***CS255 – Lab 1 – Reverse Engineering***

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**Setup**

* For analyzing these crackme files and running them, I used Ghidra and Docker desktop….
* Following the instructions as posted in the video on Yuja, I installed Ghidra to decompile and analyze the code files
* To run the code, I installed docker desktop and used the command shared on piazza – << sudo docker run -v $(pwd):/binaries -w /binaries -it --rm i386/ubuntu:bionic ./crackme0x00>>

**Crackme0x00**

Password – *250382*

*A screenshot of a computer

Description automatically generated*

Analysis –

* Using Ghidra to decompile binary file crackme0x00 we can find the main function (as seen in the screenshot below)

A screenshot of a computer

Description automatically generated

* A static analysis of the main function reveals that the file reads input from the user using scanf and stores it in a string variable called local\_1c
* The next step is comparison of local\_1c and correct password. Shown below is a generic model of how we can get “Password OK” or “Invalid Password” (reference – slides by Zhengchuan Liang)A diagram of a computer

  Description automatically generated
* In this case the program uses strcmp function which returns 0 if the two strings being compared are the same. The result is stored in a variable called iVar1.
* Using strcmp, the comparison is with the processed input and the correct password which is exposed and the value is “250382”
* And it prints “Password OK :)” if the input string is the same as “250382”.
* In all other cases it prints “Invalid password!”

**Crackme0x01**

Password – *5274*

A screenshot of a computer

Description automatically generated

Analysis –

* Using Ghidra to decompile binary file crackme0x01 we can find the main function (as seen in the screenshot below)

A screenshot of a computer

Description automatically generated

* A static analysis of the main function reveals that the file reads input from the user using scanf and stores it in a integer variable called local\_8
* This time the comparison is b/w two numbers, one the value input by the user and the second one is a hexadecimal value ‘0x149a’ which in decimal is ‘5274’.
* It doesn’t matter if we are comparing hexadecimal and decimal numbers as the values are all converted to their binary representations. This is just a simple obfuscation on the correct password.
* Thus, if the user input is ‘5274’, the program prints “Password OK : )”
* For any other user input, it prints “Invalid Password!”

**Crackme0x02**

Password – *338724*

A screenshot of a computer

Description automatically generated

Analysis –

* Using Ghidra to decompile binary file crackme0x02 we can find the main function (as seen in the screenshot below)

A screenshot of a computer

Description automatically generated

* This code is very similar to the previous one (0x01). This time again we have a comparison b/w two numbers, one the value input by the user and the second one is a hexadecimal value ‘0x52b24’ which in decimal is ‘338724’.
* It doesn’t matter if we are comparing hexadecimal and decimal numbers as the values are all converted to their binary representations (A simple obfuscation once again)
* Thus, if the user input is ‘338724’, the program prints “Password OK : )”
* And just as before, for any other input, it prints “Invalid Password!”

**Crackme0x03**

Password – *338724*

A screenshot of a computer

Description automatically generated

Analysis –

* Using Ghidra to decompile binary file crackme0x03 we can find the main function (as seen in the screenshot below)

A screenshot of a computer

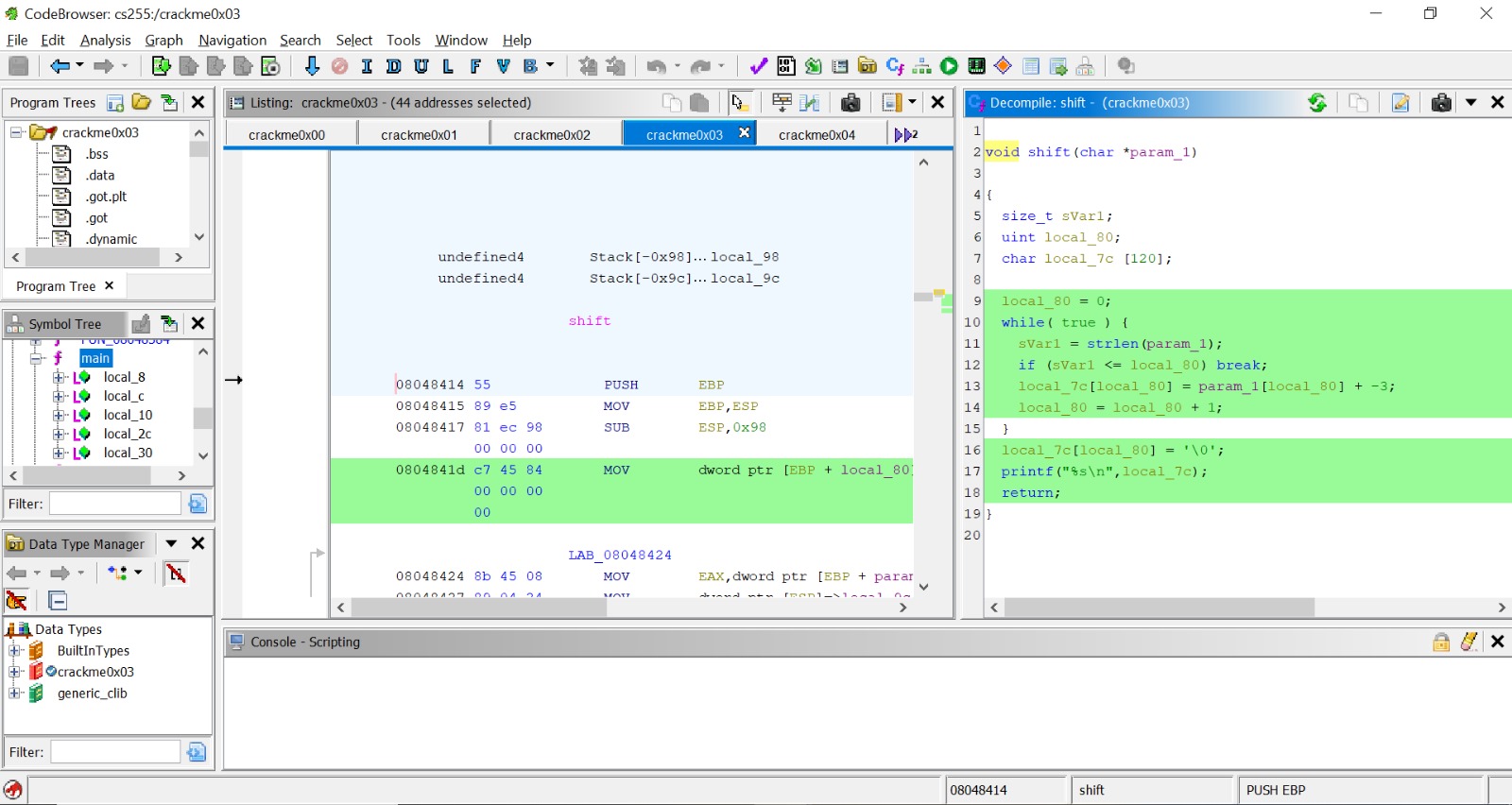
Description automatically generated

* A static analysis of the main function reveals that the file reads input from the user using scanf and stores it in a local variable called local\_8
* Now, instead of direct comparison, the program calls a test function with local\_8 and the hexadecimal value ‘0x52b24’ as arguments. It finally returns 0.
* Next let’s look at the test function

A screenshot of a computer

Description automatically generated

* The test function compares the two integer parameters, and if they are equal, it calls the shift function with the string “Sdvvzrug#RN$$$#=,” as an argument
* If they are not equal, it still calls the shift function but with a different string – “Lqydolg#Sdvvzrug$”
* Now let’s take a look at the shift function

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* The shift function takes a string called param\_1 as an argument
* It keeps track of the size of param\_1 using sVar1 and uses a local\_80 as a counter for the while loop.
* The code in the while loop is basically a simple character shift. It is subtracting 3 from the ASCII values of each character in the string param\_1 and updates it into the corresponding location in a new char array local\_7c.
* It is essentially creating a new string one character at a time.
* Lastly it terminates the string by adding ‘\0’ character to local\_7c and then prints it.
* By performing this shift operation (subtracting 3 in ASCII value for each character) on the string “Sdvvzrug#RN$$$#=,” gives us – “Password OK!!! : )”
* With string “Lqydolg#Sdvvzrug$”, it gives us – “Invalid Password!”
* This just provides a simple obfuscation on the output strings printed, but the value that is actually being compared with the user input is still ‘0x52b24’ or ‘338724’
* Thus, we can conclude that if the user enters the value ‘338724’, it prints “Password OK!!! : )”
* In all other cases, it prints “Invalid Password!”

**Crackme0x04**

Password –

*Sum of the digits in the input starting from the leftmost one should be 15 at some point (incrementally)*

*eg: 78, 781, 7813143251435 etc.*

A screenshot of a computer

Description automatically generated

Analysis –

* Using Ghidra to decompile binary file crackme0x04 we can find the main function (as seen in the screenshot below)

A screenshot of a computer program

Description automatically generated

* A static analysis of the main function reveals that the file reads input from the user using scanf and stores it in a local string variable called local\_7c
* Now, instead of direct comparison with the correct password, the program calls a check function with local\_7c as the argument. It finally returns 0.
* Next let’s look at the check function

A screenshot of a computer

Description automatically generated

* The check function takes a string param\_1 as an argument. It also has a bunch of local variables
* sVar1 to keep size of the string param\_1.
* A char variable local\_11 to read and temporarily store each character of the string param\_1
* An integer local\_10 which works as a counter for the while loop, which is initialized to 0
* An integer local\_c which stores the sum so far and is initialized to 0.
* And an integer local\_8 which stores the int value of the character local\_11
* In the while loop, there is a check if the counter local\_10 exceeds the size of param1, in which case, it prints “Password Incorrect!” and returns.
* If the condition is false, i.e the current char is not the last char of the string param\_1, then it reads that character and stores it in local\_11
* It then uses sscanf to convert that character to an integer and stores it in local\_8
* Next, it increments adds the value of local\_8 to the sum so far, i.e to local\_c and stores it in local\_c
* Next, it checks if the sum so far (local\_c) is equal to 0xf (which is 15 in decimal system). If that is true, it breaks out of the loop.
* And then it prints “Password OK!” and returns
* Else, it increments the counter local\_10 by 1 and goes to the next iteration.
* Since it is checking the sum of digits incrementally from the left and prints “Password OK!” as long as the sum so far reaches exactly 15 and doesn’t check the rest of the digits in the string, all valid passwords are the ones in which if the sum of digits of the input from the left equal 15 at any time.
* Invalid passwords are all in which the sum of digits from the left is not equal to 15 at any time.

**Crackme0x05**

Password –

*Sum of the digits in the input starting from the leftmost one should be 16 at some point (incrementally)*

*And*

*Number must be even.*

*eg: 88, 4444, 970, 974568, 882 etc.*

A screenshot of a computer program

Description automatically generated

Analysis –

* Using Ghidra to decompile binary file crackme0x05 we can find the main function (as seen in the screenshot below)

A screenshot of a computer

Description automatically generated

* A static analysis of the main function reveals that the file reads input from the user using scanf and stores it in a local string variable called local\_7c
* Now, instead of direct comparison with the correct password, the program calls a check function with local\_7c as the argument. It finally returns 0.
* Next let’s look at the check function

A screenshot of a computer

Description automatically generated

* The check function takes a string param\_1 as an argument. It also has a bunch of local variables similar to the previous one
* sVar1 to keep size of the string param\_1.
* A char variable local\_11 to read and temporarily store each character of the string param\_1
* An integer local\_10 which works as a counter for the while loop, which is initialized to 0
* An integer local\_c which stores the sum so far and is initialized to 0.
* And an integer local\_8 which stores the int value of the character local\_11
* Next we have an indefinite while loop, within which we check if length of string param\_1 is less than or equal to local\_10. In case it is true, we break out of the loop
* Next, we read a character from the string param\_1 (at the index local\_10 which is a counter) and store it in local\_11
* We then convert the character stored in local\_11 into an integer using sscanf and store it in local\_8
* We then add local\_8 to the sum so far, i.e. local\_c and store it in local\_c
* We now check, if the sum so far or local\_c is equal to the value ‘0x10’, which is 16 in decimal system, if it is true we call the parell function while passing the string param\_1
* We then increment the value of the counter local\_10 by 1
* If the loop exits without the sum of digits from the left ever reaching 16 or 0x10, we print “Password Incorrect!”
* Now let’s take a look at the parell function -

A screenshot of a computer

Description automatically generated

* The parell function takes a string argument called param\_1
* It also has a local integer variable called local\_8
* It first converts the string param\_1 into an integer and stores it in local\_8 using sscanf
* Now it checks if the number local\_8 is even using bitwise AND operation
* If it is even, it prints “Password OK!” and exits the program.
* Since it is checking the sum of digits incrementally from the left and prints “Password OK!” as long as the sum so far reaches exactly 16 and the number is even and doesn’t check the rest of the digits in the string
* all valid passwords are the ones in which if the sum of digits of the input from the left equal 16 at any time and that the input is even.
* Invalid passwords are all in which the sum of digits from the left is not equal to 16 at any time and cases where the sum is 16, but the number is not even.

**Crackme0x06**

Password –

*Sum of the digits in the input starting from the leftmost one should be 16 at some point (incrementally)*

*And*

*Set an env variable whose first three characters are LOL*

*And*

*Number must be even.*

*eg: 88, 4444, 970, 974568, 882 etc.*

A screenshot of a computer program

Description automatically generated

Analysis –

* Using Ghidra to decompile binary file crackme0x06 we can find the main function (as seen in the screenshot below)

A screenshot of a computer

Description automatically generated

* A static analysis of the main function reveals that the file reads input from the user using scanf and stores it in a local string variable called local\_7c
* Param\_3 is nothing but an environment variable
* Now, instead of direct comparison with the correct password, the program calls a check function with local\_7c and param\_3 as arguments. It finally returns 0.
* Next let’s look at the check function

A screenshot of a computer

Description automatically generated

* The check function takes string param\_1 and integer param\_2 as arguments. It also has a bunch of local variables similar to the previous one
* sVar1 to keep size of the string param\_1.
* A char variable local\_11 to read and temporarily store each character of the string param\_1
* An integer local\_10 which works as a counter for the while loop, which is initialized to 0
* An integer local\_c which stores the sum so far and is initialized to 0.
* And an integer local\_8 which stores the int value of the character local\_11
* Next, we have an indefinite while loop, within which we check if length of string param\_1 is less than or equal to local\_10. In case it is true, we break out of the loop
* Next, we read a character from the string param\_1 (at the index local\_10 which is a counter) and store it in local\_11
* We then convert the character stored in local\_11 into an integer using sscanf and store it in local\_8
* We then add local\_8 to the sum so far, i.e. local\_c and store it in local\_c
* We now check, if the sum so far or local\_c is equal to the value ‘0x10’, which is 16 in decimal system, if it is true we call the parell function while passing the string param\_1 and integer param\_2
* We then increment the value of the counter local\_10 by 1
* If the loop exits without the sum of digits from the left ever reaching 16 or 0x10, we print “Password Incorrect!”
* Now let’s take a look at the parell function –

A screenshot of a computer

Description automatically generated

* The parell function takes string arguments called param\_1 and an integer param\_2
* It also has a local integer variable called local\_8
* It first converts the string param\_1 into an integer and stores it in local\_8 using sscanf
* Next it calls the dummy function and stores it’s return value (0 or 1) into the iVar1 variable
* Now it checks if the iVar1 is not zero, if it’s not 0, it goes into the loop that runs 10 times
* In the loop it checks if the number local\_8 is even using bitwise AND operation
* If it is even, it prints “Password OK!” and exits the program.
* Now let’s take a look at the dummy function –

A screenshot of a computer

Description automatically generated

* The dummy function takes string arguments called param\_1 and an integer param\_2
* It also has local integer variable called local\_8 and iVar1
* The variable local\_8 is initialized to 0
* And then we have a do while loop which runs as long as iVar1 is not 0
* Now, in the loop it checks if the value stored at the location which is found by the local\_8 \* 4 + param\_2 is equal to zero. If it is, the function returns 0. And the code prints “Password Incorrect!” This is basically checking if the environment variable has been set or not
* Next, iVar1 is set to the value local\_8 \* 4, the memory location
* It then increments the value of local\_8 by 1, this acts as the counter for the loop
* The next line uses strncmp to compare the first 3 characters of the string stored at the memory location with the string "LOLO", which is nothing but LOL. If the comparison is not equal to 0, it continues the loop.
* the loop exits without returning 0, it returns 1, indicating success.
* In this case, the dummy function returns 1, which is used to set iVar1 in parell function
* Next, if the password is even, the code prints “Password OK!”
* In all other cases like, if the sum is not 16, if the num is not even, and if the env variable is not set and if it is and it’s first 3 characters doesn’t match LOL, it prints “Password Incorrect!”