Fundamentals of Information & Network Security
ECE 471/571

Lecture #29: User Authentication & Passwords

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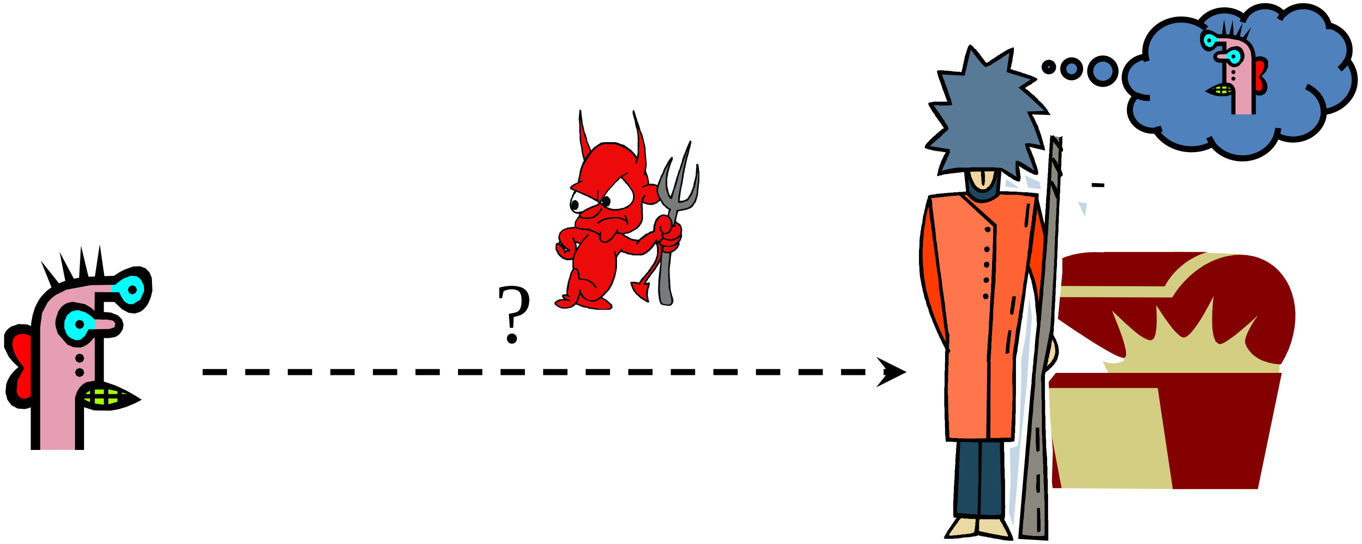
Basic Problem



How do you prove to someone that you are who you claim to be?

Any system with access control must solve this problem

Authentication

- Binding of an identity to a subject (e.g., a person or a machine)
- Proof of information
  - What you know
  - What you have
  - What you are
  - Where you are
- Who is being authenticated?
  - Authenticate a person to a server
  - Authenticate a machine to a machine
  - Authenticate both a person and a machine to a server
  - A machine stores high-quality secret; a person memorizes low-quality password

Authentication of People

- User authentication: a computer verifies that you are who you claim to be
- Main techniques
  - What you know: password, SSN, Birth date
  - What you have: physical keys credit cards, smart card
  - What you are: biometrics

Password-Based Authentication

- *What you know*
- User has a secret password.
  System checks it to authenticate the user.
- Password in plaintext is sent over for authentication.
- Problems
    - Eavesdropping
    - Database reading
    - Password guessing: on-line, off-line (dictionary attack)
- telnet, ftp

Storing User Password

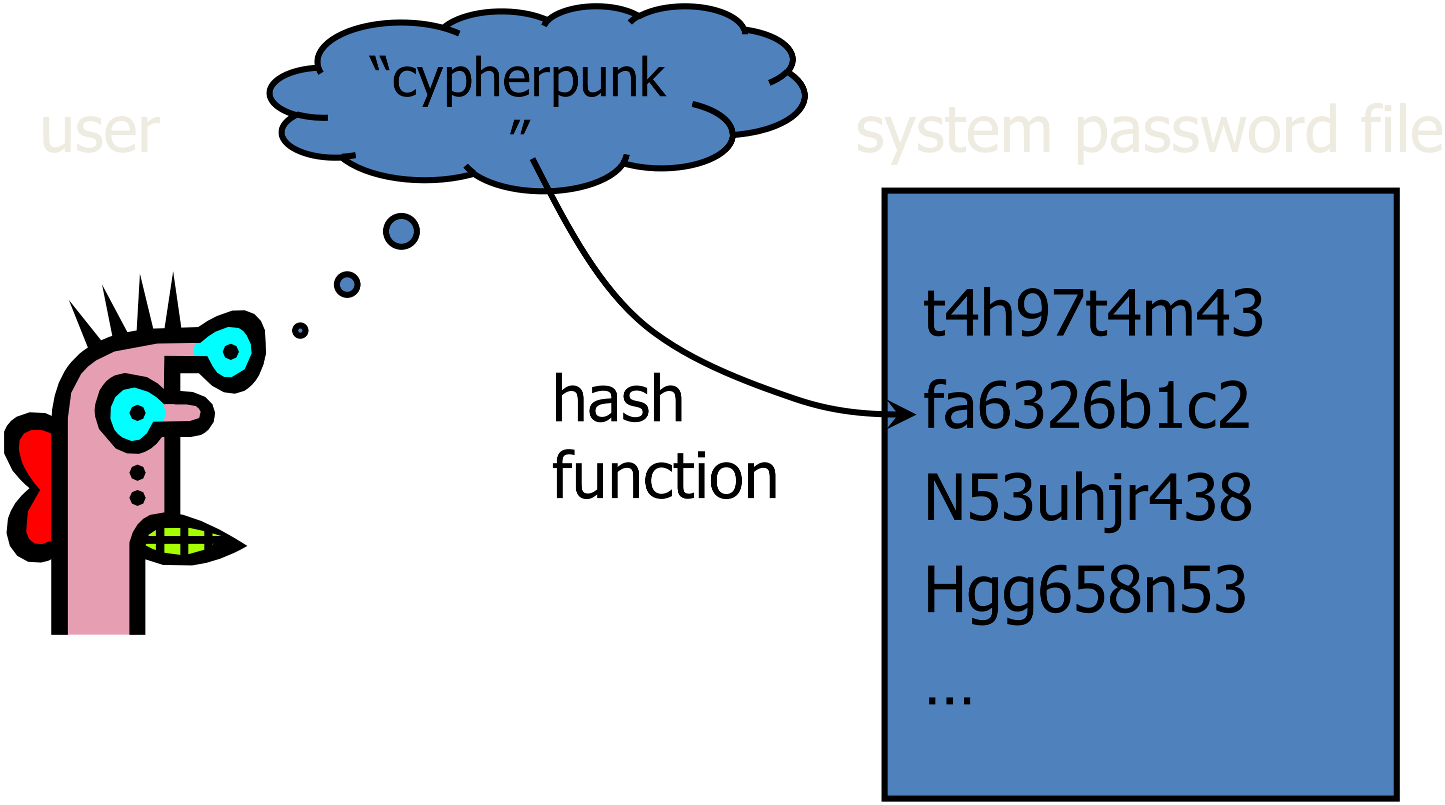
Where to store

- Store passwords individually on each server
- Store all passwords at authentication storage node
  - Retrieve password information from storage node; authentication is done at server node
- Store all passwords at authentication facilitator node
  - Send the login info received to facilitator node; authentication is done at facilitator node; result is sent back to server node.

In what format

- Store plain passwords
- Store hashes of passwords
  - Password guessing
- Store encrypted passwords
  - Involves high-quality key, cannot do password guessing; vulnerable to insider attack.

UNIX-Style Passwords



user

“cypherpunk
”

hash
function

system password file

t4h97t4m43
fa6326b1c2
N53uhjr438
Hgg658n53
…

Password Hashing

- Instead of user password, store H(password)
- When user enters password, compute its hash and compare with entry in password file
  - System does not store actual passwords!
- Hash function H must have some properties
  - One-way: given H(password), hard to find password
    - No known algorithm better than trial and error
  - Collision-resistant: given H(password1), hard to find password2 such that H(password1)=H(password2)

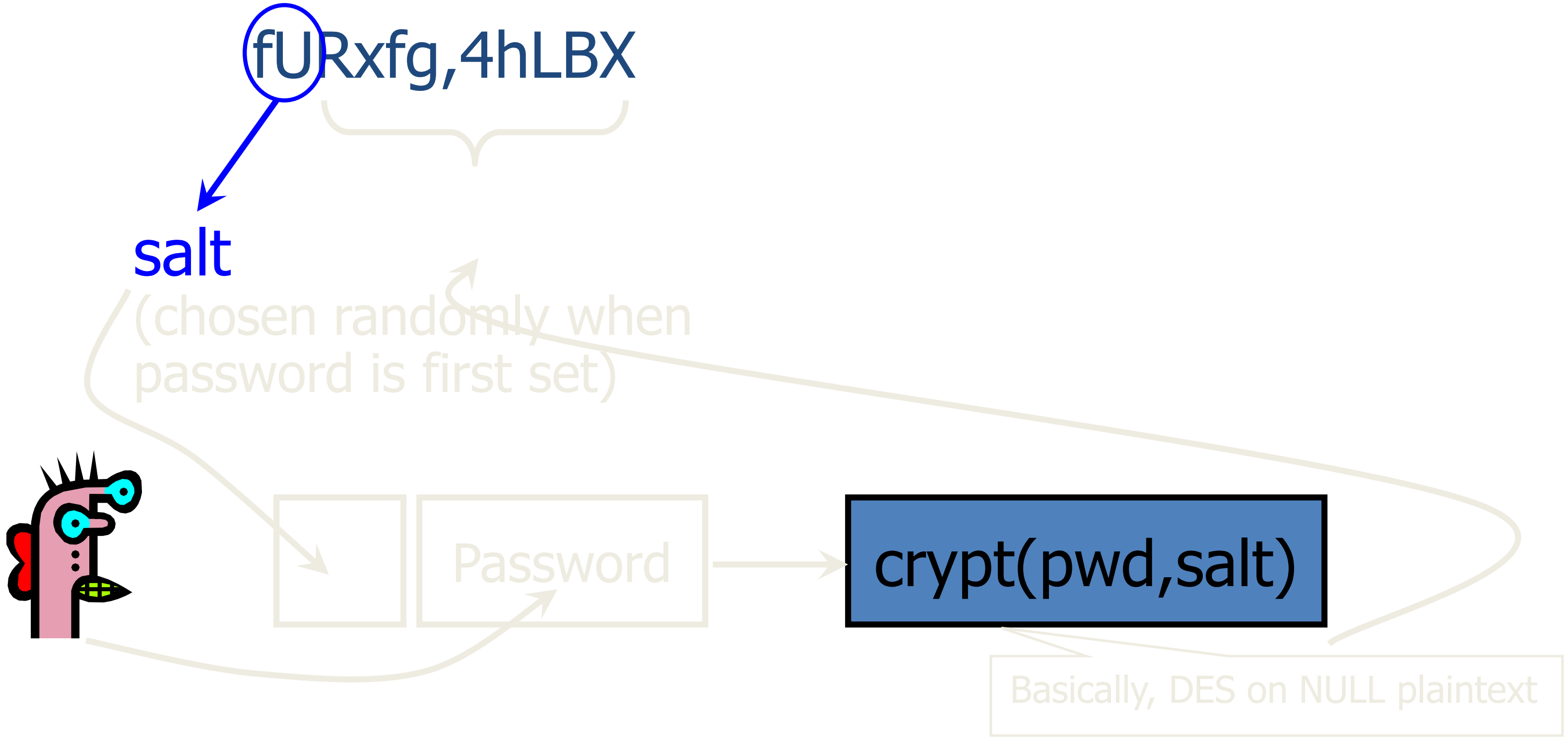
UNIX Password System

- Problem: passwords are not truly random
  - With 52 upper- and lower-case letters, 10 digits and 32 punctuation symbols, there are $94^8 \approx$ 6 quadrillion possible 8-character passwords
- Uses modified DES as if it were a hash function
  - Encrypt NULL string using password as the key
    - Truncates passwords to 8 characters!
  - Artificial slowdown: run DES 25 times
  - Humans like to use dictionary words, human and pet names ≈ 1 million common passwords

Dictionary Attack

- Password file /etc/passwd is world-readable
- Contains user IDs and group IDs which are used by many system programs
- Dictionary attack is possible because many passwords come from a small dictionary
  - Attacker can compute H(word) for every word in the dictionary and see if the result is in the password file
  - With 1,000,000-word dictionary and assuming 10 guesses per second, brute-force online attack takes 50,000 seconds (14 hours) on average
    - This is very conservative. Offline attack is much faster!

Salt



fURxfg,4hLBX

salt

(chosen randomly when password is first set)

Password

crypt(pwd,salt)

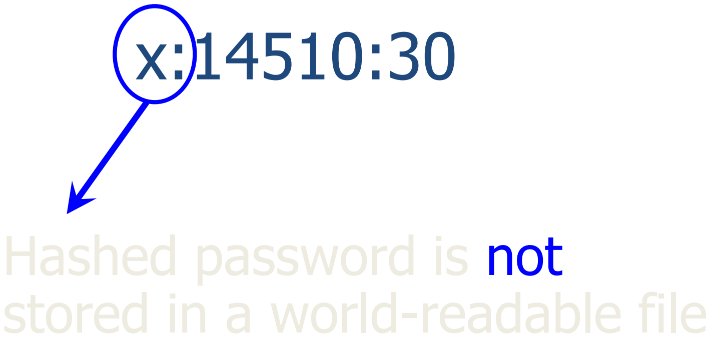
Basically, DES on NULL plaintext

- Users with the same password have <u>different</u> entries in the password file
- Dictionary attack is still possible!

Advantages of Salting

- Without salt, attacker can pre-compute hashes of all dictionary words once for all password entries
  - Same hash function on all UNIX machines
  - Identical passwords hash to identical values; one table of hash values can be used for all password files
- With salt, attacker must compute hashes of all dictionary words once for each password entry
  - With 12-bit random salt, same password can hash to 2^{12} different hash values
  - Attacker must try all dictionary words for each salt value in the password file

Shadow Passwords



x:14510:30

Hashed password is not stored in a world-readable file

- Store hashed passwords in /etc/shadow file which is only readable by system administrator (root)
- Add expiration dates for passwords