FP-Scanner:
The privacy implications of browser fingerprint inconsistencies

A. Vastel, P. Laperdrix, W. Rudametkin, R. Rouvoy

Université de Lille

Inria inventeurs du monde numérique

Browser fingerprinting in a nutshell

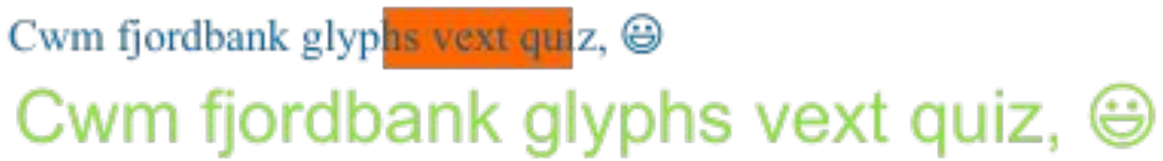
Stateless tracking technique

Combination of attributes from the browser:

User agent: “*Mozilla/5.0 (X11; **Linux** x86_64) AppleWebKit/537.36 (KHTML, like Gecko) **Chrome/67**.0.3396.87 Safari/537.36*”

Screen resolution: “*1280x720x24*”

Canvas: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Defense against fingerprinting

Different strategies:

- **Script blocking**: break collection
- **Attribute blocking**: decrease entropy
- **Attribute switching with pre-existing values:** break stability
- **Attribute blurring:** break stability

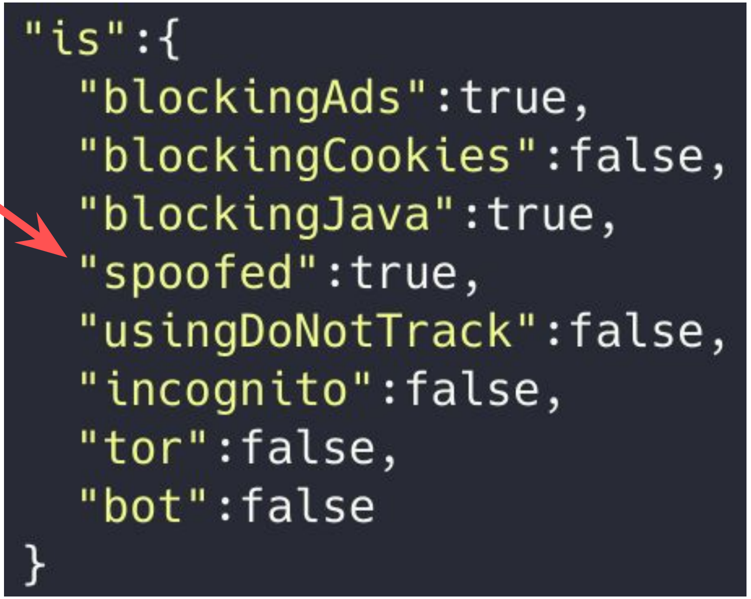
Different kinds of tools: browser extensions, forked browsers

Detecting countermeasures (1)

Fingerprinters may try to **detect countermeasures**:

- Augur
- FingerprintJS2
- Security fingerprinting scripts

Can be used as another fingerprinting attribute



```
"is":{
  "blockingAds":true,
  "blockingCookies":false,
  "blockingJava":true,
  "spoofed":true,
  "usingDoNotTrack":false,
  "incognito":false,
  "tor":false,
  "bot":false
}
```

Detecting countermeasures (2)

Use **inconsistencies** introduced by the countermeasure (Nikiforakis2013)

Example with a naive user agent spoofer:

- Real configuration: **Linux** with **Firefox**
- **navigator.userAgent** = *Mozilla/5.0 (**Windows NT 10.0**; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) **Chrome**/60.0.3112.113 Safari/537.36*
- **navigator.platform** = ***Linux** x86_64*

The user agent says **Windows**, the platform says **Linux**

FP-Scanner

Verify if attributes of a fingerprint have been modified

Extend to all kinds of countermeasures

Use **inconsistencies** introduced by countermeasures

Split into 4 components:

- OS, browser, device, canvas

OS inconsistencies

Verify OS extracted from the user agent with:

- **Navigator.platform**
- **WebGL**

OS	**Vendor**
MacOS	Intel, ATI
Android	Qualcomm, ARM, Imagination

Browser inconsistencies (1)

Errors may be browser dependent:

Firefox

```
{
  depth: 108421,
  errorMessage: "too much
recursion",
  errorName: "InternalError",
  errorStacklength: 6912
}
```

Chrome

```
{
 depth: 11416,
 errorMessage: "Maximum call stack
size exceeded",
 errorName: "RangeError",
 errorStacklength: 1723
}
```

Browser inconsistencies (2)

Browser features: depends on **browser** and **version**

Function representation: `eval.toString()`

- **Safari** and **Firefox** →
```
"function eval() {
    [native code]
}"
```
- **Chrome** → `"function eval() { [native code] }"`

Device inconsistencies

Is it really a **computer** or a **smartphone**?

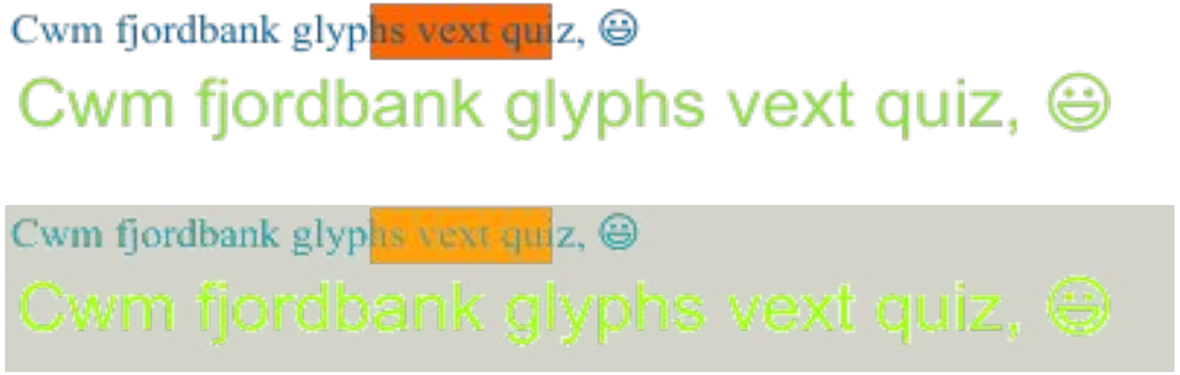
Test the presence of events/sensors:

- Mouse on a phone: **onmousemove**
- Smartphone with no **accelerometer**

Canvas inconsistencies (1)

High entropy: depends on the device, browser, OS

High stability: important for tracking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Canvas inconsistencies (2)

A human can detect a visual difference between the 2 canvas

Constraints when defining the canvas:

- Background should be transparent
- There should not be isolated pixels
- Pixels in the rectangle should be (255, 102, 0, 100)

Verify if **toDataURL** and **getImageData** overridden:

```
HTMLCanvasElement.prototype.toDataURL.toString();
```

Evaluation

Evaluation using **7 countermeasures**:

- Canvas defender, Canvas FP Block, FP-Random **(Canvas)**
- Random Agent Spoofer, User agent spoofers
- Firefox protection, Brave

Compare with **FingerprintJS2/Augur:** verify OS, screen resolution, device, browser

Collect fingerprints with and without countermeasures from multiple devices

Results

Countermeasure	Accuracy FP-Scanner	Accuracy FP-JS2 / Augur
Random Agent Spoofer	1.0	0.55
User agent spoofers	1.0	0.86
Canvas Defender	1.0	0.0
Firefox protection	1.0	0.0
Canvas FP Block	1.0	0.0
FP-Random	1.0	0.0
Brave	1.0	0.0
No countermeasure	1.0	1.0

Tests failed by countermeasures

Random Agent Spoofer: No accelerometer, **navigator.vendor** overriden

Canvas extensions and FP-Random: **Pixels** and **toDataURL** overridden

Brave: **navigator.mediaDevices.enumerateDevices**

Firefox fingerprinting protection: **WebGL** and **media queries**

Recovering ground values

Infer the real nature of the device: OS, browser + version

Recovering the **OS**: combine **plugin extensions**, **WebGL**, **media queries**, **fonts**

Recovering the **browser**:

- **Family: eval.toString().length** and **navigator.productSub**
- **Version: Modernizr features**

Infer real OS and browser family, but not the precise version

Privacy implications

Discrimination: similar to what happens with anti-adblockers

Trackability: can make the **user more easily trackable** (multiple factors):

1. Identify the countermeasure
2. Number of users
3. Ability to recover original values
4. Information leaked

Does the anonymity gain provided by the countermeasure outweigh the anonymity loss caused by its detection?

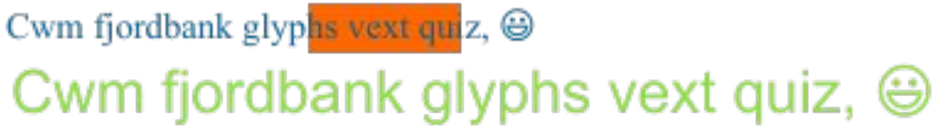
Example: Canvas Defender (1)

Chrome and Firefox extension: **≈25k users**

Randomize canvas by **adding noise**

Override **toDataURL** and **getImageData**

Genuine Canvas: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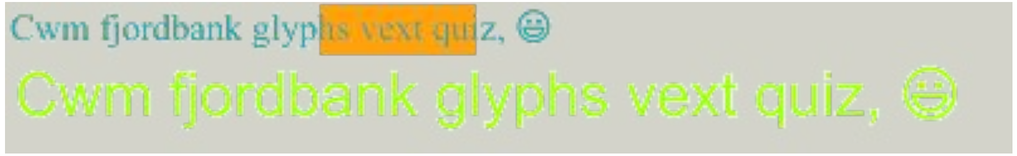
Modified Canvas: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Example: Canvas Defender (2)

```
> HTMLCanvasElement.prototype.toDataURL.toString();
```

```
'function () {
    var width = this.width;
    var height = this.height;
    var context = this.getContext("2d");
    var imageData = context.getImageData(0, 0, width, height);
    for (var i = 0; i < height; i++) {
        ...
    }
    context.putImageData(imageData, 0, 0);
    showNotification();
    return old.apply(this, arguments);
}'
```

Example: Canvas Defender (3)

Clone original **toDataURL** before Canvas Defender executes its code

```
const getOriginalFunction = Function.prototype.call.bind(
    Function.prototype.bind,
    Function.prototype.call
);
const originalToDataURL =
getOriginalFunction(HTMLCanvasElement.prototype.toDataURL);
```

Execute original function after DOMContentLoaded so that emojis are rendered correctly

Example: Canvas Defender (4)

Generate **random noise vector** (r, g, b, a)

➔ Add noise component to each pixel

Detect when Canvas Defender code is added to the DOM (MutationObserver):

- **Extract the parameters of the function**, i.e. the noise vector

Example: Canvas Defender (5)

Canvas Defender can be identified

Small number of users **~25k**

- ➜ Being detected with Canvas Defender is discriminative in itself

Can recover **original canvas value**

Leaks a potentially **stable identifier** (noise vector)

Conclusion

Fingerprinters can detect countermeasures using inconsistencies

Privacy implications:

- **Discrimination**
- **Tracking**

Same techniques could also be used to detect extensions with different settings