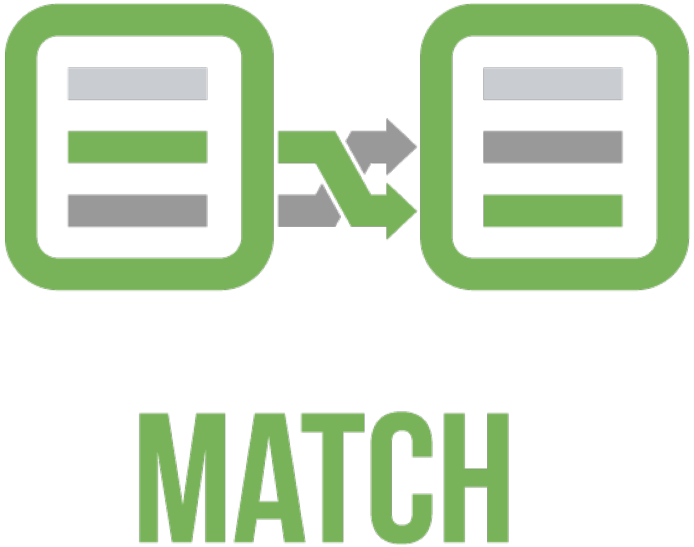
BRUTE FORCE ATTACK



- Brute force guessing attack against passwords tries to guess password by enumerating all passwords and their hashes in sequence, and check whether they match the target hashes.
- A measure against brute force attack is to increase the space of possible passwords, e.g., longer passwords, allowing more varieties of symbols (alphabets, numerals, signs).

Password policy is an important means to increase difficulties of brute force attack

PASSWORD ENTROPY-measured by 2^k

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$\rightarrow c$ $\downarrow n$	26 (lowercase)	36 (lowercase alphanumeric)	62 (mixed case alphanumeric)	95 (keyboard characters)
5	23.5	25.9	29.8	32.9
6	28.2	31.0	35.7	39.4
7	32.9	36.2	41.7	46.0
8	37.6	41.4	47.6	52.6
9	42.3	46.5	53.6	59.1
10	47.0	51.7	59.5	65.7

Table 10.1: *Bitsize of password space for various character combinations. The number of n-character passwords, given c choices per character, is c^n. The table gives the base-2 logarithm of this number of possible passwords.*

Source: Menezes et al. Handbook of Applied Cryptography.

At present, software password crackers can crack up to 16 million pswd/sec per pc.

Write a program to calculate how long it will take to bruteforce passwords for each entry.

Explanation of Table

- 1st entry corresponds to 5 char lower case passwords.
- How many such passwords around?
- 26^5!
- To find complexity of this password, solve 2^k = 26^5
- Get k = [lg(26^5)]/lg2 = 23.5!

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Now **2^35** complexity can be cracked within **a day** on a 3GHz PC (generous est).

1 FPGA Hardware cracker can crack 56 bits within **5 days** (est).

ASIC crackers can be more than 10 times faster than FPGA.

DICTIONARY ATTACK

- Choosing passwords with high entropy prevents brute-force attack.
- However, hashed passwords, especially for human-generated passwords, are still vulnerable to *dictionary attack*.
- This exploits weakness in human-chosen passwords, which tend to derive from words in natural languages.

Users with same password will have same hash value stored in password file.

- Guess some commonly used passwords
- Compute their hash values
- Look for the same hash values in the password file

PRE-COMPUTED HASH TABLE

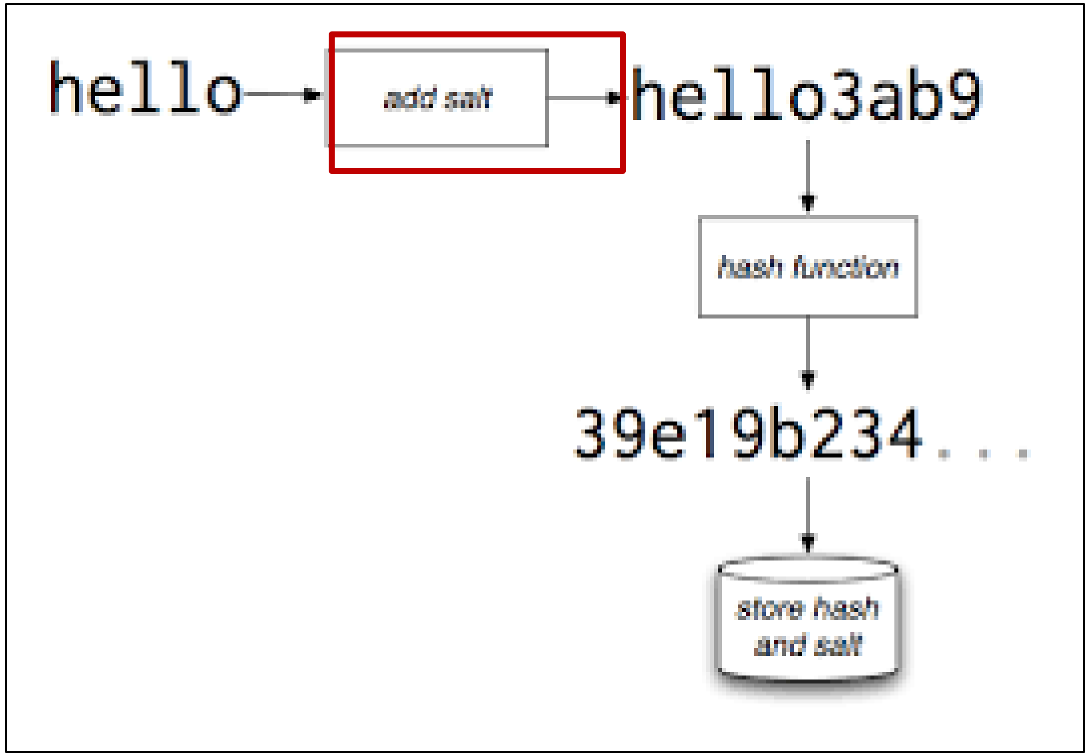
Strategy
A strategy for cracking hashed passwords is to pre-compute a hash table, containing pairs of passwords and their hashes.

- If we have k password candidates and each hash has n bit, then we have a table of size $k \times n$.
- This may not be practical if k is large.

PASSWORD SALTING

Salting

Illustration



- To reduce the effectiveness of offline attacks using pre-computed hashes, a *salt* is added to a password before applying the hash function.
- A salt is just a random string.
- Each password has its own salt.
- The salt value is stored along with the hash of password+salt.
- For a salt of n-bit, the attacker needs to pre-compute 2^n of hashes for *the same password*.

Password Storage Cheat Sheet

Introduction¶

- It is essential to store passwords in a way that prevents them from being obtained by an attacker even if the application or database is compromised.
- After an attacker has acquired stored password hashes, they are always able to brute force hashes offline.
- As a defender, it is only possible to slow down offline attacks by selecting hash algorithms that are as resource intensive as possible.