black hat ASIA 2023

MAY 11–12

BRIEFINGS

DATADOME

# Leveraging Streaming-Based Outlier Detection and SliceLine to Stop Heavily Distributed Bot Attacks

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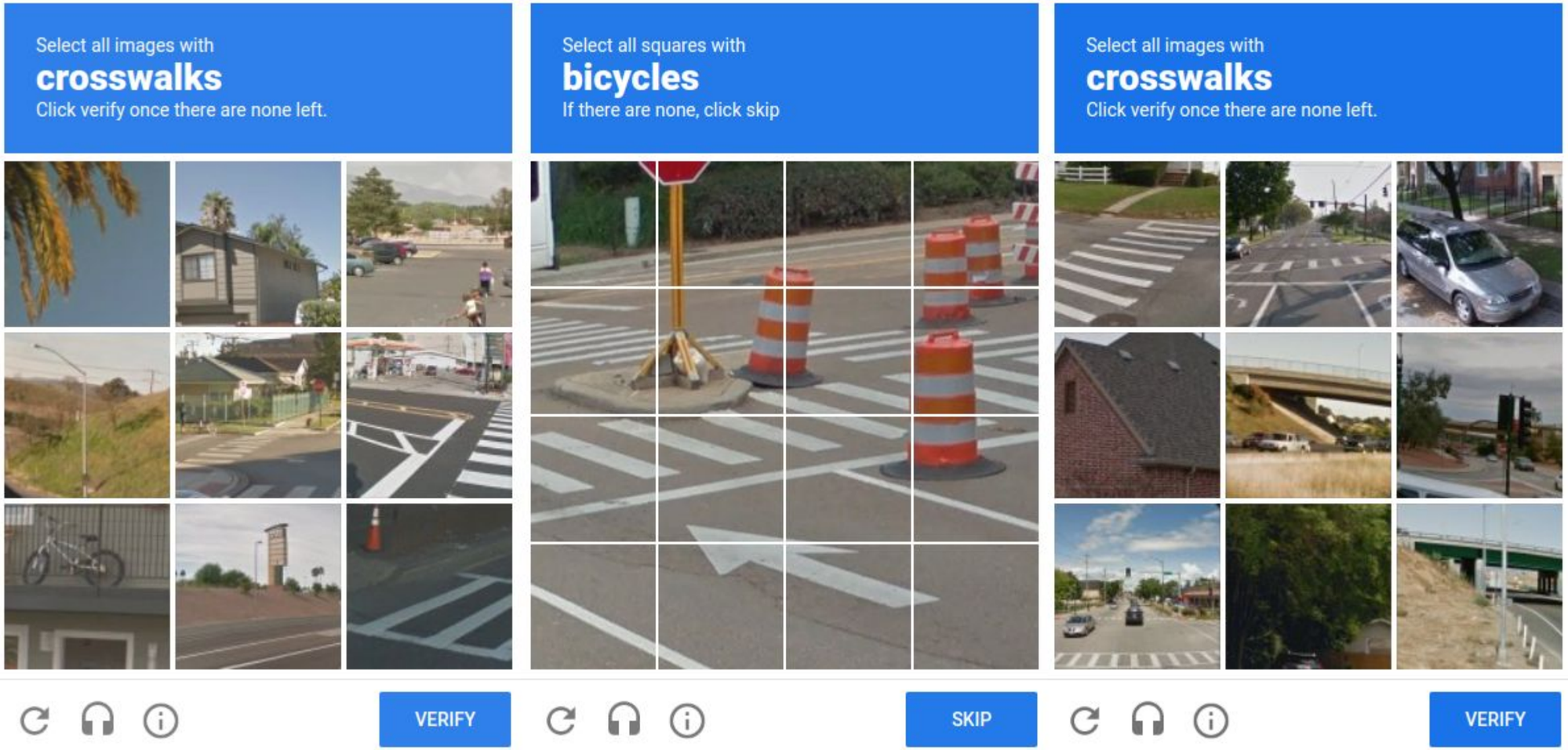
Select all images with
crosswalks
Click verify once there are none left.
VERIFY
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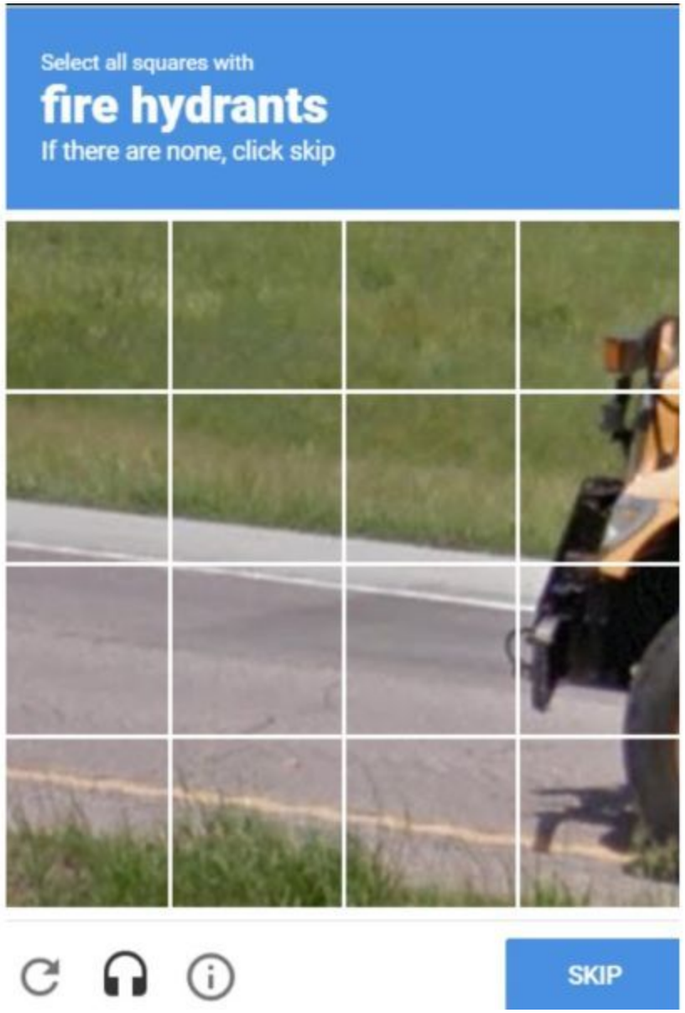
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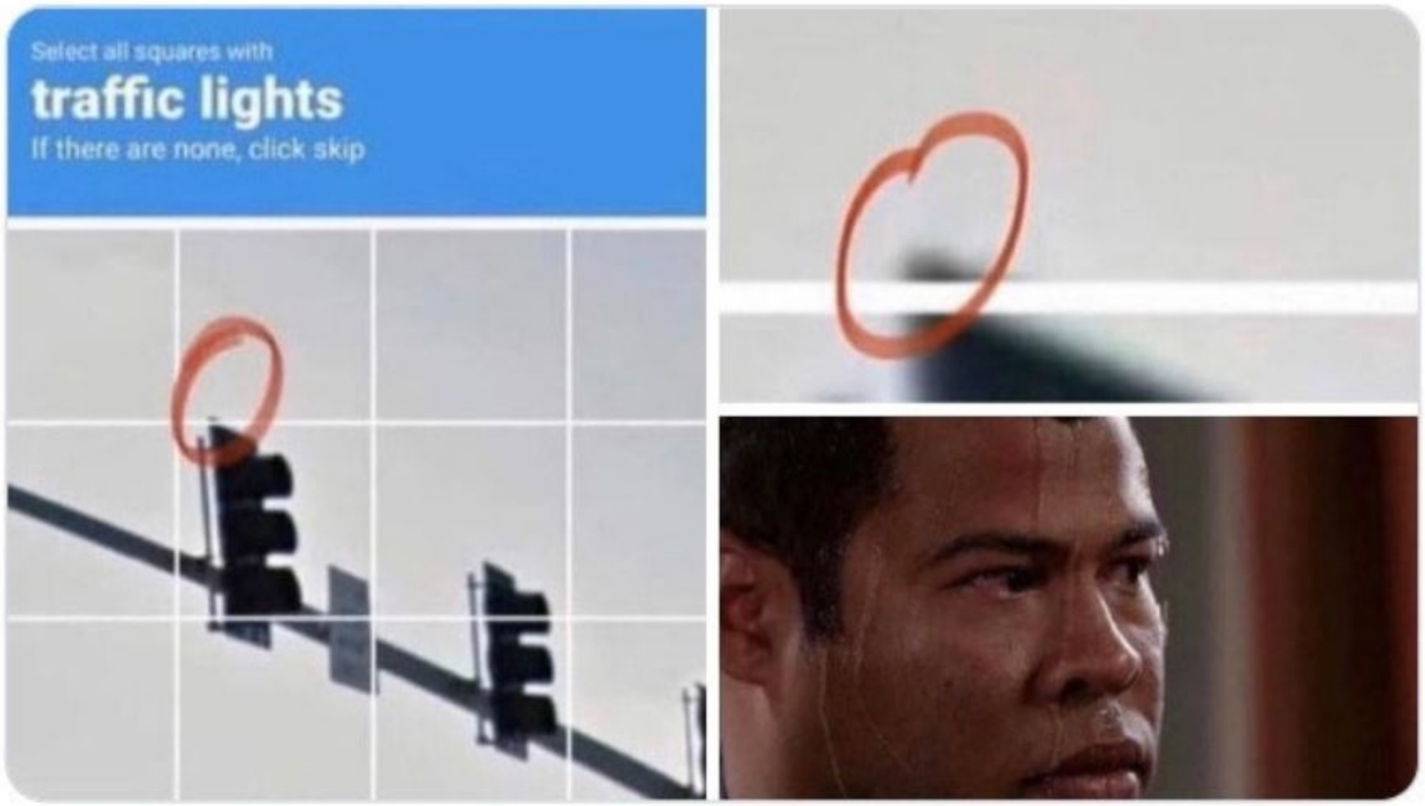
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traffic lights
If there are none, click skip

# All these CAPTCHAs because of bad bots.

# But can we detect bad bots without CAPTCHAs?

# Introduction to (Bad) Bots

# What's a bot?

Program to **automate actions**.

Can be used for positive purposes:

- Automated **website testing**.

Nefarious purposes:

- Test batch of **stolen credentials**.
- Generate **fake video views/retweets**.

# Attacks conducted by bots

**Credential stuffing/account takeover** → Steal user accounts.

**DDoS** → Make website/mobile app unavailable.

**Carding** → Test stolen credit cards.

**Vote manipulation** → Generate fake views, increase number of likes, retweets, etc.

# Bot Technologies: HTTP Clients

Axios
Got

Aiohttp
Requests

net/http

Low CPU/RAM resources needed.

No JavaScript execution.

(Potentially) inconsistent:

- HTTP Headers
- TLS Fingerprints

# Bot Technologies: Automated Browsers

Puppeteer + (headless) Chrome 


Selenium + (headless) Firefox 


Playwright + (headless) Webkit 

More CPU/RAM resources needed.

Execute JavaScript (JS) natively.

Consistent **HTTP headers** and **TLS fingerprints**.

Potentially inconsistent browser fingerprint (JS).

# How to detect bots?

# How to detect bots?

**Signatures**/(browser/TLS/ HTTP) fingerprints.

**Behavioral analysis:**

- Volume of requests.
- Browsing patterns.

**Reputation:** IP/session, proxy detection.

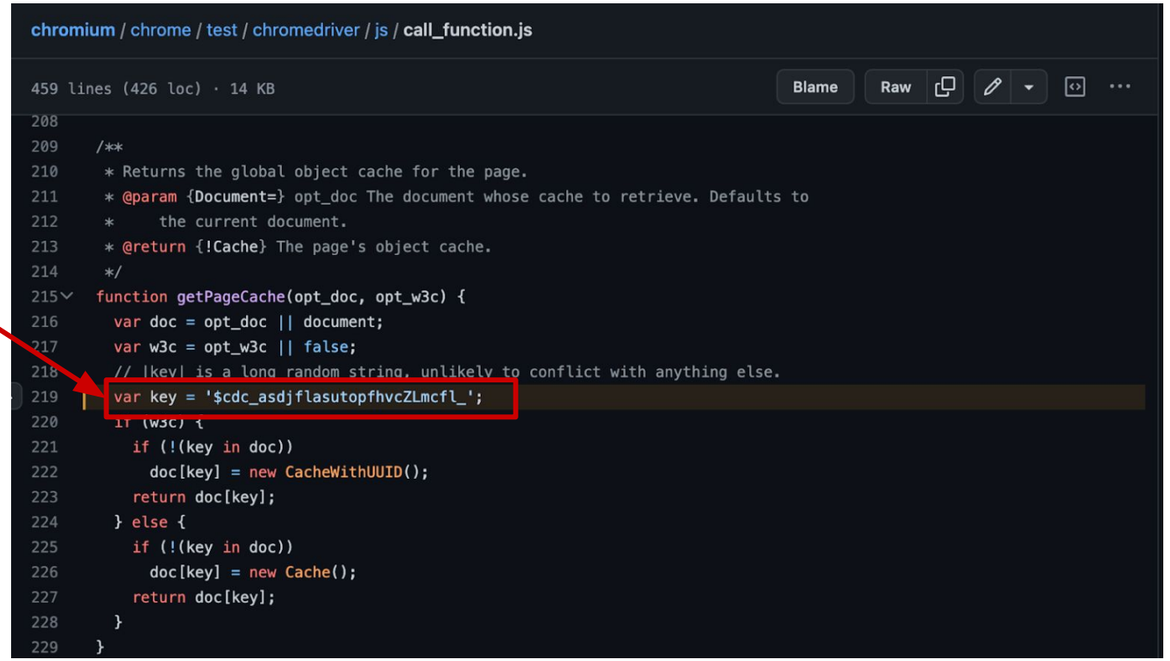
**Context:** country, time of the day, website targeted.

# Detection Example: Selenium

Detection using browser fingerprinting (JS).

Selenium introduces attribute:

**document.$cdc_asdjflasutopfhvcZLmcfl_**



# Bypass Techniques Used by Bots

Forge TLS fingerprints.


Forge browser fingerprint and HTTP headers.
https://github.com/intoli/user-agents


```
{
  "appName": "Netscape",
  "connection": {
    "downlink": 10,
    "effectiveType": "4g",
    "rtt": 0
  },
  "platform": "Win32",
  "pluginsLength": 3,
  "vendor": "Google Inc.",
  "userAgent": "Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (
  "viewportHeight": 660,
  "viewportWidth": 1260,
  "deviceCategory": "desktop",
  "screenHeight": 800,
  "screenWidth": 1280
}
```


Fake/simulate JavaScript execution:

- Forge JS proof of work payload (reverse engineer).

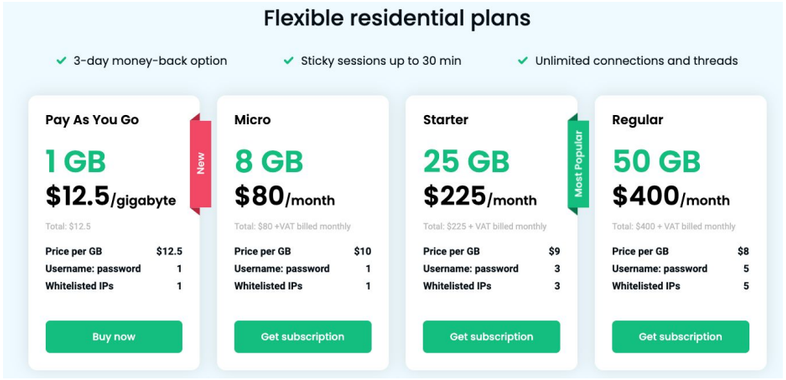
# Bypass Techniques Used by Bots

Distribute attack using **proxies**:

→ Avoid IP-based rate limiting.

Distribute attack using **residential proxies**:

→ Avoid reputation-based blocking.

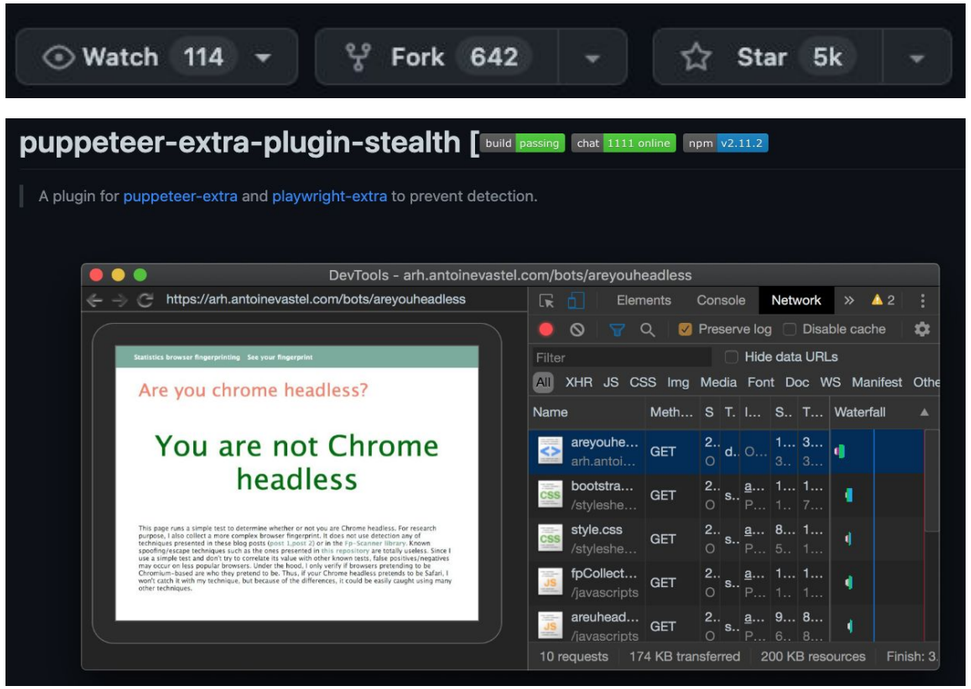


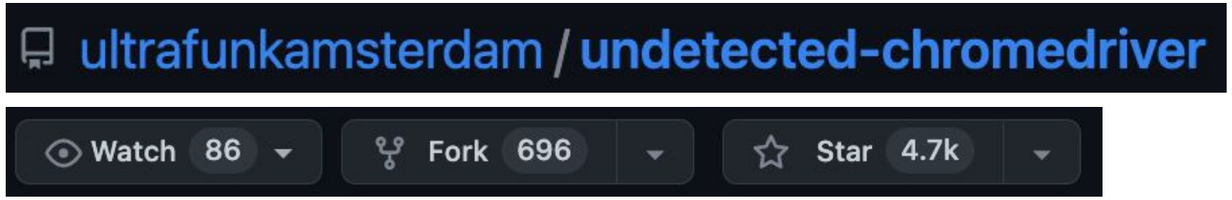

Distribute attack using **residential proxies located in same country as website targeted**:

→ Avoid geo-blocking.

# Community Driven Anti-Detection Frameworks

Generic, for (headless) automated browsers:



# To Conduct Credential Stuffing Attacks

README.md

OPEN BULLET 2

OpenBullet 2 is a cross platform automation suite powered by .NET core. It allows to perform requests towards a target webapp and offers a lot of tools to work with the results. This software can be used for **scraping** and **parsing data**, automated **pentesting** and much more.

Link to the Official Forum where you can find guides and become part of the community behind OpenBullet.

Found a bug? Create an issue!

**IMPORTANT!** Performing (D)DoS attacks or credential stuffing on sites you do not own (or you do not have permission to test) is **illegal!** The developer will not be held responsible for improper use of this software.

# Bad Bots in 2023: Summary

Distribute their attacks.

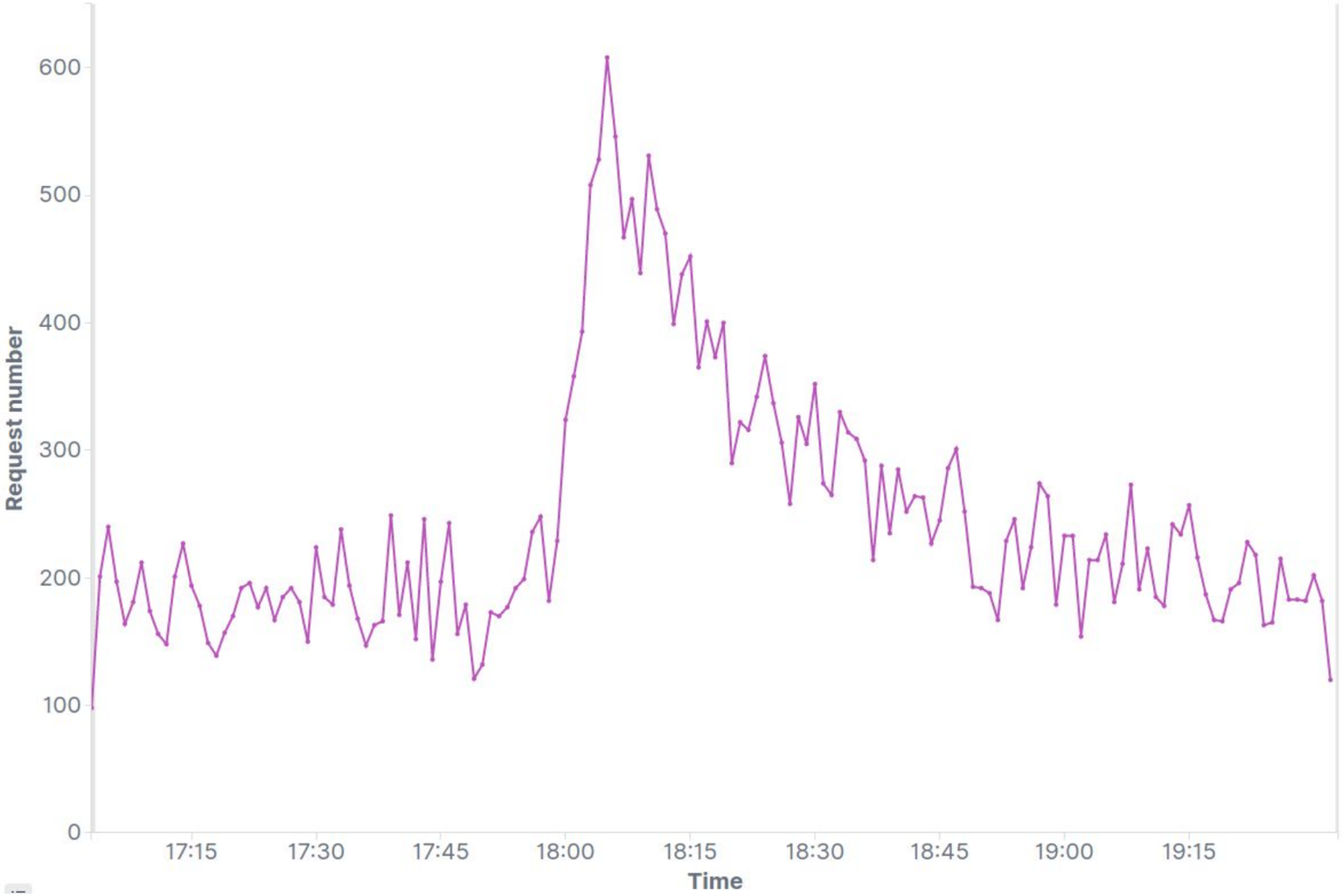
Leverage thousands of residential proxies.

Constantly change and forge their signatures/fingerprints.

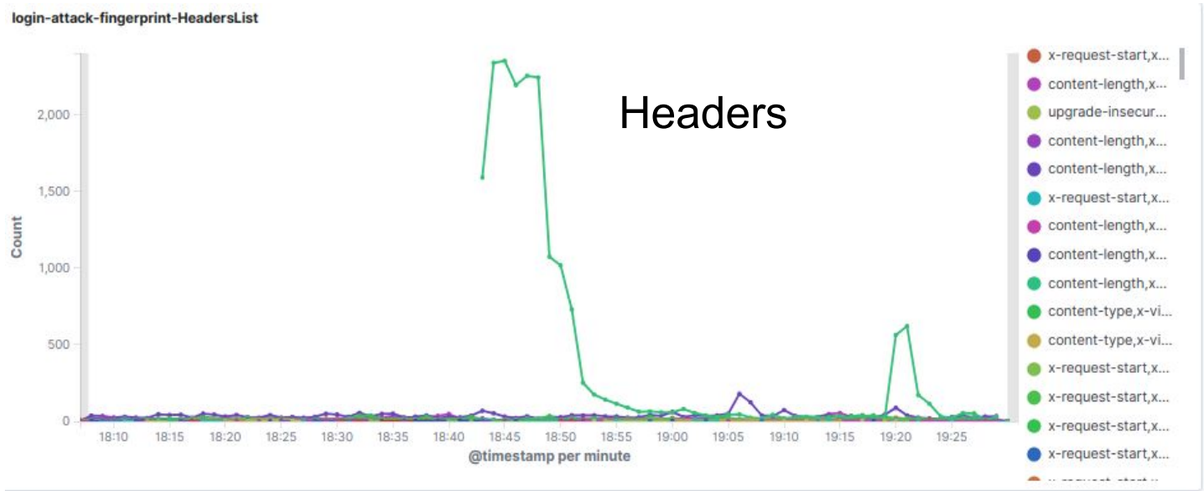
# Q: How to block these ever-evolving and distributed bots?

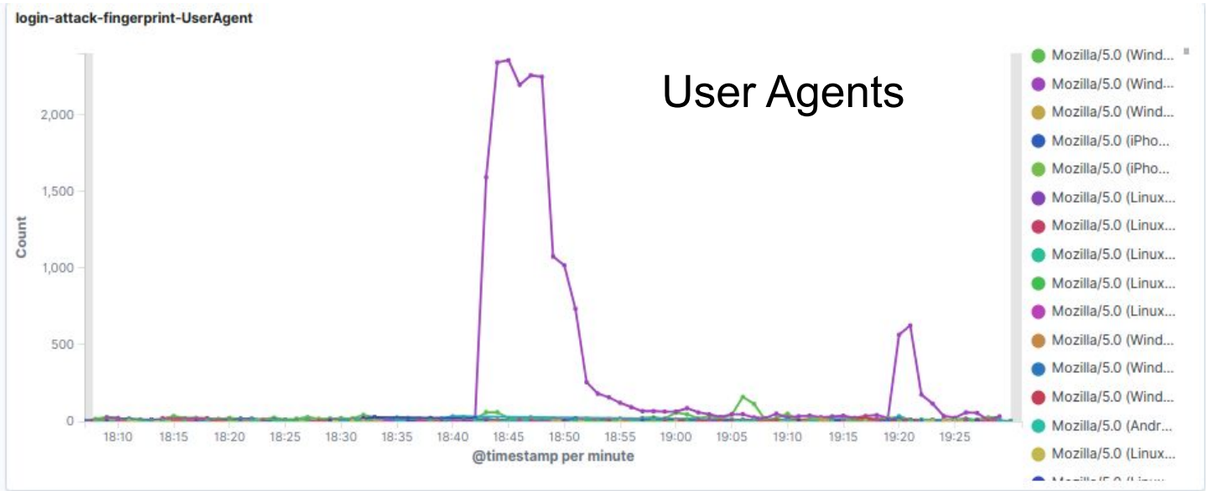
# Detecting and Blocking Distributed Attacks Manually

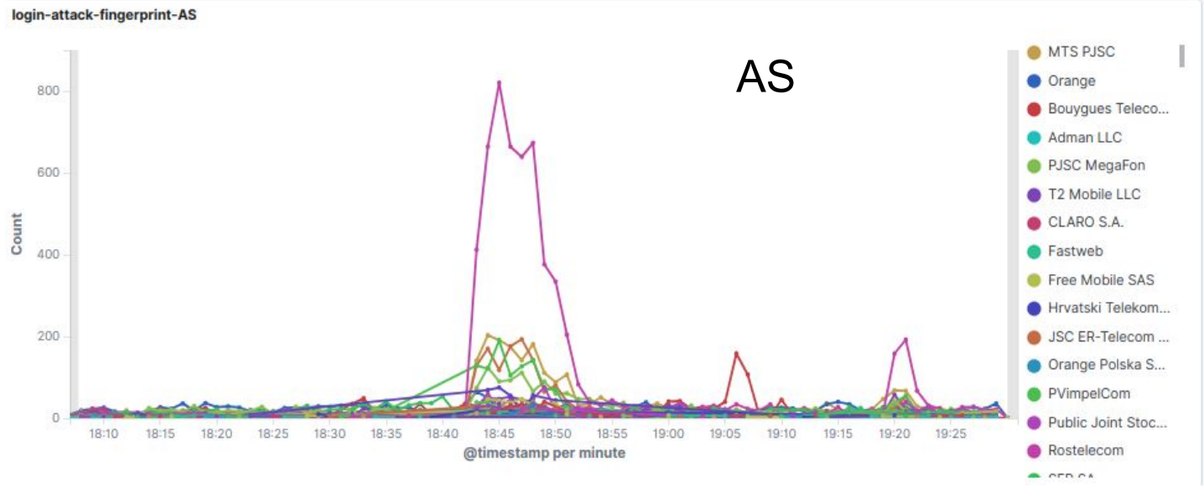
# Detect a Traffic Spike

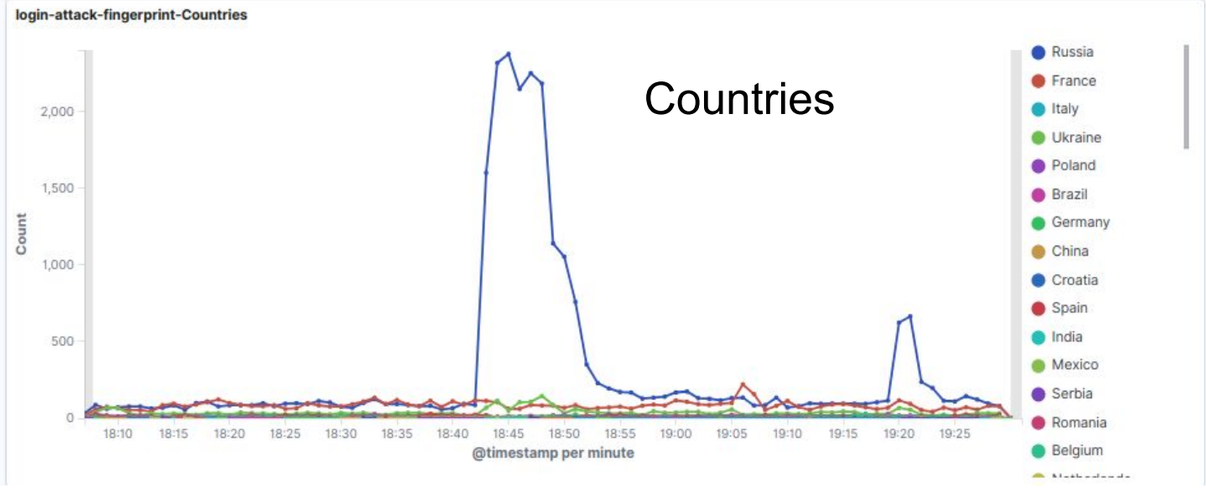


# Drill-Down on Different Features



# Derive Rules

Find a rule.

```
Country=Russia && User Agent=Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_3) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/99.0.4844.84 Safari/537.36
```

## How to automate the analysis?

# Detecting Distributed Attacks

# Detecting Distributed Attacks

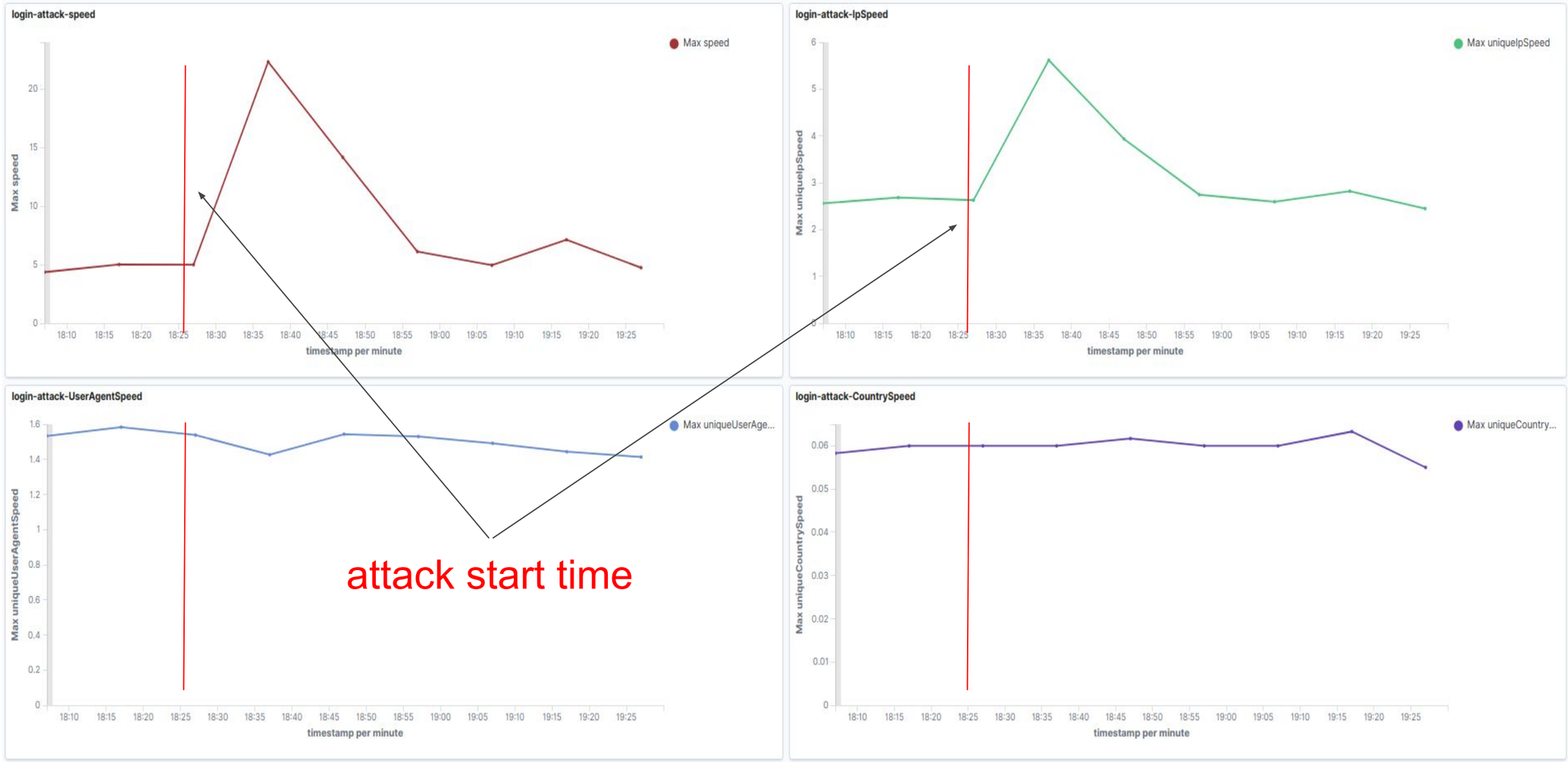
- Compute **aggregate statistics on login:**
  - Number of unique User Agents.
  - Number of unique IPs.
  - Number of sessions.

- Detect **anomalies** on the resulting **time-series using a z-score based anomaly detection algorithm.**

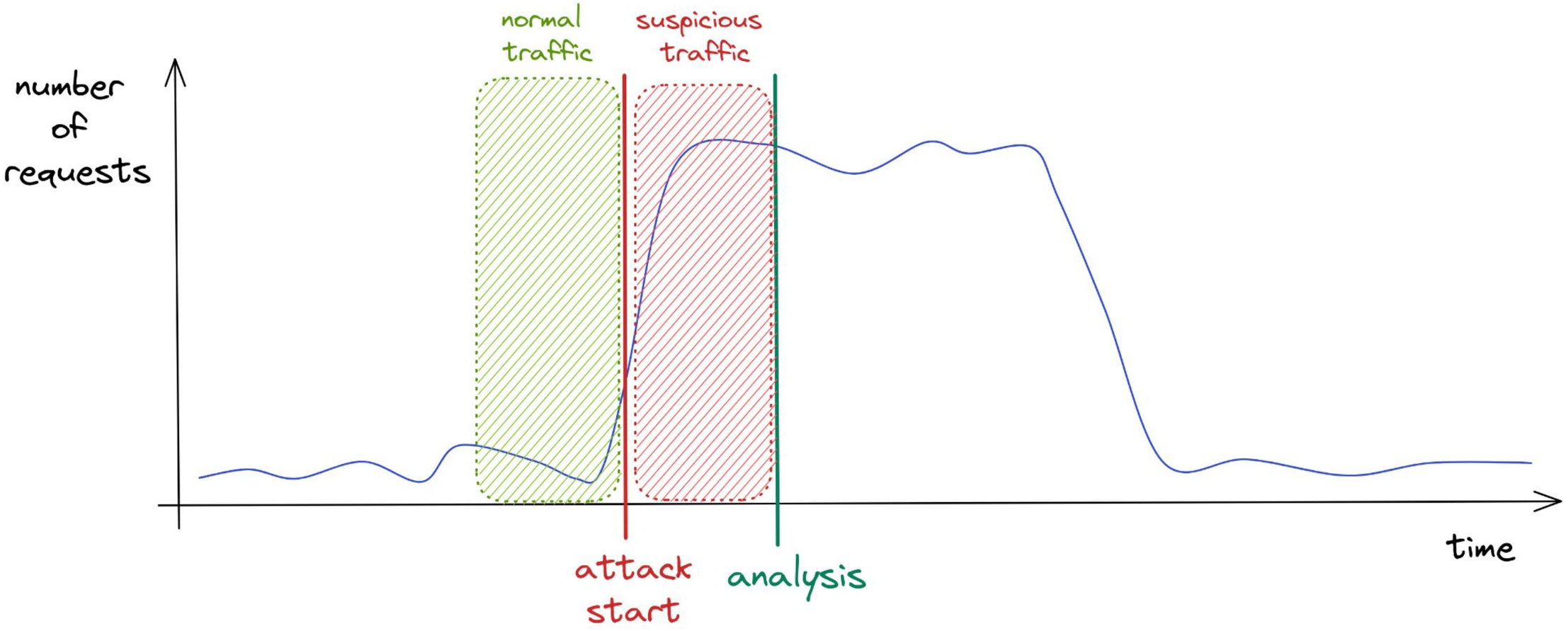
- **Push an event** describing the attack (customer, start time).

- Implemented in streaming (Apache Flink).

# Detecting Distributed Attacks



# General Idea



# Next Step: Automate Rule Generation

# Introducing Sliceline

# What is Sliceline?

Algorithm to find **slices** of data where an ML model performs badly.

| country | UA | IP type | error |
|---|---|---|---|
| FR | Chrome | residential | 0.1 |
| FR | Firefox | data_center | 0.2 |
| DE | Chrome | data_center | 0.9 |
| FR | Chrome | data_center | 0.8 |
| CN | Firefox | residential | 0.2 |
| CN | Chrome | residential | 0.1 |

**Slice:** a conjunction of conditions.

country = DE

UA=Firefox && IP type=data_center

*https://dl.acm.org/doi/10.1145/3448016.3457323*

# Generating Rules Using Sliceline

Use Sliceline to target groups of data instead of bad-performing slices.

| country | UA | IP type | group |
|---|---|---|---|
| FR | Chrome | residential | 0 |
| FR | Firefox | data_center | 0 |
| DE | Chrome | data_center | 1 |
| FR | Chrome | data_center | 1 |
| CN | Firefox | residential | 0 |
| CN | Chrome | residential | 0 |

Group definitions:

- **Human traffic** => group 0
- **Suspicious traffic** => group 1

# How does it really work?

- Searches for slices with large errors.
  → **Need a way to quickly compute slice errors.**

- Uses matrix algebra to evaluate slices.
  → **Can profit from optimized implementations of matrix multiplication.**

- Uses pruning to reduce the search space without accessing the data.
  → **Reduces memory access for large datasets.**

# Sliceline Internals: Encoding

| country | UA | IP type | error |
|---|---|---|---|
| FR | Chrome | residential | 0.1 |
| FR | Firefox | data_center | 0.2 |
| DE | Chrome | data_center | 0.9 |
| FR | Chrome | data_center | 0.8 |
| CN | Firefox | residential | 0.2 |
| CN | Chrome | residential | 0.1 |

1. One-hot encoding.

2. Express rules as binary vectors.

| country = FR | country = DE | country = CN | UA = Chrome | UA = Firefox | IP type = residential | IP type = data_center | error |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0.1 |
| 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0.2 |
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0.9 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0.8 |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0.2 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 | 1 |

# Sliceline Internals: Matching Rules With Matrix Multiplication

| country = FR | country = DE | country = CN | UA = Chrome | UA = Firefox | IP type = residential | IP type = data_center | error |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0.1 |
| 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0.2 |
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0.9 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0.8 |
| 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0.2 |
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0.1 |

F: feature matrix

E

X

| | |
|---|---|
| 0 | 0 |
| 1 | 0 |
| 0 | 0 |
| 0 | 1 |
| 0 | 0 |
| 0 | 0 |
| 0 | 1 |

R

| | |
|---|---|
| 0 | 0 |
| 0 | 0 |
| 1 | 1 |
| 0 | 1 |
| 0 | 0 |
| 0 | 0 |

F x R

country = DE UA=Firefox && IP type=data_center

# Sliceline Internals: Slice Errors

| error |
|---|
| 0.1 |
| 0.2 |
| 0.9 |
| 0.8 |
| 0.2 |
| 0.1 |

E

L = FxR

| | |
|---|---|
| 0 | 0 |
| 0 | 0 |
| 1 | 1 |
| 0 | 1 |
| 0 | 0 |
| 0 | 0 |

country = DE  UA=Firefox &&
IP type=data_center

$E^T$ x L

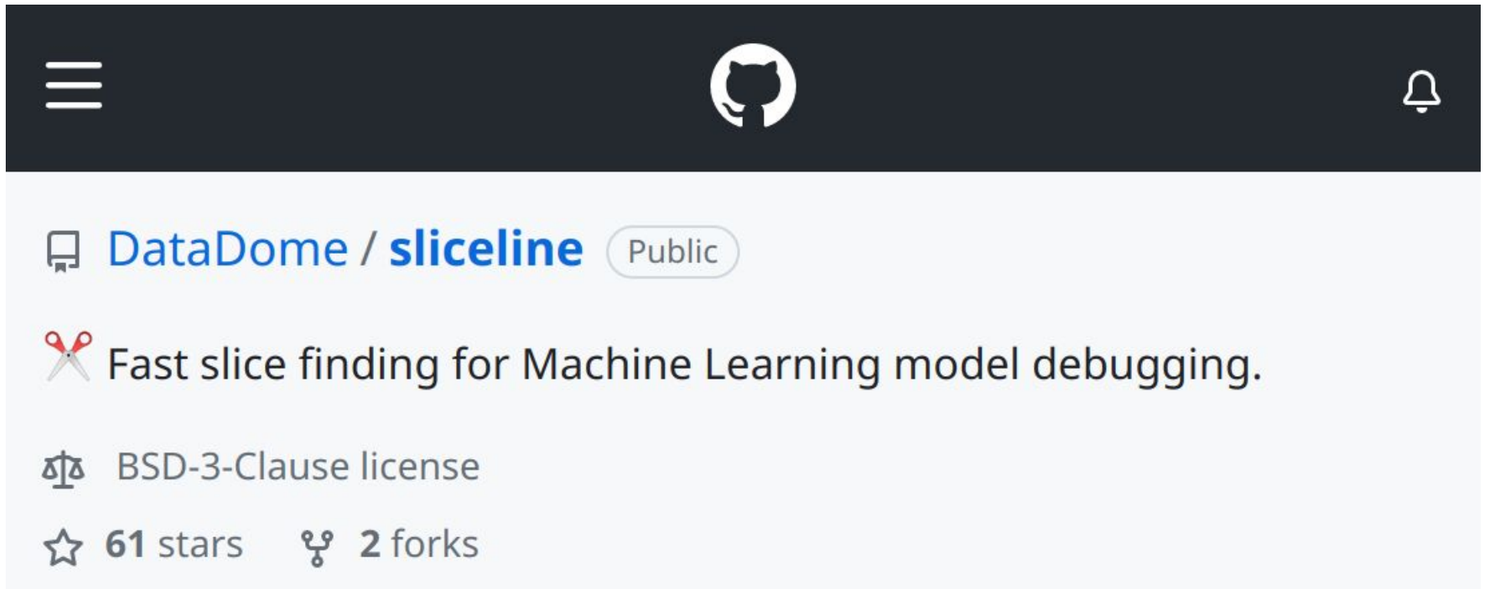
| | |
|---|---|
| total slice error | 0.9 \| 1.7 |

$I^T$ x L

| | |
|---|---|
| slice size | 1 \| 2 |

| | |
|---|---|
| mean slice error | 0.9 \| 0.8.5 |

# Open Source Package




Original algorithm implemented in R.

Implemented in Python:

- Rewrote some part of R implementation using **matrix multiplications**.
- Leverage **numpy optimizations**.
- Compatible with pandas.

**Speed up > x 1000**

Syntax-agnostic: can generate **rules for any rule-engine**.

# Code Example

| User Agent | User Agent Version | Country | Accept Language | Headers List | Autonomous System | Accept Header | group |
|---|---|---|---|---|---|---|---|
| Chrome | 111.0 | Germany | en-US,en;q=0.9 | host,user-agent,sec-ch-ua,sec-ch-ua-mobile,sec... | Vodafone GmbH | text/html,application/xhtml+xml,application/xm... | 1 |
| Chrome | 111.0 | Germany | en-US,en;q=0.9 | host,user-agent,sec-ch-ua,sec-ch-ua-mobile,sec... | First Root UG (haftungsbeschraenkt) | text/html,application/xhtml+xml,application/xm... | 1 |
| Chrome | 111.0 | Germany | en-US,en;q=0.9 | host,user-agent,sec-ch-ua,sec-ch-ua-mobile,sec... | First Root UG (haftungsbeschraenkt) | text/html,application/xhtml+xml,application/xm... | 1 |
| Chrome | 111.0 | Germany | en-US,en;q=0.9 | host,user-agent,sec-ch-ua,sec-ch-ua-mobile,sec... | Hivelocity Inc | text/html,application/xhtml+xml,application/xm... | 1 |
| Chrome | 110.0 | Germany | en-US,en;q=0.9 | host,user-agent,sec-ch-ua,sec-ch-ua-mobile,sec... | M247 Europe SRL | text/html,application/xhtml+xml,application/xm... | 1 |
| ... | ... | ... | ... | ... | ... | ... | ... |
| Chrome | 112.0 | France | fr,fr-FR;q=0.9,en;q=0.8,en-GB;q=0.7,en-US;q=0.6 | content-length,sec-ch-ua,sec-ch-ua-platform,se... | Orange | */* | 0 |
| Chrome Mobile | 112.0 | France | fr-FR,fr;q=0.9,en-US;q=0.8,en;q=0.7 | host,user-agent,content-length,cookie,sec-ch-u... | Free SAS | application/json | 0 |
| Chrome | 111.0 | France | en-US,en;q=0.9 | host,user-agent,content-length,sec-ch-ua,conte... | Free SAS | */* | 0 |
| Chrome | 109.0 | France | fr-FR,fr;q=0.9,en-US;q=0.8,en;q=0.7 | host,user-agent,cookie,sec-ch-ua,sec-ch-ua-mob... | Orange | text/html,application/xhtml+xml,application/xm... | 0 |
| Chrome | 112.0 | France | fr-FR,fr;q=0.9,en-US;q=0.8,en;q=0.7 | host,user-agent,cookie,sec-ch-ua,x-datadome-cl... | Orange | */* | 0 |

**Example Dataset:**

- Gathered from a French e-commerce website.
- Human traffic (group 0): requests with old session.
- Suspicious traffic (group 1): requests from non french speaking countries and datacenter IPs.

# Code Example

```
sf = Slicefinder(
    alpha = 0.80,
    k = 4,
    max_l = df.shape[1],
    min_sup = 1,
    verbose = True
)

sf.fit(df.drop("group", axis=1), df["group"])
```

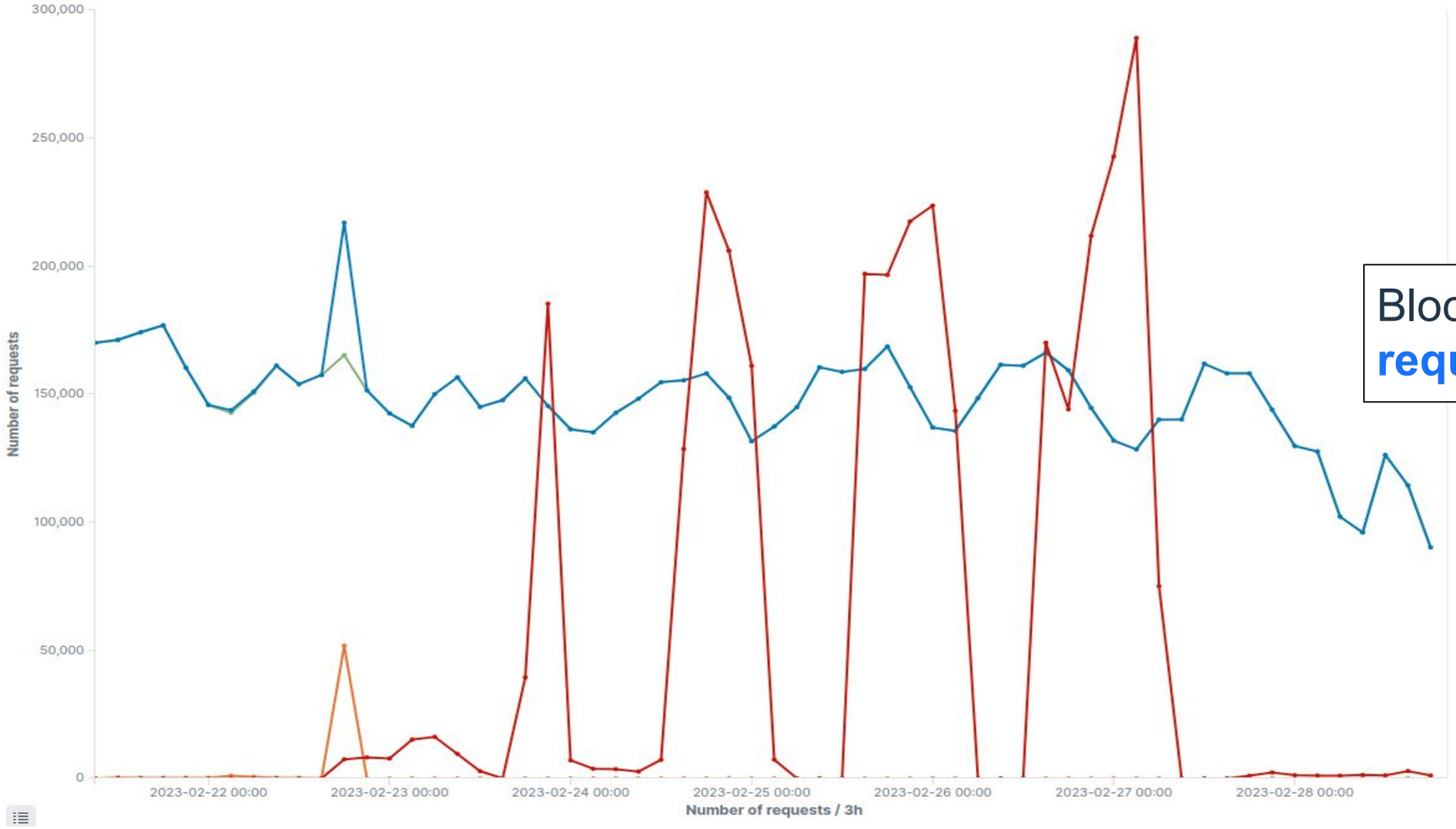
Apply the algorithm with 2 lines of code!

Get rules in the format you want!

```
for slice, stats in zip(sf.top_slices_, sf.top_slices_statistics_):
    rule = None
    for feat, value in zip(df.columns, slice):
        if value is not None:
            if rule is None:
                rule = f"`{feat}`=`{value}`"
            else:
                rule += f" && `{feat}`=`{value}`"
    print(f"{rule} | slice size: {stats['slice_size']}")
```

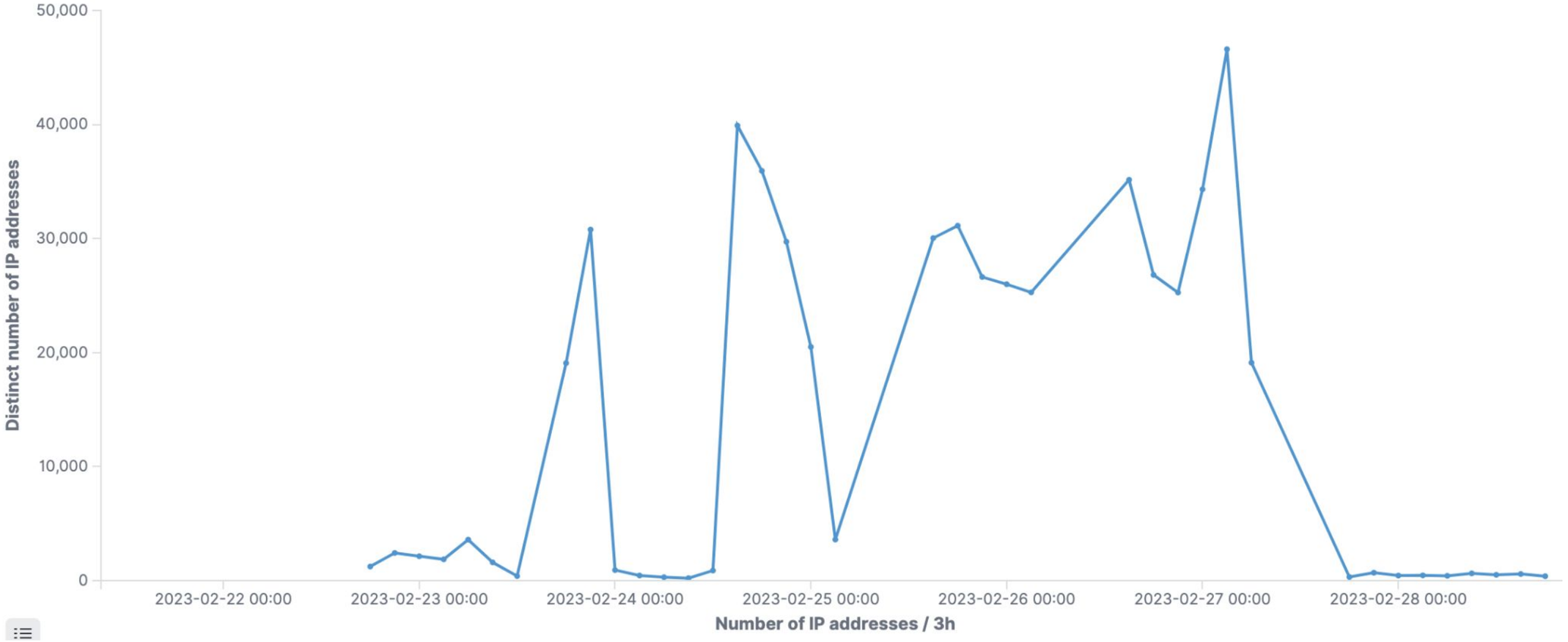
```
`Country`=`Germany` | slice size: 4149.0
`User Agent`=`Chrome` && `Country`=`Germany` | slice size: 4133.0
`Country`=`Germany` && `Accept Language`=`en-US,en;q=0.9` | slice size: 4097.0
`User Agent`=`Chrome` && `Country`=`Germany` && `Accept Language`=`en-US,en;q=0.9` | slice size: 4097.0
```

# Credential Stuffing Attack on Gaming Platform




Blocked more than **3M requests** in a week.

# Heavily Distributed Attack: > 187k IP Addresses



# Takeaways

Approach to **detect distributed attacks** using traffic aggregations and anomaly detection.

We leverage Sliceline to **infer malicious signatures and to generate rules**.

Efficient against **bots that frequently adapt** and modify/forge their fingerprints.

Sliceline **can be applied to other security use cases** that rely on a rule engine.

# Contact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