Authentication: something you know

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1 Something you know

- 'Proof of knowledge'
- Guessing secrets
- Online or offline?
- Storing secrets

Idea: Something you know

- We have a prover and a verifier.
- Prover must convince verifier he knows some secret.

Idea: Password

- Prover and verifier shares a secret value.
- Prover tells verifier the value to convince the verifier.

Remark

- If the adversary learns the secret, he can convince the verifier he is the prover.

Example

- Adversary might 'overhear the conversation'.
- Adversary might 'trick' the prover to reveal the secret.
- Adversary might guess the secret.

Idea

- The secret x is chosen from a probability distribution.
- The probability of guessing correctly is $\Pr[X = x]$.

Remark

- The question is: what is the probability distribution?

Example (Cryptographic keys)

- The distribution is *very* close to the uniform distribution.
- *I.e.* $\Pr[X = x] = 1/n$, where X can take n possible values.
- In crypto, normally $n = 2^{128}$.

Example (Password)

- Distribution of passwords is affected by so many factors.
- The individual, situation, password policies, *etc.*

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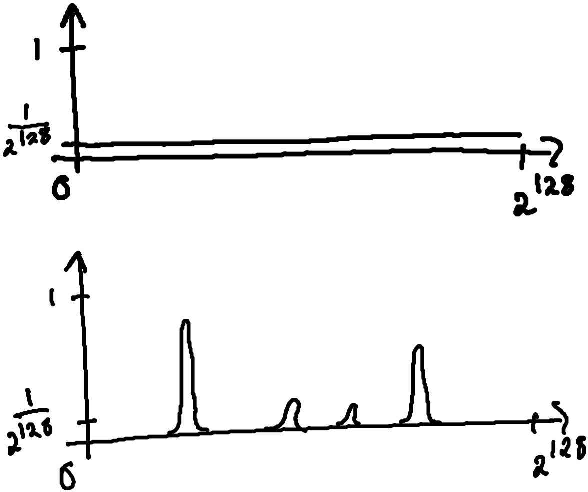
Guessing secrets



Idea: Guessing passwords

- Find a way to approximate the distribution.

Example (Basic guessing)

- Using dictionaries of words.
- Adapt guesses to password policy, if known.
- . . .

Example (Improved guessing)

- Use leaked passwords as guesses.
- Take grammar into account, depending on the password type [Bon12; BS12].

Example (Machine learning)

- Use machine learning [Rip; Cas+17; Wei+09].
- Train algorithm on leaked password databases.
- Generate list of password-looking guesses.

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Remark

- There is a PhD thesis on the topic of guessing passwords: **GuessingHumanChosenSecrets**.
- There is even a conference dedicated to passwords: PasswordsCon.

Remark

- This is relevant when the user has chosen a password.
- In many situations it's not.

Example

- There are many devices with default passwords.
- *E.g.* home routers, ...

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Example (Mirai botnet [Her16])

- Botnet infecting primarily surveillance cameras and home routers.
- Attempts default passwords and other vulnerabilities.
- Managed the largest distributed denial-of-service (DDoS) attack hitherto.

Remark

- These default passwords have very high probability.

Idea: Autogenerate passwords

- Generate passwords for users.
- This yields a uniform distribution.

Remark: Usability

- This will likely reduce security by use of post-it notes.
- Not a problem for a home router.
- Otherwise: will require password managers.

Idea: Password policy

- Introduce rules to affect how users choose passwords.
- We require upper, lower case, numbers, special characters.
- Then passwords will be more uniform-looking.

Remark: Usability

- This has been proven a bad idea.
- Research has estimated the distribution under various policies [Kom+11].
- Better to only require length.

Idea: Password ageing

- Let passwords age and expire.
- Then users change them frequently.
- If it takes six months to guess and we change every three . . .

Remark: Usability

- This has been proven a bad idea.
- Annoying with too short intervals.
- Will reduce security once users introduce systems to remember their last changed password.

- Grassi et al. [Gra+19] summarizes the current recommendations.
- At least 10 characters.
- Force renewal only after security breach.

Definition (Online)

- The adversary must interact with the system for each guess.

Example (Online)

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- *For online guessing, rate limit the attempts.*
- *This makes guessing too slow.*

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Exercise

- How will rate limiting affect these?

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for u in users:
  for p in passwds:
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Remark

- Maybe the adversary doesn't care about which user.
- If a password is common, then it's likely that *some* user chose it.
- And if the adversary tries one password for each user, that might not trigger the rate limiting.

Remark: Offline

- Consider data which is encrypted with a password.
- You cannot change a password for data that is already stolen.
- You cannot limit the number of attempts either.
- You can just control the guessability of the password.

Remark

- The user can store the secret in its mind.
- This is assumed inaccessible (for now).

Question

- The verifier is a machine.
- The verifier must verify what the prover says.
- This means that the verifier must have some data to check against.
- How should this be stored?

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Remark

- Our concern is that someone can read this data.
- This helps better approximate the distribution.
- Password reuse for other services?

Solution (Passwords)

- *We want to compare user-entered and stored password.*
- *We do an irreversible one-way transformation on both.*
- *Then they are still comparable.*
- *The preimage cannot be gained from storage.*

Example

- Cryptographic hash function $h\colon \{0,1\}^* \to \{0,1\}^n$.
- On registration, store $h(p)$.
- User authenticates with p', check if $h(p') \stackrel{?}{=} h(p)$ equals what we stored.

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Remark

- Consider guessing again.
- The used password space is small.
- We only need to evaluate a subset: $h\colon \{0,1\}^m \to \{0,1\}^n$.
- With faster computers we can guess a lot.

Solution

- *Choose h to be slow to compute.*
- E.g. *iterate it over itself 10 000 times ($h^{10000}(p)$).*
- *This will slow down guessing attacks.*

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Remark

- A list of password hashes reveals if two users have the same password.
- Can guess the password for all users at once:
  1. Make a guess, compute the hash.
  2. Check if it matches *any* user's password.

Solution

- *Add a salt: a small random value (e.g. 128 bits) unique for each user.*
- *Salt* $s \xleftarrow{\$} \{0,1\}^{128}$, *change hash to* $h(s, p)$.
- *Now all hashes will be unique.*

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Remark

- The salt is not a secret, it just adds uniqueness.
- It can be stored in plain text along with the password hash.

Example

- There are many libraries.
- bcrypt [PM99] implements all this functionality.
- Argon2 is another, more recent technique.
- They should also be available in most languages and libraries.

[Bon12] Joseph Bonneau. 'Guessing human-chosen secrets'. PhD thesis. University of Cambridge, May 2012. URL: http://www.cl.cam.ac.uk/~jcb82/doc/2012-jbonneau-phd_thesis.pdf.

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[Her16] Ben Herzberg. *Breaking Down Mirai: An IoT DDoS Botnet Analysis*. Oct. 2016. URL: https://www.incapsula.com/blog/malware-analysis-mirai-ddos-botnet.html (visited on 18/02/2017).

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