

COSC 345 – Homework 1

Passwords & Cryptography

Part 1: Writing a Password Cracker (55 pts)

Objective

This is a small programming assignment to get the feeling for how a password cracking program works. You also should learn some about one-way encryption and why choosing a good password is important.

Background info

If you use C:

The Unix `crypt(3c)` function is used to encrypt a password. It is a function that implements a one-way encryption algorithm used for password encryption and requires `#include <unistd.h>`. It takes two `const char*` parameters and returns a `char*`. The first parameter is the password to encrypt (only the first 8 chars are significant). The second parameter is a "salt" used by the encryption algorithm. The salt is a two-character string chosen from the set `[a-zA-Z0-9./]`. On a successful encryption `crypt()` returns a pointer to the encrypted password. The string returned is 13 characters (from the set `[a-zA-Z0-9./]`) long and the first two chars are the salt. On an error it returns a null pointer. (*Linux note: you need to link with `libcrypt`, `-lcrypt`*). Be sure to read the entire man page Linux: `man 3 crypt`.

If you use python:

15.1. [hashlib](https://docs.python.org/3/library/hashlib.html) — Secure hashes and message digests

<https://docs.python.org/3/library/hashlib.html>

Source code: [Lib/hashlib.py](#)

This module implements a common interface to many different secure hash and message digest algorithms. Included are the FIPS secure hash algorithms SHA1, SHA224, SHA256, SHA384, and SHA512 (defined in FIPS 180-2) as well as RSA's MD5 algorithm (defined in Internet [RFC 1321](#)). The terms "secure hash" and "message digest" are interchangeable. Older algorithms were called message digests. The modern term is secure hash.

Since `crypt()` or `hashlib` provide a one way encryption the password cannot simply be decrypted. So given an encrypted version of a password it seems that we cannot get the plaintext password. However, we can make guesses and see if one of our guesses encrypts to the same thing. If it is then chances are we have guessed the password (or at least something that encrypts to the same thing, which is all we really need). Knowing these things one can write a password cracker. A

brute force cracker would try all possible passwords. If we know properties of the password this could be feasible. Other crackers (hashcat, john the ripper) use rules and a dictionary of words to generate guesses (like capitalize the first char of a word and follow with a number).

Assignment

Now, finally to the assignment. You will write a password cracker that uses some rules and does a brute force attack on a set of passwords given those rules. Your program must be written in C++ or Python and work on any size password file that was encrypted using the **SHA-256** hashing. The format of the password file is (with one entry per line):

```
username:encryption[:otherstuff]
```

[`:otherstuff`] is optional (some password files have it, some do not, so your program needs to be able to handle both ways).

Rules to implement in your password cracker

- A seven char word from `/usr/share/dict/words` (Linux or Mac) which gets the first letter capitalized and a 1-digit number appended.
- A ten digit password with at least one of the following special characters in the beginning: `*, ~, !, #`
- A five char word from `/usr/share/dict/words` with the letter 'a' in it which gets replaced with the special character `@` and the character 'l' is substituted by the number '1'.
- Any word that is made with digits up to 100 digits length.
- Any number of chars single word from `/usr/share/dict/words` (Linux or Mac)

Your cracker should work as follows. In a loop generate guesses based on the rule you are implementing. When you have found a match print it out to standard output and to a file in the format `encrypted:password`. Your program should stop once it has cracked all the passwords in the file or you run out of combinations for that rule. You may want to generate test cases of your own as well.

Some samples to test if your cracker is working

```
Puzzles42 -> homer:7e11ed17256ef7ee697ece97d8edc25c558108aa18583de639c96ba2769bd0c3:20:Homer
Simpson:/home/homer:/bin/tcsh
~0011234512 -> marge:
3564c21155d772de5cb58ba122d2131f1c060bdf081730ea9518a45bd966c2e4:351:Marge
Simpson:/home/marge:/bin/tcsh
be@ch -> lisa:e77599c90db264dbe4b449565a03b5a26c989e975089fcc7dc3c55a720928e66:353:Lisa
Simpson:/home/lisa:/bin/tcsh
programming ->
Maggie:ab2620f9b7154d9f9dc1b3c2d949d85d595fe77f45411b3dbe6e5b47da564177:42:20:Maggie
Simpson:/home/maggie:/bin/tcsh
```

Note that your code will also be tested with other passwords.

Think how you could improve the speed of your password cracker software and implement the solution or at least develop your thoughts in your report.

Part 2: Cryptography (30 pts)

1. DES

(*weak DES keys*) There are four so called *weak* DES keys. One of those keys is
 $K = 00011111\ 00011111\ 00011111\ 00011111\ 00001110\ 00001110\ 00001110\ 00001110$.

a) What happens if you use this key?

b) Can you find the other three weak keys?

2. RSA

In this exercise we consider an RSA modulus $n = p \times q$ where p and q are large prime numbers (here, by large we mean at least equal to 5). We consider a valid RSA exponent e for RSA.

- Show that neither $(p \bmod 3)$ nor $(q \bmod 3)$ can be equal to 0.
- Under which condition e is a valid exponent for a modulus n ?
- From now on, we will assume that $e = 3$. Show that neither $p - 1$ nor $q - 1$ can be multiples of 3.
- Deduce that $p \bmod 3 = q \bmod 3 = 2$.
- What is the value of $n \bmod 3$?

3. CTFs and Cryptanalysis (15 pts)

In this assignment you will need to solve at least three cryptanalysis challenges from:
<https://www.root-me.org/en/Challenges/Cryptanalysis/>. You can pick your own combination of five challenges with the following criteria: (i) at least two challenges worth 10 – 20 points, (ii) at least one challenges worth more than 20 points. What you will need to submit:

- A screenshot that clearly shows your solution and that you have solved the challenge.
- A short, bullet point, writeup about the steps, tools, code, and your thought process to solve each solution.