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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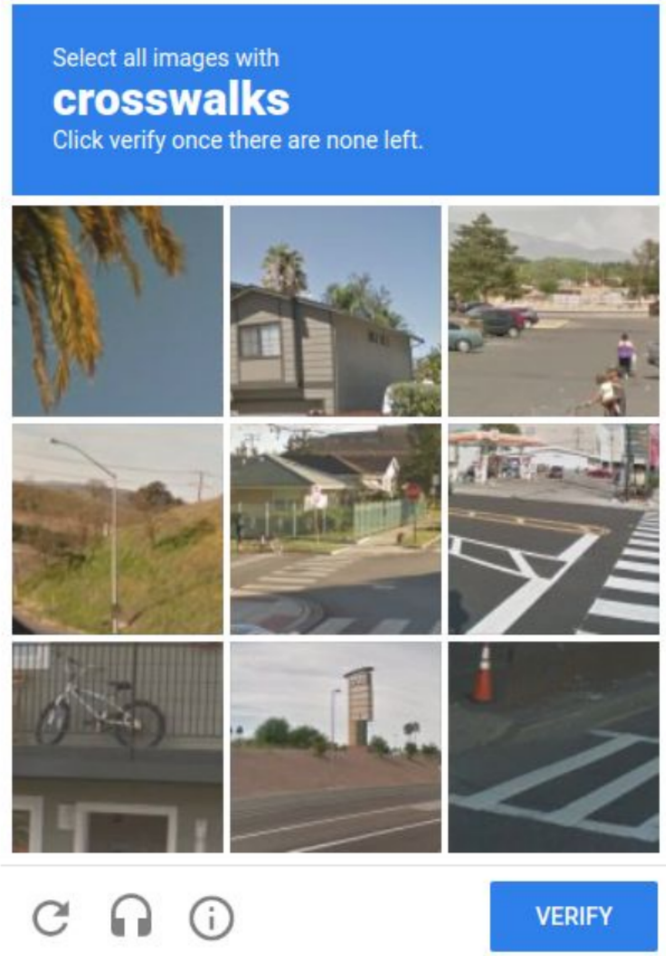
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VERIFY

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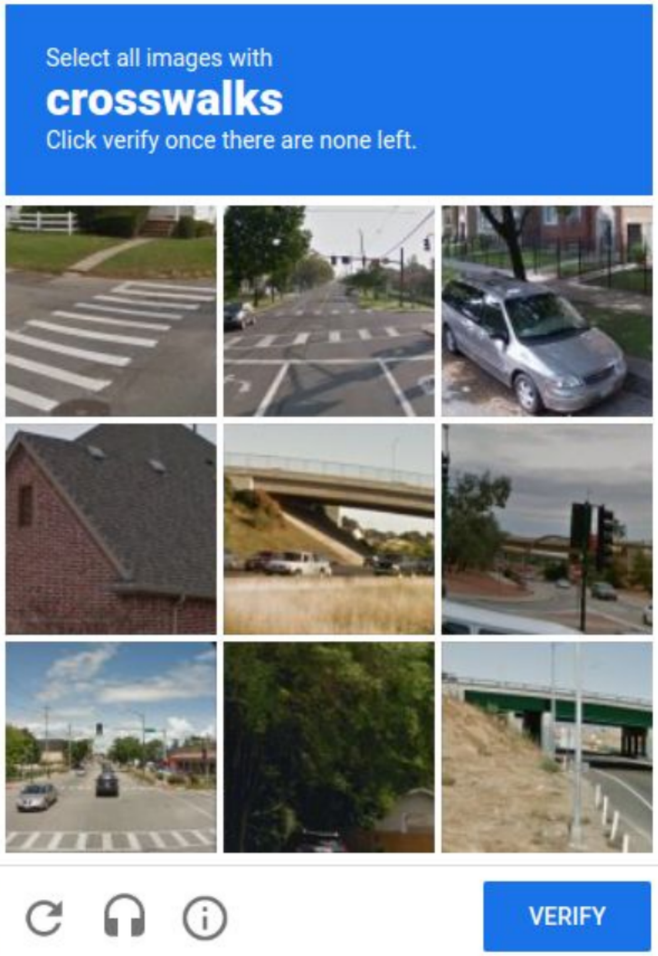
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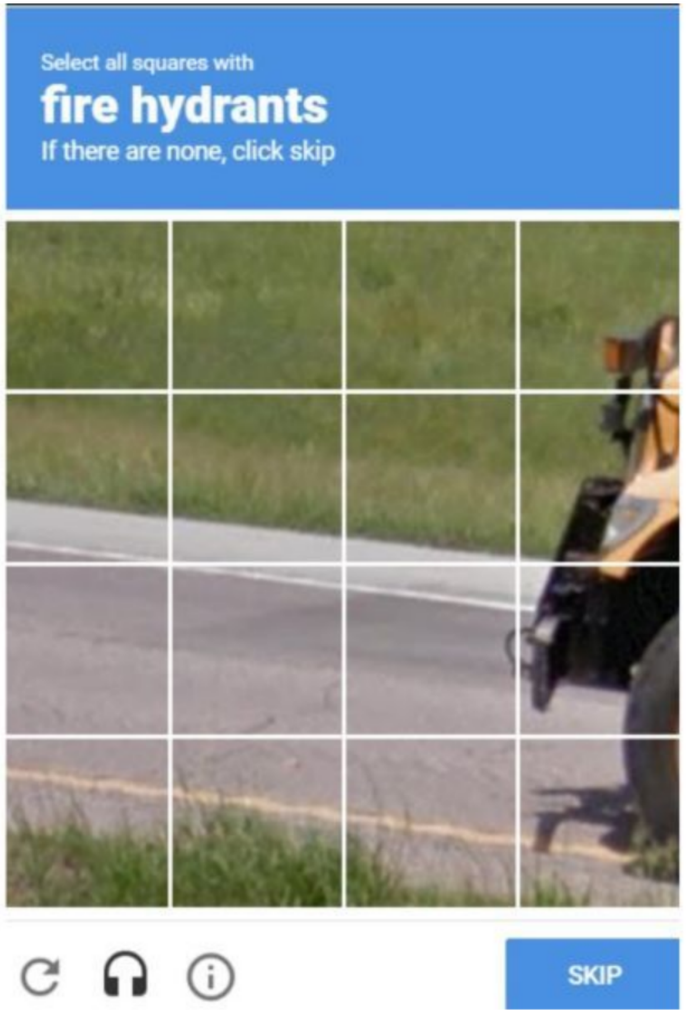
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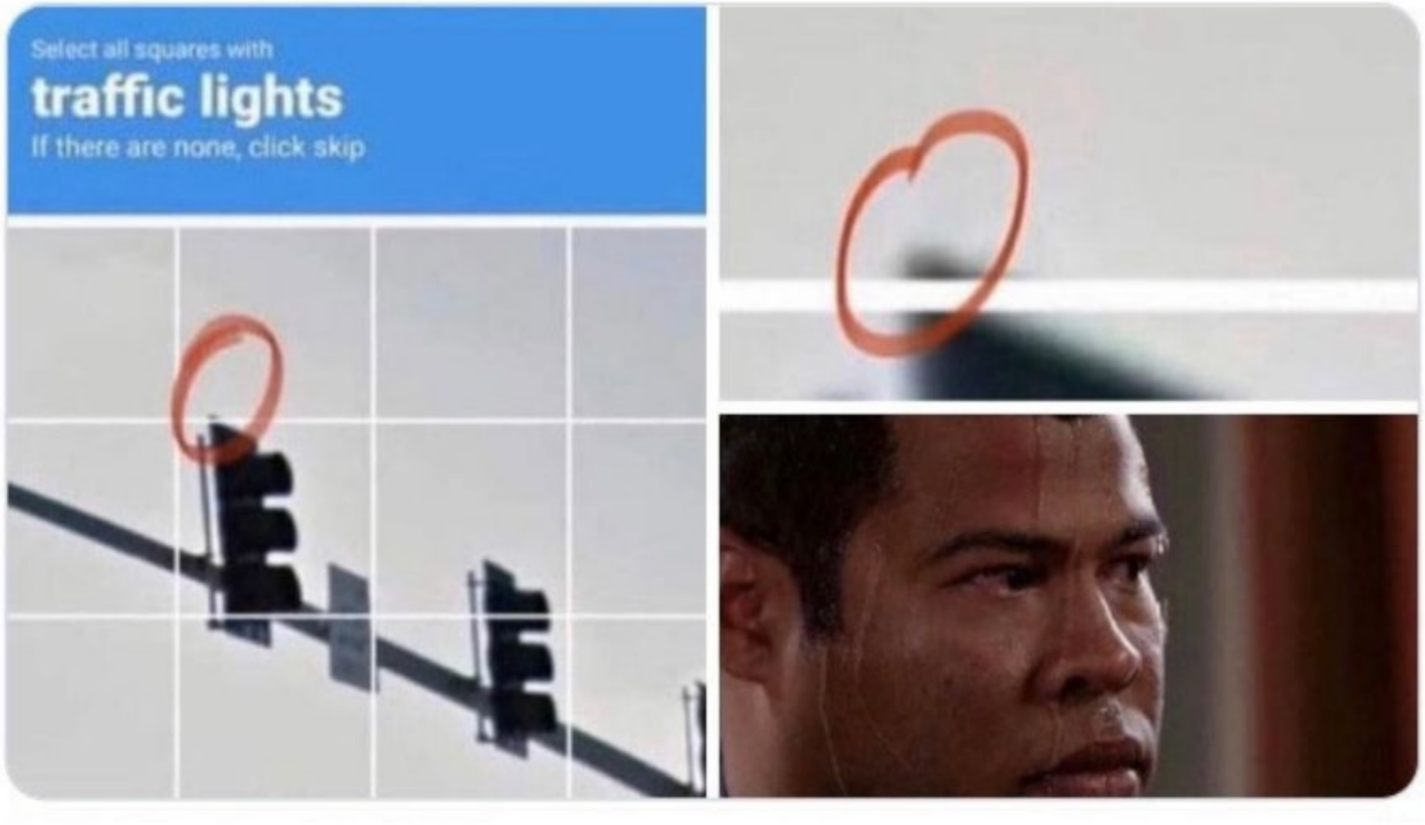
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traffic lights
If there are none, click skip

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

node	python	GO
Axios	Aiohttp	net/http
Got	Requests	

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_

chromium / chrome / test / chromedriver / js / call_function.js

459 lines (426 loc) · 14 KB Blame Raw

```
/**
 * Returns the global object cache for the page.
 * @param {Document=} opt_doc The document whose cache to retrieve. Defaults to
 *     the current document.
 * @return {!Cache} The page's object cache.
 */
function getPageCache(opt_doc, opt_w3c) {
  var doc = opt_doc || document;
  var w3c = opt_w3c || false;
  // |key| is a long random string, unlikely to conflict with anything else.
  var key = '$cdc_asdjflasutopfhvcZLmcfl_';
  if (w3c) {
    if (!(key in doc))
      doc[key] = new CacheWithUUID();
    return doc[key];
  } else {
    if (!(key in doc))
      doc[key] = new Cache();
    return doc[key];
  }
}
```

Bypass Techniques Used by Bots

Forge TLS fingerprints.

CYCLETLS

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).

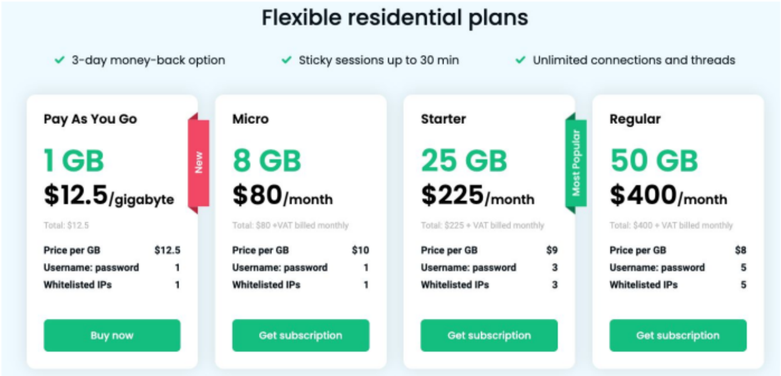
Bypass Techniques Used by Bots

Distribute attack using **proxies**:

→ Avoid IP-based rate limiting.

Distribute attack using **residential proxies**:

→ Avoid reputation-based blocking.

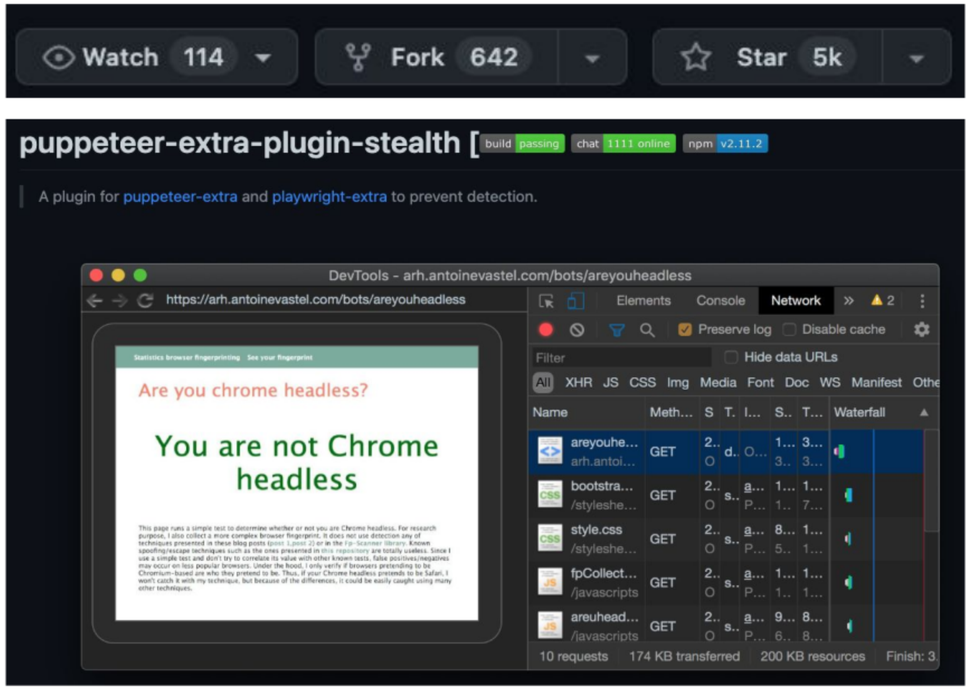


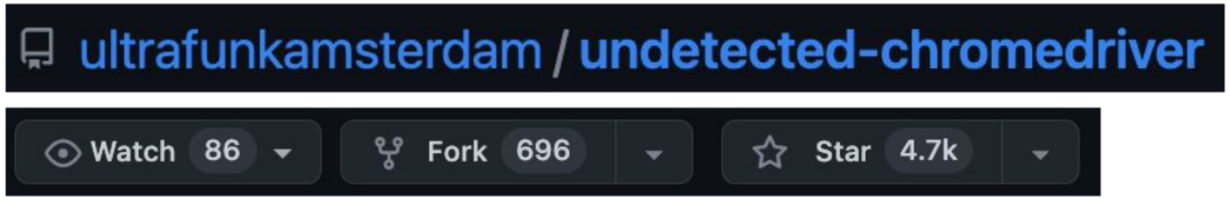
Distribute attack using **residential proxies located in same country as website targeted**:

→ 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.

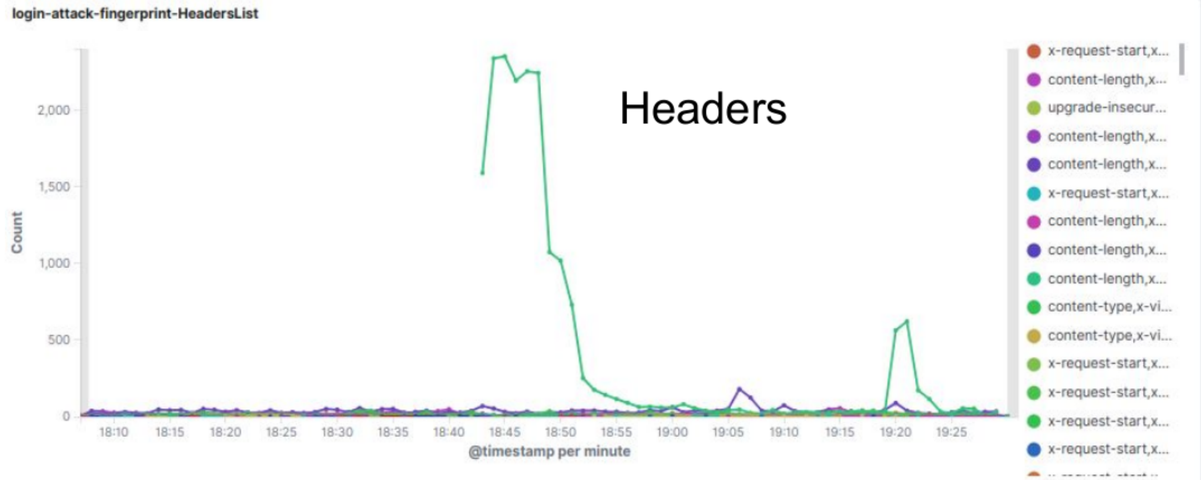
Constantly change and forge their signatures/fingerprints.

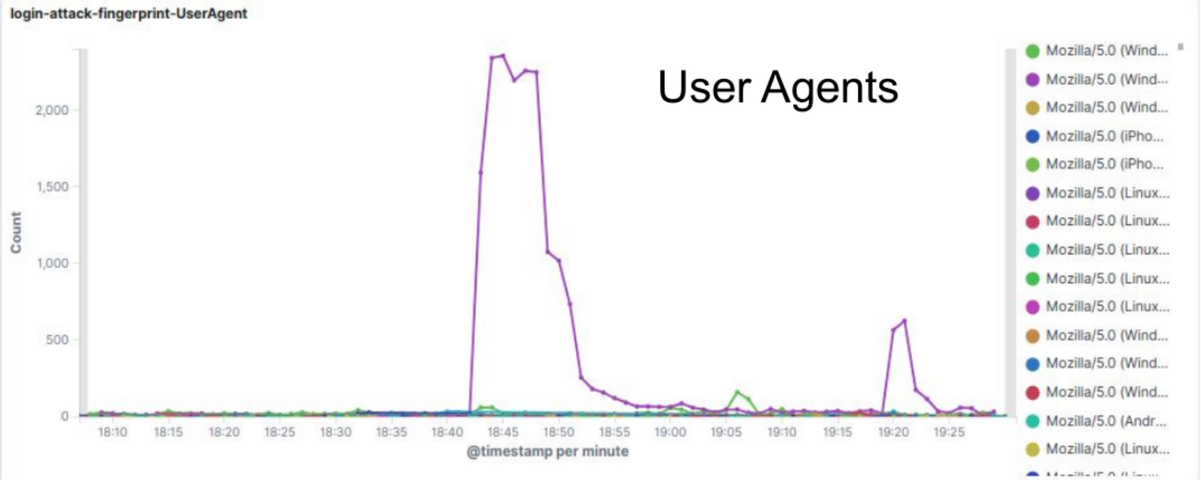
Q: How to block these ever-evolving and distributed bots?

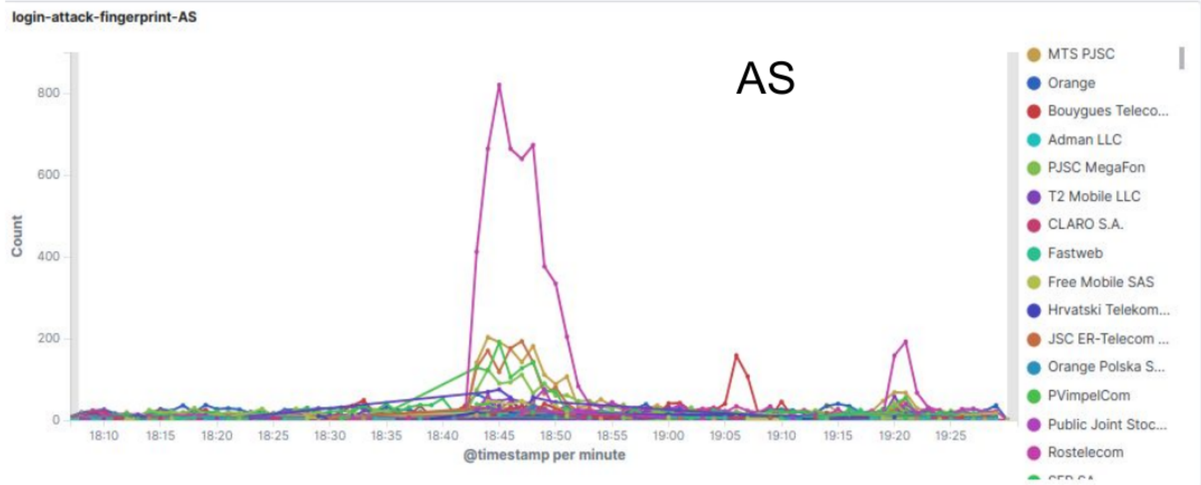
Detecting and Blocking Distributed Attacks Manually

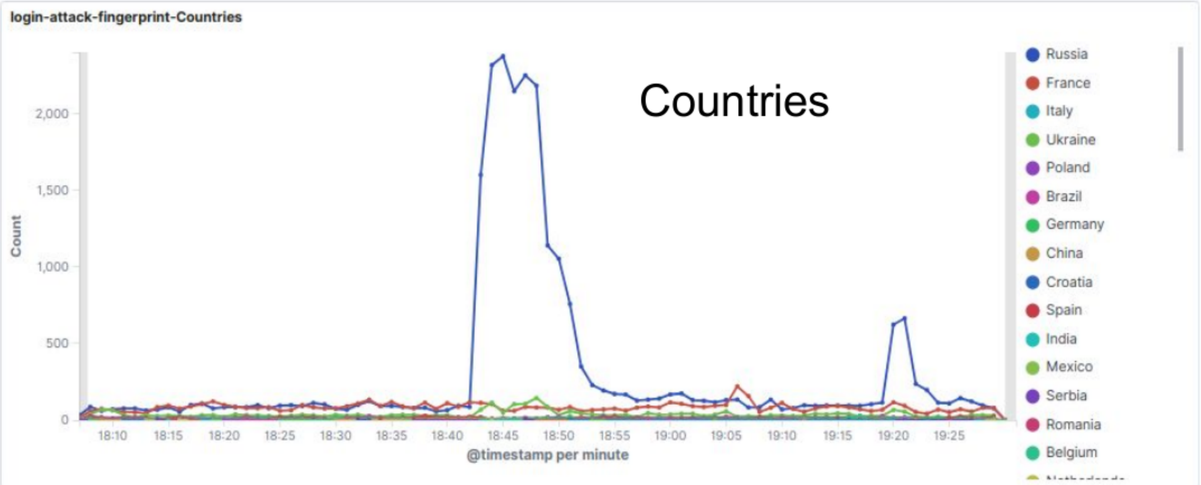
Detect a Traffic Spike

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
```

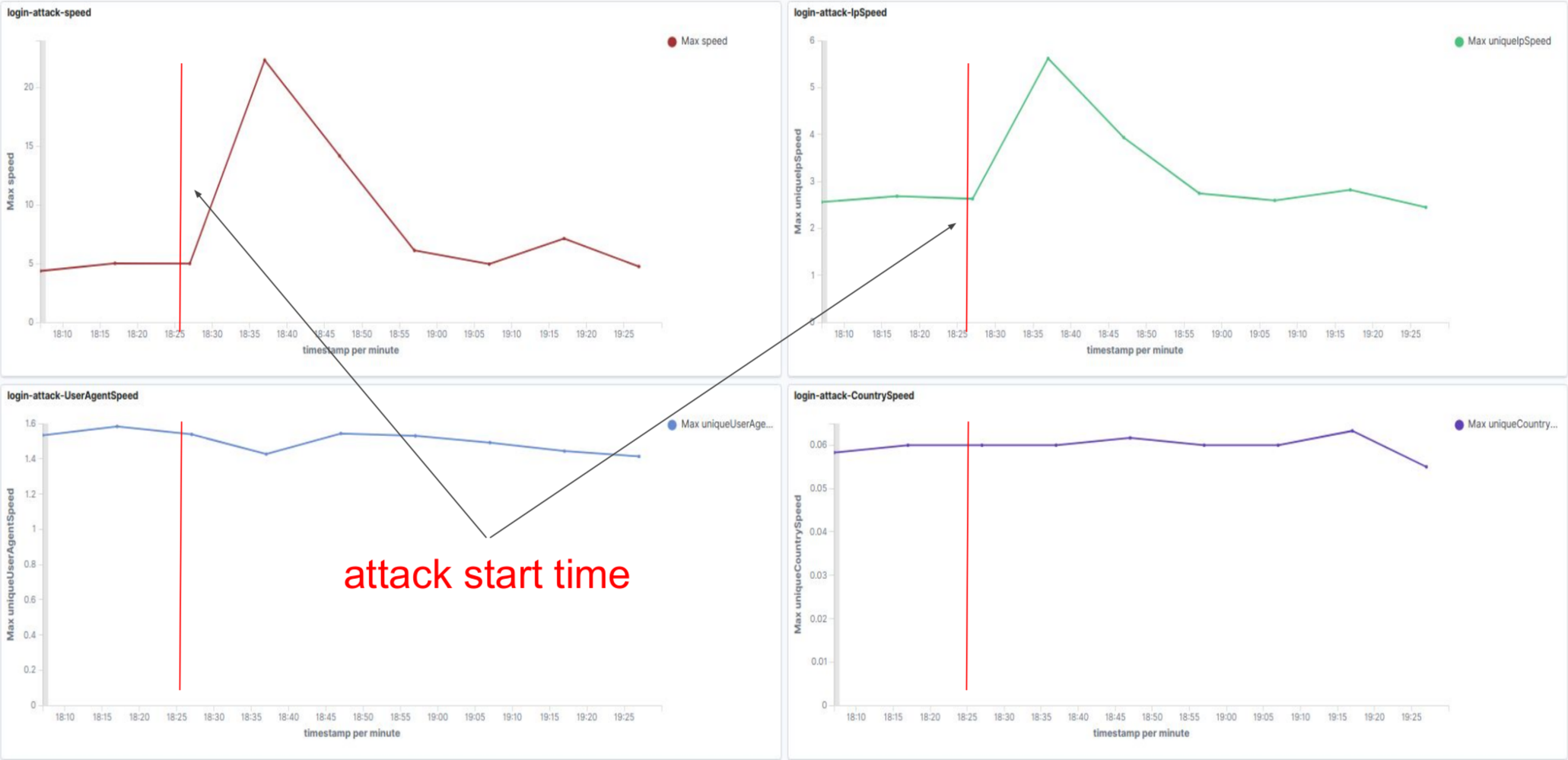
How to automate the analysis?

Detecting Distributed Attacks

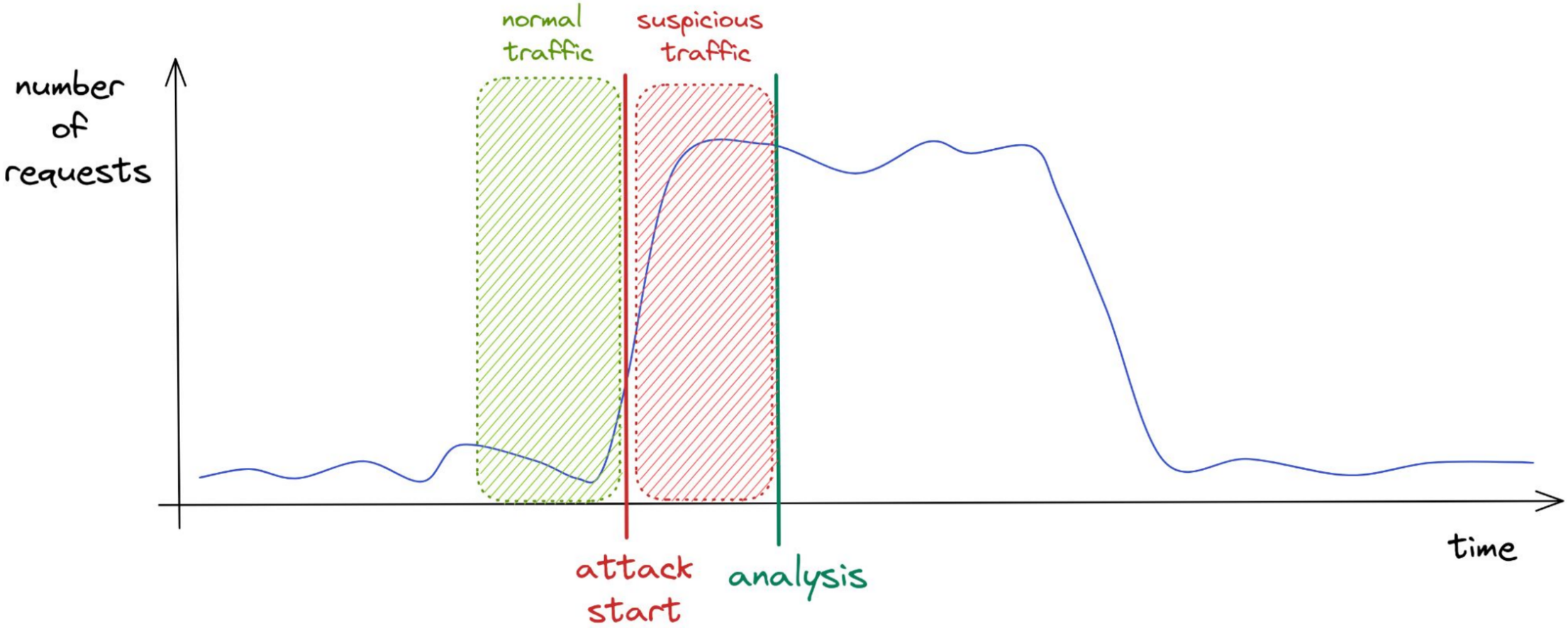
Detecting Distributed Attacks

- 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).

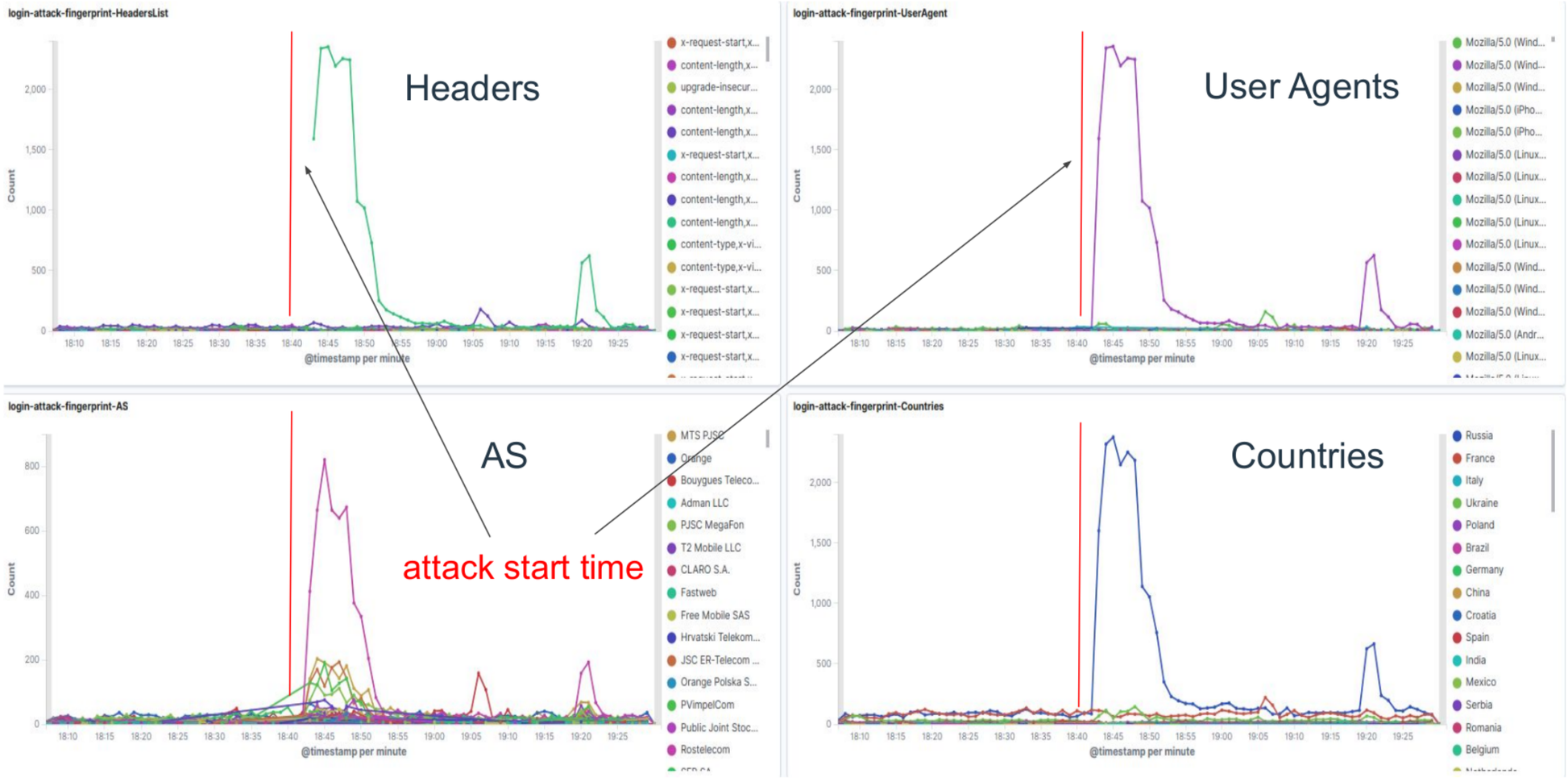
Detecting Distributed Attacks



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

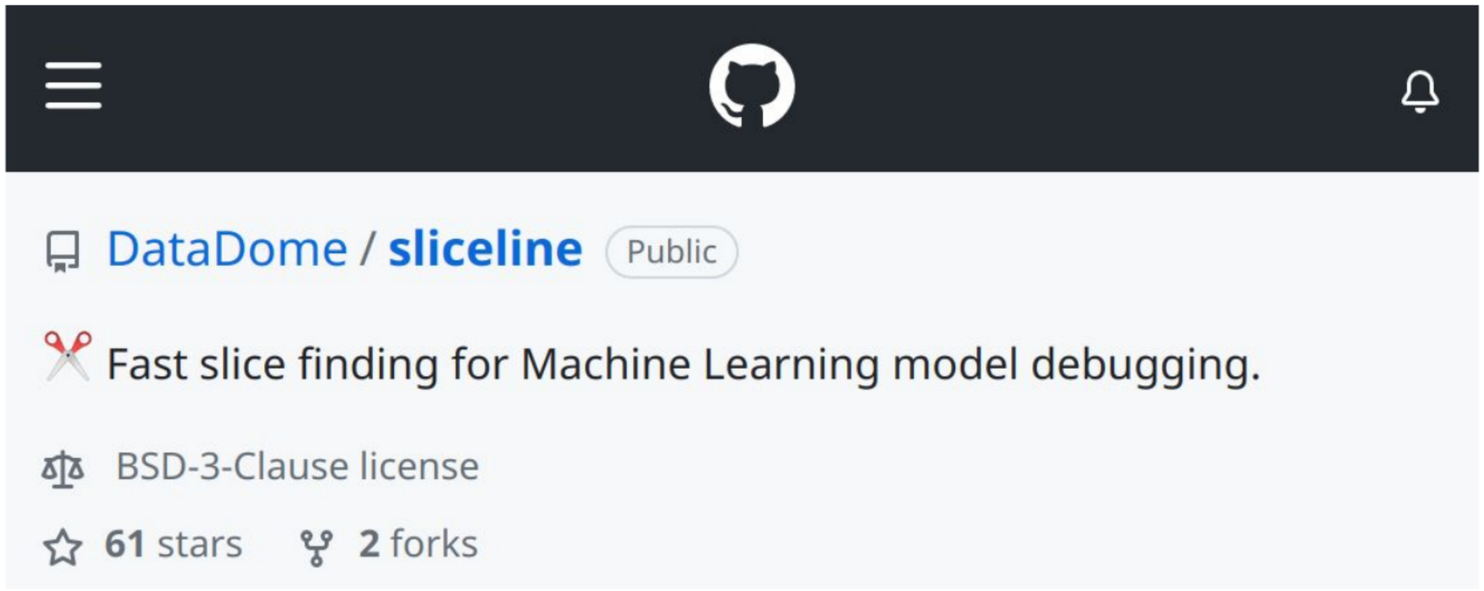
total slice error	0.9	1.7

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"])
```

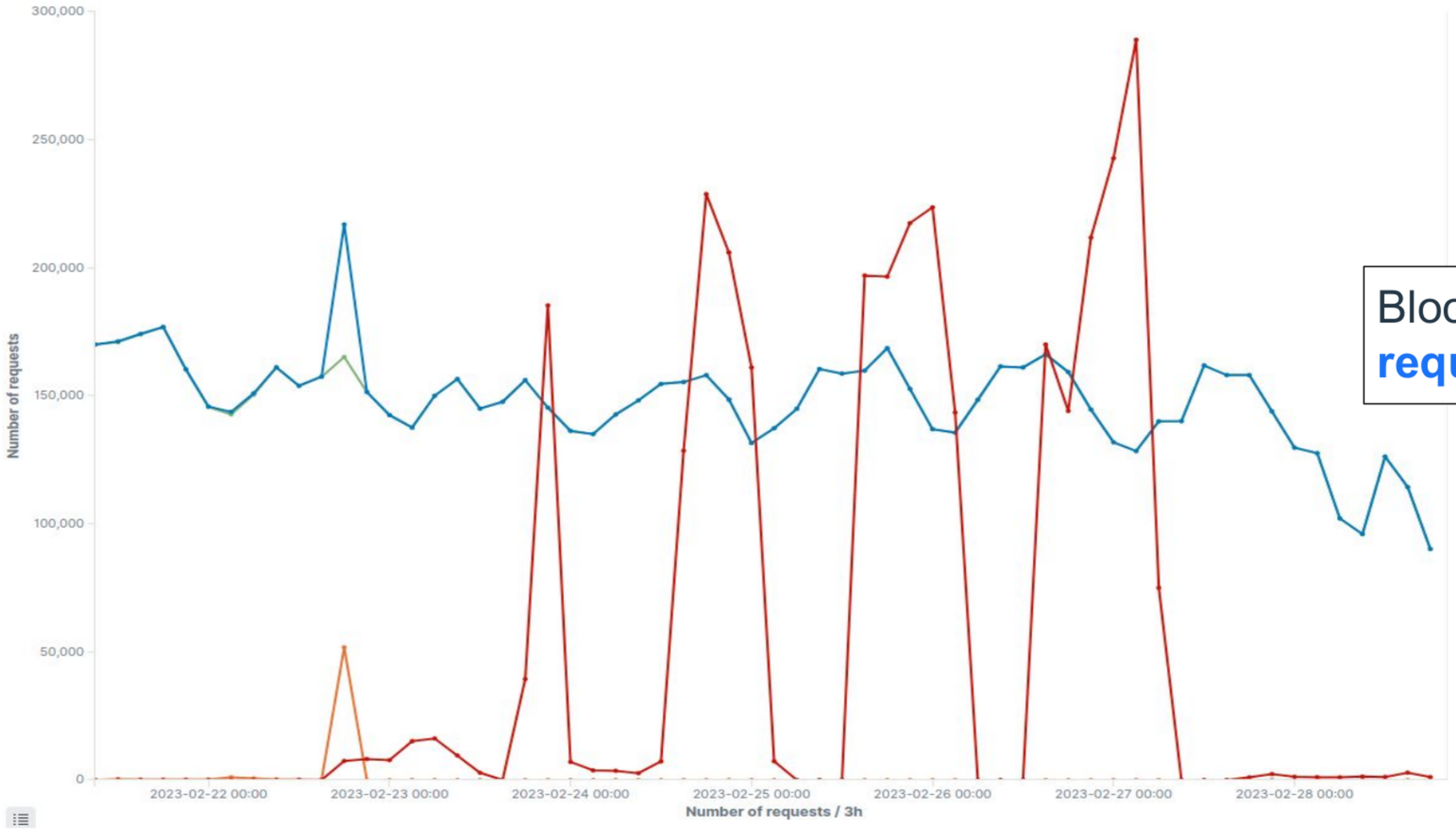
Apply the algorithm with 2 lines of code!

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']}")
```

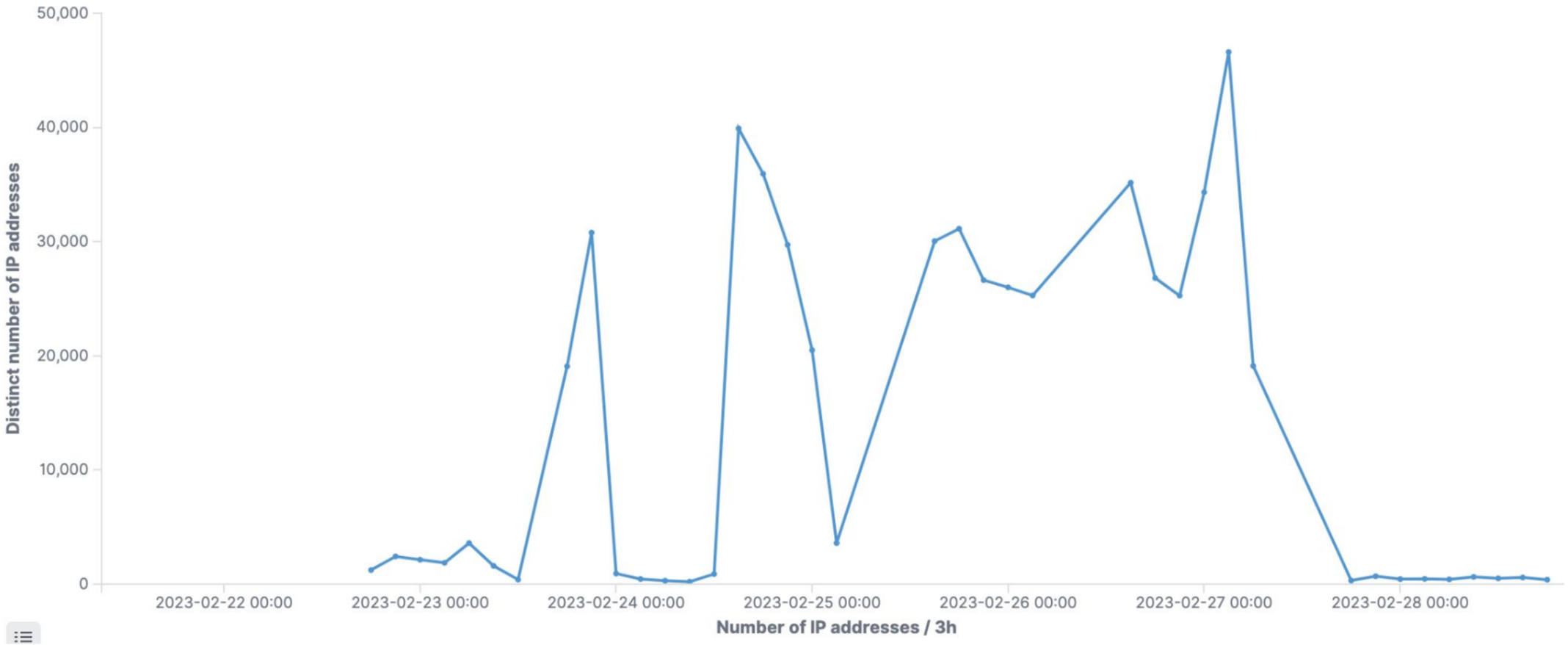
```
`Country`=`Germany` | slice size: 4149.0
`User Agent`=`Chrome` && `Country`=`Germany` | slice size: 4133.0
`Country`=`Germany` && `Accept Language`=`en-US,en;q=0.9` | slice size: 4097.0
`User Agent`=`Chrome` && `Country`=`Germany` && `Accept Language`=`en-US,en;q=0.9` | slice size: 4097.0
```

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

DATADOME

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