# Remote code execution in cdnjs of Cloudflare

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## Remote code execution in cdnjs of Cloudflare

* *2021-07-16* * 1885 **cdnjsVulnerabilityGoSupply ChainRCE

## Preface

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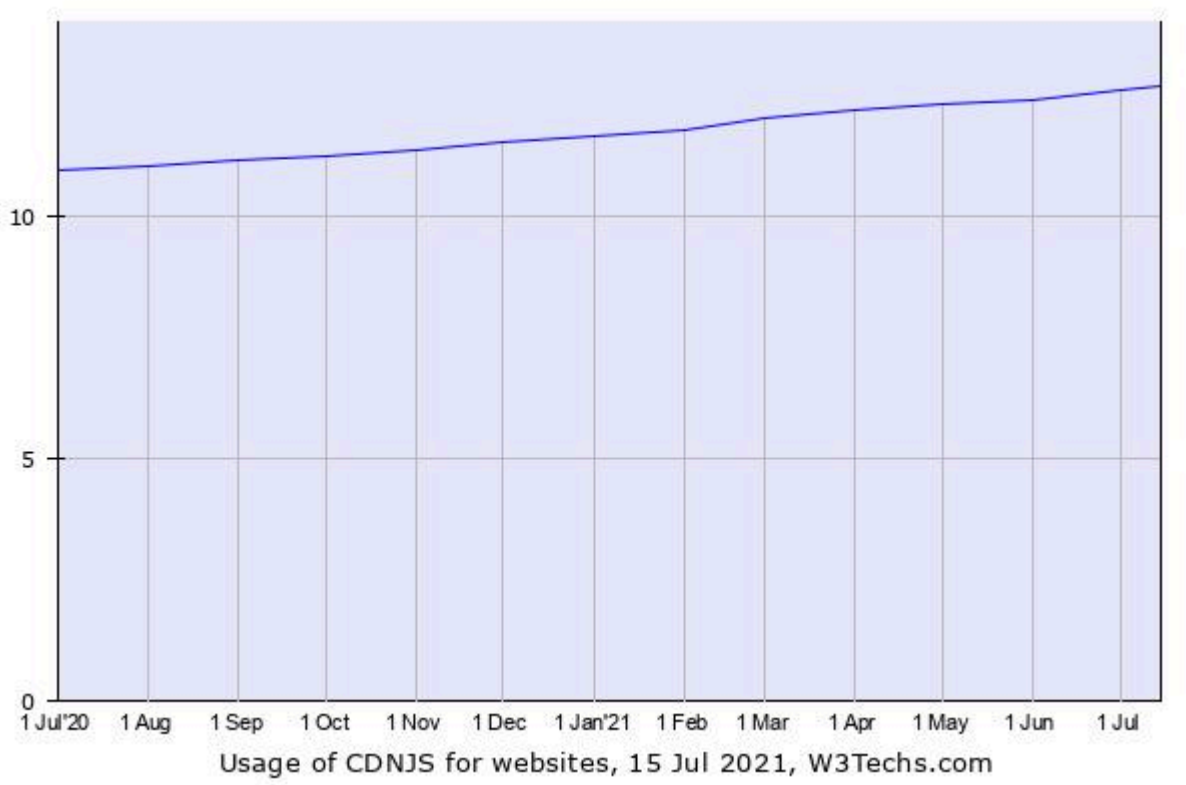
Cloudflare, which runs cdnjs, is running a “Vulnerability Disclosure Program” on HackerOne, which allows hackers to perform vulnerability assessments. This article describes vulnerabilities reported through this program and published with the permission of the Cloudflare security team. So this article is not intended to recommend you to perform an unauthorized vulnerability assessment. If you found any vulnerabilities in Cloudflare’s product, please report it to Cloudflare’s vulnerability disclosure program.

## TL;DR

There was a vulnerability in the cdnjs library update server that could execute arbitrary commands, and as a result, cdnjs could be completely compromised. This allows an attacker to tamper 12.7%1 of all websites on the internet once caches are expired.

## About cdnjs

cdnjs is a JavaScript/CSS library CDN that is owned by Cloudflare, which is used by 12.7% of all websites on the internet as of 15 July 2021. This is the second most widely used library CDN after 12.8%2 of Google Hosted Libraries, and considering the current usage rate, it will be the most used JavaScript library CDN in the near future.




Usage graph of cdnjs from W3Techs, as of 15 July 2021

## Reason for investigation

A few weeks before my last investigation into "Remote code execution in Homebrew by compromising the official Cask repository", I was investigating supply chain attacks. While finding a service that many software depends on, and is allowing users to perform the vulnerability assessment, I found cdnjs. So I decided to investigate it.

## Initial investigation

While browsing the cdnjs website, I found the following description.

> 

Couldn't find the library you're looking for? You can make a request to have it added on our GitHub repository.

I found out that the library information is managed on the GitHub repository, so I checked the repositories of the GitHub Organization that is used by cdnjs.

As a result, it was found that the repository is used in the following ways.

- cdnjs/packages: Stores library information that is supported in cdnjs

- cdnjs/cdnjs: Stores files of libraries
- cdnjs/logs: Stores update logs of libraries
- cdnjs/SRIs: Stores SRI (Subresource Integrity) of libraries
- cdnjs/static-website: Source code of cdnjs.com
- cdnjs/origin-worker: Cloudflare Worker for origin of cdnjs.cloudflare.com
- cdnjs/tools: cdnjs management tools
- cdnjs/bot-ansible: Ansible repository of the cdnjs library update server

As you can see from these repositories, most of the cdnjs infrastructure is centralized in this GitHub Organization. I was interested in cdnjs/bot-ansible and cdnjs/tools because it automates library updates. After reading codes of these 2 repositories, it turned out cdnjs/bot-ansible executes `autoupdate` command of cdnjs/tools in the cdnjs library update server periodically, to check updates of library from cdnjs/packages by downloading npm package / Git repository.

## Investigation of automatic update

The automatic update function updates the library by downloading the user-managed Git repository / npm package and copying the target file from them. And npm registry compress libraries into `.tgz` to make it downloadable. Since the tool for this automatic update is written in Go, I guessed that it may use Go's `compress/gzip` and `archive/tar` to extract the archive file. Go's `archive/tar` returns the filename contained in the archive without sanitizing3, so if the archive is extracted into the disk based on the filename returned from `archive/tar`, archives that contain filename like `../../../../../../tmp/test` may overwrite arbitrary files on the system. 4 From the information in cdnjs/bot-ansible, I knew that some scripts were running regularly and the user that runs the `autoupdate` command had write permission for them, so I focused on overwriting files via path traversal.

```
" tar.vim version v29
" Browsing tarfile /private/tmp/exploit.tgz
" Select a file with cursor and press ENTER

../../../../../../tmp/ryotak
../../../../../../tmp/ryotak.sh
package.json
```

## Path traversal

To find path traversal, I started reading the `main` function of the `autoupdate` command.

```
func main() {
    [...]
    switch *pckg.Autoupdate.Source {
    case "npm":
      {
        util.Debugf(ctx, "running npm update")
        newVersionsToCommit, allVersions = updateNpm(ctx, pckg)
      }
    case "git":
      {
        util.Debugf(ctx, "running git update")
        newVersionsToCommit, allVersions = updateGit(ctx, pckg)
      }
    [...]
}
```

As you can see from the code snippet above, if `npm` is specified as a source of auto-update, it passes package information to the `updateNpm` function.

```
func updateNpm(ctx context.Context, pckg *packages.Package) ([]newVersionToCommit, []version) {
    [...]
    newVersionsToCommit = doUpdateNpm(ctx, pckg, newNpmVersions)
    [...]
}
```

Then, `updateNpm` passes information about the new library version to `doUpdateNpm` function.

```
func doUpdateNpm(ctx context.Context, pckg *packages.Package, versions []npm.Version) []newVersionToCommit {
  [...]
  for _, version := range versions {
    [...]
    tarballDir := npm.DownloadTar(ctx, version.Tarball)
    filesToCopy := pckg.NpmFilesFrom(tarballDir)
    [...]
}
```

And `doUpdateNpm` passes the URL of `.tgz` file into `npm.DownloadTar`.

```
func DownloadTar(ctx context.Context, url string) string {
    dest, err := ioutil.TempDir("", "npmtarball")
    util.Check(err)

    util.Debugf(ctx, "download %s in %s", url, dest)

    resp, err := http.Get(url)
    util.Check(err)

    defer resp.Body.Close()

    util.Check(Untar(dest, resp.Body))
    return dest
}
```

Finally, pass the `.tgz` file obtained using `http.Get` to the `Untar` function.

```
func Untar(dst string, r io.Reader) error {
    gzr, err := gzip.NewReader(r)
    if err != nil {
        return err
    }
    defer gzr.Close()
    tr := tar.NewReader(gzr)
    for {
        header, err := tr.Next()
        [...]
        // the target location where the dir/file should be created
        target := filepath.Join(dst, removePackageDir(header.Name))
        [...]
        // check the file type
        switch header.Typeflag {
        [...]
        // if it's a file create it
        case tar.TypeReg:
            {
                [...]
                f, err := os.OpenFile(target, os.O_CREATE|os.O_RDWR, os.FileMode(header.Mode))
                [...]
                // copy over contents
                if _, err := io.Copy(f, tr); err != nil {
                    return err
                }
            }
        }
    }
}
```

As I guessed, `compress/gzip` and `archive/tar` were used in `Untar` function to extract `.tgz` file. At first, I thought that it's sanitizing the path in the `removePackageDir` function, but when I checked the contents of the function, I noticed that it's just removing `package/` from the path. From these code snippets, I confirmed that arbitrary code can be executed after performing path traversal from the `.tgz` file published to npm and overwriting the script that is executed regularly on the server.

## Demonstration of vulnerability

Because Cloudflare is running a vulnerability disclosure program on HackerOne, it's likely that HackerOne's triage team won't forward the report to Cloudflare unless it indicates that the vulnerability is actually exploitable. Therefore, I decided to do a demonstration to show that vulnerability can actually be exploited.

The attack procedure is as follows.

- Publish the `.tgz` file that contains the crafted filename to the npm registry.
- Wait for the cdnjs library update server to process the crafted `.tgz` file.
- The contents of the file that is published in step 1 are written into a regularly executed script file and arbitrary command is executed.

... and after writing the attack procedure into my notepad, for some reason, I started wondering how automatic updates based on the Git repository works. So, I read codes a bit before demonstrating the vulnerability, and it seemed that the symlinks aren't considered when copying files from the Git repository.

```
func MoveFile(sourcePath, destPath string) error {
	inputFile, err := os.Open(sourcePath)
	if err != nil {
		return fmt.Errorf("Couldn't open source file: %s", err)
	}
	outputFile, err := os.Create(destPath)
	if err != nil {
		inputFile.Close()
		return fmt.Errorf("Couldn't open dest file: %s", err)
	}
	defer outputFile.Close()
	_, err = io.Copy(outputFile, inputFile)
	inputFile.Close()
	if err != nil {
		return fmt.Errorf("Writing to output file failed: %s", err)
	}
	// The copy was successful, so now delete the original file
	err = os.Remove(sourcePath)
	if err != nil {
		return fmt.Errorf("Failed removing original file: %s", err)
	}
	return nil
}
```

As Git supports symbolic links by default, it may be possible to read arbitrary files from the cdnjs library update server by adding symlink into the Git repository.

If the regularly executed script file is overwritten to execute arbitrary commands, the automatic update function may be broken, so I decided to check the arbitrary file reading first. Along with this, the attack procedure was changed as follows.

- Add a symbolic link that points harmless file (Assumed `/proc/self/maps` here) into the Git repository.
- Publish a new version in the repository.

- Wait for the cdnjs library update server to process the crafted repository.
- The specified file is published on cdnjs.

It was around 20:00 at this point, but what I have to do was creating a symlink, so I decided to eat dinner after creating the symbolic link and publishing it.5

```
ln -s /proc/self/maps test.js
```

## Incident

Once I finished the dinner and returning to my PC desk, I was able to confirm that cdnjs has released a version containing symbolic links.

After checking the contents of the file to send the report, I was surprised. Surprisingly, clearly sensitive information such as `GITHUB_REPO_API_KEY` and `WORKERS_KV_API_TOKEN` was displayed. I couldn't understand what happened for a moment, and when I checked the command log, I found that I accidentally put a link to `/proc/self/environ` instead of `/proc/self/maps`.6 As mentioned earlier, if cdnjs' GitHub Organization is compromised, it's possible to compromise most of the cdnjs infrastructure. I needed to take immediate action, so I sent the report that only contains a link that shows the current situation, and requested them to revoke all credentials.

At this point, I was very confused and hadn't confirmed it, but in fact, these tokens were invalidated before I sent the report. It seems that GitHub notified Cloudflare immediately because `GITHUB_REPO_API_KEY` (API key of GitHub) was included in the repository, and Cloudflare started incident response immediately after the notification. I felt that they're a great security team because they invalidated all credentials within minutes after cdnjs processed the specially crafted repository.

## Determinate impact

After the incident, I investigated what could be impacted. `GITHUB_REPO_API_KEY` was an API key for robocdnjs, which belongs to cdnjs organization, and had write permission against each repository. This means it was possible to tamper arbitrary libraries on the cdnjs or tamper the cdnjs.com itself.

Also, `WORKERS_KV_API_TOKEN` had permission against KV of Cloudflare Workers that is used in the cdnjs, it could be used to tamper the libraries on the KV cache. By combining these permissions, the core part of cdnjs, such as the origin data of cdnjs, the KV cache, and even the cdnjs website, could be completely tampered.

## Conclusion

In this article, I described the vulnerability that was existed in cdnjs. While this vulnerability could be exploited without any special skills, it could impact many websites. Given that there are many vulnerabilities in the supply chain, which are easy to exploit but have a large impact, I feel that it's

very scary. If you have any questions/comments about this article, please send a message to @ryotkak on Twitter.

## Timeline

| Date (JST) | Event | | | April 6, 2021 19:00 | Found a vulnerability | | | April 6, 2021 20:00 | Published a crafted symlink | | | April 6, 2021 20:30 | cdnjs processed the file | | | At the same time | GitHub sent an alert to Cloudflare | | | At the same time | Cloudflare started an incident response | | | Within minutes | Cloudflare finished revocation of credentials | | | April 6, 2021 20:40 | I sent an initial report | | | April 6, 2021 21:00 | I sent detailed report | | | April 7, 2021- | Secondary fix has applied | | | June 3, 2021 | Complete fix has applied | | | July 16, 2021 | Published this article | |

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Quoted from W3Techs as of 15 July 2021. Due to the presence of SRI / cache, fewer websites could tamper immediately.

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Quoted from W3Techs as of 15 July 2021.

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https://github.com/golang/go/issues/25849

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Archives like this can be created by using tools such as evilarc.

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I don't know if this is correct, but I remember that the dinner on that day was frozen gyoza (dumplings). (It was yummy!)

-

Because I was tired from work and I was hungry, I ran the command completed by shell without any confirmation.