Cybersecurity

Rainbow Table Lab

Rainbow Table Lab Materials

- In this lab students will perform password cracking via the use of rainbow tables.
- Materials needed
  - Kali Linux
- Software Tools used
  - rainbowcrack (Password Cracking Tool)

Objectives Covered

- Security+ Objectives (SY0-701)
  - Objective 2.4 - Given a scenario, analyze indicators of malicious activity.
    - Password attacks

Rainbow Table Lab Overview

1. Learn/Review the terminology (5 slides)
2. Log into Kali Linux
3. Create Rainbow Table
4. Create Hashes from example passwords
5. Use Rainbowcrack to crack a hash
6. Use Rainbowcrack to crack a file of hashes
7. Observe the results

What is a Hash?

- A hashing algorithm is an algorithm that converts input data (or a message) of varying size to a hash output of a fixed size
- A hash is a one-way function, impossible to revert.
- Generally, the longer the fixed output the less possibility of collisions (two inputs producing the same output), thus the more secure the hashing algorithm

$$\underbrace{\begin{array}{l}\texttt{SomeBigLongValue}\\ \texttt{tinyval}\\ \texttt{NggYuNgLYDngraaDY}\end{array}}_{\text{Variable size input}} \longrightarrow \underbrace{\begin{array}{l}\texttt{33ce0634}\\ \texttt{0c430308}\\ \texttt{3803062f}\end{array}}_{\text{Fixed size output}}$$

What is a Rainbow Table?

- Pre-calculated series of hashes using known hashing algorithms
- Commonly used for cracking passwords
  - Find the matching hash string of text
  - Look up the input text that gave the result
  - *Voila!* There's the password/input string
- Rainbow tables are application-specific
  - Built for each different application or OS
  - No one table for all uses

Plaintext	**MD5 Checksum**
Alice	`64489c85dc2fe0787b85cd87214b3810`
Bob	`2fc1c0beb992cd7096975cfebf9d5c3b`
Carol	`150c16d9d096e70af3596111d7402397`
Dave	`083d9a270e6e16b2fbb08d35067aae5f`

How does a Rainbow Table work?

- Get the first **x** characters of a hash
  - Hash these characters
- Get the first **x** characters of *that* hash
  - Hash *these* characters
- Do this repeatedly…
  - This creates a "chain"
  - Each chain can be referred to as a color "red" (first hash), "orange" (second hash), "yellow" (third hash), etc.
- After obtaining enough chains, they create a table
  - A table of all the colors... like a rainbow. Hence a "rainbow table".
- Only store the plaintext and final hash value for each chain
  - All values in between plaintext and final hash can be re-computed as needed

How does a Rainbow Table work (cont.)?

- To use the table, take the first **x** characters of the target hashed password and look for a match in the table.
  - If a match is not found, take the first **x** characters, hash, and search again
  - If a match *is* found, you know the plaintext at the front of that chain is part of the target password – this narrows the search by **x** characters.
    - Take the next **x** characters and start the process again
- It is a narrowing down of the thousand and millions of possibilities

Rainbow Tables vs. Brute Force

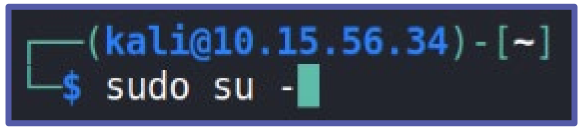
- Advantages of a Rainbow Table
  - No need to match the whole string, looking for parts
  - Not trying all values, only searching a table (fast)
  - Can be done offline
    - System does not know attempts are being made to crack the password of its users!
- Advantages of a Brute Force
  - Does not need to store the large Rainbow Table dataset
    - Which can be large! Can be *gigs* of text or even terabytes
  - Works for all passwords, just takes time (*lots and lots and lots of time*)

Log into Kali Linux

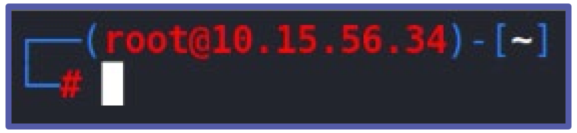
- Open the Kali Linux Environment
- Open Terminal
- Login as the root user with the following command:

  `sudo su -`

- Notice the command prompt is now **`root@kali`**



```
┌──(kali@10.15.56.34)-[~]
└─$ sudo su -
```



```
┌──(root@10.15.56.34)-[~]
└─#
```

Create Rainbow Table

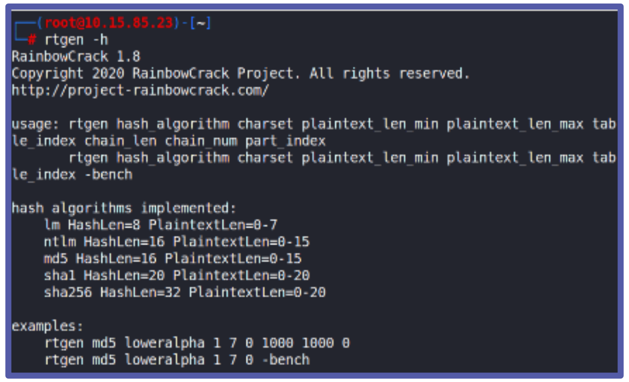
- Type the following command*:

```
rtgen -h
```

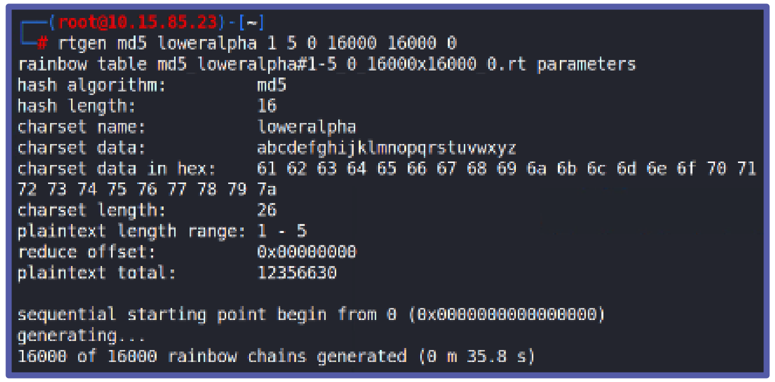
- Read the options available when using this command to create a rainbow table
- Type the following command:

```
rtgen md5 loweralpha 1 5 0 16000 16000 0
```

- This will create a rainbow table using the MD5 hash algorithm with a hash length of 16 based on input restricted to 5 characters that are lowercase letters
- *This will take time!*



```
┌──(root@10.15.85.23)-[~]
└─# rtgen -h
RainbowCrack 1.8
Copyright 2020 RainbowCrack Project. All rights reserved.
http://project-rainbowcrack.com/

usage: rtgen hash_algorithm charset plaintext_len_min plaintext_len_max tab
le_index chain_len chain_num part_index
       rtgen hash_algorithm charset plaintext_len_min plaintext_len_max tab
le_index -bench

hash algorithms implemented:
    lm HashLen=8 PlaintextLen=0-7
    ntlm HashLen=16 PlaintextLen=0-15
    md5 HashLen=16 PlaintextLen=0-15
    sha1 HashLen=20 PlaintextLen=0-20
    sha256 HashLen=32 PlaintextLen=0-20

examples:
    rtgen md5 loweralpha 1 7 0 1000 1000 0
    rtgen md5 loweralpha 1 7 0 -bench
```



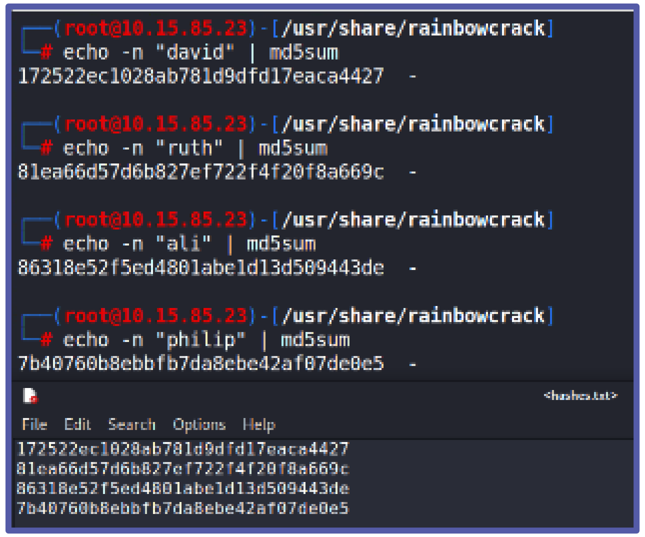
```
┌──(root@10.15.85.23)-[~]
└─# rtgen md5 loweralpha 1 5 0 16000 16000 0
rainbow table md5_loweralpha#1-5_0_16000x16000_0.rt parameters
hash algorithm:         md5
hash length:            16
charset name:           loweralpha
charset data:           abcdefghijklmnopqrstuvwxyz
charset data in hex:    61 62 63 64 65 66 67 68 69 6a 6b 6c 6d 6e 6f 70 71
72 73 74 75 76 77 78 79 7a
charset length:         26
plaintext length range: 1 - 5
reduce offset:          0x00000000
plaintext total:        12356630

sequential starting point begin from 0 (0x0000000000000000)
generating...
16000 of 16000 rainbow chains generated (0 m 35.8 s)
```

*RainbowCrack (rtgen) is already installed on the CYBER.ORG Range
Use the following command to install (if not installed):

```
sudo apt-get install rainbowcrack
```

Create Hashes

- Navigate to the folder with Rainbowcrack
  `cd /usr/share/rainbowcrack`
- Create a sample hash for a 5-character lowercase input by using the following command:
  `echo -n "david" | md5sum`
- Repeat this process three more times for other inputs
- Create a new file called “*hashes.txt*” in a text editor
  `leafpad hashes.txt`
- Copy and paste each output into the “*hashes.txt*” file
- Input each hash on a new line
- Save the file (hashes.txt)
- Close leafpad



```
┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# echo -n "david" | md5sum
172522ec1028ab781d9dfd17eaca4427  -

┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# echo -n "ruth" | md5sum
81ea66d57d6b827ef722f4f20f8a669c  -

┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# echo -n "ali" | md5sum
86318e52f5ed4801abe1d13d509443de  -

┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# echo -n "philip" | md5sum
7b40760b8ebbfb7da8ebe42af07de0e5  -
```

```
172522ec1028ab781d9dfd17eaca4427
81ea66d57d6b827ef722f4f20f8a669c
86318e52f5ed4801abe1d13d509443de
7b40760b8ebbfb7da8ebe42af07de0e5
```

CYBER.ORG

Crack a Hash using Rainbowcrack

- Run the following command to sort all *.rt* tables in the current directory to make binary search possible

  ```
  rtsort .
  ```

- Copy the MD5 hash output from the previous command:

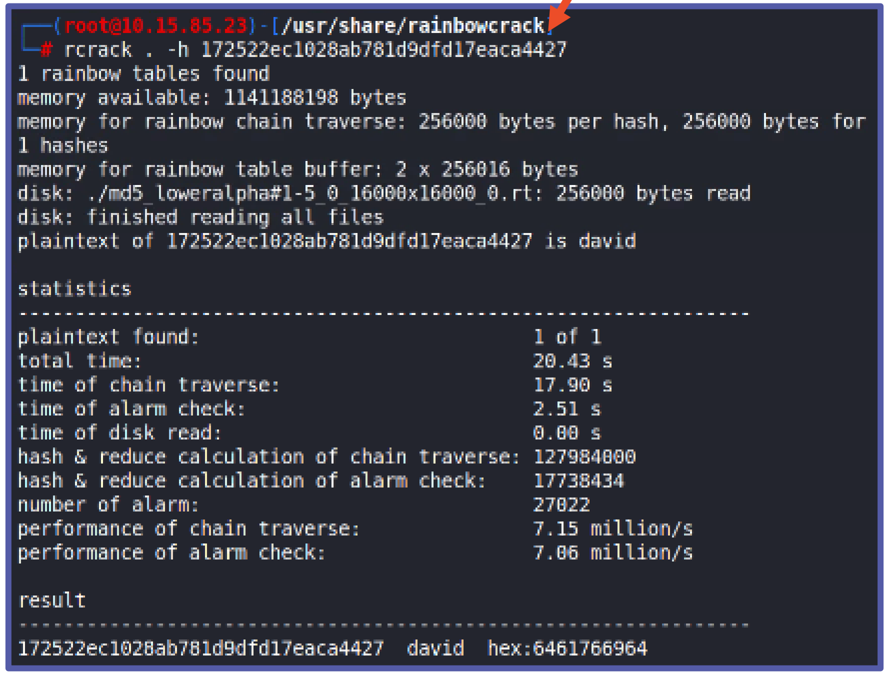
  ```
  echo -n "<name>" | md5sum
  ```

- Crack the hash using the command

  ```
  rcrack . -h <MD5 hash>
  ```

- Observe the output with the plaintext answer shown for the matching hash

Hash from “david”

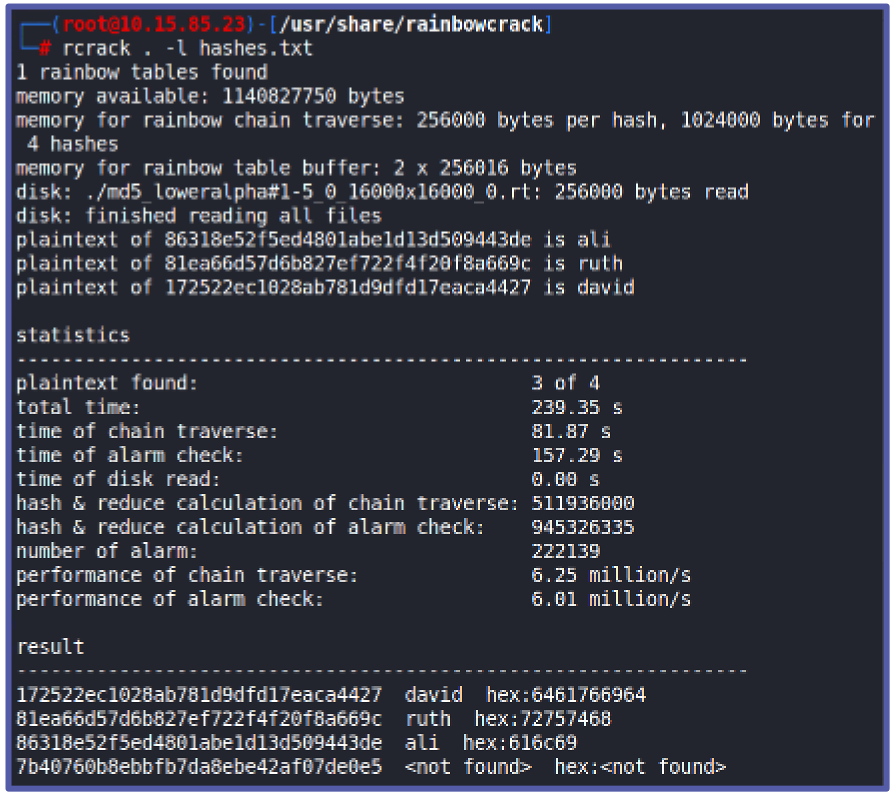


```
┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# rcrack . -h 172522ec1028ab781d9dfd17eaca4427
1 rainbow tables found
memory available: 1141188198 bytes
memory for rainbow chain traverse: 256000 bytes per hash, 256000 bytes for
1 hashes
memory for rainbow table buffer: 2 x 256016 bytes
disk: ./md5_loweralpha#1-5_0_16000x16000_0.rt: 256000 bytes read
disk: finished reading all files
plaintext of 172522ec1028ab781d9dfd17eaca4427 is david

statistics
----------------------------------------------------------------
plaintext found:                             1 of 1
total time:                                  20.43 s
time of chain traverse:                      17.90 s
time of alarm check:                         2.51 s
time of disk read:                           0.00 s
hash & reduce calculation of chain traverse: 127984000
hash & reduce calculation of alarm check:    17738434
number of alarm:                             27022
performance of chain traverse:               7.15 million/s
performance of alarm check:                  7.06 million/s

result
----------------------------------------------------------------
172522ec1028ab781d9dfd17eaca4427  david  hex:6461766964
```

Crack a file of hashes using Rainbowcrack

- Crack multiple hashes at once stored in a file using the command:

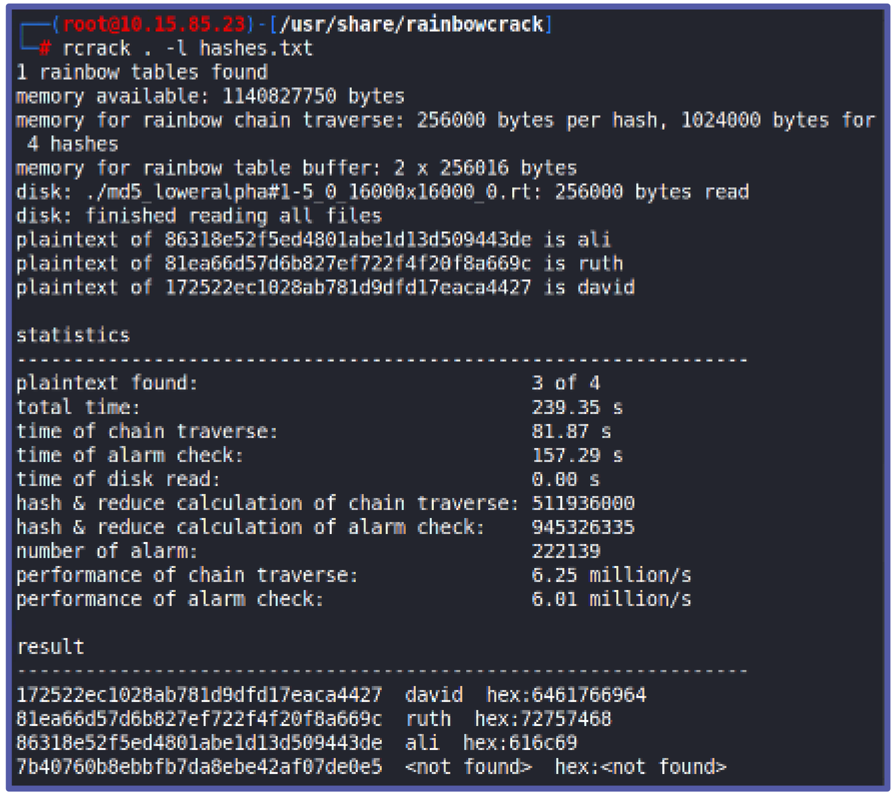
  `rcrack . -l` ***`<filename>`***



```
┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# rcrack . -l hashes.txt
1 rainbow tables found
memory available: 1140827750 bytes
memory for rainbow chain traverse: 256000 bytes per hash, 1024000 bytes for
 4 hashes
memory for rainbow table buffer: 2 x 256016 bytes
disk: ./md5_loweralpha#1-5_0_16000x16000_0.rt: 256000 bytes read
disk: finished reading all files
plaintext of 86318e52f5ed4801abe1d13d509443de is ali
plaintext of 81ea66d57d6b827ef722f4f20f8a669c is ruth
plaintext of 172522ec1028ab781d9dfd17eaca4427 is david

statistics
----------------------------------------------------------------
plaintext found:                             3 of 4
total time:                                  239.35 s
time of chain traverse:                      81.87 s
time of alarm check:                         157.29 s
time of disk read:                           0.00 s
hash & reduce calculation of chain traverse: 511936000
hash & reduce calculation of alarm check:    945326335
number of alarm:                             222139
performance of chain traverse:               6.25 million/s
performance of alarm check:                  6.01 million/s

result
----------------------------------------------------------------
172522ec1028ab781d9dfd17eaca4427  david  hex:6461766964
81ea66d57d6b827ef722f4f20f8a669c  ruth  hex:72757468
86318e52f5ed4801abe1d13d509443de  ali  hex:616c69
7b40760b8ebbfb7da8ebe42af07de0e5  <not found>  hex:<not found>
```

Observe the Results

- The rainbow table created, solved 3 out of 4 hashes
- The one plaintext it did not find was for "*philip*" which is more than 5 characters
- If the word is between 1-5 characters in length, the table can solve ~100% of the password
- The more rainbow tables we generate, and the longer they are, the more possibilities to crack the password – however long tables require a LOT of space!



```
┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# rcrack . -l hashes.txt
1 rainbow tables found
memory available: 1140827750 bytes
memory for rainbow chain traverse: 256000 bytes per hash, 1024000 bytes for
 4 hashes
memory for rainbow table buffer: 2 x 256016 bytes
disk: ./md5_loweralpha#1-5_0_16000x16000_0.rt: 256000 bytes read
disk: finished reading all files
plaintext of 86318e52f5ed4801abe1d13d509443de is ali
plaintext of 81ea66d57d6b827ef722f4f20f8a669c is ruth
plaintext of 172522ec1028ab781d9dfd17eaca4427 is david

statistics
----------------------------------------------------------------
plaintext found:                             3 of 4
total time:                                  239.35 s
time of chain traverse:                      81.87 s
time of alarm check:                         157.29 s
time of disk read:                           0.00 s
hash & reduce calculation of chain traverse: 511936000
hash & reduce calculation of alarm check:    945326335
number of alarm:                             222139
performance of chain traverse:               6.25 million/s
performance of alarm check:                  6.01 million/s

result
----------------------------------------------------------------
172522ec1028ab781d9dfd17eaca4427  david  hex:6461766964
81ea66d57d6b827ef722f4f20f8a669c  ruth  hex:72757468
86318e52f5ed4801abe1d13d509443de  ali  hex:616c69
7b40760b8ebbfb7da8ebe42af07de0e5  <not found>  hex:<not found>
```

How to Defend against Rainbow Table Attacks

- Salt those passwords!
  - A salt is string of characters added to a password before it is hashed
  - Using a unique salt for each user makes using a rainbow table more difficult
    - The rainbow table has to be recomputed for each user.
    - If a password is found, which part is the hash and which is the password?
- Key Stretching
  - “Hashing the hash”
  - Hashed values are hashed multiple times to increase the computation time required to hash each password
- How else can you defend against Rainbow Tables?