Secure Remote Password (SRP) Authentication

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Authentication in General

- What you are
  - Fingerprints, retinal scans, voiceprints
- What you have
  - Token cards, smart cards
- What you know
  - Passwords, PINs

Password Authentication

- Concentrates on “what you know”
- No long-term client-side storage
- Advantages
  - Convenience and portability
  - Low cost
- Disadvantages
  - People pick “bad” passwords
  - Most password methods are weak

Problems and Issues

- Dictionary attacks
- Plaintext-equivalence
- Forward secrecy

Dictionary Attacks

- An off-line, brute force guessing attack conducted by an attacker on the network
- Attacker usually has a “dictionary” of commonly-used passwords to try
- People pick easily remembered passwords
- “Easy-to-remember” is also “easy-to-guess”
- Can be either passive or active

Passwords in the Real World

- Entropy is less than most people think
- Dictionary words, e.g. “pudding”, “plan9”
  – Entropy: 20 bits or less
- Word pairs or phrases, e.g. “hate2die”
  – Represents average password quality
  – Entropy: around 30 bits
- Random printable text, e.g. “nDz2\u>O”
  – Entropy: slightly over 50 bits

Plaintext-equivalence

- Any piece of data that can be used in place of the actual password is “plaintext-equivalent”
- Applies to:
  - Password databases and files
  - Authentication servers (Kerberos KDC)
- One compromise brings entire system down

Forward Secrecy

- Prevents one compromise from causing further damage

Compromising	Should Not Compromise
Current password	Future passwords
Old password	Current password
Current password	Current or past session keys
Current session key	Current password

In The Beginning...

- Plaintext passwords
  - e.g. unauthenticated Telnet, rlogin, ftp
  - Still most common method in use
- "Encoded" passwords
  - e.g. HTTP Basic authentication
- Using password to encrypt verifiable text
  - e.g. Kerberos
  - vulnerable to dictionary attack

More Weak Authentication

- Challenge-Response authentication
  – e.g. S/Key, OPIE, CRAM
  – User receives C, responds with f(C, P)
  – Susceptible to passive dictionary attack
- "Public-Key-Assisted" Login
  – e.g. stel, SRA Telnet
  – Uses plain Diffie-Hellman or ephemeral RSA
  – Susceptible to active attacks

Augmenting Weak Methods

- Iterated hashing
  - Increases amount of time required for attack
  - Also slows down legitimate authentication
  - Maximum improvement is less than 10 bits
- Computer-generated passwords
  - Have higher entropy
  - Easy to forget, and are more likely to be written down (a security problem in itself)

The Empire Strikes Back

- 20-25 bits can be attacked easily today
- Even *one* successful password guess (weakest link in chain) lets an intruder in
- Attacks are easily parallelizable
- Moore's law constantly erodes security of weak methods
  - Lose 2 bits of strength every three years

Better Weapons

- EKE
  - Bellovin & Merritt: 1992
- "Secret public-key"
  - Gong, Lomas, Needham, Saltzer: 1993
- SPEKE
  - Jablon: 1996
- OKE
  - Lucks: 1997

Advantages of Strong Methods

- Attacker must solve at least one “hard” public-key problem first
- Key exchange after successful login
- Some also offer:
  - Resistance to active attacks
  - Forward secrecy
- But these are still plaintext-equivalent...

Return of the Jedi

- A-EKE
  – Bellovin & Merritt: 1994
- B-SPEKE
  – Jablon: 1997
- SRP
  – Wu: 1997
- All are verifier-based

History of SRP

- Originally designed to handle authentication between Java applet and Java-based server at Stanford
- Widespread applicability and interest led to development of software suite
- Discussions on `sci.crypt` led to final version, sometimes called SRP-3

The SRP Protocol

m = large safe prime ($2q+1$, q prime)
g = primitive root mod m
P = plaintext password
Carol knows the password, $x = H(P)$
Steve knows the verifier, $v = g^x \pmod{m}$

Carol (the client)		Steve (the server)
Generates random a		Generates random b, u
$A = g^a \pmod{m}$	$\rightleftarrows$	$B = v + g^b \pmod{m}$, u
$K = (B - g^x)^{a+ux} \pmod{m}$		$K = (Av^u)^b \pmod{m}$

Each side then proves it knows K

Security Analysis

- g must be primitive root to avoid leaking information about v
- Carol must be first to issue proof of K
- u must not be revealed before A
- Random numbers a, b must be discarded when protocol finishes
- Check for invalid inputs, e.g. A, B == 0

Protocol Families

- A- and B- protocols sometimes called "extended" methods
  - Two key-exchange rounds
  - A-EKE: extra digital signature
  - B-SPEKE: extra El Gamal key exchange
- SRP is part of a third family (AKE)
  - Password and verifier are integrated into a single key-exchange round

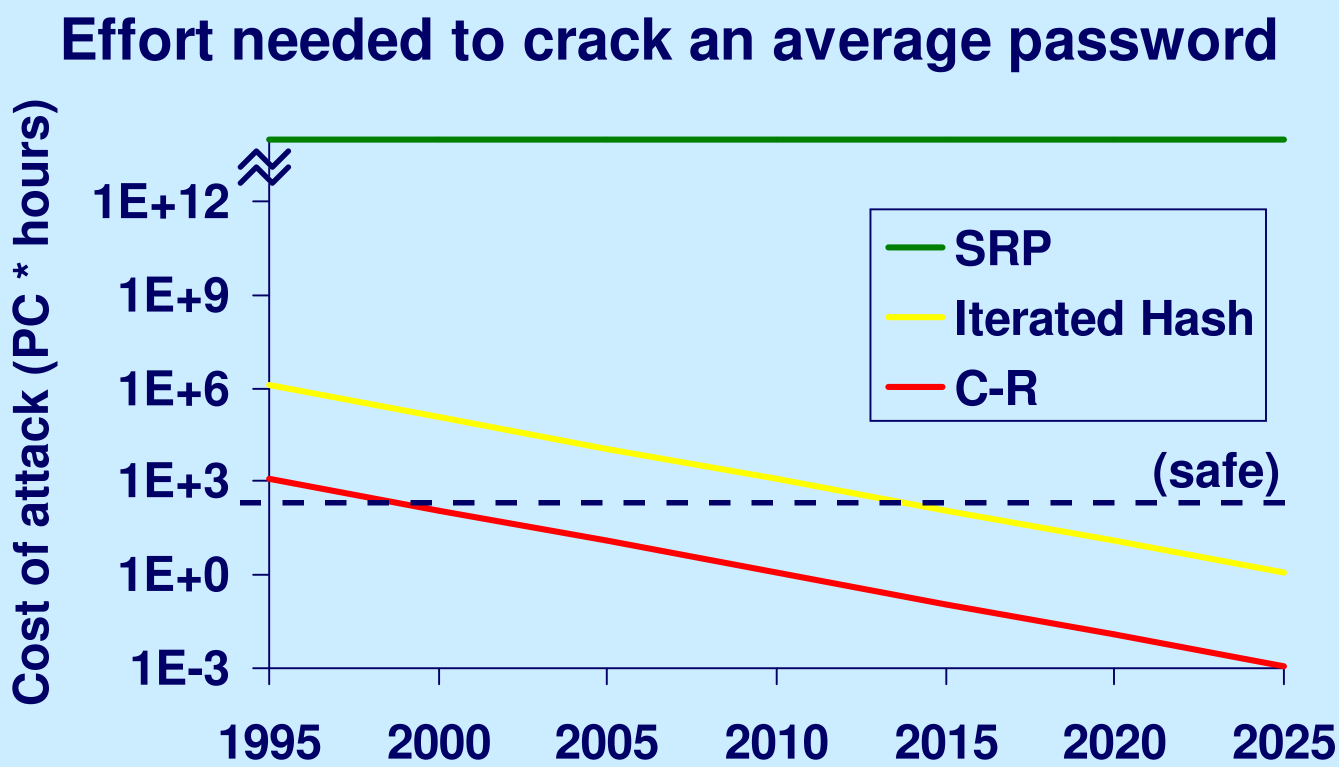
How They Stack Up

	Cleartext Password	Challenge-Response	Strong Password (SPEKE)	Verifier-based (SRP)
Does not reveal password	No	Yes	Yes	Yes
Resists dictionary attack	No	No	Yes	Yes
Not plaintext-equivalent	Yes	No	No	Yes
Provides forward secrecy	No	No	Yes	Yes

Some Scary Trends

- Inexpensive PCs can exceed 10K crypts/sec
- No Moore's Law for human memory
- Increased size of Internet means more access to free CPU cycles
- Even forcing "good" password choices only delays inevitable
- "Bad guys" have caught up and taken the lead (CERT Advisory 94:01)...

Strong vs. Weak Methods



Impact of Strong Authentication

- Best known algorithms for compromising SRP (discrete log) not easily parallelizable
- Places off-line attack against even short passwords out of reach
- “Infinitely” stronger than weak methods
- Designed as drop-in replacements
- Low cost and socially acceptable

Applications

- Remote login/access (Telnet, FTP)
- E-mail (POP, IMAP)
- World Wide Web
- Firewalls
- Network computers
- Any situation where an actual person needs to be authenticated

The SRP Project

- Freeware API library in both C and Java
- Telnet and FTP for Unix and Windows
- Distributed architecture being developed
- Public collaboration w/Internet community
- Drafts submitted to IETF, IEEE P1363
- Help always appreciated
  - Join the mailing list

Looking Ahead

- Increase awareness of “broken” systems
  - Kerberos V4, V5, Windows NT, S/Key, ...
- Fix these systems where possible
  - Jaspan, 1996 describes Kerberos fix
- Strong authentication mechanisms have become “Best Current Practice”
  - No excuse to use broken methods anymore
  - Good guys are winning again...

For More Information

- SRP Web Site
  - `http://srp.stanford.edu/srp/`
  - Contains links to download source code and information about mailing list
- E-mail
  - *`tjw@cs.Stanford.EDU`*