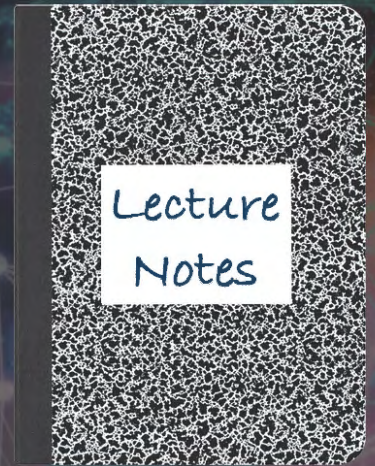


CS 419: Computer Security

Week 1: Part 2

Security Goals & Threats



Paul Krzyzanowski

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Security Goals

Prevention: prevent attackers from violating the security policy

- Implement mechanisms that users cannot override
- *Example: ask for a password*

Detection: detect & report attacks

- Important when prevention fails
- Indicates & identifies weaknesses in prevention
- Also: detect attacks even if prevention is successful

Recovery: stop the attack, repair the damage

- ... Or continue to function correctly even if an attack succeeds
- **Forensics:** identify what happened so you can fix it
- *Example: restoration from backups*

Policies & Mechanisms

Policy: what is or is not allowed

- Can be expressed in natural language (“this is our security policy”)
- ... or formally via mathematics
- **Policy language** – goal is to provide precision together with ease of understanding

Mechanisms: implement and enforce policies

- E.g., password entry & authentication

- *What mechanisms do we need to secure a system?*
- *What level of assurance is associated with them?*

Security Engineering

- **Security Architecture**
 - How do we put a secure system together?
 - How do we identify potential weaknesses?
- **Security Engineering**
 - Implement mechanisms & policy into a system
- **Engineering = making compromises**
 - Understand tradeoffs
 - Security vs. cost, performance, acceptability, usability
 - Cost-benefit analysis
 - Is it cheaper to prevent an attack or recover?
 - Who pays & who gets punished?

Microsoft and the device manufacturer and installer exclude all implied warranties and conditions, including those of merchantability, fitness for a particular purpose, and non-infringement. you may not under this limited warranty, under any other part of this agreement, or under any theory, recover any damages or other remedy, including lost profits or direct, consequential, special, indirect, or incidental damages.

Microsoft Windows 10 End-User License Agreement

Protection: Know Your Enemy!

Different attackers
... have different goals
... and different skill levels



“If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle.”

— Sun Tzu, The Art of War

Who do we want to – or need to – guard against?

What are you securing your system against?

And from whom?

- You accidentally deleting important system files?
- Your colleagues not being able to look at your files on a file server?
- A company trying to find out about you and get personal data?
- A phone carrier tracking your movement?
- A grenade destroying your system?
- Video surveillance on streets?
- The NSA?

Risk analysis

Should we protect something?

- If so, how carefully?
- And how much should we spend?

Laws & customs

- **Are any security measures illegal?**
 - Example: types of encryption
- **Are any measures unlikely to be used?**
 - Examples: retina scans, urine tests
 - Conformance: balance security vs. effort

Definitions

Vulnerability

A weakness in the implementation or operation of a system: a bad policy or a bug

Exploit

Software, commands, or instructions to take advantage of a vulnerability

Attack Vector

The type of attack – the technique that's used to attack the system

Attack (cyber attack)

The use of an exploit via the attack vector to subvert security policies and mechanisms

Threat

An adversary that is capable of attacking

Attack surface

All the attack vectors in the system

We need to be aware of the attack surface of an environment

- Otherwise, we don't know what to defend
- If possible, reduce the attack surface: that way, there will be less to protect

Vulnerabilities

- Failures in the system
- Bugs
- Big focus in security classes

What if a system had no vulnerabilities?

Would you not worry about threats?

Some vulnerabilities can be really old

16-Year-Old HP Printer-Driver Bug Impacts Millions of Windows Machines



The bug could allow cyberattackers to bypass security products, tamper with data and run code in kernel mode.

Tara Seals • July 20, 2021

Researchers have released technical details on a high-severity privilege-escalation flaw in HP printer drivers (also used by Samsung and Xerox), which impacts hundreds of millions of Windows machines.

If exploited, cyberattackers could bypass security products; install programs; view, change, encrypt or delete data; or create new accounts with more extensive user rights.

The bug (CVE-2021-3438) has lurked in systems for 16 years, researchers at SentinelOne said, but was only uncovered this year. It carries an 8.8 out of 10 rating on the CVSS scale, making it high-severity.

<https://threatpost.com/hp-printer-driver-bug-windows/167944/>

Some vulnerabilities can be really old

Hack Brief: Microsoft Warns of a 17-Year-Old 'Wormable' Bug



The SigRed vulnerability exists in Windows DNS, used by practically every small and medium-sized organization in the world.

Andy Greenberg • July 14, 2020

Since Wannacry and NotPetya struck the internet just over three years ago, the security industry has scrutinized every new Windows bug that could be used to create a similar world-shaking worm. Now one potentially "wormable" vulnerability—meaning **an attack can spread from one machine to another with no human interaction**—has appeared in Microsoft's implementation of the domain name system protocol, one of the fundamental building blocks of the internet.

As part of its Patch Tuesday batch of software updates, Microsoft today released a fix for a bug discovered by Israeli security firm Check Point, which the company's researchers have named SigRed. **The SigRed bug exploits Windows DNS, one of the most popular kinds of DNS software that translates domain names into IP addresses.** Windows DNS runs on the DNS servers of practically every small and medium-sized organization around the world. The bug, Check Point says, has existed in that software for a remarkable 17 years.

Check Point and Microsoft warn that **the flaw is critical, a 10 out of 10 on the common vulnerability scoring system,** an industry-standard severity rating.

Lots of systems aren't updated

You've still not patched it? Hackers are using these old software flaws to deliver ransomware



Significant vulnerabilities like Log4j have been the focus of cybersecurity staff - but that focus could be allowing attackers to slip by using older security bugs.

Danny Palmer • February 8, 2022

The focus on Log4j, described at the time as one of the most serious cybersecurity vulnerabilities to ever emerge, was understandably the key issue for enterprise cybersecurity teams in the final weeks of 2021.

...

But cybersecurity researchers at Digital Shadows have detailed several other vulnerabilities that appeared last year – or that are even older and continue to be left unpatched and exploited – which may have been missed and continue to provide opportunities for cyber criminals.

...

Failure to patch these vulnerabilities could have potentially dangerous consequences for businesses as malicious hackers exploit them to launch ransomware attacks, malware campaigns and other cyber-criminal activity.

In total, researchers identified 260 vulnerabilities being actively exploited for attacks in the final quarter of 2021 – and a third of them, a total of 87 vulnerabilities, being used in association with ransomware campaigns.

<https://www.zdnet.com/article/youve-still-not-patched-it-hackers-are-using-these-old-software-flaws-to-deliver-ransomware/>

Lots of systems aren't updated

Hackers are using this old trick to dodge security protections



CVE-2015-2291 is a years-old security vulnerability - but cyber criminals are still able to take advantage of unpatched systems to compromise networks.

Danny Palmer • January 13, 2023

Cyber criminals are exploiting an old vulnerability in Intel drivers in an attempt to gain access to networks in a way that allows them to bypass cybersecurity protections.

...

Once inside a network, Scattered Spider uses a technique that CrowdStrike describes as 'Bring Your Own Vulnerable Driver' (BYOVD), which targets loopholes in Windows security.

While Microsoft attempts to limit the capabilities of malware gaining access to systems by preventing unsigned kernel-mode drivers to be run by default, attackers can get around this with BYOVD, which enables them to install a legitimately signed but malicious driver to carry out attacks.

...

One of the ways they do this operation as stealthily as possible is by not using malware, but instead installing a range of legitimate remote access tools to ensure persistence on the compromised system.

According to analysis by CrowdStrike, the attackers are delivering malicious kernel drivers through a vulnerability in the Intel Ethernet diagnostics driver for Windows (tracked as CVE-2015-2291).

<https://www.zdnet.com/article/hackers-are-using-this-old-trick-to-dodge-security-protections/>

Lots of systems aren't updated

Nation state hackers exploited years-old bug to breach a US federal agency



Carly Page • March 16, 2023

The U.S. government has warned that multiple cybercriminal gangs, including a nation state-backed hacking group, exploited a four-year-old software vulnerability in order to compromise a U.S. federal government agency.

A joint alert released by the CISA, the FBI and the Multi-State Information Sharing and Analysis Center (known as MS-ISAC) on Wednesday revealed that hackers from multiple hacking groups exploited known vulnerabilities in Telerik, a user interface tool for web servers. This software — designed for building components and themes for web applications — was running on the U.S. agency's internet-facing web server.

<https://techcrunch.com/2023/03/16/cisa-nation-state-hackers-breach-federal-agency/>

Lots of systems aren't updated

10-year-old Windows bug with 'opt-in' fix exploited in 3CX attack

BLEEPINGCOMPUTER

Carly Page • March 16, 2023

A 10-year-old Windows vulnerability is still being exploited in attacks to make it appear that executables are legitimately signed, with the fix from Microsoft still "opt-in" after all these years. Even worse, the fix is removed after upgrading to Windows 11.

On Wednesday night, news broke that VoIP communications company 3CX was compromised to distribute trojanized versions of its Windows desktop application in a large-scale supply chain attack.

As part of this supply chain attack, two DLLs used by the Windows desktop application were replaced with malicious versions that download additional malware to computers, such as an information-stealing trojan.

One of the malicious DLLs used in the attack is usually a legitimate DLL signed by Microsoft named d3dcompiler_47.dll. However, the threat actors modified the DLL to include an encrypted malicious payload at the end of the file.

As first noted yesterday, even though the file was modified, Windows still showed it as correctly signed by Microsoft.

<https://www.bleepingcomputer.com/news/microsoft/10-year-old-windows-bug-with-opt-in-fix-exploited-in-3cx-attack/>

Lots of systems aren't updated



Old CVEs die hard and big tech gets hit hardest by bugs, top 2022 vulnerability trends

Derek B. Johnson • August 3, 2023

The most-frequently exploited vulnerabilities in 2022 include older bugs and high-profile flaws affecting major products, according to a new joint cybersecurity advisory from Five Eyes governments.

The advisory, signed by multiple agencies from the U.S., UK, Australian, Canadian and New Zealand governments, puts the focus on a persistent problem in cybersecurity. Namely, that the vulnerabilities most often leveraged by ransomware actors, nation states and cybercriminal groups have often already been discovered, disclosed and patched for years.

...

Half of the 12 vulnerabilities listed by the governments allow for remote code execution – unsurprising but a reminder of why such security researchers tend to sound the alarm bells around such vulnerabilities, even when the chances of exploitability may be low or in dispute.

The oldest vulnerability listed in the top 12, an SSL Virtual Private Network bug affecting FortiOS and Fortiguard (CVE-2018-13379) that can expose credentials, dates back to 2018. It was also listed in the 2020 and 2021 advisories and its continued exploitation “indicates that many organizations failed to patch software in a timely manner and remain vulnerable” today, the agencies warn.

<https://www.scmagazine.com/news/old-cves-die-hard-and-big-tech-gets-hit-hardest-by-bugs-top-2022-vulnerability-trends>

Lots of systems aren't updated

Attackers Exploit 6-Year-Old Microsoft Office Bug to Spread Spyware DARKREADING

Attackers are exploiting a 6-year-old Microsoft Office remote code execution (RCE) flaw to deliver spyware, in an email campaign weaponized by malicious Excel attachments and characterized by sophisticated evasion tactics.

Elizabeth Montalbano • December 20, 2023

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Threat actors dangle lures relating to business activity in spam emails that deliver files that contain CVE-2017-11882, an RCE flaw that **dates back to 2014 and can allow for system takeover**, Zscaler revealed in a blog post published Dec. 19. The end goal of the attack is to load Agent Tesla, a remote access Trojan (RAT) and advanced keylogger first discovered in 2014, and exfiltrate credentials and other data from an infected system via a Telegram bot run by the attackers.

CVE-20170-11882 is a **memory-corruption flaw found in the Equation Editor of Microsoft Office**. An attacker who successfully exploits the flaw can run arbitrary code in the context of the current user and even take over the affected system if a user is logged on with administrator rights. Though the vulnerability has long been patched, older versions of Microsoft Office still in use may be vulnerable.

<https://www.darkreading.com/cloud-security/attackers-exploit-microsoft-office-bug-spyware>

Lots of systems aren't updated

Majority of Ransomware Attacks Last Year Exploited Old Bugs

New research shows that 57 vulnerabilities that threat actors are currently using in ransomware attacks enable everything from initial access to data theft.

Jai Vijayan • February 20, 2023

Many vulnerabilities that ransomware operators used in 2022 attacks were years old and paved the way for the attackers to establish persistence and move laterally in order to execute their missions.

...

Ivanti's analysis showed that ransomware operators exploited a total of 344 unique vulnerabilities in attacks last year — an increase of 56 compared with 2021. Of this, a startling 76% of the flaws were from 2019 or before. The oldest vulnerabilities in the set were three remote code execution (RCE) bugs from 2012 in Oracle's products: CVE-2012-1710 in Oracle Fusion middleware and CVE-2012-1723 and CVE-2012-4681 in the Java Runtime Environment.

<https://www.darkreading.com/cyberattacks-data-breaches/dozens-of-vulns-in-ransomware-attacks-offer-adversaries-full-kill-chain>

Vulnerabilities are on the rise

2021 breaks the record for security vulnerabilities

SECURITY

Maria Henriquez • December 9, 2021

The US-CERT Vulnerability database has recorded 18376 vulnerabilities as of December 8, 2021, which surpasses the 2020 record of 18351.

More than 50 common vulnerabilities and exposures (CVEs) were logged every day in 2021, according to Redscan Labs researchers.

In addition, Redscan Labs analysis shows:

- 90% of all CVEs uncovered in 2021 so far can be exploited by attackers with little technical skills
- CVEs that require no user interaction, such as clicking a link, downloading a file or sharing their credentials, accounted for 61% of the total volume up to now
- 54% of vulnerabilities so far this year are categorized as having “high” availability, meaning they are readily accessible/exploitable by attackers.

Redscan analysis, however, revealed that no privilege CVEs continued to decline in 2021: 55% of 2021 CVEs require no privileges to exploit, down from 59% in 2020 and 66% in 2019. Vulnerabilities with a high confidentiality rating dropped from 59% to 53% of CVEs over the past year — these are CVEs believed to impact confidential data.

<https://www.securitymagazine.com/articles/96668-2021-breaks-the-record-for-security-vulnerabilities>

Vulnerabilities are on the rise: 2022 beats 2021

We analysed 90,000+ software vulnerabilities: Here's what we learned

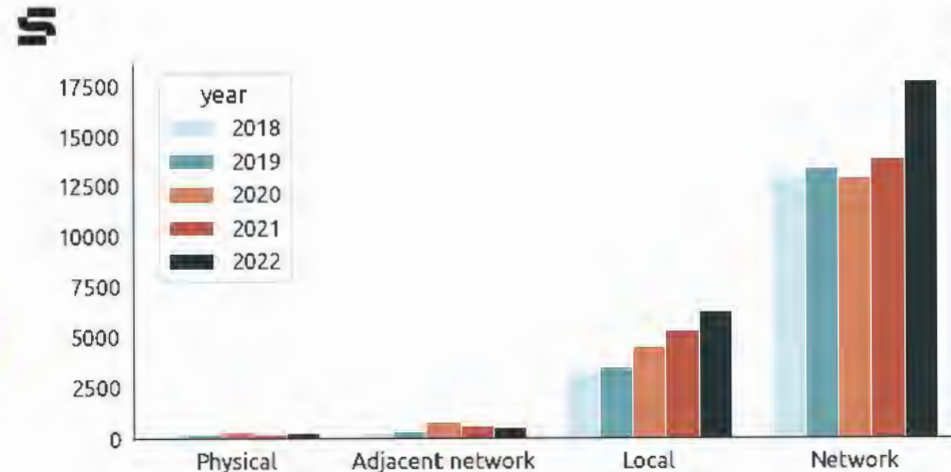


Ed Targett • January 9, 2023

A record 26,448 software security flaws were reported in 2022, with the number of critical vulnerabilities up 59% on 2021 to 4,135, according to analysis by The Stack of Common Vulnerabilities and Exposures (CVEs) data.

...

As the chart of attack vectors below shows, the vast majority do not require physical or local network access, but can potentially be exploited remotely (dependent on a concatenation of things coming together for an attacker.)



Graphic: Nick Sexton for The Stack. Source: nvd.nvst.gov

<https://www.securitymagazine.com/articles/96668-2021-breaks-the-record-for-security-vulnerabilities>

Vulnerabilities are on the rise: 2023 beats 2022

Majority of 2023's critical cyberattacks stemmed from fewer than 1% of vulnerabilities

Duncan Riley • December 19, 2023



There were 26,447 vulnerabilities discovered in 2023, surpassing the number of vulnerabilities disclosed in 2022 by more than 1,500 and the highest number ever disclosed. Of the disclosed vulnerabilities, more than 7,000 had proof-of-concept exploit code that could potentially result in successful exploitation. But the exploit code was typically of lower quality, which may reduce the likelihood of a successful attack.

Some 206 vulnerabilities had weaponized exploit code available, meaning they were highly likely to compromise the target system if used. There were 115 vulnerabilities that were routinely exploited by threat actors, malware and ransomware groups such as Clop.

More than a third of the identified high-risk vulnerabilities identified could be exploited remotely. The five most prevalent types of vulnerabilities comprised over 70% of the total discovered.

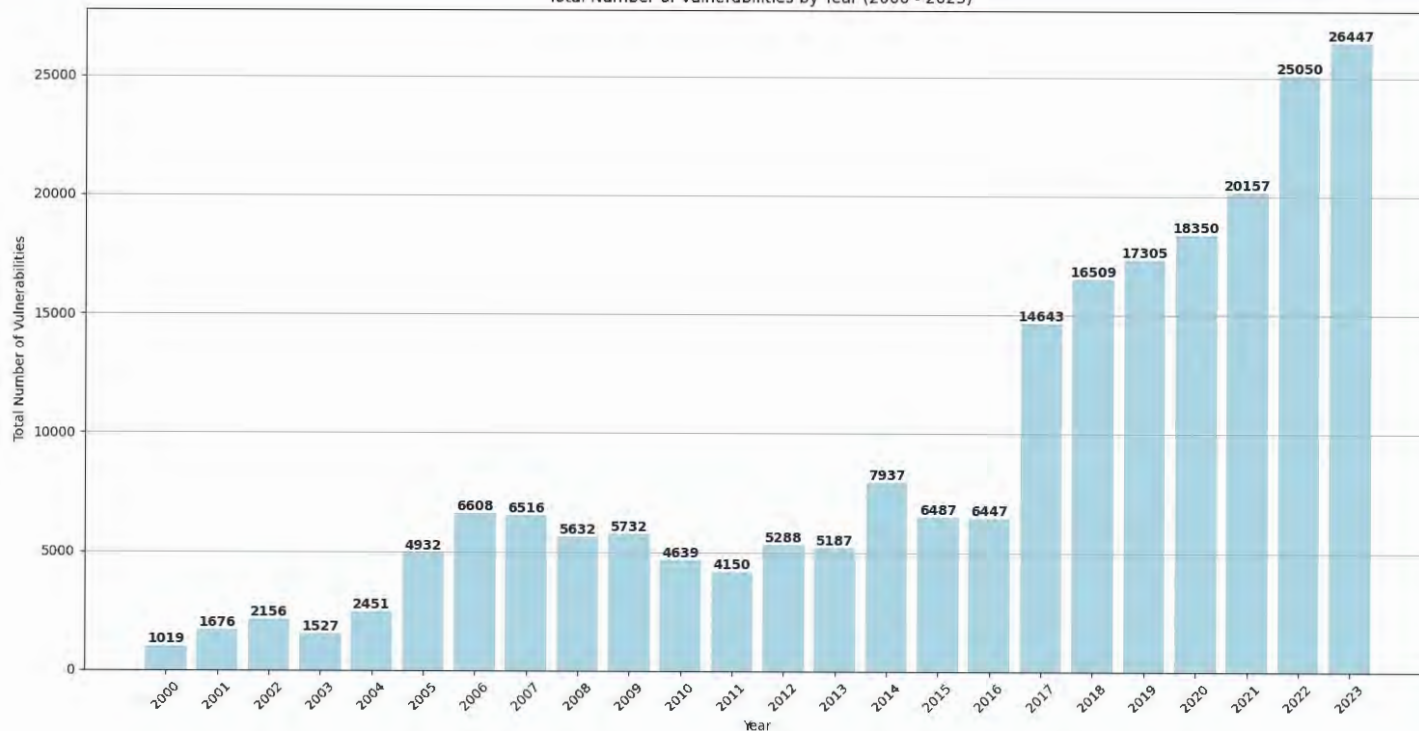
The mean time to exploit high-risk vulnerabilities in 2023 came in at about 44 days. However, the report notes that in numerous instances, exploitation occurred almost instantaneously, with some vulnerabilities exploited on the very day they were published.

<https://siliconangle.com/2023/12/19/majority-2023s-critical-cyber-attacks-stemmed-less-1-vulnerabilities/>

Vulnerabilities 2000 – 2023



Total Number of Vulnerabilities by Year (2000 - 2023)



<https://blog.qualys.com/vulnerabilities-threat-research/2023/12/19/2023-threat-landscape-year-in-review-part-one>

Vulnerabilities are on the rise

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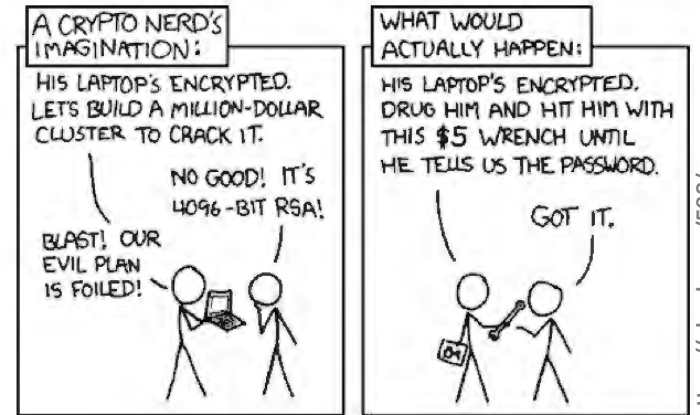
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Threats

Threats – the potential attackers

- Who are the adversaries?
- Lot of variations
- Different attackers have different abilities
- Are enemies sufficiently motivated to attack you?
- Attackers can often resort to the **three Bs: Burglary, Bribery, or Blackmail**



AT&T employees took bribes to plant malware on the company's network



DOJ charges Pakistani man with bribing AT&T employees more than \$1 million to install malware on the company's network, unlock more than 2 million devices.

By Catalin Cimpanu for Zero Day | August 6, 2019 -- 14:02 GMT (07:02 PDT)



AT&T employees took bribes to unlock millions of smartphones, and to install malware and unauthorized hardware on the company's network, the Department of Justice said yesterday.

These details come from a DOJ case opened against Muhammad Fahd, a 34-year-old man from Pakistan, and his co-conspirator, Ghulam Jiwani, believed to be deceased.

July 2020 Twitter (X) Breach

- **Hackers targeted 130 users**
- **Tweeted cryptocurrency scam from 45 accounts they were able to access**
 - Changing the email address & login credentials
- **Brought in \$120,000**
- **Not a big deal ... but could have been a lot worse**
 - Twitter is used by political & business leaders
 - The right tweet can move markets or start conflicts



What happened?

Internal employee changed email addresses and turned off security features of certain high-profile accounts.

It wasn't social engineering, it was bribery — a Twitter employee was paid.

Insider threat problem: Twitter had almost 5,000 employees at the time.



Jason Koebler @jason_koebler · Jul 15, 2020
Replying to @jason_koebler

OK, we talked to another hacker. Were able to confirm how they got accounts: Twitter employee used internal tool to change email addresses associated with accounts. Twitter seems to have just confirmed this in tweets as well



Hackers Convinced Twitter Employee to Help Them Hijack Acc...
After a wave of account takeovers, screenshots of an internal Twitter user administration tool are being shared in the hackin...
🔗 vice.com

Jason Koebler @jason_koebler

we spoke to two hackers and we were able to independently verify they were in control of hijacked accounts today. One of them said they paid the Twitter employee to help them take over accounts; not sure on the specifics here at the moment

10:50 PM · Jul 15, 2020

2.2K 1.2K people are Tweeting about this

<https://www.theverge.com/2020/7/15/21326656/twitter-hack-explanation-bitcoin-accounts-employee->

Exclusive: More than 1,000 people at Twitter had ability to aid hack of accounts



Joseph Menn, Katie Paul, Raphael Satter • July 23, 2020

SAN FRANCISCO (Reuters) - More than a thousand Twitter employees and contractors as of earlier this year had access to internal tools that could change user account settings and hand control to others, two former employees said, making it hard to defend against the hacking that occurred last week.

Twitter said on Saturday that the perpetrators "manipulated a small number of employees and used their credentials" to log into tools and turn over access to 45 accounts. here On Wednesday, it said that the hackers could have read direct messages to and from 36 accounts but did not identify the affected users.

The former employees familiar with Twitter security practices said that too many people could have done the same thing, more than 1,000 as of earlier in 2020, including some at contractors like Cognizant.

<https://www.reuters.com/article/us-twitter-cyber-access-exclusive/exclusive-more-than-1000-people-at-twitter-had-ability-to-aid-hack-of-accounts-idUSKCN24O34E>

Threat categories

- **Disclosure: Unauthorized access to data**
 - Snooping (wiretapping)
- **Deception: Acceptance of false data**
 - Injection of data, modification of data, denial of receipt
- **Disruption: Interruption or prevention of correct operation**
 - Denial of service, data deletion, or modification
- **Usurpation: Unauthorized control of some part of a system**
 - May lead to modification, spoofing, delay, denial of service

Threat actions – what might an attacker do?

- **Snooping: unauthorized interception of information**
 - Form of disclosure
 - Counter with confidentiality services
- **Modification or alteration: unauthorized change of information**
 - Form of deception, disruption or usurpation
 - Counter with integrity services
- **Masquerading or spoofing: impersonation of one entity by another**
 - Form of deception and usurpation
 - Counter with integrity services
- **Repudiation of origin: false denial that an entity sent or created something**
 - Form of deception and usurpation
 - Counter with integrity services

Threat actions – what might an attacker do?

- **Denial of receipt: false denial that an entity received data or a message**
 - Form of deception
 - Counter with integrity & availability mechanisms
- **Delay: temporary inhibition of a service**
 - Form of disruption (possibly via usurpation)
 - Counter with availability mechanisms
- **Denial of service: long-term inhibition of a service**
 - Form of disruption (possibly via usurpation)
 - Counter with availability mechanisms

The End