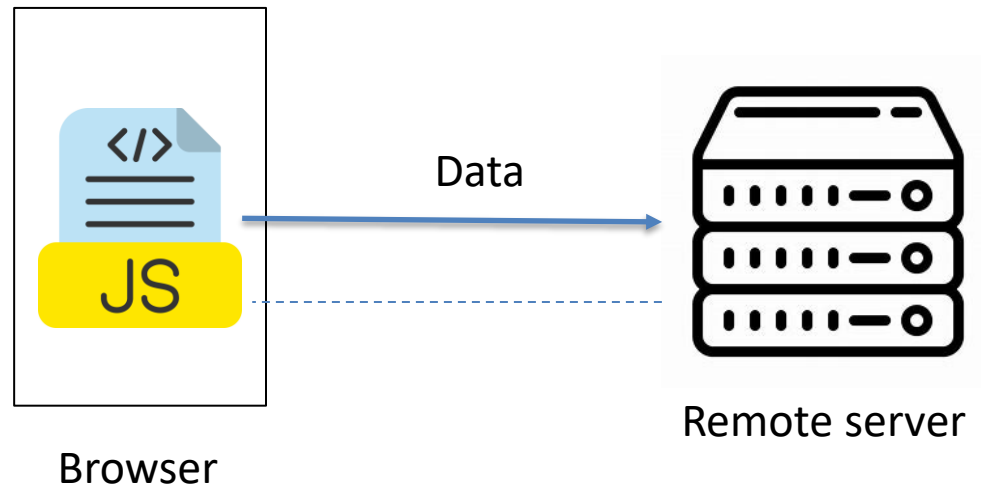


FP-tracer: Fine-grained Browser Fingerprinting Detection via Taint-tracking and Entropy-based Thresholds.

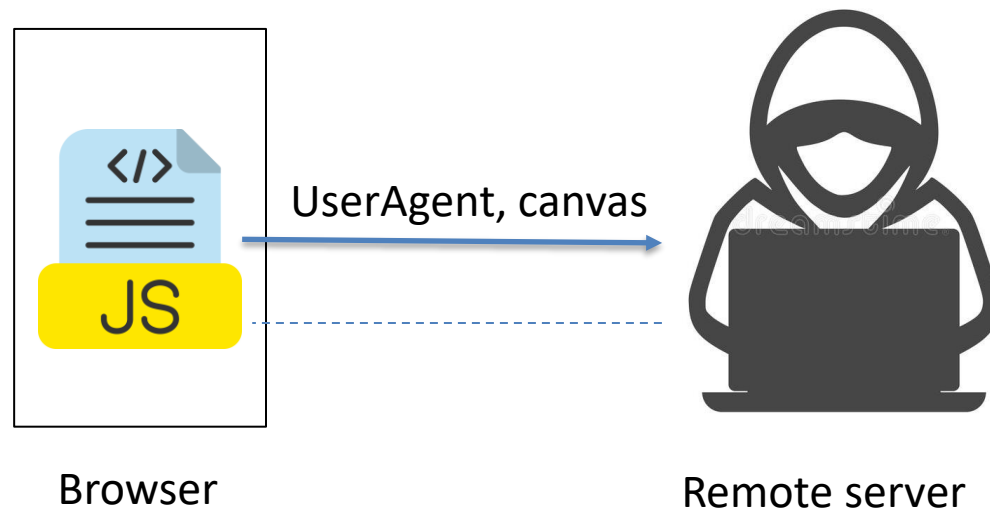
- Soumaya Boussaha [1,2]
- Lukas Hock [1]
- Miguel Bermejo [4]
- Rubén Cuevas Rumin [4]
- Angel Cuevas Rumin [4]
- David Klein [3]
- Martin Johns [3]
- Luca Compagna [1]
- Daniele Antonioli [2]
- Thomas Barber[1]

[1] SAP, [2] Eurecom, [3] TU Braunschweig, [4]UC3M

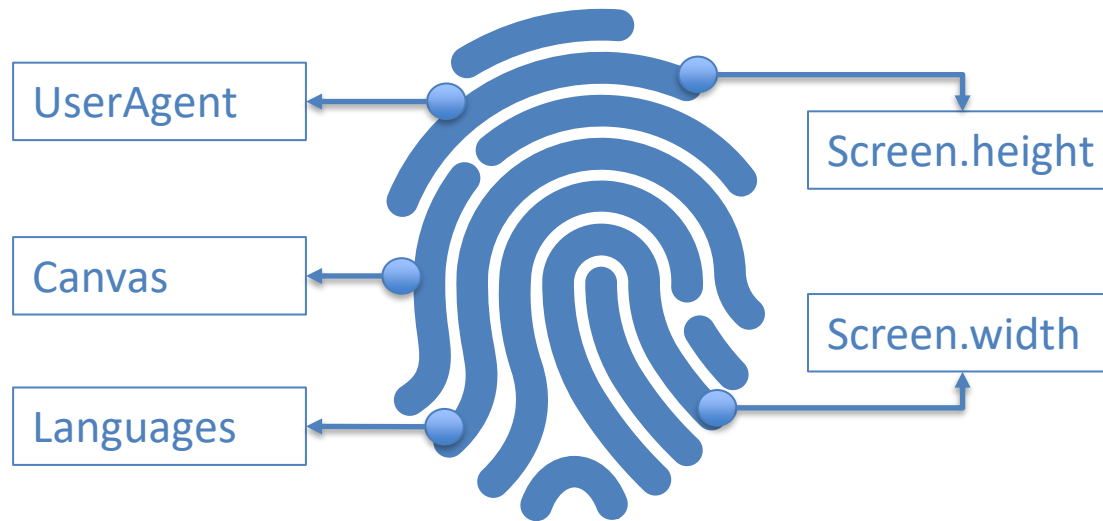
Understanding Browser Fingerprinting



Understanding Browser Fingerprinting



Understanding Browser Fingerprinting



Understanding Browser Fingerprinting

```
let height = screen.height  
let width = screen.width  
let userAgent = navigator.userAgent
```

Collect
Attributes

```
let screenRes = width * height  
let fingerprint = [screenRes, userAgent]
```

Combine
Attributes

```
let userId = hash(fingerprint)  
let returnUrl = 'http://example.com?userId=' + userId
```

Calculate
Identifier

```
fetch(returnUrl)
```

Send
Identifier

Real-World Fingerprinter

Fingerprint – Raw

```
{
  "components": {
    "fonts": {
      "value": [
        "Agency FB",
        "Calibri",
        "Century",
        "Century Gothic",
        "Franklin Gothic",
        "Haettenschweiler",
        "Lucida Bright",
        "Lucida Sans",
        "MS Outlook",
        "MS Reference Specialty",
        "MS UI Gothic",
        "MT Extra",
        "Marlett",
        "Monotype Corsiva",
        "Pristina",
        "Segoe UI Light"
      ],
      "duration": 256
    },
    "domBlockers": {
      "duration": 236
    },
    "fontPreferences": {
      "value": {
        "default": 149.3125,
        "apple": 149.3125,
        "serif": 149.3125,
        "sans": 144.015625,
        "mono": 121.515625,
        "min": 9.34375,
        "system": 147.859375
      },
      "duration": 245
    },
    "audio": {
      "value": 124.04347527516074,
      "duration": 7
    },
    "screenFrame": {
      "value": [
        0,
        0,
        50,
        0
      ],
      "duration": 0
    },
    "osCpu": {
      "duration": 0
    },
    "languages": {
      "value": [
        [
          "en-US"
        ]
      ],
      "duration": 0
    },
    "colorDepth": {
      "value": 24,
      "duration": 0
    },
    "deviceMemory": {
      "value": 8,
      "duration": 1
    },
    "screenResolution": {
      "value": [
        3440,
        1440
      ],
      "duration": 0
    },
    "hardwareConcurrency": {
      "value": 8,
      "duration": 0
    },
    "timezone": {
      "value": "Europe/Berlin",
      "duration": 13
    },
    "sessionStorage": {
      "value": true,
      "duration": 0
    },
    "localStorage": {
      "value": true,
      "duration": 1
    },
    "indexedDB": {
      "value": true,
      "duration": 0
    },
    "openDatabase": {
      "value": true,
      "duration": 0
    },
    "cpuClass": {
      "duration": 0
    },
    "platform": {
      "value": "Win32",
      "duration": 0
    },
    "plugins": {
      "value": [
        {
          "name": "PDF Viewer",
          "description": "Portable Document Format",
          "mimeType": [
            {
              "type": "application/pdf",
              "suffixes": "pdf"
            }
          ],
          "type": "text/pdf",
          "suffixes": "pdf"
        },
        {
          "name": "Chrome PDF Viewer",
          "description": "Portable Document Format",
          "mimeType": [
            {
              "type": "application/pdf",
              "suffixes": "pdf"
            }
          ],
          "type": "text/pdf",
          "suffixes": "pdf"
        },
        {
          "name": "Chromium PDF Viewer",
          "description": "Portable Document Format",
          "mimeType": [
            {
              "type": "application/pdf",
              "suffixes": "pdf"
            }
          ],
          "type": "text/pdf",
          "suffixes": "pdf"
        },
        {
          "name": "Microsoft Edge PDF Viewer",
          "description": "Portable Document Format",
          "mimeType": [
            {
              "type": "application/pdf",
              "suffixes": "pdf"
            }
          ],
          "type": "text/pdf",
          "suffixes": "pdf"
        },
        {
          "name": "WebKit built-in PDF",
          "description": "Portable Document Format",
          "mimeType": [
            {
              "type": "application/pdf",
              "suffixes": "pdf"
            }
          ],
          "type": "text/pdf",
          "suffixes": "pdf"
        }
      ],
      "duration": 1
    },
    "canvas": {
      "value": {
        "winding": true,
        "geometry": "data:image/png;base64,iVBORw0KGgoAAAANSUuEUGAAAHoAAABuCA.....",
        "text": "data:image/png;base64,iVBORw0KGgoAAAANSUuEUGAAAHoAAABuCA.....",
        "duration": 101
      },
      "touchSupport": {
        "value": {
          "maxTouchPoints": 10,
          "touchEvent": false,
          "touchStart": false,
          "duration": 0
        },
        "vendor": {
          "value": "Google Inc.",
          "duration": 0
        },
        "vendorFlavors": {
          "value": [
            "chrome"
          ],
          "duration": 0
        },
        "cookiesEnabled": {
          "value": true,
          "duration": 1
        },
        "colorGamut": {
          "value": {
            "srgb": {
              "duration": 0
            },
            "invertedColors": {
              "duration": 0
            },
            "forcedColors": {
              "value": false,
              "duration": 0
            },
            "monochrome": {
              "value": 0,
              "duration": 0
            },
            "contrast": {
              "value": 0,
              "duration": 0
            },
            "reducedMotion": {
              "value": false,
              "duration": 0
            },
            "hdr": {
              "value": false,
              "duration": 0
            },
            "math": {
              "value": {
                "acos": 1.4473588658278522,
                "acosh": 709.889355822726,
                "acoshPf": 355.291251501643,
                "asin": 0.12343746096704435,
                "asinh": 0.881373587019543,
                "asinhPf": 0.8813735870195429,
                "atanh": 0.5493061443340548,
                "atanhPf": 0.5493061443340548,
                "atan": 0.4636476090008061,
                "sin": 0.8178819121159085,
                "sinh": 1.1752011936438014,
                "sinhPf": 2.534342107873324,
                "cos": -0.8390715290095377,
                "cosh": 1.5430806348152437,
                "coshPf": 1.5430806348152437,
                "tan": -1.4214488238747245,
                "tanh": 0.7615941559557649,
                "tanhPf": 0.7615941559557649,
                "exp": 2.718281828459045,
                "expm1": 1.718281828459045,
                "expm1Pf": 1.718281828459045,
                "logp": 2.3978952727983707,
                "loglpPf": 2.3978952727983707,
                "powPi": 1.9275814160560204e-50
              },
              "duration": 1
            }
          },
          "version": "3.3.3"
        }
      }
    }
  }
}
```

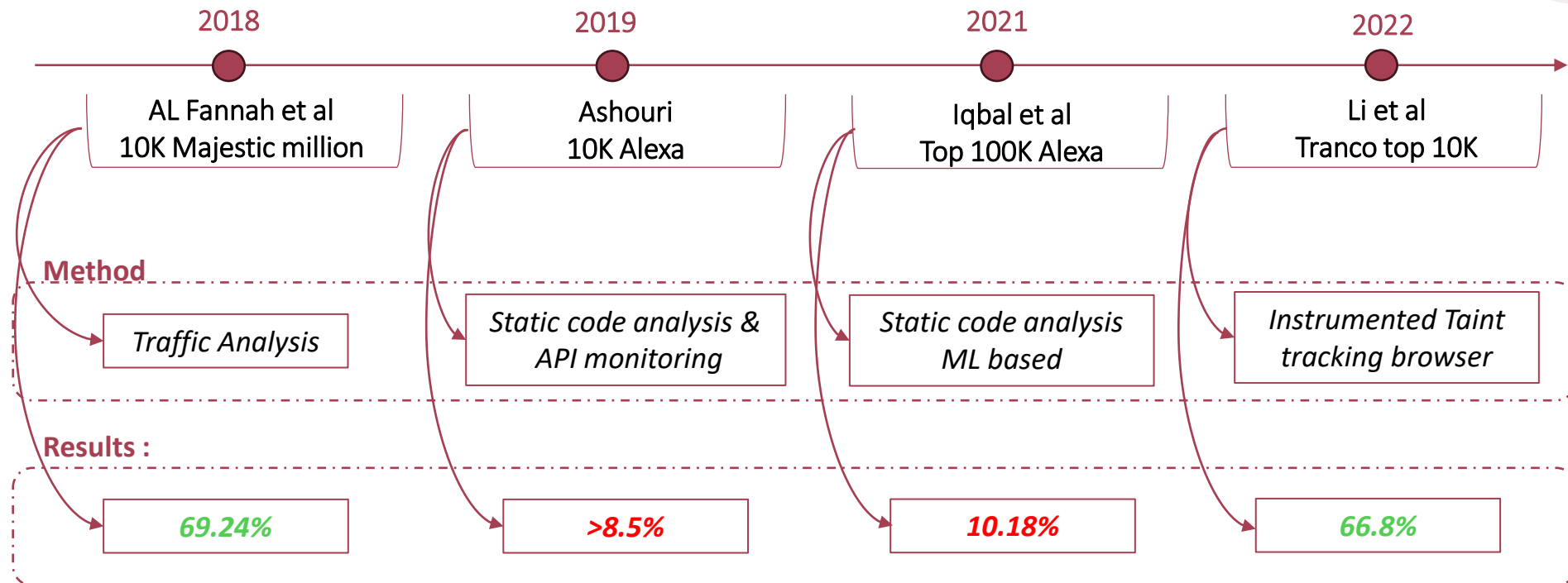
Fingerprinting Script



Fingerprint – Visitor ID

635afc5fe99c745eba9d30a34bb0073a

CHALLENGING DETECTION



FP-TRACER: CONTRIBUTIONS

1

We introduce a **granular** method to **detect** browser fingerprinting flows using **taint-tracking**.

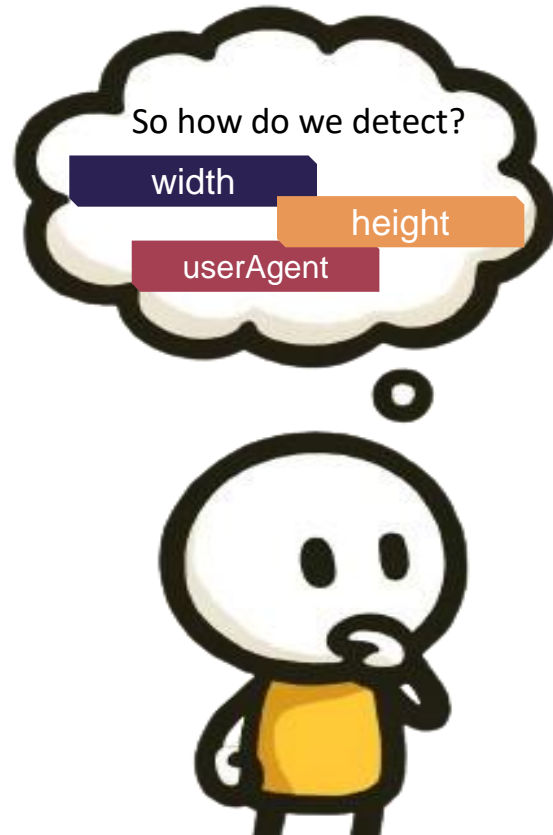
2

We propose to detect **different levels** of fingerprinting sorted by their **privacy impact**.

3

We conducted **a large-scale** experiment on the Tranco Top 100K.

FIRST PROBLEM : CHALLENGING FLOW DETECTION



TAINT TRACKING FOR BROWSER FINGERPRINTING

```
let height = screen.height  
let width = screen.width  
let userAgent = navigator.userAgent
```

height

width

userAgent

Collect
Attributes

```
let screenRes = width * height  
let fingerprint = [screenRes, userAgent]
```

width

height

width

height

userAgent

Combine
Attributes

```
let userId = hash(fingerprint)  
let returnUrl = 'http://example.com?userId=' + userId
```

width

height

userAgent

width

height

userAgent

Calculate
Identifier

```
fetch(returnUrl)
```

width

height

userAgent

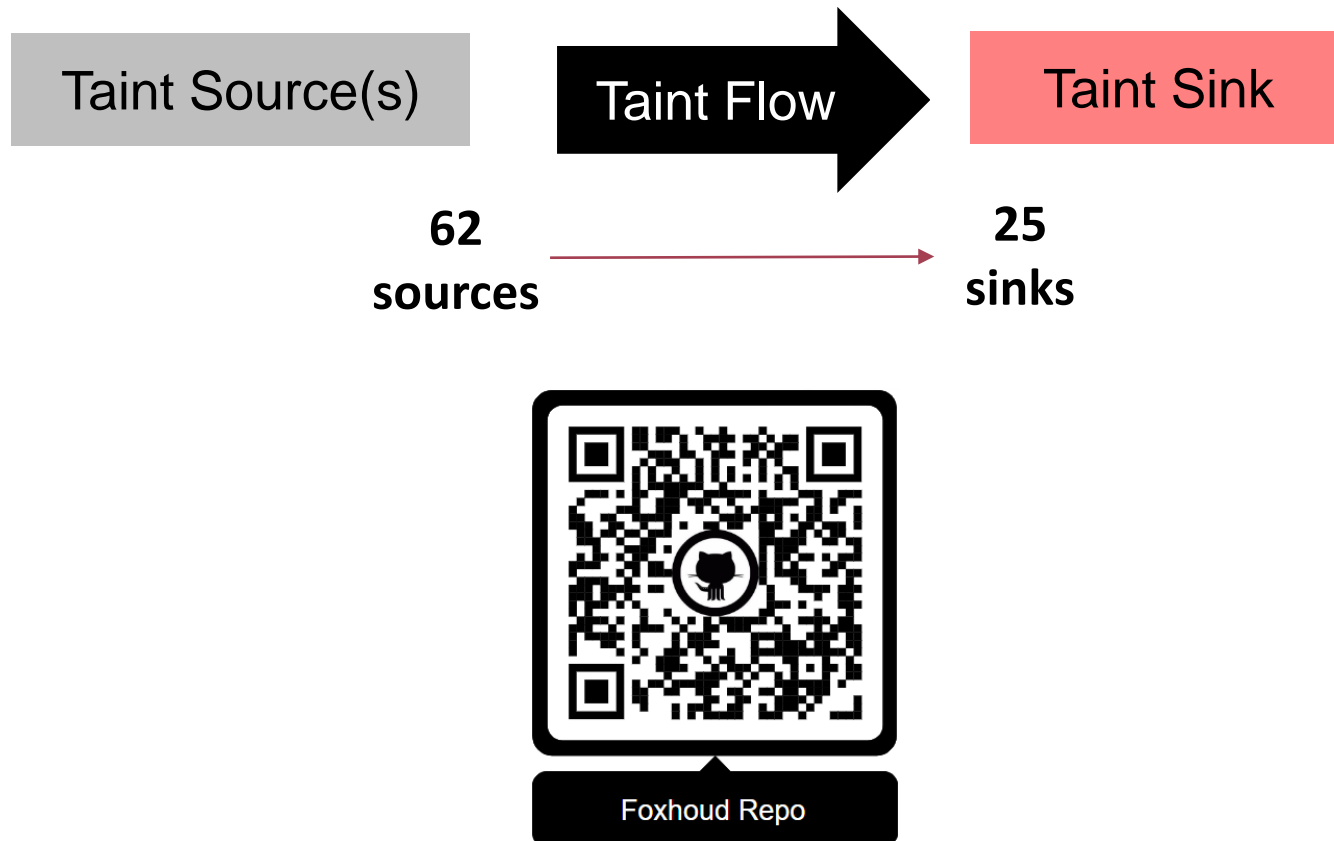
Send
Identifier

Taint Source(s)

Taint Flow

Taint Sink

TAINT TRACKING FOR BROWSER FINGERPRINTING



SECOND PROBLEM : CHALLENGING CLASSIFICATION

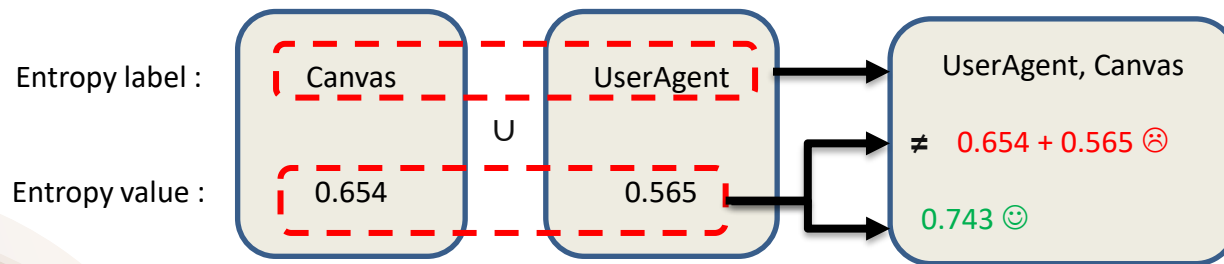


Screen dimensions
Height X Width are
related

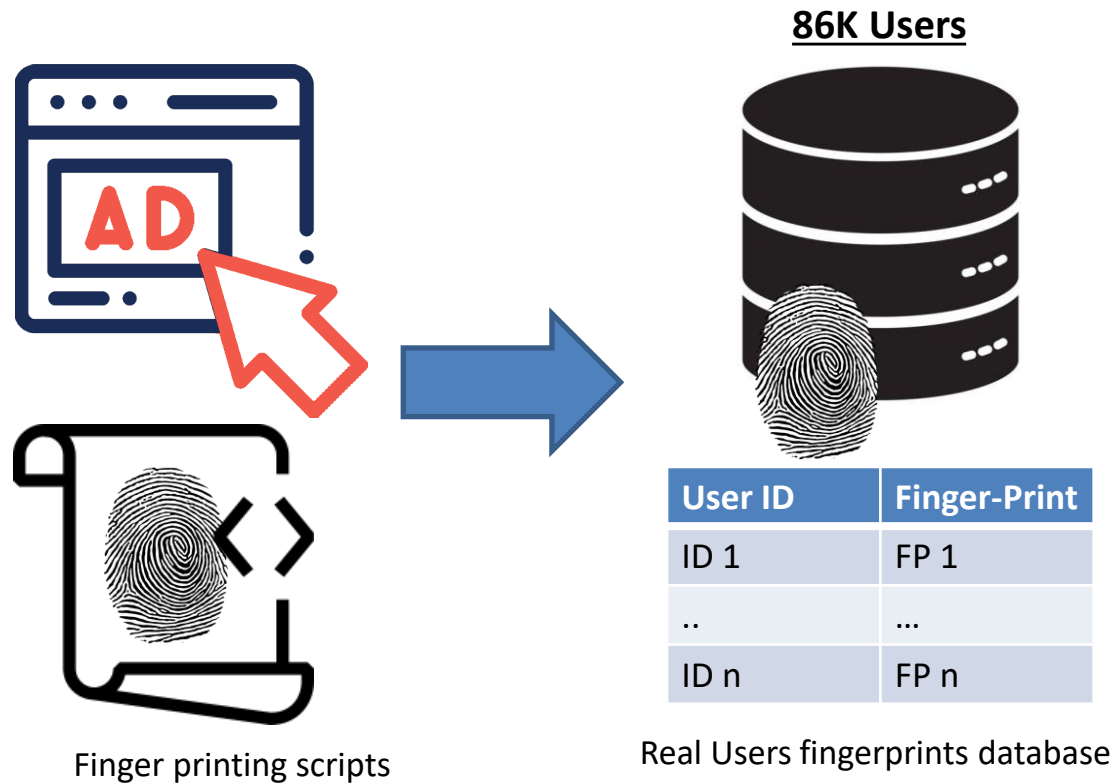


Classification: Joint-Entropy

$$H(X_1, \dots, X_n) = - \sum_{x_1 \in \mathcal{A}_{x_1}} \dots \sum_{x_n \in \mathcal{A}_{x_n}} P(x_1, \dots, x_n) \cdot \log_b P(x_1, \dots, x_n),$$



Evaluation data-set



The paper's experiments have obtained the approval of our institution's Institutional Review Board (IRB) via the relevant DPO.

Main crawl

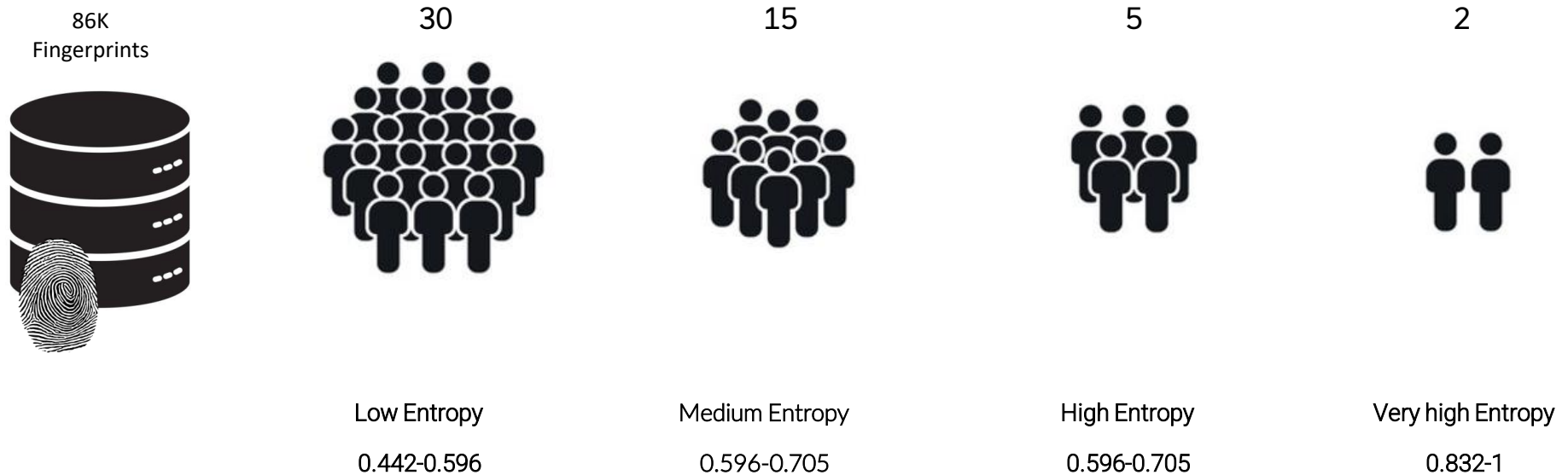


100,000
Tranco most popular websites

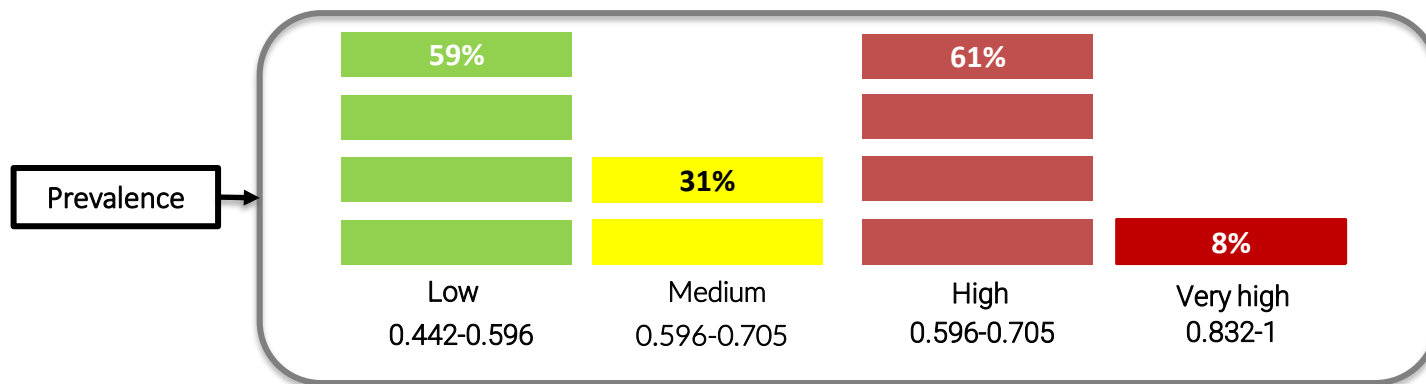


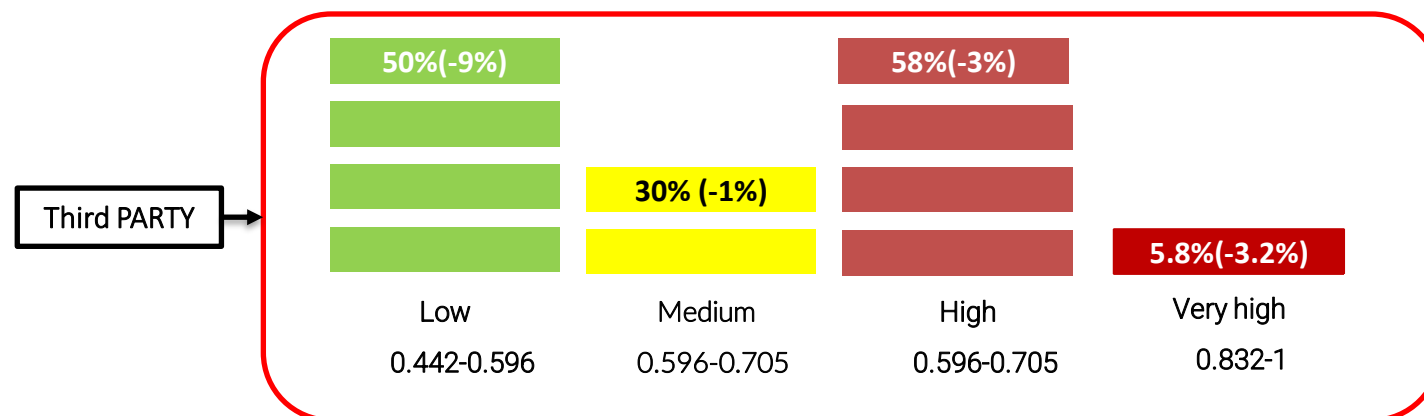
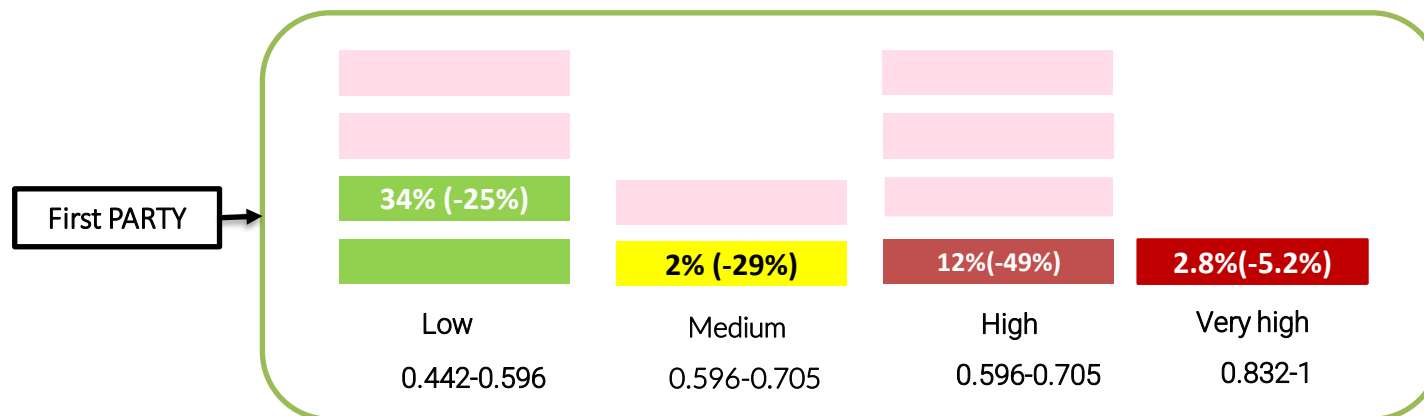
7.5M
source→sink
flows

Levels of fingerprinting

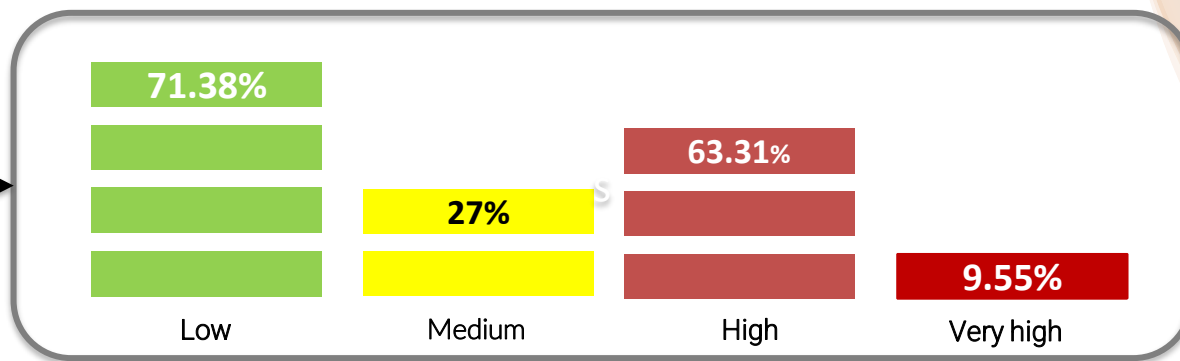


For more details on the clustering approach , refer to the paper.

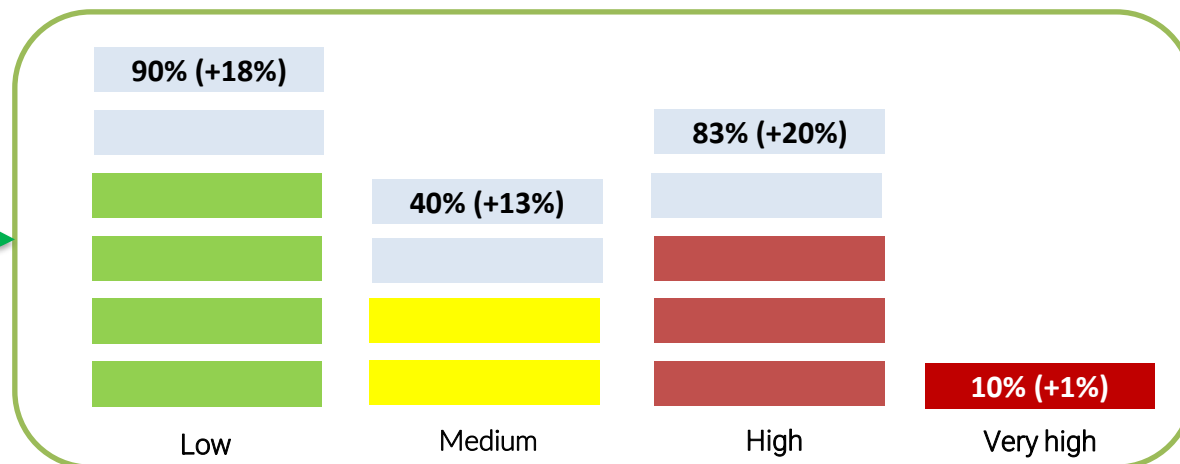




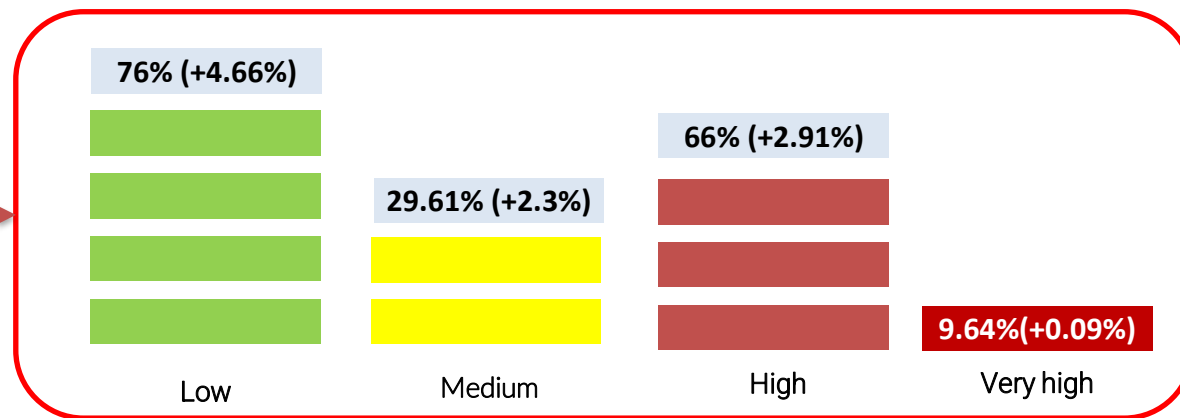
Do nothing



Accept ALL



Reject ALL



Formatting of leaked attributes

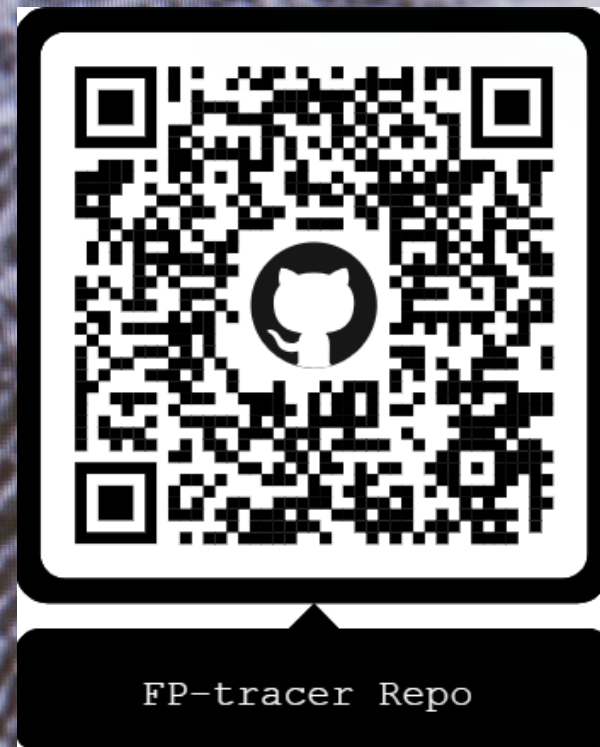
Thanks to our character level taint tracking implementation we detect **6.8 million tainted strings** .

Only 5% aggregated on the browser.

Only 47.3% of Very high entropy were in plain text .

Summary

- Browser Fingerprinting occurs in multiple levels that can identify different groups of users.
- Third party activity tend to be overall more prevalent then first party activity.
- The aggregation & obfuscation of fingerprints is more common for Very high entropy vectors.
- User consent is not respected



Contact us:

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