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Intro

<p>Start Instance</p> <p>Start playing the challenge.</p>	<p>CHALLENGE DESCRIPTION</p> <p>I've made the coolest calculator. It's pretty simple, I don't need to parse the Input and take care of execution order, bash does it for me!! I've also made sure to remove characters like \$ or ` to not allow code execution, that will surely be enough.</p>
<p>Download Files</p>	

I started the instance and used netcat to interact with the calculator:

```

kali@kali:~$ nc 206.189.121.78 30131
(kali@kali)-[~] Control Channel: TLSv1.3, cipher TLSv1.3 TLS_AES_256_GCM_SHA384
$ nc 206.189.121.78 30131
CALCULATOR 21:48:42 TLS: move session: dest=TM ACTIVE src=
2023-09-23 21:48:42 TLS: tls_multi_process: initial untrusted session promoted
Operation: 7*7 48:42 PUSH: Received control message: 'PUSH
49 route-gateway 10.10.14.1, topology subnet, ping 10, ping-
per-id 40, cipher AES-256-CBC'
Operation: 1+1 48:42 OPTIONS IMPORT: --itconfig/up options
2023-09-23 21:48:42 OPTIONS IMPORT: route options modified

```

Testing Functionality

```

kali@kali:~$ nc 206.189.121.78 30131
(kali@kali)-[~] Control Channel: TLSv1.3, cipher TLSv1.3 TLS_AES_256_GCM_SHA384
$ nc 206.189.121.78 30131
CALCULATOR 21:48:42 TLS: move session: dest=TM ACTIVE src=
2023-09-23 21:48:42 TLS: tls_multi_process: initial untrusted session promoted
Operation: 7*7 48:42 PUSH: Received control message: 'PUSH
49 route-gateway 10.10.14.1, topology subnet, ping 10, ping-
per-id 40, cipher AES-256-CBC'
Operation: 1+1 48:42 OPTIONS IMPORT: --itconfig/up options
2023-09-23 21:48:42 OPTIONS IMPORT: route options modified

```

We understand that the code executes the provided operation. What happens when we try to use a bash command?

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```

Operation: $whoami
1      '$' removed
0
Operation:

```

It seems that the code has removed the “\$” character in order to avoid code execution. Its time to look at the source code I got in the zip file.

Main.go

```

1  package main
2
3  import (
4      "bufio"
5      "context"
6      "fmt"
7      "net"
8      "os"
9      "os/exec"
10     "strconv"
11     "strings"
12     "time"
13 )
14
15 const (
16     connHost = "0.0.0.0"
17     connPort = "1337"
18     connType = "tcp"
19 )
20
21 func main() { // Used to stablish connections with the clients (not part of the challenge)
22     fmt.Println("Starting " + connType + " server on " + connHost + ":" + connPort)
23     l, err := net.Listen(connType, connHost+":"+connPort)
24     if err != nil {
25         fmt.Println("Error listening: ", err.Error())
26         os.Exit(1)
27     }
28     defer l.Close()
29
30     for {
31         conn, err := l.Accept()
32         if err != nil {
33             continue
34         }
35         fmt.Println("Client " + conn.RemoteAddr().String() + " connected.")
36
37         go minConnection(conn)
38         go handleConnection(conn)
39         defer conn.Close()
40     }
41 }
42
43 func minConnection(conn net.Conn) {
44     time.Sleep(600 * time.Second)
45     conn.Close()
46 }
47
48 type LocalShell struct{}
49
50 func (_ LocalShell) Execute(ctx context.Context, cmd string) ([]byte, error) {
51     wrapperCmd := exec.CommandContext(ctx, "bash", "-c", cmd)
52     return wrapperCmd.Output()
53 }
54
55 func handleConnection(conn net.Conn) {
56     conn.Write([]byte("CALCULATOR\n"))
57     for {
58         conn.Write([]byte("\nOperation: "))
59         buffer, err := bufio.NewReader(conn).ReadBytes('\n')
60         if err != nil {
61             conn.Close()
62             return
63         }
64     }

```

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```

65         op := string(buffer[:len(buffer)-1])
66         firewall := []string{" ", "`", "$", "&", "|", ";", ">"}
67         for _, v := range firewall {
68             opL1 := len(op)
69             op = strings.ReplaceAll(op, v, "")
70             opL2 := len(op)
71             if opL1 > opL2 {
72                 conn.Write([]byte(strconv.Itoa(opL1-opL2) + " " + v + " removed\n"))
73             }
74         }
75         shell := LocalShell{}
76         command := "echo $({ " + op + " })"
77         output, _ := shell.Execute(context.Background(), command)
78         fmt.Println(conn.RemoteAddr().String() + ": " + command + " " + string(output))
79         conn.Write(output)
80     }
81 }
82

```

Note this part:

```

66         firewall := []string{" ", "`", "$", "&", "|", ";", ">"}
67         for _, v := range firewall {
68             opL1 := len(op)
69             op = strings.ReplaceAll(op, v, "")
70             opL2 := len(op)
71             if opL1 > opL2 {
72                 conn.Write([]byte(strconv.Itoa(opL1-opL2) + " " + v + " removed\n"))
73             }
74         }

```

firewall := []string{" ", "`", "\$", "&", "|", ";", ">"}

This line defines a slice named `firewall` containing several strings. Each string in the `firewall` slice represents a character that the code wants to remove from the client's input. These characters include space, backtick (```), dollar sign (`$`), ampersand (`&`), pipe (`|`), semicolon (`;`), and greater-than sign (`>`).

for _, v := range firewall {

This line starts a loop that iterates through each character (represented by `v`) in the `firewall` slice. The underscore (`_`) is used to indicate that we are not interested in the index of the character in the slice; we only care about the character itself.

opL1 := len(op)

This line calculates the length of the current expression `op` before any character removal. It stores this length in the variable `opL1`.

op = strings.ReplaceAll(op, v, "")

This line replaces all occurrences of the character `v` (from the `firewall` slice) with an empty string in the `op` expression. This effectively removes all instances of the character from the expression.

opL2 := len(op)

After removing characters using `strings.ReplaceAll`, this line calculates the length of the modified `op` expression and stores it in the variable `opL2`.

if opL1 > opL2 {

This conditional statement checks whether any characters were actually removed from the original expression. It compares the length of the original expression (`opL1`) with the length of the modified expression (`opL2`).

conn.Write([]byte(strconv.Itoa(opL1-opL2) + " " + v + " removed\n"))

If characters were removed (i.e., `opL1` is greater than `opL2`), this line sends a message to the client indicating how many characters were removed and which character was removed. It does this by:

Calculating the difference between `opL1` and `opL2` (i.e., how many characters were removed).

Converting the difference to a string using `strconv.Itoa`.

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Concatenating the difference, the removed character `v`, and the string `" removed"` into a single string.

Converting the resulting string into a byte slice using `[]byte`.

Sending this message to the client connection using `conn.Write`.

There is another interesting file, for the command execution mase by the code:

```

1 func (_ LocalShell) Execute(ctx context.Context, cmd string) ([]byte, error) {
2     wrapperCmd := exec.CommandContext(ctx, "bash", "-c", cmd)
3     return wrapperCmd.Output()
4 }
5
6
7     conn.Write([]byte(strconv.Itoa(opL1-opL2) + " " + v + " removed\n"))
8 }
9 shell := LocalShell{}
10 command := "echo $((" + op + "))"
11 output, _ := shell.Execute(context.Background(), command)
12 fmt.Println(conn.RemoteAddr().String() + ": " + command + " " + string(output))
13 conn.Write(output)
14 }
15 }

```

wrapperCmd := exec.CommandContext(ctx, "bash", "-c", cmd)

This line creates a new command by calling `exec.CommandContext`. It constructs a shell command with the following components:

`ctx` - The execution context passed as a parameter.

`"bash"`: The name of the shell to use for executing the command. In this case, it's the Bash shell.

`"-c"`: The `-c` option is used to tell Bash that the command to be executed is provided as an argument (specified by the `cmd` parameter).

`cmd`: The actual shell command provided as an argument to be executed.

So we can conclude that the command structure is `"bash -c echo '$((YOUR_INPUT))' "`

Therefore I ran some tests:

```

Operation: ((7*7)) 100.100 device tund opened
49 09-23 21:40:42 net: face mfu set: mfu 1500 for tund
09-23 21:40:42 net: face up: set tund up
Operation: ((7*7) ) net: addr v4 add: 10.10.14.125/23 dev: tund
1 09-23 21:40:42 net: face mfu set: mfu 1500 for tund
49 09-23 21:40:42 net: face up: set tund up
09-23 21:40:42 net: addr v6 add: dead-beef:2::107b:64 dev: tund
Operation: ((7*7) ) net: ) net: v4 add: 10.10.10.0/23 via 10.10.14.1
49 09-23 21:40:42 net: route v4 add: 10.10.0.0/16 via 10.10.14.1

```

```

Operation: whoami) net_addr_v6 add: dead:beef::107b/64
0 2023-09-23 21:48:42 net_route_v4 add: 10.10.10.0/23 via 1
2023-09-23 21:48:42 net_route_v4 add: 10.129.0.0/16 via 1
Operation: whoami) add ) route ipv6:dead:beef::/64 -> dead
2023-09-23 21:48:42 net_route_v6 add: dead:beef::/64 via
Operation: whoami) Init() finalat # Sequence Completed
ctf 2023-09-23 21:48:42 Data Channel: cipher 'AES-256-CBC', a
2023-09-23 21:48:42 Timers: ping 10, ping-restart 120
Operation: █

```

In Bash and similar shell environments, the `$((expression))` syntax is used for arithmetic evaluation. It treats expression as a mathematical expression and calculates the result. However, the behavior of the shell can change when you introduce additional characters or spaces.

Consider this example:

`$((expression))`: This syntax correctly evaluates the mathematical expression enclosed within the double parentheses. It calculates the result of the mathematical operation.

Now, let's look at this variation:

`$((expression))`: Here, the last `)` character is followed by a space. This subtle change can affect how the shell interprets the command. When the shell encounters a space before the closing `)`, it may interpret it as the end of the arithmetic expression and start interpreting the contents of the parentheses as a command to execute.

The use of `#` in your payload (command) `) #` is significant because `#` is the comment character in many shell languages, including Bash. When the shell encounters `#`, it treats everything following it on the same line as a comment and ignores it.

So, in the payload command `) #`, the following occurs:

command)): The shell may interpret this as an attempt to execute a command with extra parentheses. It might not be a valid command, but the shell will attempt to execute it.

`#`

The `#` character marks the rest of the line as a comment. Any characters or commands following the `#` are ignored by the shell.

The payload is crafted to exploit a situation where the shell misinterprets the input, potentially leading to unintended command execution. This kind of behaviour is a classic example of how command injection vulnerabilities can arise when input is not properly sanitized or validated by an application.

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Remember to use tabs since spaces are not allowed.

```
Operation: pwd) _ _ _ _ _ # _ _ _ _ _  
/home/ctf  
Operation: ls -l /) _ _ _ _ _ # _ _ _ _ _  
bin calculator dev etc flag.txt home lib media mnt opt proc root run sbin srv sys tmp usr var _
```

```
Operation: cat48/flag.txt)lization Sequence Comple#  
HTB{ ?}lpher 'AES-256-C
```