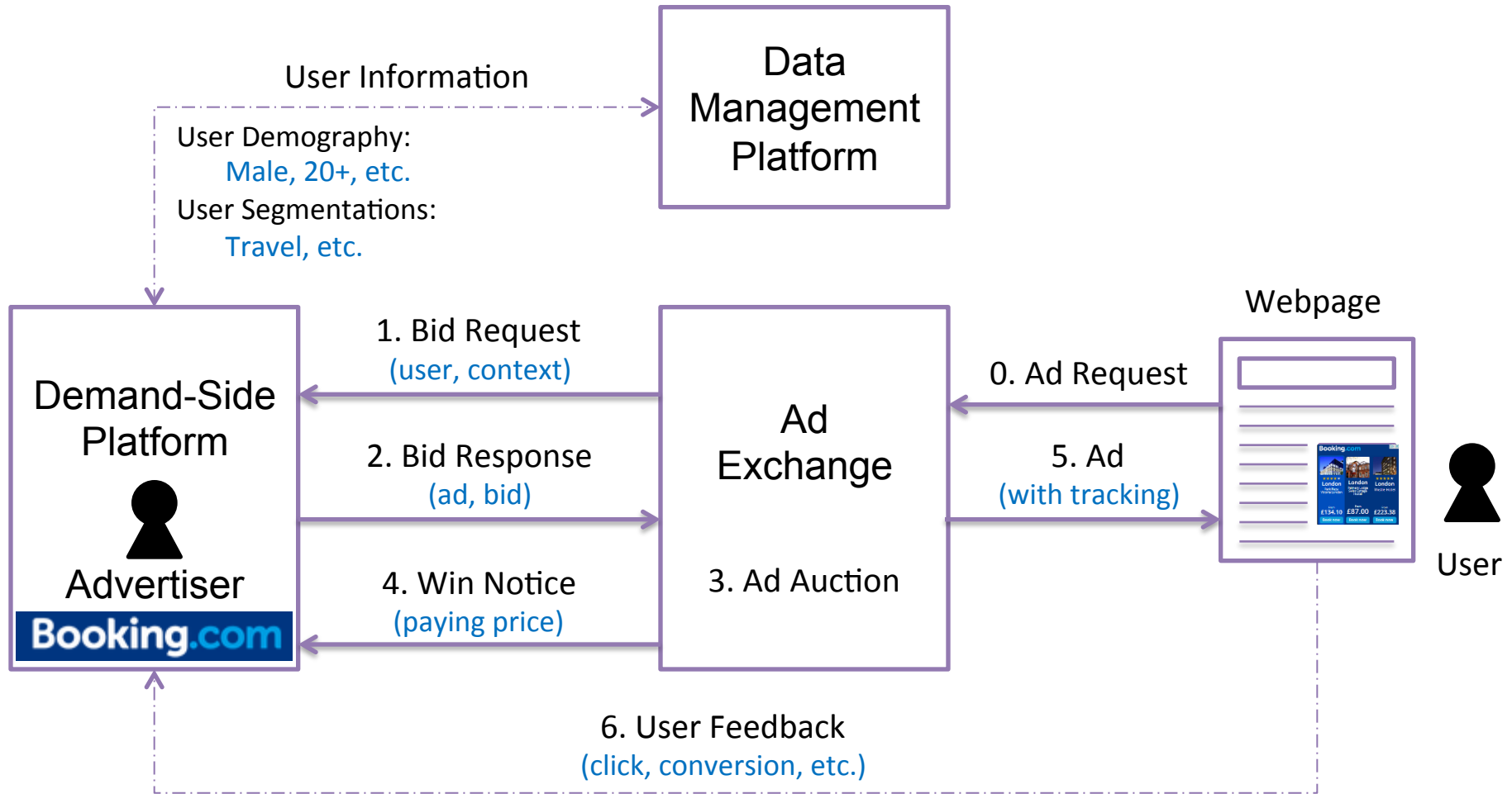
★★★★★
London
Thistle Hotel

From
£223.38
Book now

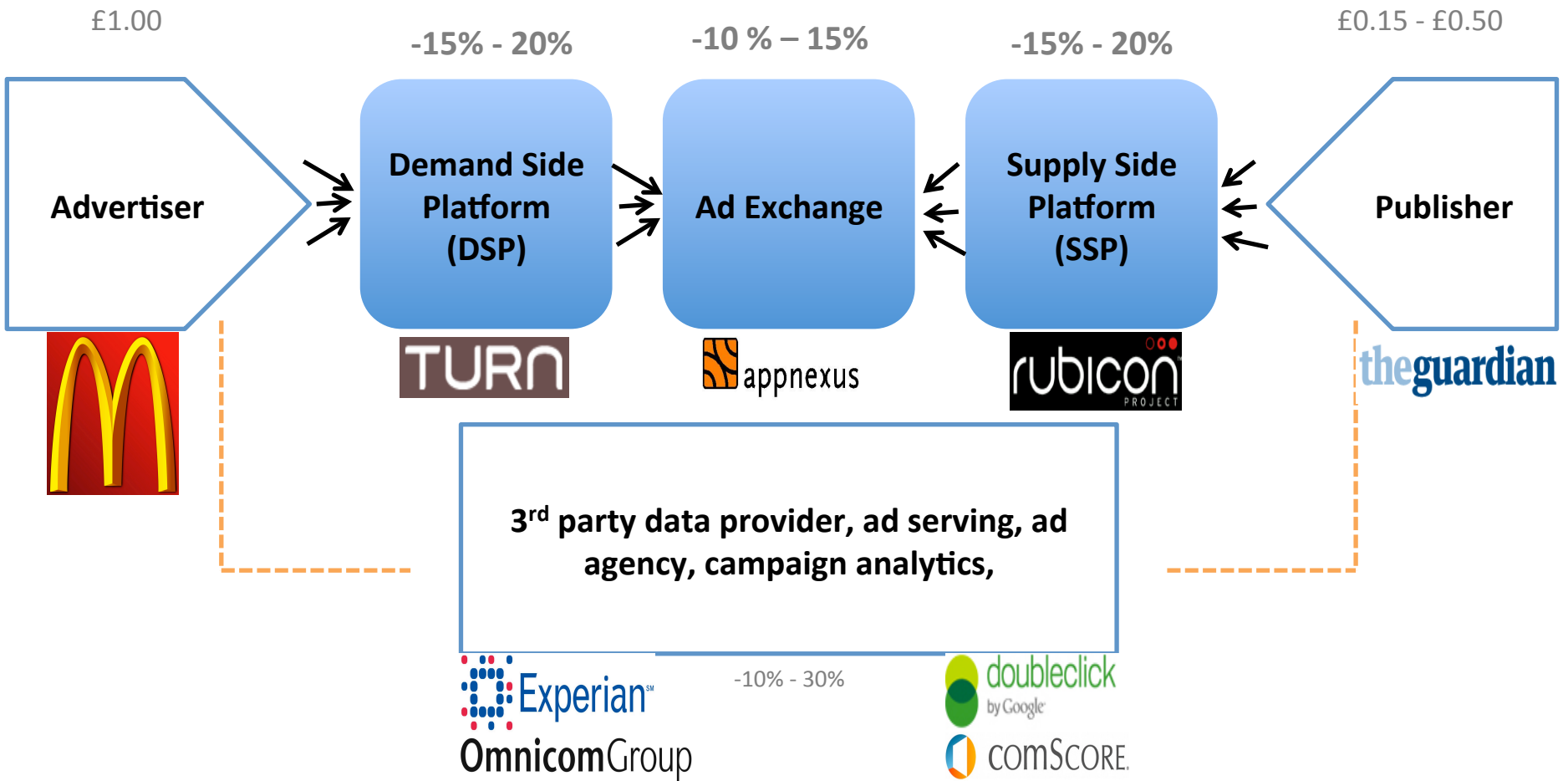
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Talk at Nanjing Big Data Meetup

RTB auction : 0.2 seconds



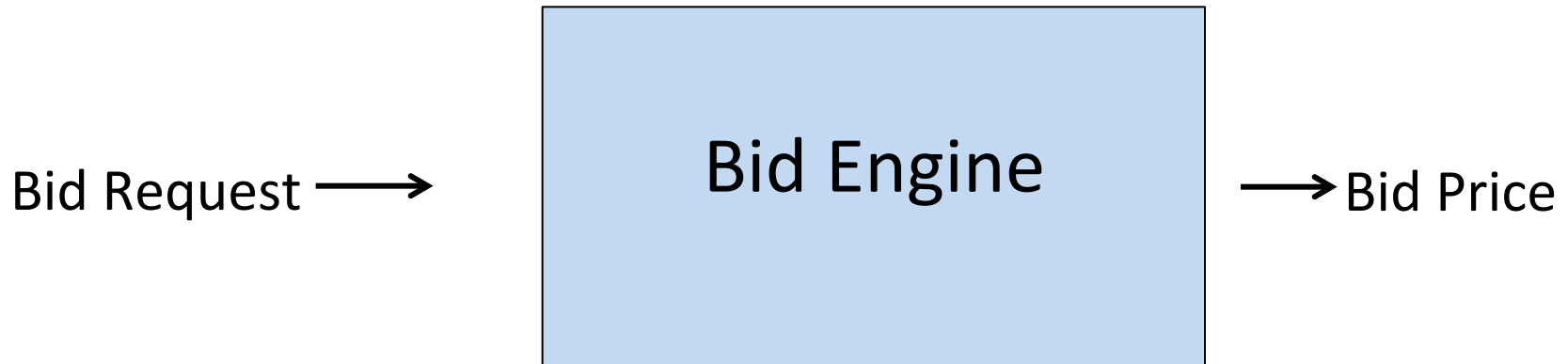
The new RTB eco-system



What is in the bid request

- `{u'geo_country': u'GB', u'raw_spec': u'openrtb_2.1', u'start_time': 1440520749356176236, u'raw_request': u'{"id":"6C97E840-134D-4963-BF8C-1A452B4ED093", "imp":[{"id":"1", "tagid":"41503", "banner":{"w": 300, "h": 250, "topframe": 1}}], "site":{"id":"34908", "domain":"http://www.reklamport.com", "page":"ib.adnxs.com", "ref":"http://ib.adnxs.com/bounce?/tt?id=4943149&size=300x250&cb=11265809432", "publisher":{"id":"33643"}}, "device":{"ip":"178.62.36.210", "ua":"Mozilla/5.0 (Windows; U; Windows NT 5.1; en-US; rv:1.9.2.28) Gecko/20120306 Firefox/3.6.28", "carrier":"LLC Sirius", "language":"en-us", "js": 1, "devicetype": 2, "geo": {"country":"GB", "region":"H9", "city":"London", "lat": 51.5149002, "lon": -0.0951889977, "type": 2}, "ext": {"otherdeviceid":"30a1d7750b0bb70779f95a671da0b43bd6125e2", "hash": 1, "res":"800x600", "freq": 0, "pf": 1}}, "user":{"ext":{"tmz":"-05.00"}}, "ext": {"bidguidefloor": 0.12}}', u'end_time': 1440520749357444228, u'request_id': u'6C97E840-134D-4963-BF8C-1A452B4ED093', u'format_key': u'300x250', u'impid': u'1'}`

Learning to bid: Problem Definition



Input: bid request include
Cookie information
(anonymous profile), website
category & page, user terminal,
location etc

Output: bid price

Considerations: Historic data,
CRM (first party data), DMP (3rd
party data from Data
Management Platform)

**What is the optimal bidder given a
budget constraint?**

e.g., Maximise

$$R = \sum (Clk + Conv * weight)$$

Subject to the budget constraint

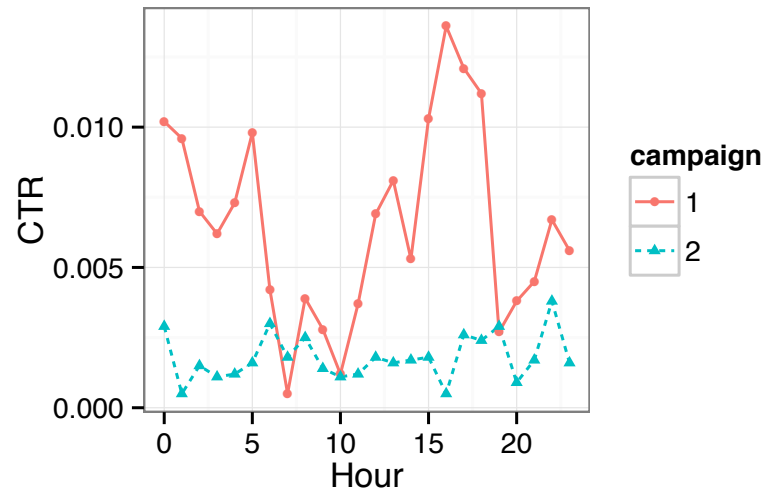
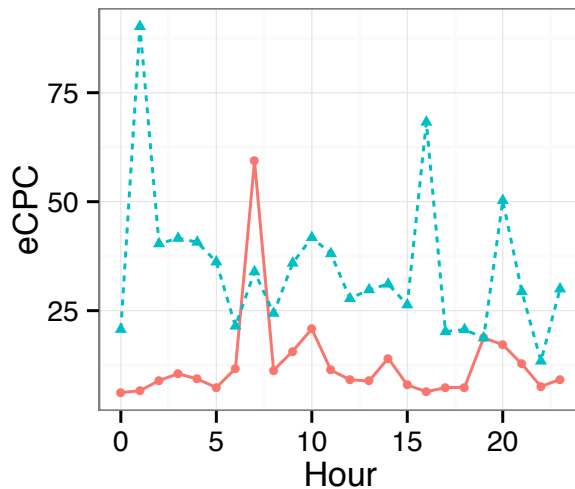
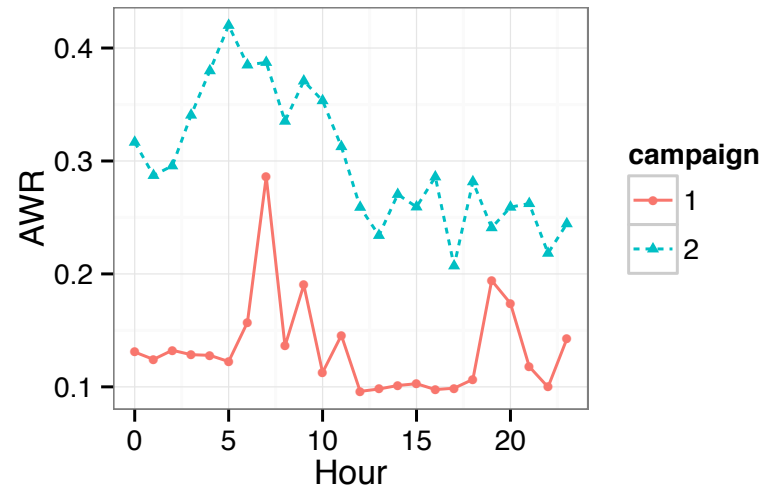
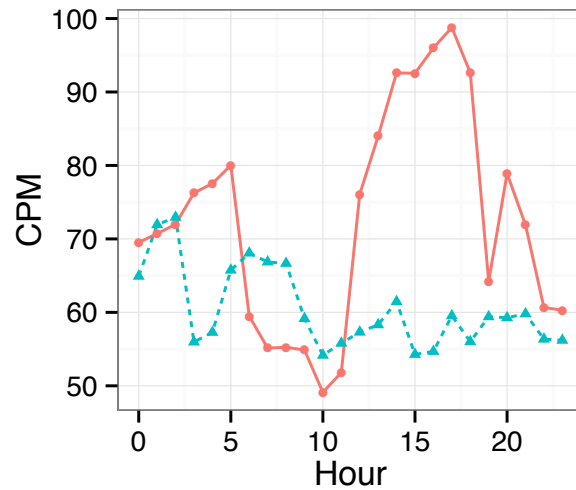
Online Evaluation Result of iPinYou Bidding Algorithm Competition Third Season

The iPinYou global RTB bidding algorithm competition third and last season has been successfully concluded. The UCL-CA, V_V, PoundsXXX, Run_Fast and Tiger teams have participated in the **three-day online finals** from Dec 26th, 2013 to Dec 28th, 2013. The final results, which have been carefully checked by the committee and audited by the jury, are as follows:

rank	team	score
1	UCL-CA	1304
2	V_V	983
3	Run Fast	901
4	PoundsXXX	885
5	Tiger	744

where the final **score = clicks + N * reaches, N = 1**. The sensible choice of N does not influence the final ranking.

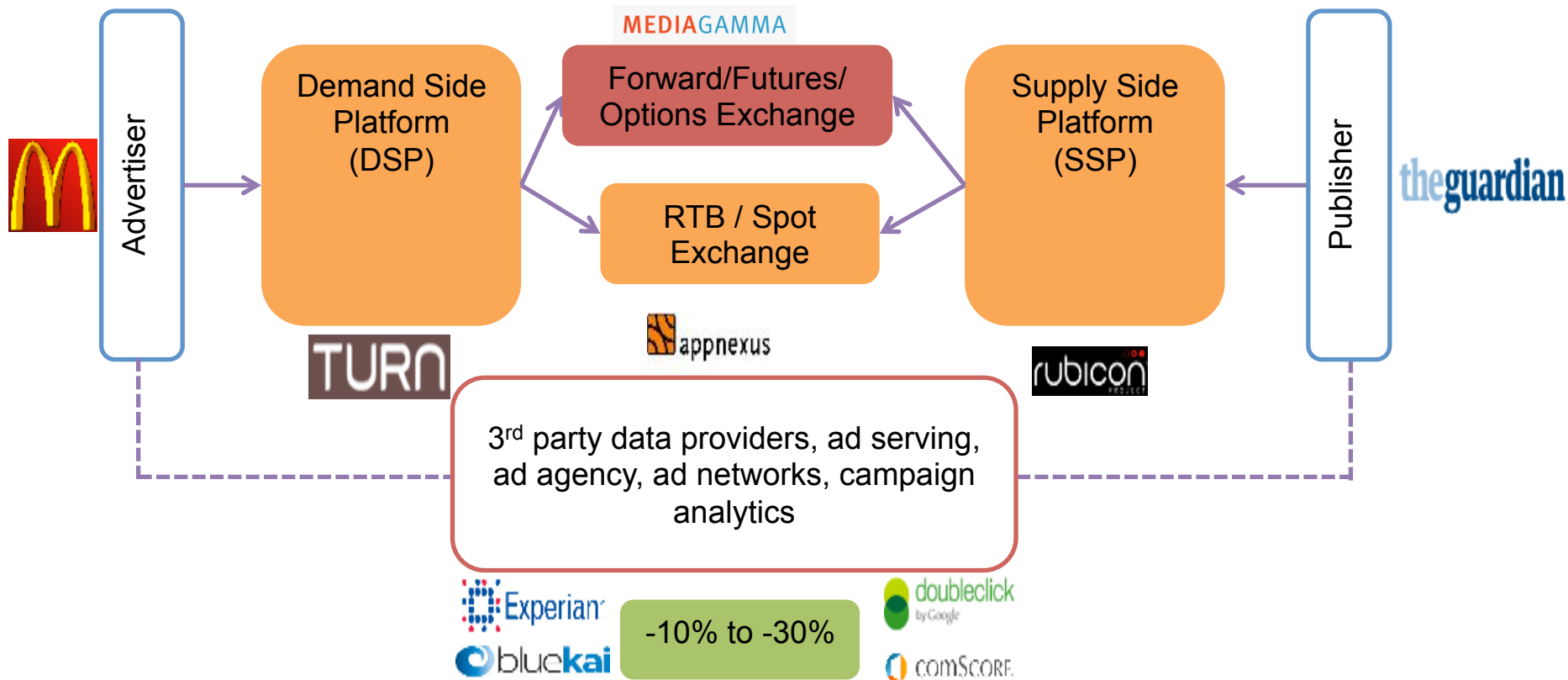
(RTB) Ads prices and user response are volatile



Advertising as Commodities (广告证券化)

- Need Ad's Futures Contract and Risk-reduction Capabilities
 - Technologies are constrained mainly to “spots” markets, i.e., any transaction where delivery takes place right away (in Real-time Advertising and Sponsored Search)
 - No principled technologies to support efficient forward pricing & risk management mechanisms

An analogy with financial markets



Solution 1:

Combine RTB with **Forward Market**, which pre-sell inventories in advance with a fixed price

Solution 2:

If we got **Futures Exchange** or provide **Option Contracts**, advertisers could *lock in* the campaign cost and Publishers could *lock in* a profit in the future

Ad Futures Illustration (1)

Suppose an **Auto Publisher** commits to sell 30k imps a month programmatically from Jan – March, and wants to protect its future programmatic income against a future price decrease

Date	Avg programmatic CPM's	Agree to sell Auto CPM future	Close off Auto CPM future value @ month end	Profit	Net CPM	
Jan	\$20.00	\$20.00	\$19.50	\$0.50	\$20.50	
Feb	\$19.50	\$19.75	\$18.75	\$1.00	\$20.50	
March	\$19.00	\$19.50	\$18.00	\$1.50	\$20.50	
Avg	\$19.50					\$20.50
Cash	\$19.50 x 3 = \$1,755			\$20.50 x 3 = \$1,845		
Increased profit using futures					\$90	

- Auto Publisher sells on RTB, while at the same time it takes a short position (agree to sell) of Auto CPM futures and close it at each month end
- Even though the Auto futures price decreased each month, because Auto Publisher sold auto futures, it profited from the price decrease to offset the decline in prices
- With no futures, Auto Publisher would have received \$1,755 via normal programmatic channels but \$1,845 with the auto futures. Not only did Auto Publisher increase its revenue but its monthly revenue is less volatile and thus more predictable (\$20.50 every month).

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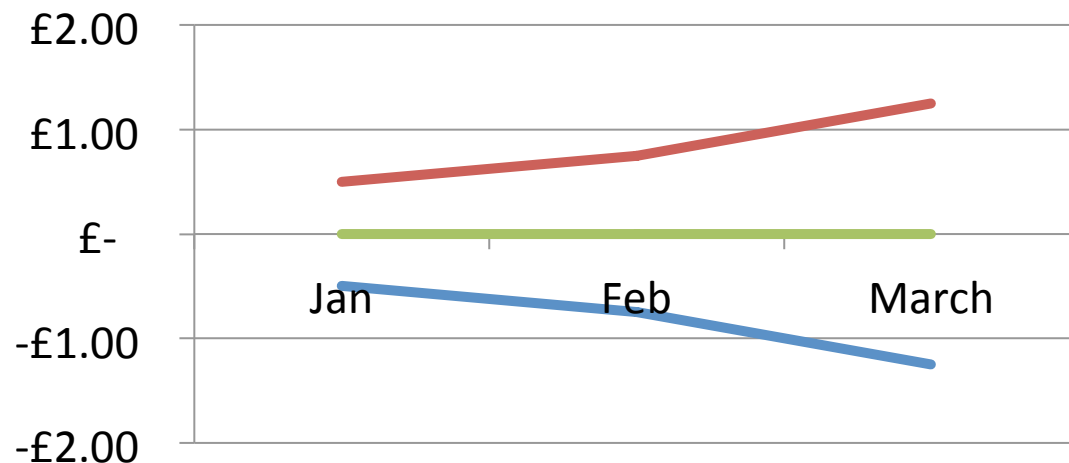
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Ad Futures Illustration (2)

Publisher wants to protect against a possible future decline in ad prices in the programmatic market (a travel publisher in the out-of season months for example)

Publisher's prices are unaffected by
programmatic market price
fluctuations

Monthly ad
price changes



— Loss in Programmatic Market — Profit on futures decrease

— Net price position

- Sell a futures contract that will work in an equal but opposite direction to the **programmatic** prices
- Regardless of how much the programmatic price declines in a month, the loss is offset by a profit made by selling the futures contract
- This leaves the publisher in a neutral price position...
- ... & results in stable & predictable revenue

RTB combined with Forward Programmatic Guaranteed/Direct Market

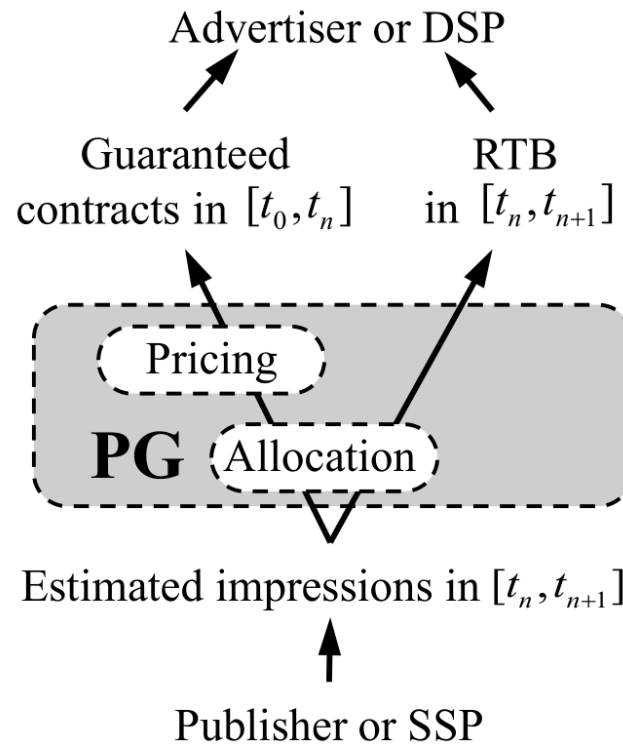
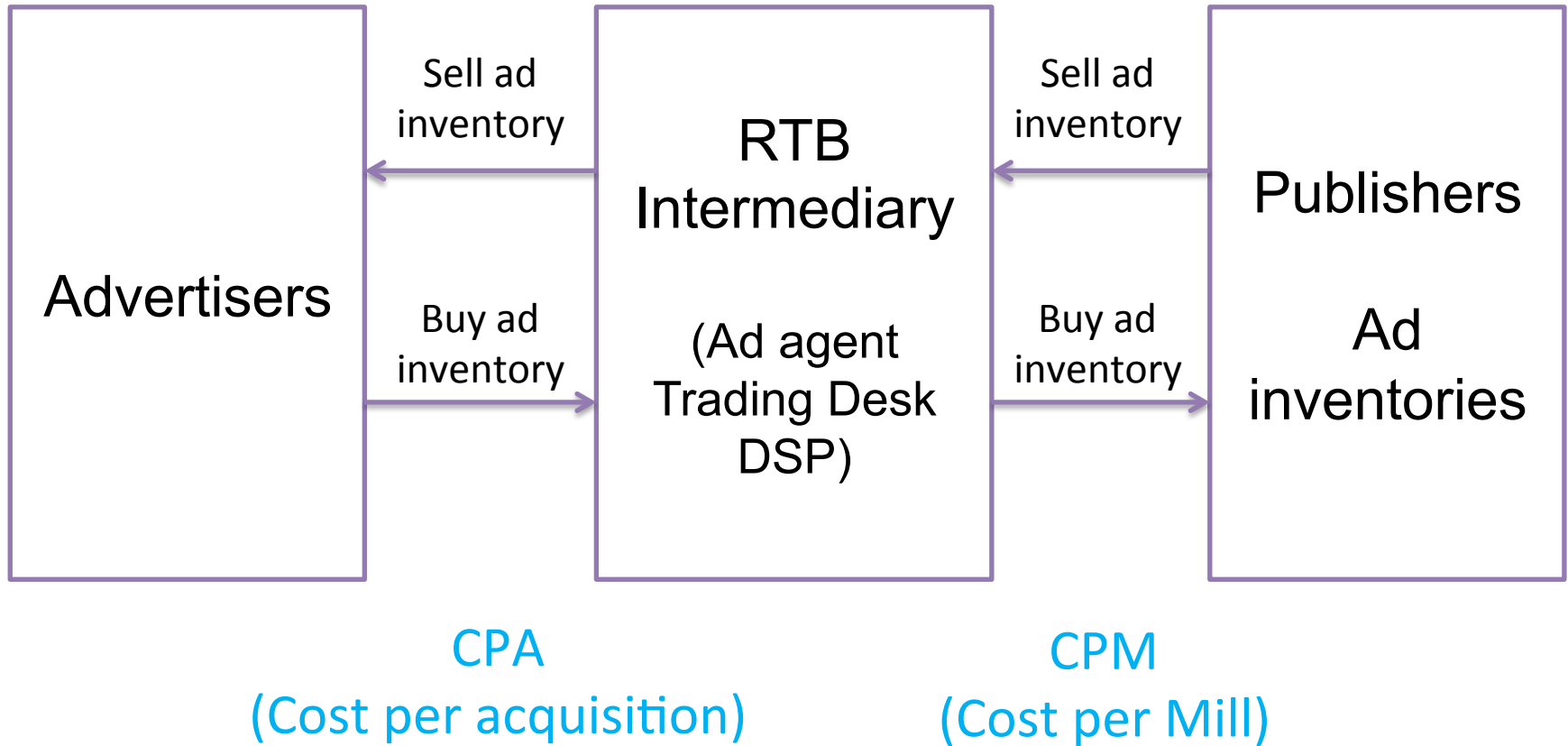


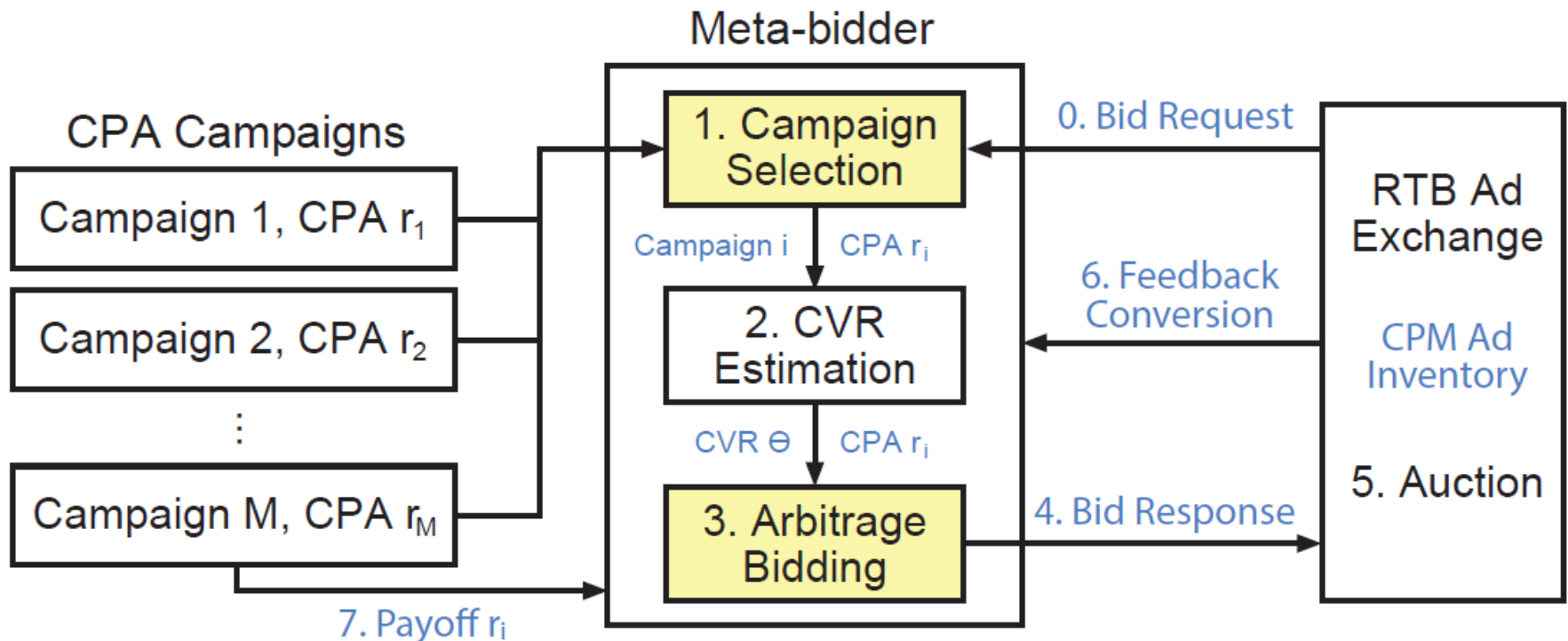
Figure 1: A systematic view of programmatic guarantee (PG) in display advertising: $[t_0, t_n]$ is the time period to sell the guaranteed impressions that will be created in future period $[t_n, t_{n+1}]$.

DSP as an Intermediary in RTB



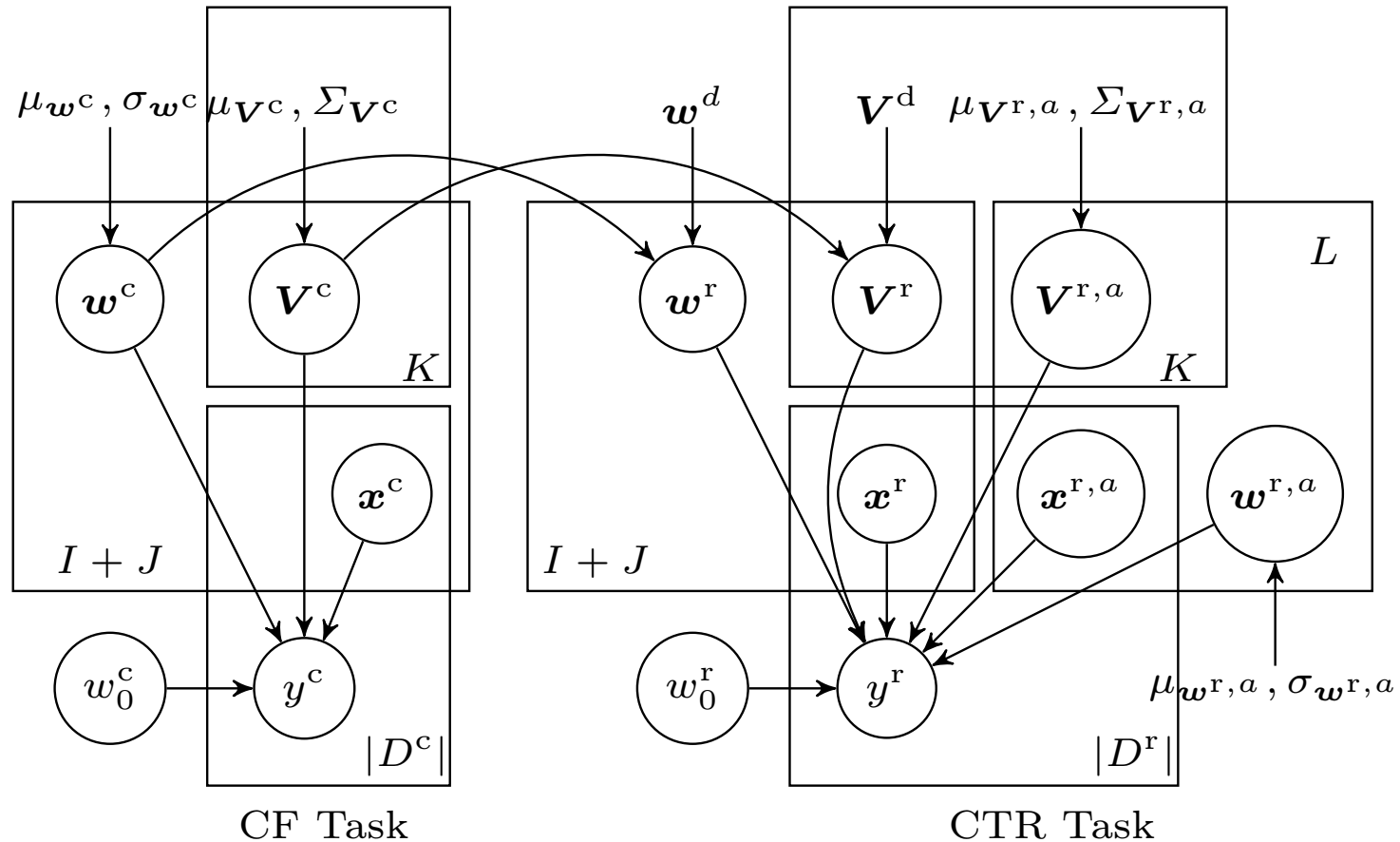
- Different pricing schemes: CPM/CPC/CPA

DSP as an intermediary in RTB



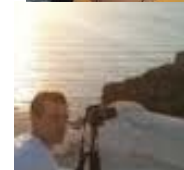
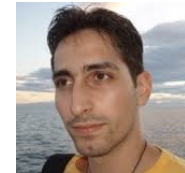
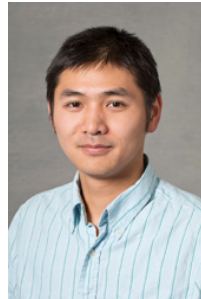
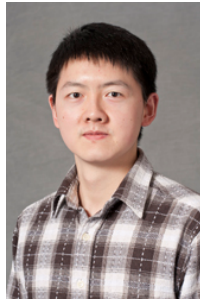
- Statistical arbitrage opportunity occurs when
(CPM) cost per conversion < (CPA) payoff per conversion

Audience is king: Lookalike modelling



Acknowledgements

- Thanks to my PhD students Weinan Zhang, Xiaoxue Zhao, Marc Sloan, Shuai Yuan, Bowei Chen



- MediaGamma 创业团队



For more information, please refer to

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Thanks for your attention



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