

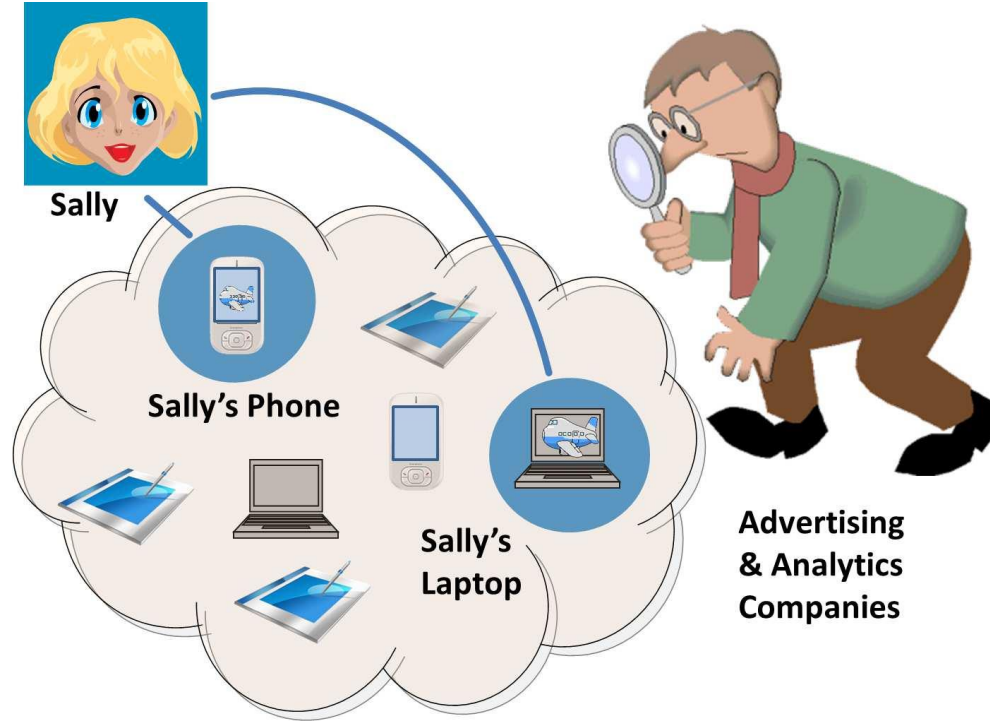
A Privacy Analysis of Cross-device Tracking

Sebastian Zimmeck, Jie S. Li, Hyungtae Kim, Steven M. Bellovin, Tony Jebara

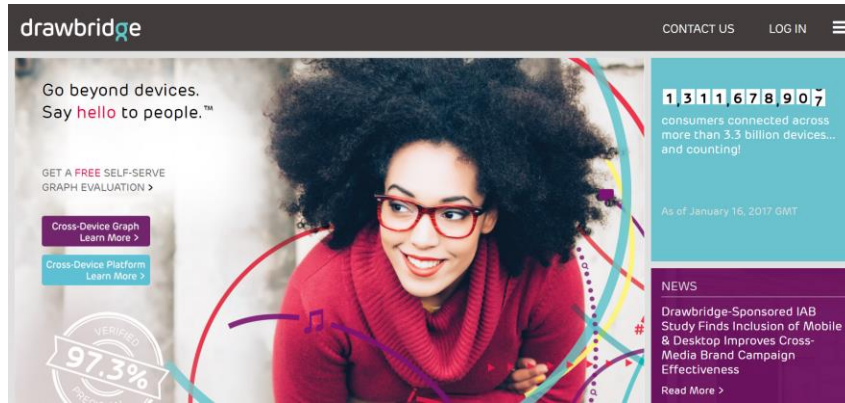
*26th USENIX Security Symposium
Vancouver, BC, Canada*

August 17, 2017

What is cross-device tracking?



What is cross-device tracking?



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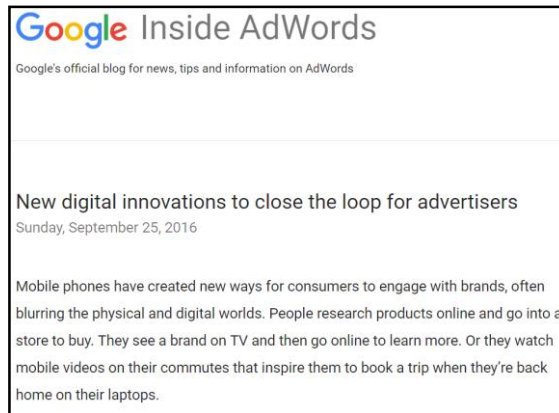
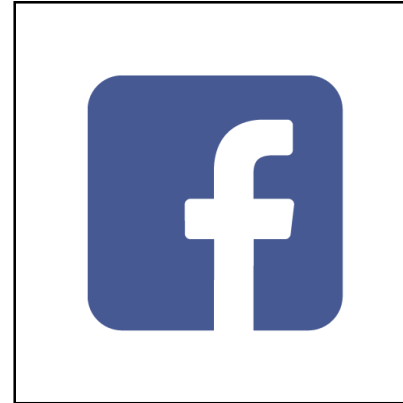
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1,311,678,907
consumers connected across more than 3.3 billion devices... and counting!

As of January 16, 2017 GMT

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Sunday, September 25, 2016

Mobile phones have created new ways for consumers to engage with brands, often blurring the physical and digital worlds. People research products online and go into a store to buy. They see a brand on TV and then go online to learn more. Or they watch mobile videos on their commutes that inspire them to book a trip when they're back home on their laptops.



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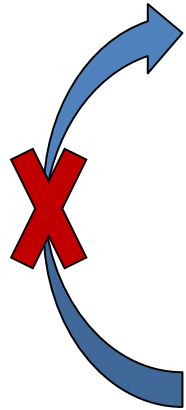
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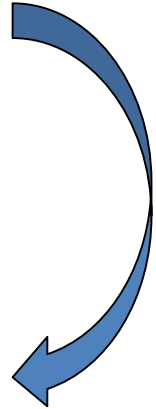
Talk Outline

1. A Black Box Data Flow Experiment
2. The Cross-device Tracking Algorithm
3. Learning from Cross-device Data
4. The Scope of Cross-device Tracking
5. Does self-regulation work?
6. The Big Picture

1. A Black Box Data Flow Experiment



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samsung.com; Galaxy TabPro S - 2-in-1 Tablet



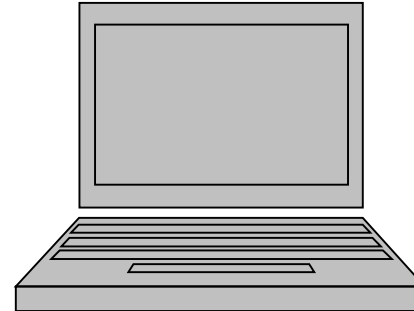
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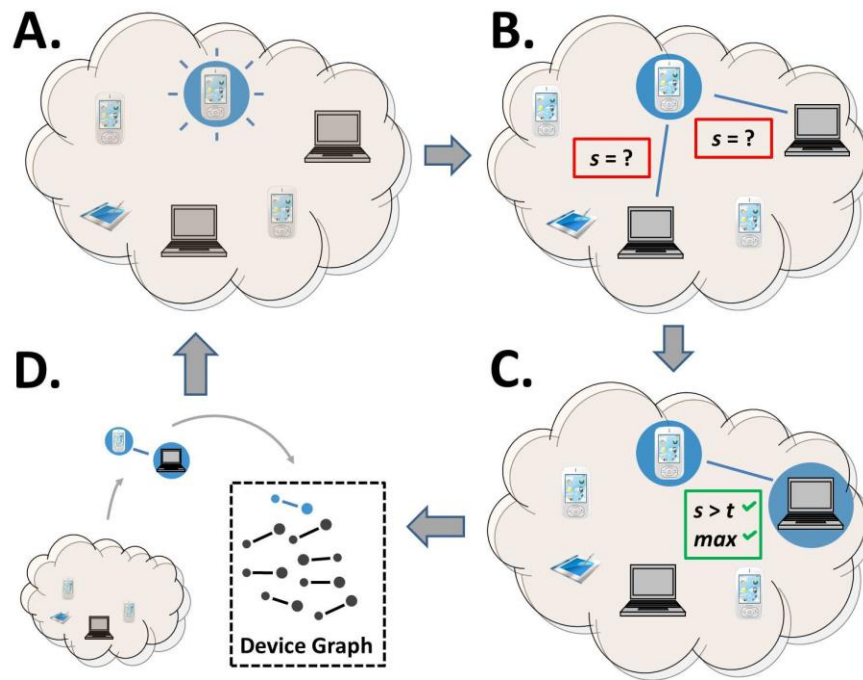


2. The Cross-device Tracking Algorithm

(12) United States Patent Wang et al.		(10) Patent No.: US 8,438,184 B1
		(45) Date of Patent: May 7, 2013
(54) UNIQUELY IDENTIFYING A NETWORK-CONNECTED ENTITY	OTHER PUBLICATIONS	
(75) Inventors: Changfeng C. Wang , Lexington, MA (US); Hsu-Tang Pu , Carlisle, MA (US)	Edge et al, "A survey of signature based methods for financial fraud detection", ScienceDirect, Computers & Security 28, pp. 381-394 (2009). Cortes et al, "Hancock: A Language for Extrating Signatures from	
(73) Assignee: Adelphic, Inc. , Lexing		
(*) Notice: Subject to any disclaimer, the term of this patent is extended or shortened under the provisions of U.S.C. 154(b) by 0 day		

(19) United States	(10) Pub. No.: US 2013/0124309 A1
(12) Patent Application Publication Traasdahl et al.	(43) Pub. Date: May 16, 2013
(54) MANAGING ASSOCIATIONS BETWEEN DEVICE IDENTIFIERS	(52) U.S. Cl. CPC G06Q 30/0251 (2013.01) USPC 705/14.49
(71) Applicant: TapAd, INC. , New York, NY (US)	(57) ABSTRACT Device identifiers for devices, such as computing devices, software, and applications, etc., are analyzed to determine whether the device identifiers are associated with each other
(72) Inventors: Are Helge Traasdahl , New York, NY (US); Dag Oeyvind Lioddén , New York, NY (US); Vivian Wei-Hua Chang , New York, NY (US)	
(73) Assignee: TAPAD, INC. , New York, NY (US)	

2. The Cross-device Tracking Algorithm



- A. Mobile Device Identification**
- B. Similarity (s) Calculation**
- C. Find $\max s > \text{Threshold } t$**
- D. Add device pair to graph**

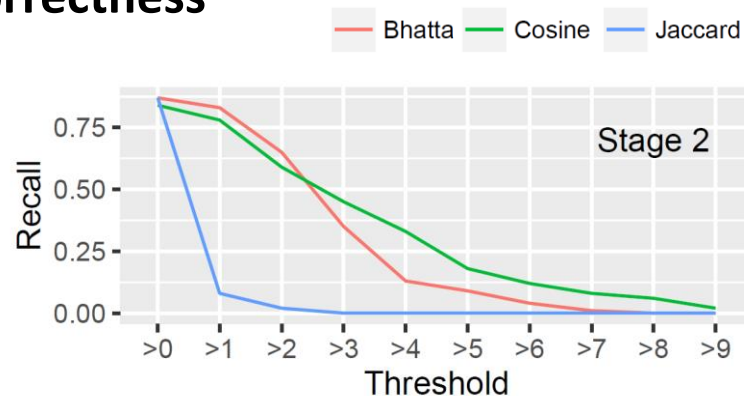
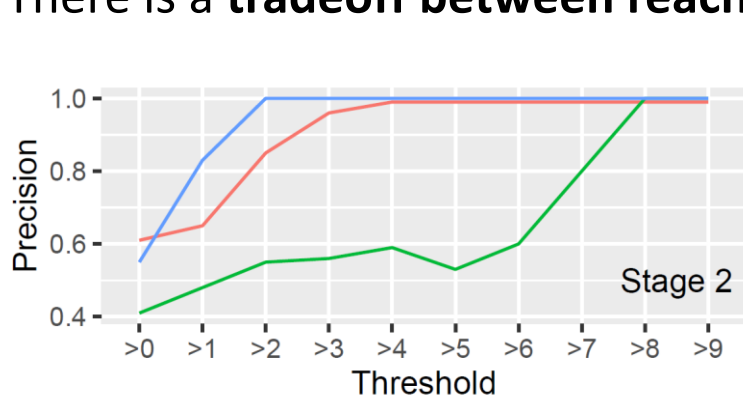
2. The Cross-device Tracking Algorithm

	Feature Mapping	Precision	Recall	F-1
Stage 1	Mob IPs to Desk IPs	1	0.63	0.77
Stage 2	Mob URLs to Desk URLs	0.85	0.59	0.7
Stage 3	Mob Apps to Desk URLs	0.19	0.5	0.27
Stage 1-3	Same as above	0.88	<u>0.95</u>	<u>0.91</u>

Feature Mapping based on Bhattacharyya Coefficient (could also use Jaccard, Cosine, ...)

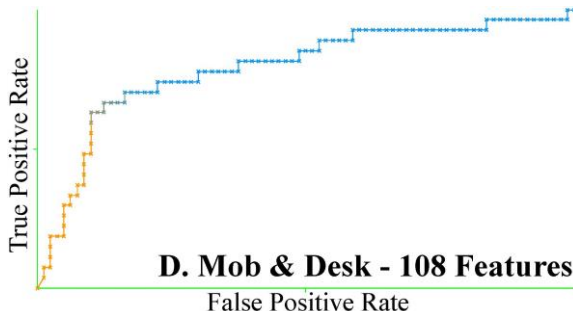
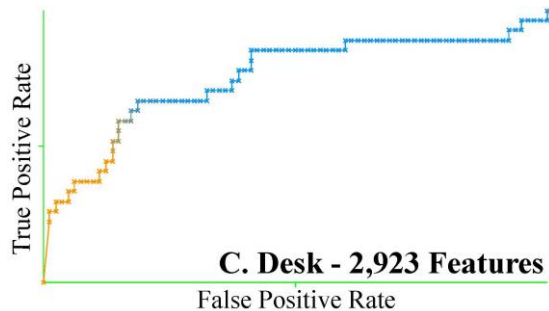
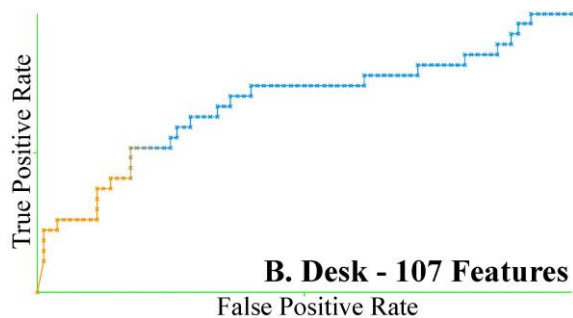
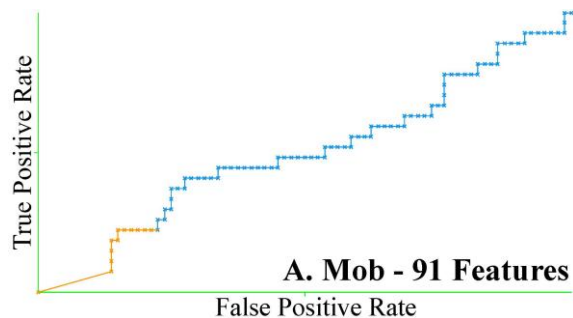
2. The Cross-device Tracking Algorithm

There is a **tradeoff between reach vs. correctness**



	Feature Mapping	Bhatta F-1, Threshold (s)	Cosine F-1, Threshold (s)	Jaccard F-1, Threshold (s)
Stage 2	Mob URLs to Desk URLs	<u>0.74, 0.2</u>	0.59, 0.1	0.67, 0

3. Learning from Cross-device Data



Predicting interest in finance **improves if both mobile and desktop domains are available**

Logistic Regression

Orange: positive predictions, i.e., users have interest in finance

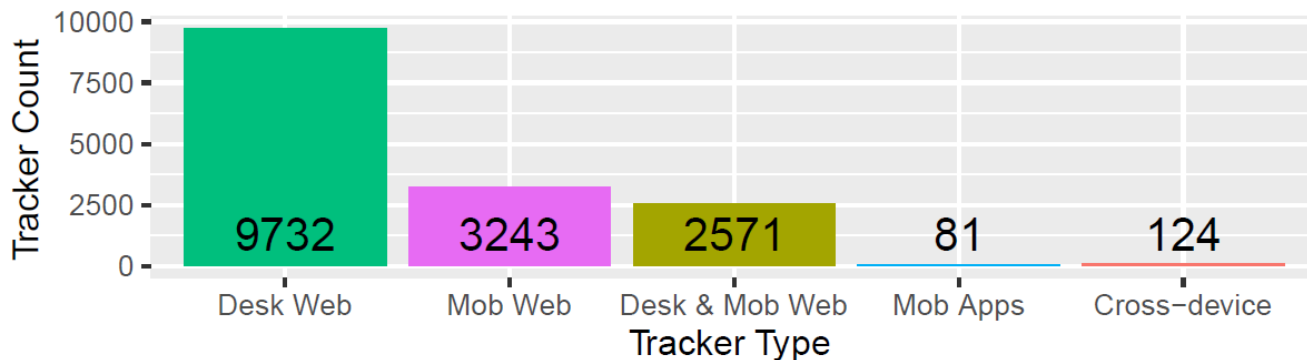
Blue: negative predictions, i.e., user do not have such interest

3. Learning from Cross-device Data

	Precision	Recall	F-1	ROC
A. Mob – 91 Features	0.26	0.22	0.24	0.5
B. Desk – 107 Features	0.5	0.52	0.51	0.68
C. Desk – 2,923 Features	0.57	0.59	0.58	0.75
D. Mob & Desk – 108 Features	0.68	0.63	<u>0.65</u>	<u>0.79</u>

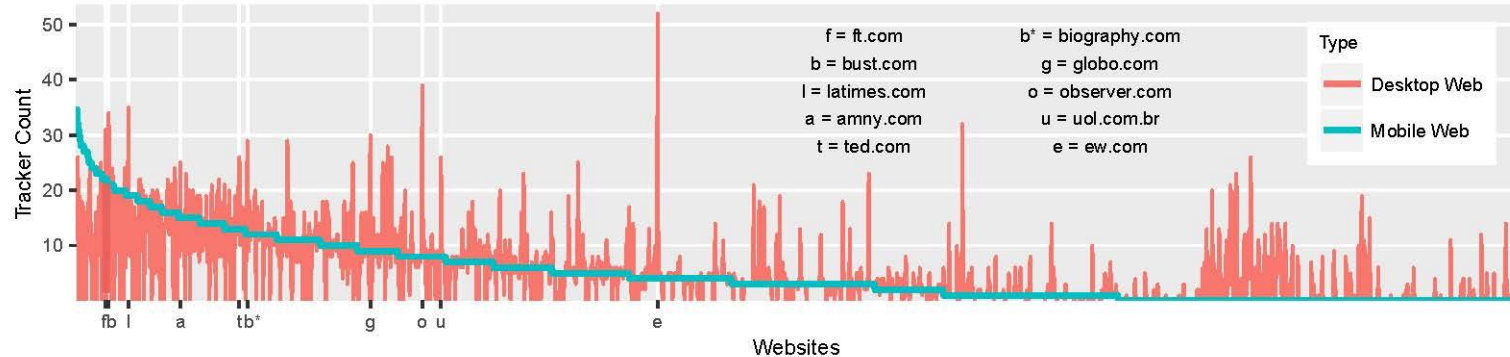
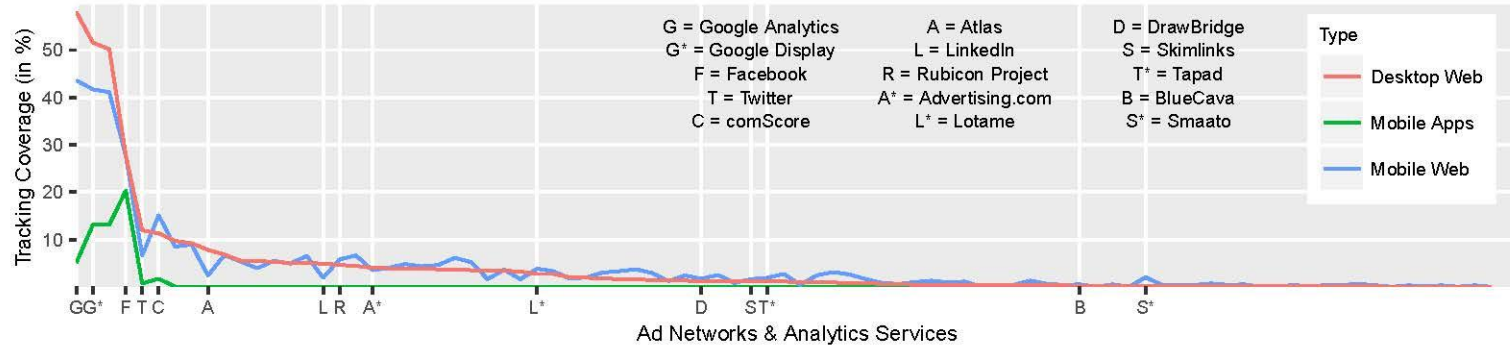
Detailed results for predicting **interest in finance**; same trend for predicting **value shopper's**, but not for **gender** (interesting observation for predicting **religion**)

4. The Scope of Cross-device Tracking



- We identified **124 cross-device trackers** (that is, trackers (1) occurring on both mobile app/web and desktop web (2) belonging to companies who disclose on their website that they engage in cross-device tracking)
- 118 trackers that appeared on both mobile and desktop websites and six software development kits associated with a desktop tracker

4. The Scope of Cross-device Tracking

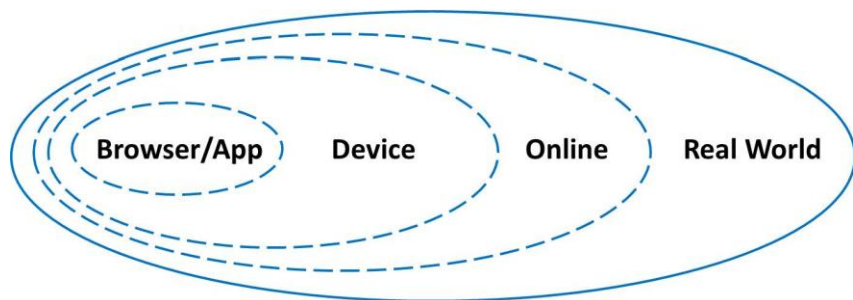


5. Does self-regulation work?

- Self-regulation by Digital Advertising Alliance (DAA) and Network Advertising Initiative, particularly, **DAA Guidance**
- We manually **checked for 40 randomly selected cross-device ad networks** (DAA members) whether their privacy policies disclose cross-device tracking
- **17 omitted mentioning cross-device tracking at all**
- As we contacted those **received a response from seven** (two pointed us to other documents. One explained that their cross-device functionality is not yet fully rolled out. Three others announced that they will change their policy. One simply claimed that they are “not violating anything.”)
- **Five silently changed their policies** and are compliant.

Results as of June 9, 2017

6. The Big Picture



- Cross-device tracking is **tracking in the IoT space**
- This form of tracking has substantial **privacy implications** in need to be further explored
- A **personalized privacy assistant?**

Dataset and Cross-device Tracking Software: https://github.com/SebastianZimmeck/Cross_Device_Tracking

Paper: <https://www.usenix.org/conference/usenixsecurity17/technical-sessions/presentation/zimmeck>



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