Password Selection and Alternatives

CMSC 426/626 - Computer Security
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Outline

- User password selection and rules
- Bloom Filters
- Token-based Authentication

Password Rules

- Users pick terrible passwords - just look at the beginning of the RockYou list:

  `123456`, `12345`, `123456789`, `password`, `iloveyou`, `princess`, `1234567`, `rockyou`, `12345678`, `abc123`, **etc.**

- Primary defenses are education and enforcement of password rules.

Other Options

- *Computer generated passwords* or pass-phrases *can* be done well but are often unpopular with users.

  Personal experience: pass-phrases are better.
- *Reactive password checking* - try to crack users' passwords on your system.
- *Proactive password checking* - check password at the time the user selects it.

Proactive Checking

- *Rule-based* - check length, proper mix of character classes, etc.

  Better than nothing, but annoying for users.
- *Dictionary-based* - do not allow passwords from a dictionary of "bad" passwords.

  Need a **big** dictionary, and it is slow.
- *Bloom Filters* - clever technique...

Bloom Filters

- Need k independent hash functions $H_i(x)$.
- Each $H_i(x)$ takes values in $\{0, 1, ..., N\text{-}1\}$.
- Need N-bit table $T = (b_0, b_1, ..., b_{N-1})$.
- For each word in dictionary of "bad" passwords, compute the k hashes and set the corresponding bits in T.

Example

- $H_0(x)$ = first nibble of MD5 hash of x.
- $H_1(x)$ = second nibble of MD5 hash of x.
- $H_2(x)$ = third nibble of MD5 hash of x.
- $H_3(x)$ = fourth nibble of MD5 hash of x.
- T starts as all zeros

- MD5 of `123456` is `f447...` so set bits 15, 4, and 7 in T.
- MD5 of `12345` is `d577...` so set bits 13, 5, and 7 in T.
- MD5 of `123456789` is `b2cf...` so set bits 11, 2, 12, and 15 in T.

T = (0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1)

- User selects new password x.
- System computes $H_0(x)$, $H_1(x)$, $H_2(x)$, $H_3(x)$ and checks corresponding bits in T.
- If **all** of the bits are set (1), then reject the password x.
- Guaranteed that `123456`, `12345` and `123456789` will be rejected.

- Continuing with the example...

  T = (0, 0, 1, 0, 1, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1)

  - Suppose user selects password “blargh”. MD5 hash is `5f71...`
  - Check bits 5, 15, 7, and 1 in T
  - 5, 15, and 7 are set, but 1 **is not set**, so we accept the password.

Real Parameters

- k in the range 2 - 6 is reasonable.
- N is large, an order of magnitude times larger than the dictionary size.
- *False Positive* - reject a password that is **not** in the dictionary. Want to minimize these!

False Positive Rate

- Let R be ratio of N to the dictionary size D, that is $R = N / D$.
- Let p be the probability of a false positive.

  $$p = (1 - e^{k/R})^k$$

  which gives

  $$R = -k / \ln(1 - p^{1/k})$$

Example

- Suppose I have a dictionary of 1,000,000 words and want to implement a Bloom Filter with $k = 6$ and false positive probability of $p = .001$. What should N be?

$$R = -6 / \ln(1 - .001^{1/6}) = 15.78406$$

so N needs to be 15,784,060, or approximately 16 million bits.

Token-based Authentication

Something you have...

- A token is a physical device that is used as part of the user authentication process.
- User must be in possession of token to be authenticated to the system.
- We'll look at two types of token: smart cards and one-time password generators.

Smart Cards

- If your mobile phone has a SIM, that is a smart card.
- Smart cards contain full-fledged processors with CPU, memory, and I/O.

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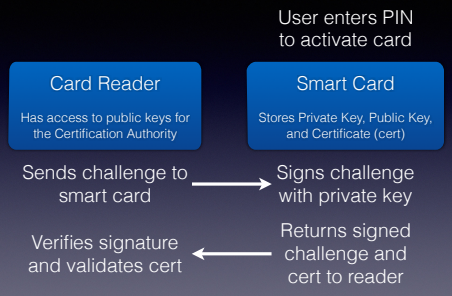
FIPS 201

- FIPS 201, *Personal Identity Verification*, defines the ways in witch a smart ID card can be used to verify identity.
- We only care about Authentication Using Asymmetric Cryptography.



- Once the reader has verified the signature and validated the certificate, it extracts the user identity from the cert and forwards it to the authorization service.
- The public key algorithm would typically be RSA with a 2048-bit modulus.

One-Time Passwords

- Eample: RSA SecurId
- Device generates a passcode every minute
- Server knows how to generate code to verify user's input
- May be used in conjunction with usual id and password

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Types of OTP

- RSA SecurId is a *Time-Based OTP* system since the creation of the passcode is based on time (well, there's also a secret key...)
- *HMAC-Based OTP* (HOTP) defined in RFC 4226.

  Uses a counter synchronized between the client and server. OTP derived from HMAC of the counter.

- *Password-Based OTP* (my term) defined in RFC 2289.

  User receives random seed from server, hashes this along with password *N* times, saving hashes. OTP derived from hashes *used in reverse order*, i.e. use the N^{th} hash, next time *N*-1^{st}, etc.

- **Why reverse order?**

Finished. See the website for exercises.