CPR E 431

BASICS OF INFORMATION SYSTEM SECURITY

User Authentication, Access Control, and Operating System

Rainbow Tables and Salting

Video Summary

- Rainbow Tables
- Salting Passwords
- Storing Passwords with Salt
- Modern Approaches

Cracking Passwords

- Store passwords and hash values in advance (instead of generating them)
- The question is how big is it?

Password is 8 Bytes + hash is 128 bits (if using MD5)

(8 Byte + 16 Byte) x 94^8 = 1.4x1017 Bytes = 146 TB (approx.)

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- Instead of generating this huge amount of data we can use

Rainbow Tables

Rainbow Tables

- A rainbow table is a precomputed dictionary of plaintext passwords and their corresponding hash values that can be used to find out what plaintext password produces a particular hash.
- Unlike brute-forcing, performing the hash function isn't the problem here. With all of the values already computed, it's simplified to just a simple search-and-compare operation on the table.

Cracking Passwords

➢Rainbow Tables

MD5 Rainbow Tables

Table ID	Charset	Plaintext Length	Key Space	Success Rate	Table Size	Files	Performance
md5_ascii-32-95#1-7	ascii-32-95	1 to 7	70,576,641,626,495	99.9 %	52 GB 64 GB	Perfect Non-perfect	Perfect Non-perfect
md5_ascii-32-95#1-8	ascii-32-95	1 to 8	6,704,780,954,517,120	96.8 %	460 GB 576 GB	Perfect Non-perfect	Perfect Non-perfect
md5_mixalpha-numeric#1-8	mixalpha-numeric	1 to 8	221,919,451,578,090	99.9 %	127 GB 160 GB	Perfect Non-perfect	Perfect Non-perfect
md5_mixalpha-numeric#1-9	mixalpha-numeric	1 to 9	13,759,005,997,841,642	96.8 %	690 GB 864 GB	Perfect Non-perfect	Perfect Non-perfect
md5_loweralpha-numeric#1-9	loweralpha-numeric	1 to 9	104,461,669,716,084	99.9 %	65 GB 80 GB	Perfect Non-perfect	Perfect Non-perfect
md5_loweralpha-numeric#1-10	loweralpha-numeric	1 to 10	3,760,620,109,779,060	96.8 %	316 GB 396 GB	Perfect Non-perfect	Perfect Non-perfect

- Lookup on 0.5 TB Rainbow Table will take only hours to find the password

http://project-rainbowcrack.com/table.htm

Pre-calculated Hashes & Rainbow Tables

- How big is such a database of pre-calculated hashes?
  - In raw form, generally too big to be practical (100's, 1000's of TB)
  - Using specialised data structures (e.g. Rainbow tables), can obtain manageable size, e.g. 1 TB
- Trade-off: reduce search time, but increase storage space
- Countermeasures:
  - Longer passwords
  - Slower hash algorithms
  - Salting the password before hashing

Salting Passwords

$$ID, Salt, H(P||Salt)$$

- When ID and password initially created, generate random s-bit value (salt), concatenate with password and then hash
- When user submits password, salt from password database is concatenated, hashed and compared
- If attacker gains database, they know the salt; same effort to find password as brute force attack
- BUT pre-calculated values (e.g. Rainbow tables) are no longer feasible
  - Space required increased by factor of 2^s

Salting Passwords

username	salt	H(password || salt)
john	a4H*1	ba586dcb7fe85064d7da80ea6361ddb6
sandy	U9(-f	816a425628d5dee17839fffeafb67144
daniel	5<as4	11842ced4203d4067ed6a6667f3f18d9
...	...	...
steve	LqM4^	184b7f9c6126c568ee50cd3364257973

- The attacker now knows the user name, the salt, and the hash
- How he is going to get the original password?
- How long this will take (worst case) ?

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- The attacker now knows the user name, the salt, and the hash
- How he is going to get the original password?
- How long this will take (worst case) ?
- What is the benefit of using Salt?

Salting Passwords

- If we used a 16-bits salt then the number of salts available are 2^{16}
- To use the Rainbow Table you have to generate a Rainbow table for each possible salt value
- 65536 Rainbow Tables x 0.5 TB per table = 23768 TB
- Another benefit of using salt is that if two users have the same password, they will have different hash values

username	password
john	mysecret
sandy	ld9a%23f
daniel	mysecret
...	...
steve	h31p_m3?

username	H(password)
john	06c219e5bc8378f3a8a3f83b4b7e4649
sandy	5fc2bb44573c7736badc8382b43fbeae
daniel	06c219e5bc8378f3a8a3f83b4b7e4649
...	...
steve	75127c78fd791c3f92a086c59c71ece0

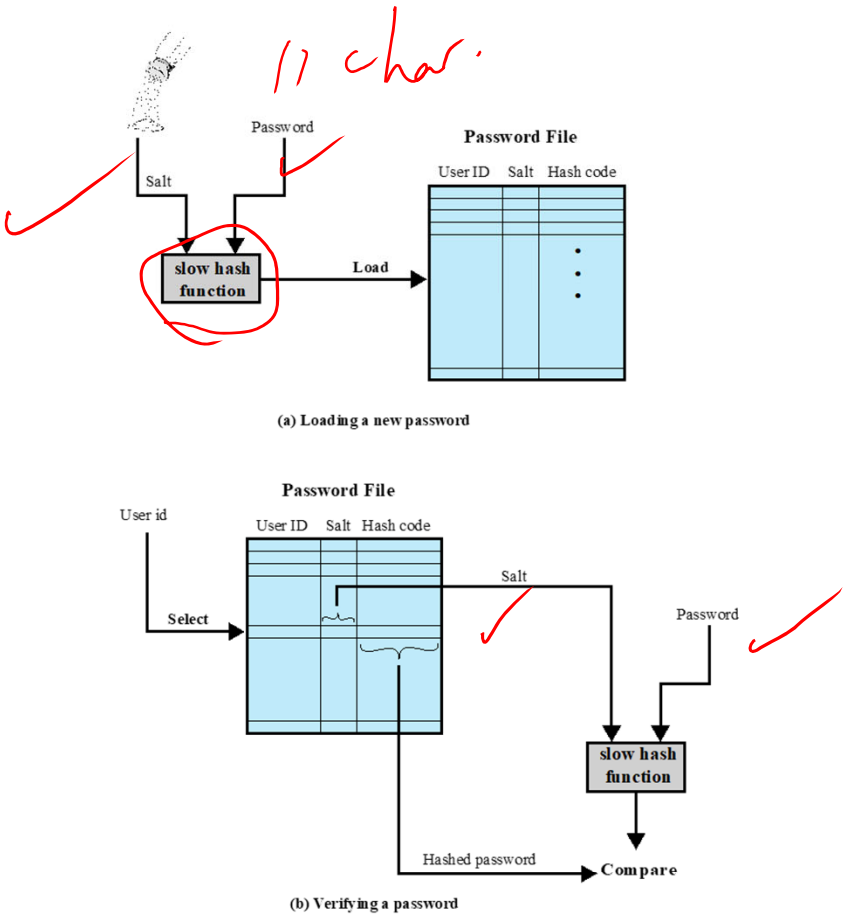


Figure 3.3 UNIX Password Scheme

Password Storage: Best Practice

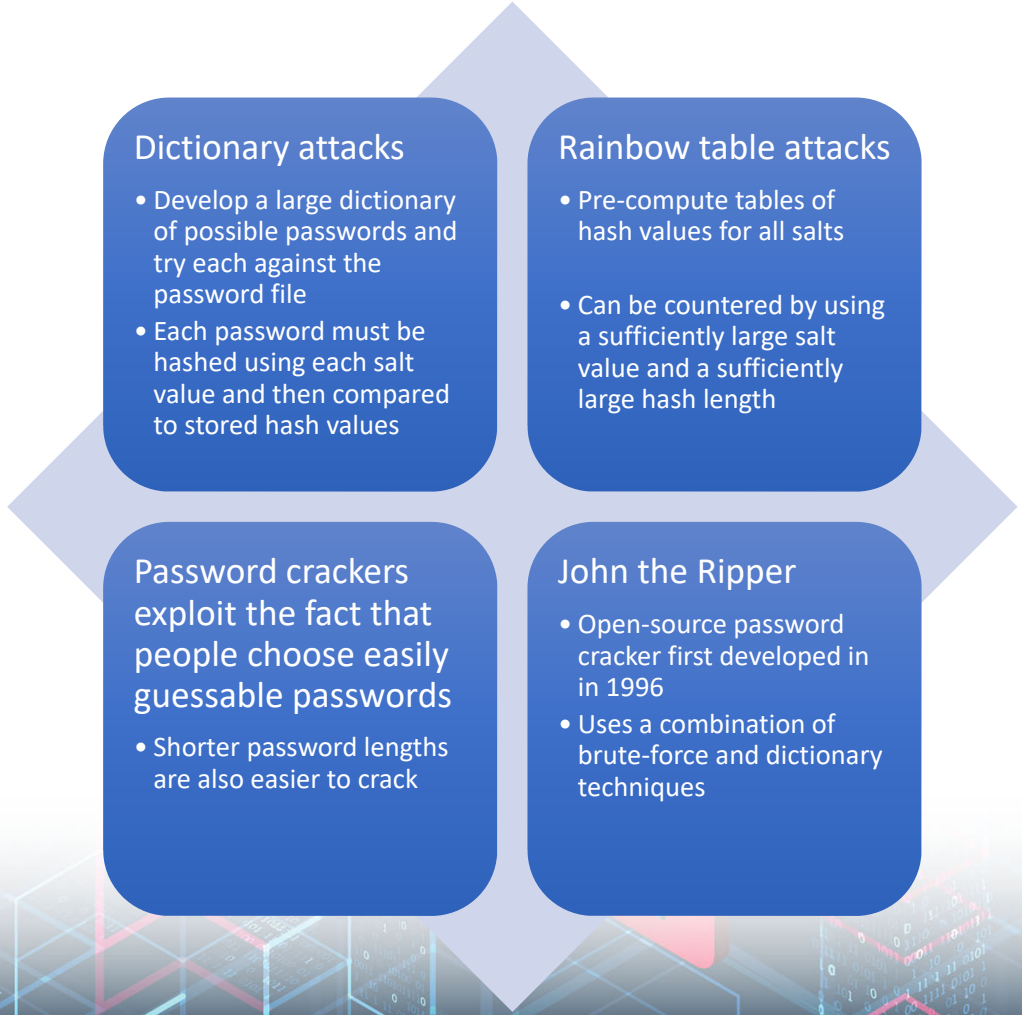
When storing user login information, always store a hash of a salted password

$$ID, Salt, H(P||Salt)$$

- Salt: random, generated when ID/password first stored; 32 bits or longer
- Hash function: slow, adaptive speed (work factor), e.g. bcrypt/scrypt, PBKDF2

Design for failure: assume password database will eventually be compromised

Password Cracking

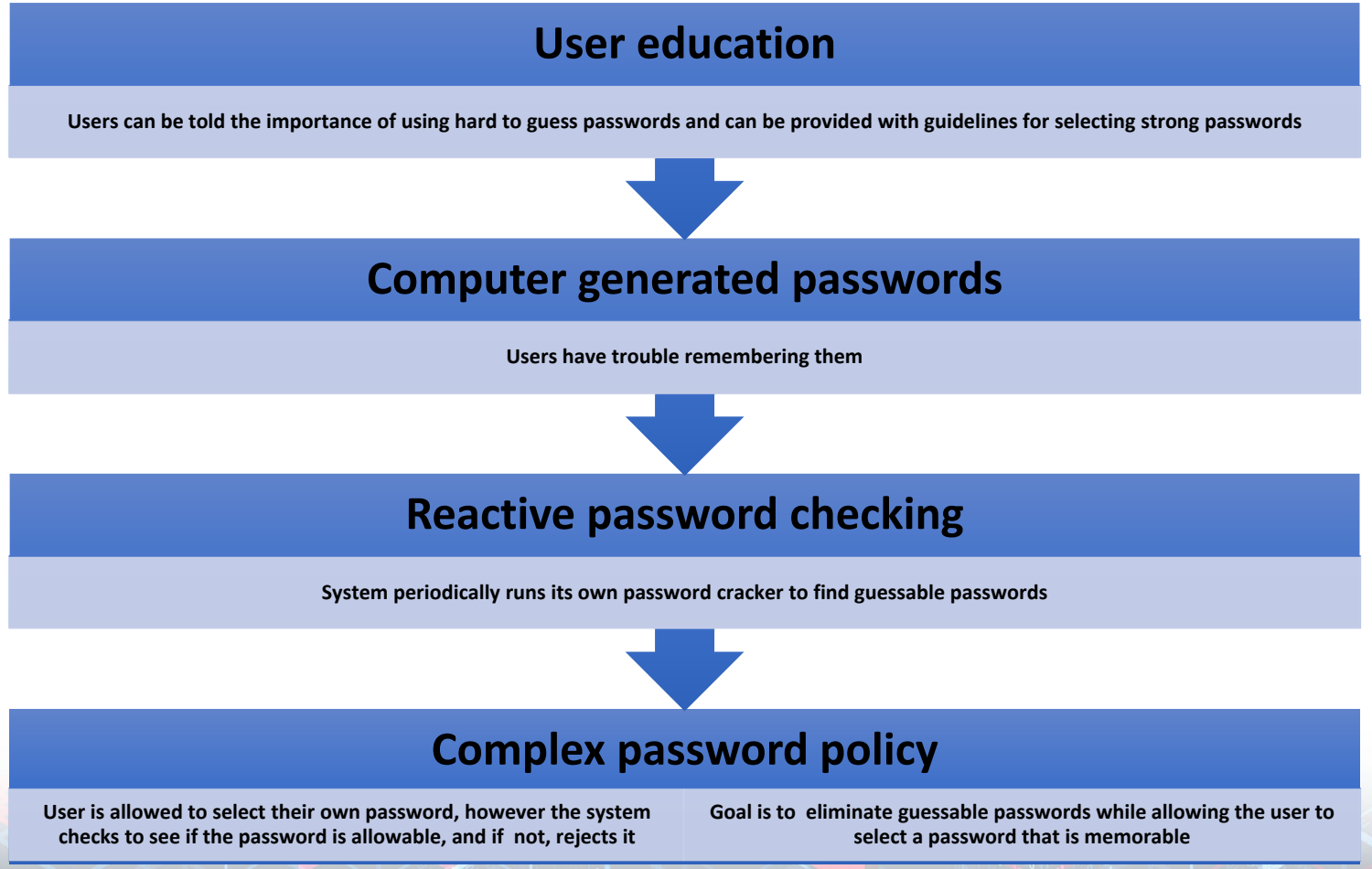


Modern Approaches

- Complex password policy
  - Forcing users to pick stronger passwords

- However password-cracking techniques have also improved
  - The processing capacity available for password cracking has increased dramatically
  - The use of sophisticated algorithms to generate potential passwords
  - Studying examples and structures of actual passwords in use

Password Selection Strategies



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