Reverse Engineering HW4:

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Dry part:

1. It is possible to get this gadget. If we would be scouting the code after the combination of the two commands opcodes (60 and C3) ,we may took part of another command in order to find the opcode 60 which is not so common.
   For example : if we had the following commands at the end of some function in the code:

   ```
   add    esp,0x60
   ret
   ```

   this is two commands that we can find in allot of function (as we need to return the stack pointer to it's original state before we reti=urn from the function).
   the opcode of the two commands is translated to :

   ```
   83 c4 60
   C3
   ```

   And the last two opcode is exactly what we need.
2. Here is a look at the stack :

1	9ad9e706	xor eax,eax
2	9ad9e704	pop ebx
3	70707061	
4	9ad9e700	Add eax, ebx
5	Deadbeef	
6	Deadbeef	
7	Deadbeef	
8	9ad9e716	Mov eax, dword ptr[eax+0fh]
9	9ad9e711	Inc eax
10	9ad9e711	Inc eax
11	9ad9e709	Mov ecx, eax
12	9ad9e716	Mov eax, dword ptr[eax+0fh]
13	9ad9e703	Pop ecx
14	9ad9e71c	pusha
15	Virtual Protect address	
16	9ad9e71a	Pop edi
17	9ad9e704	Pop ebx (will go to edi)
18	9ad9e714	Pop ebp
19	9ad9e702	Pop ebx (will go to ebp)
20	9ad9e71c	pusha

21	00001000	dwSize of page
22	40000040	R\W\X permission
23	00025000	lpfOldProtect

First, we cleared the eax register, popped ebx and added it to eax, dereferenced it's value and increased eax in order in order to store the address of the start of the page in eax register (commands 1-12).

After that, we put in inside the ecx the address of the gadget that does pusha command and stores the virtual protect address in the ebp register..(commands 13-15).

After the "pusha" gadget is called the stack look like this:

Edi-pop ebx
Esi
Ebp- POP
Ebp- POP
Ebp- POP
Esp
Ebx=VP
Edx
Ecx-pusha
Eax-address
00001000
40000040
00025000

So after ret will be excecuted to edi, esi value will pop to ebx. After that will do ret to ebp 3 times , ending in ebx storing edx (junk value) and ecx will have Vitual protect address (ebx old value). now we will do ret inside ecx – pusha and will push all the register to the stack the will look like this:

Edi-pop1
Esi
Ebp-pop
Ebp-pop
Ebp-pop
Esp
Ebx
Edx
Ecx-VP
Eax-address
Eax-address
00001000
40000040
00025000

We can noticed that both edi and ebp has not changed and ecx updated to store the address of virtual protect. Now as we did before will do ret to the ecx register (after the pops) and move to the Virtual Pprotect address. We can see the return address of VP is now the start of the page and it's parameters are:

lpadress=start of page,

dwSize=00001000,

flNewProtect=40000040,

lpfOldProtect=00025000

SO virtual protect changes the page permissions to r/w/x. saves the old permissions in 25000 and after the return to the start of the page which is exactly what we wanted.

The value of the new Permissions should be 40000040 since inserting only 40000000 will be problematic since it containing null values (00).

3. We saw in the tutorial that there are some things that we can't write when implementing stack overflow such as null (00), '\n' (0A) and more.
   We can see that we need to use the value of '\n' – 0A.

4. Because we can't use this value, we will enter the value F6 to the neg function. This way, we won't enter the value 0A in the buffer, but the value F6. Now, before we will execute anything, we can use the neg function to get the wanted value – neg(F6) = 0A.

   This will change the rop chain be inserting FFFFF000 instead of 00001000 than negating it using the rop, thus preventing us from inserting NULL char, and give us the correct value we wanted to be as the dwSize.

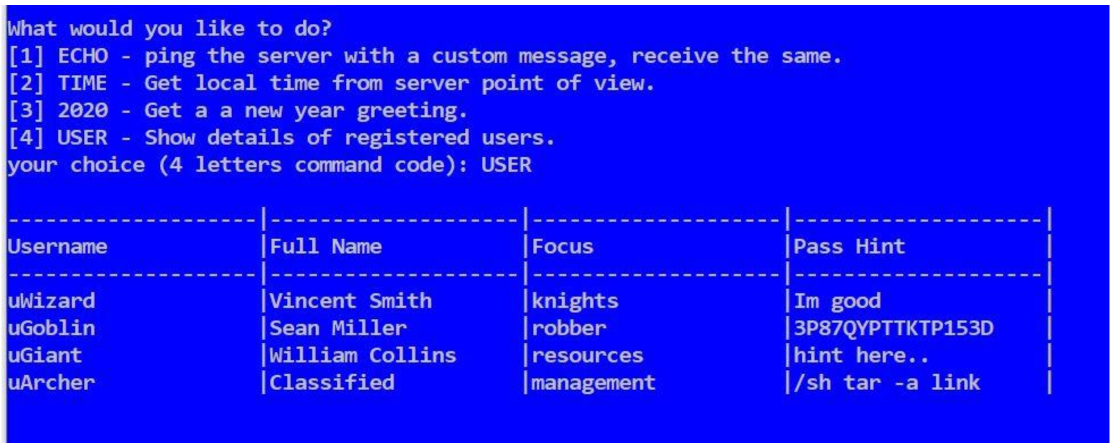
Wet part:

Part 1:

At first glance of hw4_client.exe trough IDA everything seems in order. There is a request for username and password that is checked through the server using the methods we already saw (send and recv) . after going trough couple of check up to find to any vulnerability, we found out that whilst the username length is limited to up to 31 letters there is no such limitation on the password length, and therefore the exe is exposed to buffer overflow. We needed a way to pass trough the username and password checks that are been done after we are returning from the function. So we decided to use the buffer overflow to overwrite the return address from the function and instead of making the function return to the rest of the code (and the authentication check) in address 401C3B we decided to changed it to loc_401CAE, after the authentication part and on to printing the menu and the rest of the desired user table. We wrote python script the opens a process and insert to it "USER" as a user name(which will be overwritten again as we insert the password) . After that we needed to insert a password. The problem is that the password address is located higher than the username address, so in order to reach the return address and changed it we needed to assemble the password carefully and padding with correct number of null char ("00"in hex) we reached the return address and replaced it with "401CAE".

We added the to the input the 4 char U S E R in order to get the users list.

Running the users.py and requesting the users table file gave us the following result:

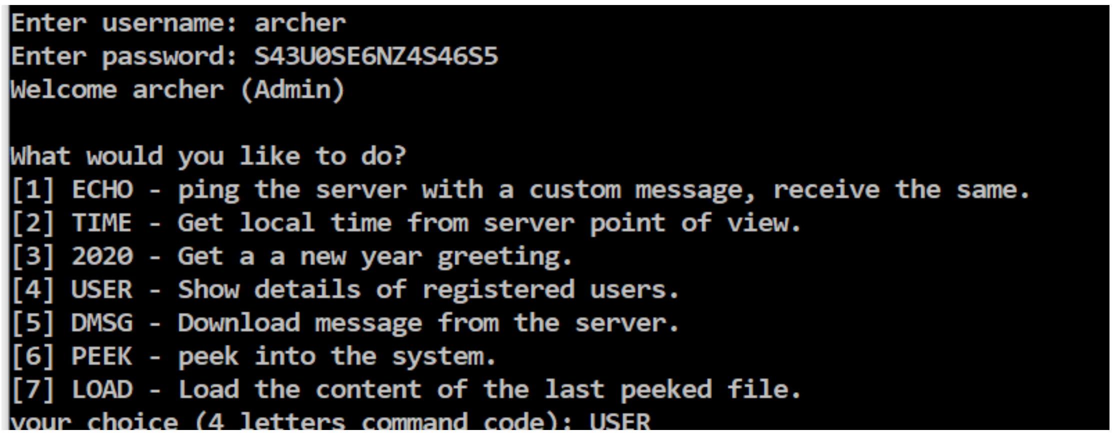


```
What would you like to do?
[1] ECHO - ping the server with a custom message, receive the same.
[2] TIME - Get local time from server point of view.
[3] 2020 - Get a a new year greeting.
[4] USER - Show details of registered users.
your choice (4 letters command code): USER

--------------------|--------------------|--------------------|--------------------|
Username            |Full Name           |Focus               |Pass Hint           |
--------------------|--------------------|--------------------|--------------------|
uWizard             |Vincent Smith       |knights             |Im good             |
uGoblin             |Sean Miller         |robber              |3P87QYPTTKTP153D    |
uGiant              |William Collins     |resources           |hint here..         |
uArcher             |Classified          |management          |/sh tar -a link     |
```

Part 2:

As we saw from the table printed to us the only given password is the one that belongs to the goblin. We tried to log in with the goblin as a username and his password and got the same table, but this time it had an additional option: DMSG. The same option that prints the message that we deciphered in the previous assignment.

We noticed that the goblin password is the same one that we found in the 1st assignment, so we tried to log in with all of the accounts. The Wizrds and the giant showed us the same menu and messages as the goblin did. But when we logged using the archer account we found out that he is an admin and there fore has more permissions and his menu contained more options:



```
Enter username: archer
Enter password: S43U0SE6NZ4S46S5
Welcome archer (Admin)

What would you like to do?
[1] ECHO - ping the server with a custom message, receive the same.
[2] TIME - Get local time from server point of view.
[3] 2020 - Get a a new year greeting.
[4] USER - Show details of registered users.
[5] DMSG - Download message from the server.
[6] PEEK - peek into the system.
[7] LOAD - Load the content of the last peeked file.
your choice (4 letters command code): USER
```

Part 3:

Part3:

After each time PEEK code is being picked as the action to send to the server, another call for scanf is placed in order the get the command the user want to be executed inside the folder designated to us. As we saw from the first part, the scanf input is not limited to any number of bytes, the buffer is located just below the sub routine sub_4019BD stack:, allowing us the overflow the stack of sub_401BFA. We overflow the stack until we reached the return address from sub_4019BD, so we overwrote it with a address we found- a gadget we search on the current modules the were being used by the program that will continue the program execution on a code we inserted in stack as part of the scanf input.

We used get functions in the utils.py file given to us in order to find a rop gadget the will allow us to jump to our code. Using getGadgetAddress allowed us to search exactly for the rop gadget we looked after – "jmp esp" .by inserting the rop opcode as an input to the function it searches for each couple of opcode for exact sequence of hex letters from the start of the module (using getModule handle to give us the address of the module in the current run of the program . lucky for us, the module ntdll.dlll loading addresss is the same one in every execution, allowing us the find the rop "jump esp" in the same location. We took the rop address and placed it the return addess, and after that the opcode for jump to the start of the buffer we wrote our shell into. So the next time sub_4019BD is finished ebp address is called- jumping to ntdll.dll rop address that will call jump esp and reading the next command from the start navigating it the our shell and executing the code that we wrote:

- Calling memset function to reset the stack for the output from the server.
- Calling scanf to receive the next peek instruction from the user.
- Calling strlen in order to calculate the length of the inserted user input.
- Comparing the input don’t' start with exit otherwise finish the execution.
- Calling loc_401892 – the function that communicates with the server and sends him the input from the user. And get back the message on the address we designated on the server (that was reset earlier).
- Jumping back to the end of sub_4019bd in order to call again jmp esp from ntdll.dll module and start the whole shellcode run again.

We padded the rest of the shell code with couple of nop's and tons of NULLs to get to the

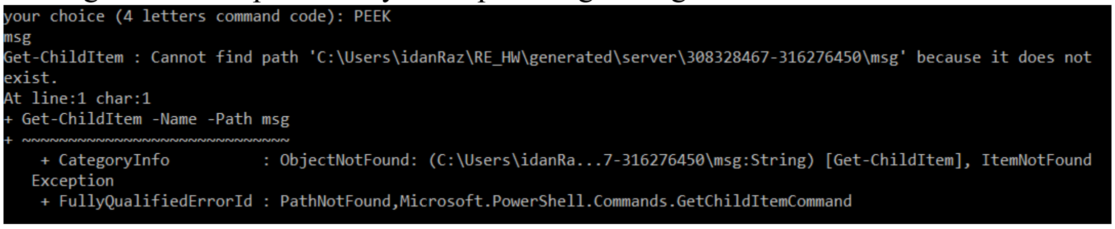
The place that was selected to contain the input from the user and the output from the server message was the rest of the stack we didn't used for our code, thus using the stack space as both execution code holder and data structure. Both spaces never collided since the input/output address was beneath our code thus preserving it from being demolished by any subsequent input/output and since the original code was place from 40000 address it was also left untouched. (Padding the rest of the stack overflown by NULL made sure that any string stored there will not be ambiguously interpreted as any other string longer than what we inserted.)

By using the loc_401892 sub routine, we didn't have to search to heavly after any kind of server data and the subroutine did the job for us in terms of communicating with the server. (assuming we gave it the right arguments).

We avoided any mistake inserting any string character than can be interpreted as others by inserting any string to the shell code and any input after that in bytes- we parsed each command and each input to byte array and inserted them carefully byte by byte.

Part 4:

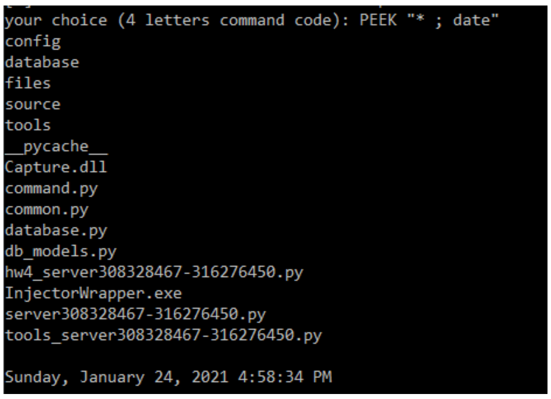
To find out what PEEK is doing, first of all we ran the command, we can see that it's waiting for some input. We try the input "msg" and got an error:



```
your choice (4 letters command code): PEEK
msg
Get-ChildItem : Cannot find path 'C:\Users\idanRaz\RE_HW\generated\server\308328467-316276450\msg' because it does not
exist.
At line:1 char:1
+ Get-ChildItem -Name -Path msg
+ ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
    + CategoryInfo          : ObjectNotFound: (C:\Users\idanRa...7-316276450\msg:String) [Get-ChildItem], ItemNotFound
   Exception
    + FullyQualifiedErrorId : PathNotFound,Microsoft.PowerShell.Commands.GetChildItemCommand
```

From the error, we can see that the command tries to find a path. So, the next thing we tried is '*' (which means all). The command PEEK with the value '*' showed us all the files\folders in the server (C:\Users\idanRaz\RE_HW\generated\server\308328467-316276450).
We found out that we can also navigate using this command – for example: the command PEEK tools will show us the content of the tools folder.
One more thing that we can do using the command PEEK is to peek a file and then use the LOAD command to see the content of this file.

We now know that PEEK runs a command. We want to run other commands. We will user basic injection for this in the following way:
We call the command PEEK and, in the input, we will insert **" * ; <command>"**.
Explanation: The char '*' is the value for the PEEK command, the char ';' represents that we finished a command and after that we can write the command we want to run on the server. For example:



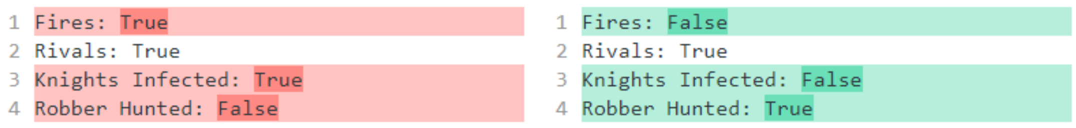
```
your choice (4 letters command code): PEEK "* ; date"
config
database
files
source
tools
__pycache__
Capture.dll
command.py
common.py
database.py
db_models.py
hw4_server308328467-316276450.py
InjectorWrapper.exe
server308328467-316276450.py
tools_server308328467-316276450.py

Sunday, January 24, 2021 4:58:34 PM
```

In the example we can see that the value we insert to the PEEK function is a '*' (as we said before) and then we run another function – date. We can see the output of date after the output of the PEEK.

In order that we keep on running commands on the server we added the script attack_shell.py a while loop that keep on reading the input interpreting it to bytes and inserting it to the shell until an exit string is being inserted.

Part 5:

We want to find a way to stop the knights and extinguish the fires. We looked at all the files and one of the files we saw was attack.config. This file is interesting because we can see in the file information about the fires and about the knights (which we could not see anywhere else). We can see, for example, that the value of the fires is True and the value of Knight Infected is True. We want to change the values of this file because we do not want the knights to be infected and we don't want fires on the board. We want to do the following changes:



```
Fires: True
Rivals: True
Knights Infected: True
Robber Hunted: False
```

```
Fires: False
Rivals: True
Knights Infected: False
Robber Hunted: True
```

From the previous part, we know that we can run commands on the server. Let's insert the command that updates the config file. The commend is:

echo 'Fires: False\nRivals: True\nKnights Infected: False\nRobber Hunted: True' > config\attack.config

Of course, we need to put the command in the following way:

PEEK "config\attack.config ; echo 'Fires: False\nRivals: True\nKnights Infected: False\nRobber Hunted: True' > config\attack.config"

Note that in the beginning, we can write anything we want (instead of "config\attack.config"). The important part is the command after the ';'.

Using the functions we build in attack_shell.py in the previous part, all we had to do is to import the functions from the previous part, execute a sub process for hw4_client.exe the same way as we did before, doing the same shell attack as before, but this time after the shell code is being executed we simply added the string overwriting attack.config file and finished the hw4_client execution.

We can see that the file updates! We logged into the website (with archer user) and saw that the fire is out.