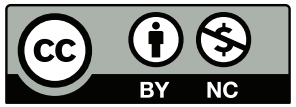
# Authentication



# Authentication

- A trilogy: identification, authentication, authorization
- ACLs and the like are forms of authorization: what you're allowed to do
- Identification is whom you claim to be be
- Authentication is how you prove it

# Forms of Authentication

- Something you know
- Something you have
- Something you are
- (Hmm, yet another trilogy)

# Forms of Authentication

- Something you know: passwords
- Something you have: smart card
- Something you are: fingerprint

# Something You Know

- Ancient: “what’s the secret word? (Supposedly dates to at least Roman times.)
- Modern incarnation: passwords
- Most common form of authentication

# Passwords

- Everyone understands the concept
- Passwords should be sufficient
- Not really. . .

# Passwords are Really Bad

- Guessable
- Forgettable
- Enumerable
- Eavesdroppable (but that isn't a word. . . )
- Replayable
- Reusable
- Leakable
- Probably a lot more reasons not to use them

# Guessable Passwords

- People tend to pick bad passwords
- Their own name, phone number, spouse's name, kids' names, etc.
- Easy to write password-guessing program (Morris and Thompson, CACM, Nov. 1979)

# Password-Guessing Programs

- Try likely words: names, dictionaries, etc.
  Use specialized dictionaries, too: other languages, science fiction terms, etc.
- Try variants: “password” $\rightarrow$ “passw0rd” or “Password”
- Use specialized, optimized algorithm
- In uncontrolled environments, at least 40-50% of people will have guessable passwords

# How Are Passwords Stored?

- Not in plaintext
  - Administrator can see them
  - Can be stolen from backup media (or recycled disk drives. . . )
  - Editor bugs can leak them
  - Something that doesn't exist can't be stolen!
- Use a one-way hash; compare stored hash with hash of entered password
- Read-protect the hashed passwords anyway

# Guessing Mechanisms

- Online: try to log in as the user
- Offline: steal a copy of the password file and try on your own machine (or on many compromised machines—including their GPUs)
- Note: that's why we read-protect the hashed passwords

# Defenses

- Rate-limit online guesses
- Perhaps lock out the account—but that leaves you vulnerable to DoS attacks
- Make password-guessing inherently slow: use a slow algorithm

# The Classic Unix Password-Hashing Algorithm

- Use DES (encryption algorithm with 56-bit keys in 8 bytes)
- Don't encrypt the password, encrypt a constant (all 0s) using the password as the key
- (Why not encrypt the password?)

☞ This is where the 8-character limit comes from

- Any decent cryptosystem can resist finding the key, given the plaintext and ciphertext
- Iterate 25 times, to really frustrate an attacker
- Guard against specialized hardware attacks by using the "salt" to modify the DES algorithm

# Salt

- Pick a random number—12 bits, for Unix—and use it to modify the password-hashing algorithm
- Store the salt (unprotected) with the hashed password
- Prevent the same password from hashing to the same value on different machines or for different users
- Makes dictionary of precomputed hashed passwords much more expensive
- Doesn't make the attack on a single password harder; makes attacks trying to find *some* password $4096\times$ harder

# Examples of Salting

*Without Salt*

joe →`0x21763a`
fred→`0xc19ecf`
pat →`0xfcef3d`
sue→`0x71ca7a`
...

*With Salt*

joe →`0,0x21763a; 1,0x0e08e7; 2,0x4fea4b; ...`
fred→`3,0xc19ecf; 4,0x55be45; 5,0xf0b015; ...`
pat →`6,0xfcef3d; 7,0x261286; 8,0x2437ba; ...`
sue→`9,0x71ca7a; 10,0x83f700; 11,0x04ed54; ...`
...

# Why Does Password-Guessing Work?

- People are predictable
- Passwords don't have much *information*
- According to Shannon, an 8-character word has 2.3 bits/character of information, or a total of 19 bits
- Empircally, the set of first names in the AT&T online phonebook had only 7.8 bits of information in the whole name
- $2^{19}$ isn't very many words to try...

# Can We Lengthen Passwords?

- There are other possible hashing algorithms that don't have an 8-character limit.
- Using 256-bit AES in the same way would let us use 32-character pass phrases; using HMAC would permit unlimited length
- Are long passphrases guessable?
- Running English text has entropy of 1.2-1.5 bits/character—but no one has built a guessing program to exploit that
- No one knows if it's even possible to exploit it

# Forgettable Passwords

- People forget seldom-used passwords
- What should the server do?
- Email them? Many web sites do that

☞ What if someone can read your email?

- Reset them?

☞ How do you authenticate the requester?

- Password hints?
- Is it bad to write down passwords? If your threat model is electronic-only, it's a fine thing to do. If your threat model is physical, forget it. (See the movie "Ghost")

# Reusable Passwords

- People tend to reuse the same passwords in different places
- If one site is compromised, the password can be stolen and used elsewhere
- At the root of “phishing” attacks

☞ A fraud incident on Stubhub is believed to have used passwords stolen from Adobe.com.

# Password Managers

- Store passwords in an encrypted file
- Who can see this file?
- How strongly is it protected?
- People use many machines today—synchronize this database? How?
- Can malware get at the database?
- How is it used?

☞ If the manager recognizes web sites, it can help protect against phishing

# Eavesdroppable

- Wiretapping the net isn't hard, especially if wireless links are used
- Done on the Internet backbone in 1993-4; see CERT Advisory CA-1994-01
- Install a keystroke logger on the client
- Install a password capture device on the server
- Play games with the DNS or routing to divert the login traffic

# Stealable

- Shoulder-surfing
- Bribery—trade a password for a candy bar
  (`http://news.bbc.co.uk/2/hi/technology/3639679.stm`)

# The Fundamental Problems

- Passwords have to be human-usable
- Passwords are static, and hence can be replayed

# Something You Have

- Many forms of tokens
- Time-based cards
- USB widgets (“dongles”)
- Rings
- Challenge/response calculators
- Mobile phones
- Smart cards
- Mag stripe cards
- More

# Disadvantages of Tokens

- They can be lost or stolen
- Lack of hardware support on many machines
- Lack of software support on many machines
- Inconvenient to use
- Cost

# The Java Ring


This ring has a Java interpreter, a crypto chip, and certificate-processing code. Google and others are pushing NFC rings.

# NSA's STU-III Secure Phone


Photos courtesy of Richard Brisson

# And the Crypto-Ignition Key

# How STU-IIIs are Used

- The phones have cryptographic keying material, and are in controlled areas
- The keys also have keying material, and user's name and clearance level
- Each party's phone will display the other party's name and clearance level
- Keys are associated with particular phones
- You need both the key and access to the right phone to abuse it
- *Two-factor* authentication

# Two-Factor Authentication

- Two of the three types of authentication technology
- Use second factor to work around limitations of first
- Example: SecurID card *plus* PIN

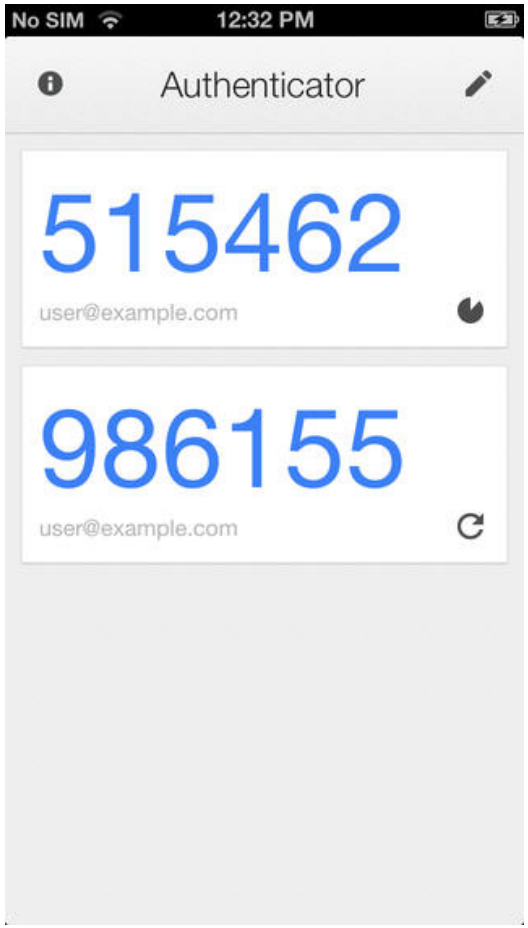
# SecurID Tokens



A SecurID token on two successive time cycles. The bars on the left of the second picture indicate how many 10-second ticks remain before the display changes, in this case about a minute. In essence, the display shows $H_k(T)$, where $T$ is the time and $H_k$ is a keyed hash function.

Generic name: TOTP (Time-based One-Time Passwords)

# Soft Tokens




- Phone apps can do the same things as dedicated tokens (CU uses `Duosec`)
- The partially-filled circle shows the time left for that code; there's a refresh button to generate a new one
- But—is the cryptographic secret protected as well as on dedicated tokens? There are hardware and software attacks possible now

# Eavesdropping Again

- Can't someone eavesdrop on a token-based or two-factor exchange?
- Sure!
- Must use other techniques as well: encryption and/or replay protection

# Replay Protection

- SecurID: code changes every minute; database prevents replay during that minute
- Challenge/response: server picks a unique number; client encrypts it
- Cryptographic protocols

# Cryptographic Authentication

- Use cryptographic techniques to authenticate
- Simultaneously, negotiate a key to use to protect the session
- But where do the original cryptographic keys come from?

# Cryptographic Keys are Long

- An AES key is at least 128 bits. Care to remember 32 hex digits as your password?
- An RSA key is at least 2048 bits. Care to remember 512 hex digits as your password?
- Solution 1: store the key on a token
- Solution 2: store the key on a computer, but encrypted

# Storing Keys on Tokens

- The most secure approach (my Java ring has an RSA key pair on it)
- Proper integration with host software can be tricky
- Generally want two-factor approach: use a password to unlock the token
- Ideally, the token is tamper-resistant

# Storing Keys on Hosts

- Software-only approach is useful for remote logins
- *Must* use passphrase to encrypt key
- Not very resistant to capture of encrypted key—we're back to offline password guessing
- Can you trust the host to protect your key?

# Use a Passphrase as a Key?

- Convert the user's passphrase to a key, and use it directly
- Approach used by Kerberos
- Remember the low information content of passphrases. . .
- Attack: eavesdrop on an encrypted message; guess at passphrases; see which one yields a sensible decryption
- Solution: use a SPAKA (Secure Password and Key Agreement) protocol

# Why Should Tokens be Tamper-Resistant?

- Prevent extraction of key if stolen
- Note: recovery of login key *may* permit decryption of old conversations
- Prevent authorized-but-unfaithful user from *giving* away the secret—you can't give it away and still have use of it yourself.
- Folks have pointed cameras at their tokens and OCRed the digits...`http://smallhacks.wordpress.com/2012/11/11/reading-codes-from-rsa-secureid-token/`

# Mobile Phones

- Use a phone as a token: send an SMS challenge to the phone
- Indepedent failure mode: will the attacker who has planted a keystroke logger on a computer also have access to the owner's phone?

☞ Eavesdropping on a phone requires very different access and technology than hacking a computer or eavesdropping on WiFi.

- Are there privacy risks from everyone having your mobile number?
- What about malware on the phone?
- Twitter's variant: app talks directly to Twitter and user; easier to use

# Other Threats

- Bogus SIM cards, with the help of a deluded carrier
- An attacker who controls the phone network
- Inceasing linkage between hosts and phones reduces the second factor: it's no longer independent

# Federated Authentication

- Log in—via strong-but-inconvenient authentication—to Facebook, Google, etc.
- These sites vouch for your identity to other sites
- What about privacy? (Mozilla's solution tries to solve this.)
- Do you trust some other site to vouch for your users? Your employees?

# Today's Status

- The evils of passwords have become very, very apparent
- There is a strong push to get rid of them, especially by Google
- But will they succeed?
- Passwords seem easy and cheap, and don't require (much) user training—but is that still true if you account for password recovery and compromise?