Cybersecurity 701

Rainbow Table Lab

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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

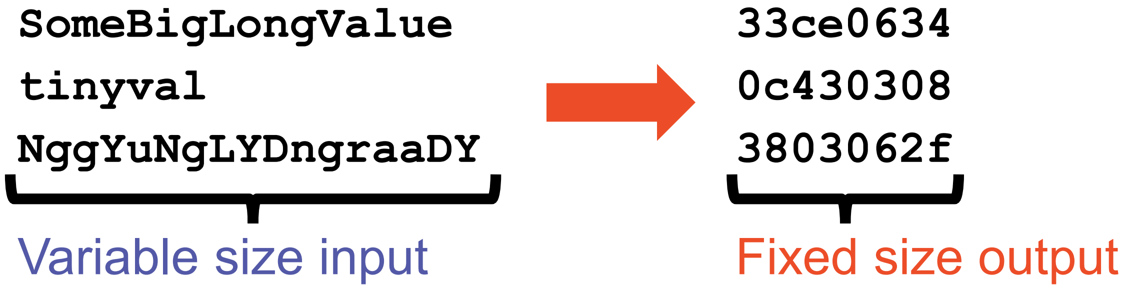
- Security+ Objectives (SY0-701)
  - Objective 2.4 - Given a scenario, analyze indicators of malicious activity.
    - Password attacks

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



SomeBigLongValue
tinyval
NggYuNgLYDngraaDY

33ce0634
0c430308
3803062f

Variable size input

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

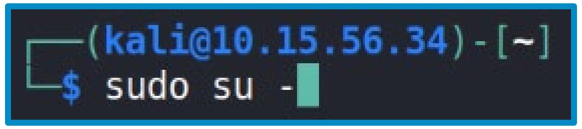
Rainbow Tables vs. Brute Force

- 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

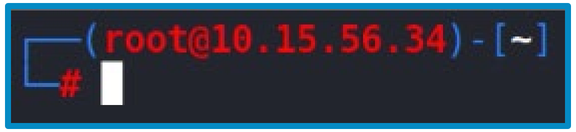
- Open the Kali Linux Environment
- Open Terminal
- Login as the root user with the following command:

```
sudo su -
```



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

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



```
┌──(root@10.15.56.34)-[~]
└─#
```

Create Rainbow Table

- Type the following command*:

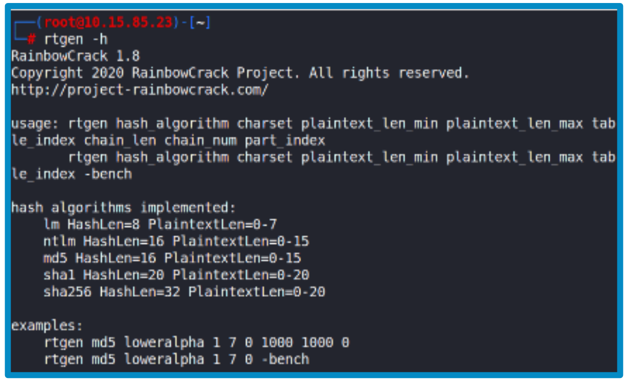
```
rtgen -h
```

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

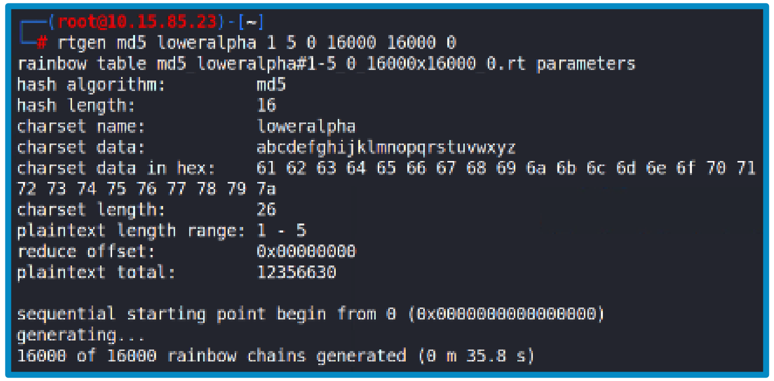
- Type the following command:

```
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
  ```

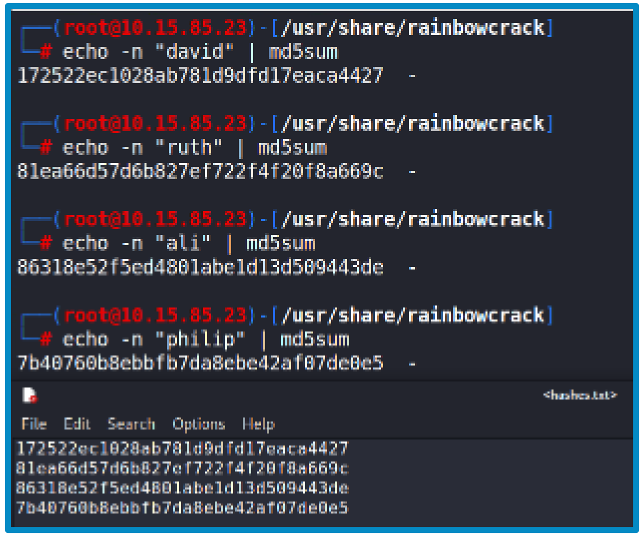
- Create a sample hash for a 5-character lowercase input by using the following command:

  ```
  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
```

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:

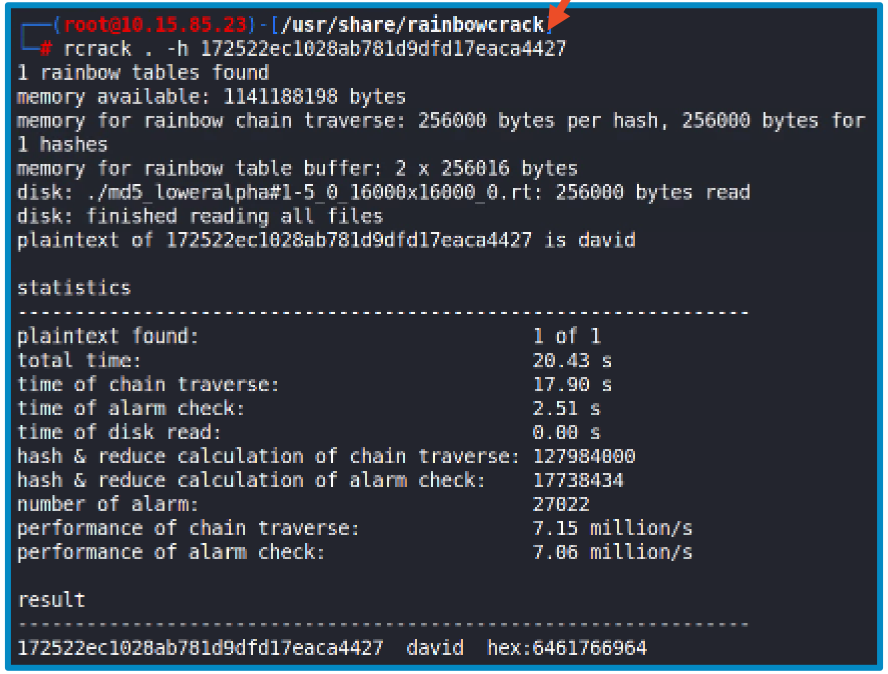
```
echo -n "<name>" | md5sum
```

- 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”

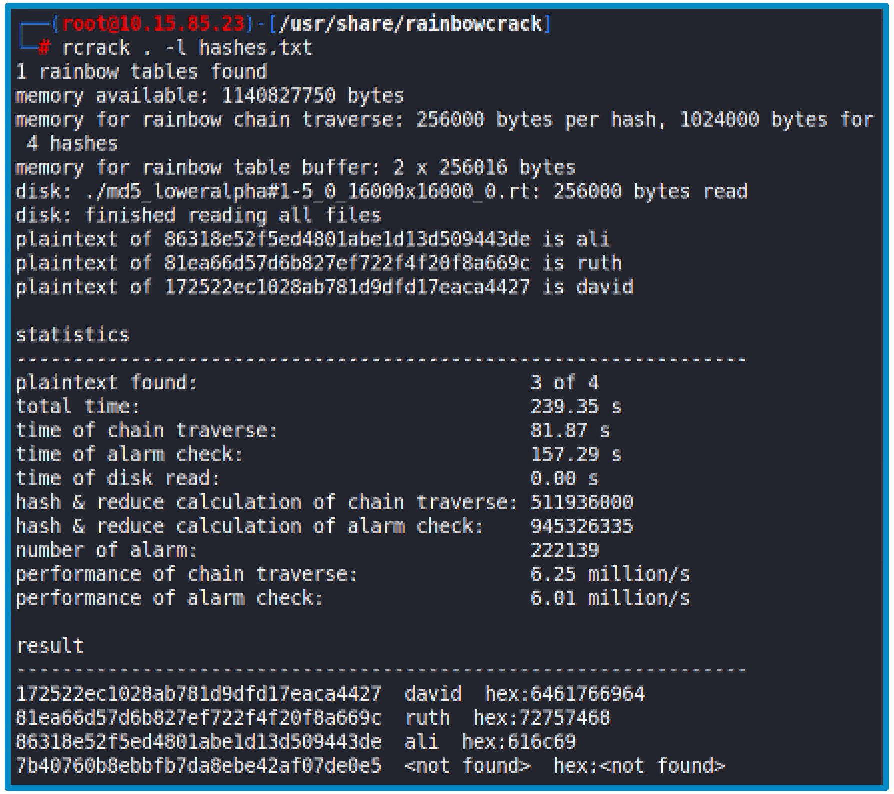


```
┌──(root@10.15.85.23)-[/usr/share/rainbowcrack]
└─# rcrack . -h 172522ec1028ab781d9dfd17eaca4427
1 rainbow tables found
memory available: 1141188198 bytes
memory for rainbow chain traverse: 256000 bytes per hash, 256000 bytes for
1 hashes
memory for rainbow table buffer: 2 x 256016 bytes
disk: ./md5_loweralpha#1-5_0_16000x16000_0.rt: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

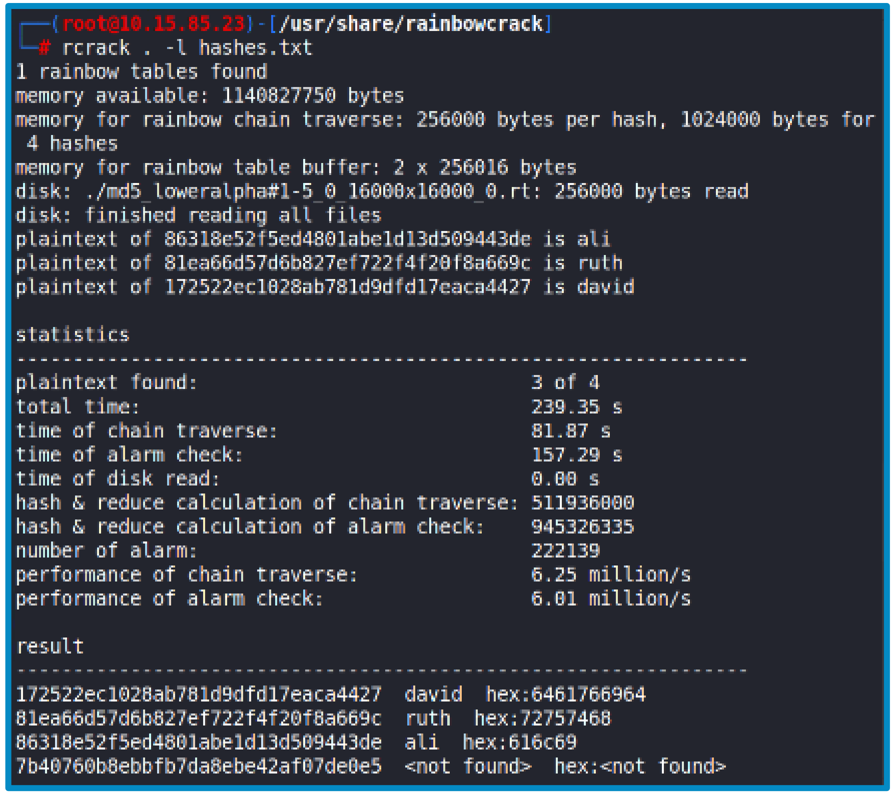
  `rcrack . -l <filename>`



```
┌──(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?