



# Secure by Design Alert

## Eliminating Directory Traversal Vulnerabilities in Software



### Malicious Cyber Actors Use Directory Traversal To Compromise Systems

[Directory traversal—or path traversal—vulnerabilities](#) remain a persistent class of defect in software products. The software industry has documented directory traversal vulnerabilities, along with effective approaches to eliminate these vulnerabilities at scale, for over two decades.<sup>1</sup> Yet software manufacturers continue to put customers at risk by developing products that allow for directory traversal exploitation. CISA and the FBI are releasing this Secure by Design Alert in response to recent well-publicized threat actor campaigns that exploited directory traversal vulnerabilities in software (e.g., [CVE-2024-1708](#), [CVE-2024-20345](#)) to compromise users of the software—impacting critical infrastructure sectors, including the Healthcare and Public Health Sector.

The software industry has known how to eliminate these defects at scale for decades, yet directory traversals remain a top exploited vulnerability with 55 currently listed in the [Known Exploited Vulnerabilities \(KEV\) catalog](#).

Additionally, this Alert highlights the prevalence, and continued threat actor exploitation of, directory traversal defects. Currently, CISA has listed 55 directory traversal vulnerabilities in our [Known Exploited Vulnerabilities \(KEV\) catalog](#). Approaches to avoid directory traversal vulnerabilities are known, yet threat actors continue to exploit these vulnerabilities which have impacted the operation of critical services, including hospital and school operations. CISA and the FBI urge software manufacturer executives to require their organizations to conduct formal testing (see OWASP testing guidance)<sup>2</sup> to determine their products' susceptibility to directory traversal vulnerabilities.

CISA and the FBI also recommend that software customers ask manufacturers whether they have conducted formal directory traversal testing. Should manufacturers discover their systems lack the appropriate mitigations, they should ensure their software developers immediately implement mitigations to eliminate this entire class of defect from all products. Building security into products from the beginning can eliminate directory traversal vulnerabilities.

### Secure by Design Lessons to Learn

A core tenet of [secure by design](#) software development is that manufacturers create safe and secure behavior in the products they provide to customers. “Secure by Design” means that manufacturers design and build their products in a way that reasonably protects against malicious cyber actors successfully exploiting product defects. Incorporating this risk mitigation at the outset—beginning in the design phase and continuing through product release and updates—reduces both the burden of cybersecurity on customers and risk to the public. Vulnerabilities like directory traversal have been called ‘[unforgivable](#)’ since at least 2007. Despite this finding, directory traversal vulnerabilities (such as CWE-22 and CWE-23) are still prevalent classes of vulnerability. For example, CWE-22 is listed in the top 25 lists for both the “most dangerous” and “stubborn” software weaknesses in 2023.<sup>3</sup> **Note:** CWE-22 is a parent of several child weaknesses that involve directory traversal variations.

<sup>1</sup> Steve Christey and The MITRE Corporation, “Unforgivable Vulnerabilities.” August 2, 2007.

[https://cwe.mitre.org/documents/unforgivable\\_vulns/unforgivable.pdf](https://cwe.mitre.org/documents/unforgivable_vulns/unforgivable.pdf). In 2007, MITRE deemed directory traversal as one of the “unforgivable” vulnerabilities (i.e., “unforgivable” that the developer allowed it to exist in their product) yet exploitation continues today.

<sup>2</sup> “Testing Directory Traversal File Include.” OWASP Web Security Testing Guide (WSTG) GitHub. Last modified July 2023.

[https://github.com/OWASP/wstg/blob/master/document/4-Web\\_Application\\_Security\\_Testing/05-Authorization\\_Testing/01-Testing\\_Directory\\_Traversal\\_File\\_Include.md](https://github.com/OWASP/wstg/blob/master/document/4-Web_Application_Security_Testing/05-Authorization_Testing/01-Testing_Directory_Traversal_File_Include.md)

<sup>3</sup> “2023 CWE Top 25 Most Dangerous Software Weaknesses, Stubborn Weaknesses in the CWE Top 25.” MITRE’s CWE Top 25, 2023.

[https://cwe.mitre.org/top25/archive/2023/2023\\_top25\\_list.html](https://cwe.mitre.org/top25/archive/2023/2023_top25_list.html),

[https://cwe.mitre.org/top25/archive/2023/2023\\_stubborn\\_weaknesses.html](https://cwe.mitre.org/top25/archive/2023/2023_stubborn_weaknesses.html)

## What Are Directory Traversal Vulnerabilities?

Directory traversal vulnerabilities involve a user manipulating inputs (i.e., input parameters or file paths) to illicitly access application files and directories that the developer did not intend for users to access. The impact can be devastating as these exploits can allow malicious cyber actors to access restricted directories and depending on the scenario, read, modify, or write arbitrary files. Exploitation of a directory traversal vulnerability may expose sensitive data and/or allow actors to further pivot and compromise systems. Directory traversal exploits succeed because technology manufacturers **fail to treat user supplied content as potentially malicious, hence failing to adequately protect their customers.**

## How Can Software Manufacturers Prevent Directory Traversal Vulnerabilities?

During the design and development of a software product, developers should implement well-known and effective mitigations to help prevent directory traversal vulnerabilities including the following:

- Consider generating a random identifier for each file and storing associated metadata separately (e.g., in a database) rather than using user input when naming files.
- In the case where the above approach is not taken, strictly limit the types of characters that can be supplied in file names, e.g., by restricting to alphanumeric characters. Also ensure that uploaded files do not have executable permissions.

For additional well-known and effective mitigations, refer to OWASP's guidance <sup>4</sup>. **Note:** Directory traversal vulnerabilities can also affect cloud services. Software manufacturers should implement the above guidance, or other known best approaches, to prevent directory traversal vulnerabilities in cloud systems.

Additionally, CISA and the FBI encourage manufacturers to learn how to protect their products from falling victim to directory traversal exploits and other preventable malicious activity by reviewing the three principles laid out in the joint guidance [Shifting the Balance of Cybersecurity Risk: Principles and Approaches for Secure by Design Software](#).

### Principle 1: Take Ownership of Customer Security Outcomes

There are key security areas manufacturers should invest in to protect their customers as well as the public. These include providing safe building blocks for their software developers to ensure that a single developer error does not compromise the data of millions of users. The cycle of vulnerability detection, mitigation, and patch deployment for vulnerabilities that have been understood for years is not a lasting approach to security. Effective mechanisms to prevent classes of vulnerabilities at scale are available and software manufacturers should implement them as early in the development cycle as possible. Adopting standard best practices, such as the guidance listed above, can help software manufacturers to root out directory traversal vulnerabilities at the source, as opposed to relying on customers to apply fixes. Manufacturers should also implement audit mechanisms through automation to measure developer compliance with these best practices.

Additionally, senior executives at software manufacturers must take accountability for the security of their customers starting by creating a governance structure for technical staff to conduct formal testing and code review to determine their susceptibility to exploitation. OWASP and other trusted entities provide guidance on testing methods with readily available techniques.<sup>5</sup> Manufacturers and developers should take ownership of securing products and eliminate this class of vulnerability.

---

<sup>4</sup> See also "Path Traversal | OWASP Foundation," 2020. [https://owasp.org/www-community/attacks/Path\\_Traversal](https://owasp.org/www-community/attacks/Path_Traversal).

<sup>5</sup> "Testing Directory Traversal File Include." OWASP Web Security Testing Guide (WSTG) GitHub. Last modified July 2023. [https://github.com/OWASP/wstg/blob/master/document/4-Web\\_Application\\_Security\\_Testing/05-Authorization\\_Testing/01-Testing\\_Directory\\_Traversal\\_File\\_Include.md](https://github.com/OWASP/wstg/blob/master/document/4-Web_Application_Security_Testing/05-Authorization_Testing/01-Testing_Directory_Traversal_File_Include.md)

## Principle 2: Embrace Radical Transparency and Accountability

Manufacturers should lead with transparency when disclosing product vulnerabilities. To that end, manufacturers should track the classes of vulnerability associated with their software and disclose them to their customers via the [CVE program](#). Manufacturers should ensure that their CVE records are correct and complete. It is especially important that manufacturers supply an accurate [CWE](#) so the industry can track classes of software defect, not just individual CVEs, and customers can understand areas where a given vendor's development practices may require improvement.<sup>6</sup> Many, but not all, directory traversals fall under [CWE-22: Improper Limitation of a Pathname to a Restricted Directory \('Path Traversal'\)](#). As such, manufacturers should identify and document the root causes of directory traversal vulnerabilities and declare it a business goal to work toward eliminating the entire class of vulnerability. Software manufacturers should also maintain a modern vulnerability disclosure program (VDP). **Note:** There are numerous resources to assist organizations in establishing and maintain a VDP, such as those [from CISA](#)<sup>7</sup>.

## Principle 3: Build Organizational Structure and Leadership to Achieve These Goals

Just as software and hardware manufacturing executives care about cost, they should prioritize the security of their products. Executives must consider the full picture: that customers, our economy, and our national security are currently bearing the brunt of business decisions to not build security into their products—as the threat actor campaigns described earlier in this Alert clearly reflect. Moreover, directing the business toward secure by design software development may reduce financial and productivity costs as well as complexity. Executives should make the appropriate investments and develop the right incentive structures that promote security as a stated business goal.

Executives should lead programs to root out entire classes of vulnerability rather than addressing them on a case-by-case basis. Additionally, executives should establish organizational structures that prioritize proactive measures, such as adopting standard best practices, to root out directory traversal vulnerabilities at the source. Executives should also ensure their organization conducts reviews to detect common and well-known vulnerabilities, like directory traversal, to determine their susceptibility, and implement the existing effective and documented mitigations. These reviews should be continually conducted to root out classes of vulnerability, as some vulnerabilities may change or develop over time. Executives should request regular updates to assess the company's progress at identifying recurring classes of vulnerability as well as progress to eliminate them and lend support to provide appropriate resources to continue such progress.

## Action Item for Software Manufacturers

Although this Secure by Design Alert focuses on approaches to mitigate directory traversals as a class of defect, it is just one part of a more comprehensive set of secure by design practices. To protect their customers from a wide range of malicious cyber activity, manufacturers should fully implement the principles and practices touched upon in this alert by reviewing [Shifting the Balance of Cybersecurity Risk: Principles and Approaches for Secure by Design Software](#). Further, CISA and the FBI urge manufacturers to publish their own secure by design roadmap to demonstrate that they are not simply implementing tactical controls but are strategically rethinking their responsibility in keeping customers safe.

This Alert is part of CISA's [Secure by Design Alert series](#), which aims to educate software manufacturers on eliminating entire classes of vulnerabilities.

---

<sup>6</sup> Common Weakness Enumeration (CWE) classification identifies classes of software/hardware weaknesses (including vulnerabilities and defects); Common Vulnerabilities and Exposures (CVE) classification identifies and labels unique vulnerabilities in specific software/hardware products.

<sup>7</sup> <https://www.cisa.gov/vulnerability-disclosure-policy-template>

## Disclaimer

The information in this report is being provided “as is” for informational purposes only. The authoring organizations do not endorse any commercial entity, product, company, or service, including any entities, products, or services linked within this document. Any reference to specific commercial entities, products, processes, or services by service mark, trademark, manufacturer, or otherwise, does not constitute or imply endorsement, recommendation, or favoring by the authoring organizations.