On the Robustness of Mobile Device Fingerprinting

Can Mobile Users Escape Modern Web-Tracking Mechanisms?

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Fingerprinting
Recognize or Identify a Device

- Extraction of characteristic attributes (*features*) of a system
  - What attributes are characteristic?

- Combination of features as vector → Fingerprint
  - Which features are most discriminant?

- Recognize or identify a device
  - Fraud detection / prevention 😊
  - User tracking 😞
Fingerprinting
Recognize or Identify a Device

Device Fingerprinting as a Privacy Issue

- Legitimate use cases exist
- But often not only device but also user gets fingerprinted
  - Location
  - User accounts
  - Browsing history
  - Shopping preferences
  - Activities
  - ...

➢ Fingerprinting is a privacy issue
Mobile Device Fingerprinting
Escaping Modern Web-Tracking

Fingerprinting Status Quo

- Web-based fingerprinting of personal computers / browsers
  - Cookie-less Monster (Nikiforakis et al.)
  - How Unique is Your Web Browser? (Eckersley)
  - Pixel Perfect: Fingerprinting Canvas in HTML5 (Mowery et al.)
  - FPDetective: Dusting the web for fingerprinters (Piessens et al.)
  - Pixel perfect timing attacks with HTML5 (Stone)

- Web-based fingerprinting for mobile devices
  - Are previous insights transferable to the mobile world?
  - Are mobile devices fingerprintable?
### Mobile Device Fingerprinting

**Escaping Modern Web-Tracking**

#### Fingerprinting

**Special Attention to Mobile Devices**

<table>
<thead>
<tr>
<th>Desktop Computers</th>
<th>Mobile Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly customizable</td>
<td>Highly standardized</td>
</tr>
<tr>
<td>Multi-Browser</td>
<td>Single-Browser</td>
</tr>
<tr>
<td>Many Plugins</td>
<td>No Plugins</td>
</tr>
<tr>
<td>Custom Fonts</td>
<td>Standard Fonts</td>
</tr>
</tbody>
</table>

- Field study with over 15,000 client systems
- A subset of *Desktops* and a subset of *Mobiles*
- Compared information value of classical features
### Mobile Device Fingerprinting

**Escaping Modern Web-Tracking**

#### Fingerprinting

**Special Attention to Mobile Devices**

<table>
<thead>
<tr>
<th>$S_{Desktop}$ Score</th>
<th>Feature</th>
<th>$S_{Mobile}$ Score</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.784</td>
<td>plugins</td>
<td>4.551</td>
<td>accept language</td>
</tr>
<tr>
<td>6.730</td>
<td>mimetypes</td>
<td>4.533</td>
<td>user agent</td>
</tr>
<tr>
<td>5.920</td>
<td>user agent</td>
<td>3.601</td>
<td>language</td>
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<td>5.865</td>
<td>accept language</td>
<td>2.119</td>
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<td>5.213</td>
<td>plugin versions</td>
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<td>screen y</td>
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<td>fonts</td>
<td>1.492</td>
<td>canvas</td>
</tr>
<tr>
<td>4.185</td>
<td>language</td>
<td>1.284</td>
<td>screen x</td>
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<td>canvas</td>
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<td>screen x</td>
<td>0.939</td>
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<td>color depth</td>
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<td>color depth</td>
<td>0.044</td>
<td>fonts</td>
</tr>
</tbody>
</table>
Fingerprinting
Aiming for Mobiles

- Existing methods not suitable for mobile devices
- Techniques will evolve
  - Will there be a fingerprinting system for mobiles?
  - Are we able to evade this system?
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Aiming for mobiles
Online Test for Everybody

- Publicly available fingerprinting website
- 45 features, 724 participants, 459 re-visitors

TrackMyMobile
Thank you for supporting our research!

Please enter the shown words into the text box below.

Submit
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Escaping Modern Web-Tracking

Aiming for mobiles
Recognition Experiments

Requirements to a Fingerprinting System

a) Recognize a revisiting device by its fingerprint  \((\text{match})\)

b) Distinguish a never-seen device from all known devices  \((\text{reject})\)
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Aiming for mobiles
Recognition Experiments

Testing the Robustness

- Determine precision of recognition of mobile devices
- Progressively remove most discriminant features from feature set
- Repeat recognition test with smaller feature set
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Aiming for mobiles
Recognition Experiments

Scenarios

1. All features

2. No cookies

3. No cookies, no localstorage and no host information

4. No cookies, no localstorage, no host information and no IP address
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Recognition Experiments

- **Single Iteration**
  - All devices (and their features) are available immediately

- **Multi Iteration**
  - Devices are available one after the other (in random order)
  - Simulate an evolving system
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Recognition Experiments

**Single Iteration**

a) Recognition performs well
b) Even without top features
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Recognition Experiments

Multi Iteration
a) Recognition still good
b) Top features relevant

✓ Fingerprinting Mobiles without Cookies
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Recognition Experiments
Evasion

- Tracking mobile devices is feasible and realistic
- Cookies are obsolete
- Device attributes sufficient for recognition

➤ Can users evade fingerprint-based tracking?
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Evasion
Changeability of Features

- Some attributes may be changed easily by a user

- popup blocker active
- DNT option enabled
- Java availability
- cookies enabled
- autofill forms
- filesystem access
- cookie ID
- local storage ID
- login status

- browsing history
- navigator language
- user agent
- display orientation
- AirPlay availability
- typing speed
- browser plugins
- accelerometer data
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Evasion
Changeability of Features

- Some attributes change depending on the environment
  - IP address
  - hostname
  - timezone
  - country
  - city
  - connection type

- Some features cannot be influenced easily
  - platform
  - operating system
  - vendor
  - productsub
  - vibration availability
  - screen height
  - screen width
  - display color depth
  - no. of touchpoints
  - is iOS / is Android
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Evasion Scenarios

- An evader has to know
  a) Which attributes are inquired for fingerprinting
  b) When these attributes are inquired

- Scenarios
  i. Use a second browser alternately
  ii. Use a second browser with different settings
  iii. Use a proxy connection
  iv. Combination: Two browsers and proxy
Evasion

Observations
a) Browser change useless
b) Proxy connection useless
c) Change Settings effective
d) Combination is best
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Evasion
Feasibility

- Strong preconditions
  - Knowledge about the fingerprinting system is needed

- Simple countermeasures fail
  - Using another browser or a proxy

- Successfull evasion requires a high effort
  - Using browsers with different settings and a proxy

➤ Evasion is possible, but neither pleasant nor easy
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Evasion
Randomness

- Emerging approach: Adding randomness to features
  - The fingerprint will be more random

- Drawbacks:
  - Cannot change all device‘s attributes
  - Attributes are also used by legitimate functions
  - How to differentiate between „good“ and „bad“ functions?
  - Legitimate use cases for fingerprinting exist
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Conclusion

- Tracking libraries do not target mobile devices, yet
  - But tracking techniques will evolve

- Mobile Web users are not safe from fingerprinting and tracking
  - Mobile devices provide sufficient characteristics

- Evading fingerprinting is hard to achieve
  - Specific knowledge about the fingerprinting system is required
  - Not all attributes are in the user’s sphere of influence
  - Randomizer, blocker and obfuscators need to discern fingerprinters
! Thank You for Your Attention!

Constant Vigilance!
A. Moody