Distributed Systems

25. Authentication

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Fall 2018

Authentication

- For a user (or process):
  - Establish & verify identity
  - Then decide whether to allow access to resources (= authorization)

Authentication

Three factors:

- something you have *key, card*
  - Can be stolen
- something you know *passwords*
  - Can be guessed, shared, stolen
- something you are *biometrics*
  - Usually needs hardware, can be copied (sometimes)
  - Once copied, you're stuck

Multi-Factor Authentication

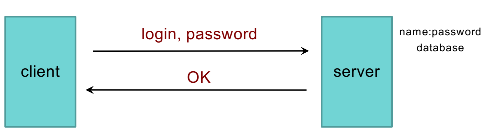
Factors may be combined

- ATM machine: 2-factor authentication
  - ATM card something you have
  - PIN something you know
- Password + code delivered via SMS: 2-factor authentication
  - Password something you know
  - Code validates that you possess your phone

Two passwords ≠ Two-factor authentication

Authentication: PAP

Password Authentication Protocol



- Unencrypted, reusable passwords
- Insecure on an open network
- Also, password file must be protected from open access
  - But administrators can still see everyone's passwords

PAP: Reusable passwords

PROBLEM: Open access to the password file

What if the password file isn't sufficiently protected and an intruder gets hold of it? All passwords are now compromised!

Even if a trusted admin sees your password, this might also be your password on other systems.

Solution:

Store a hash of the password in a file

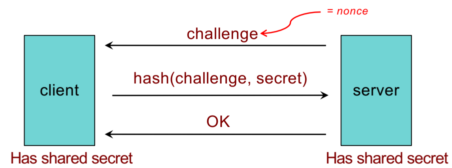
- Given a file, you don't get the passwords
- Have to resort to a dictionary or brute-force attack
- Example, passwords hashed with SHA-512 hashes (SHA-2)

What is salt?

- How to speed up a dictionary attack
  - Create a table of precomputed hashes
  - Search(hashed_password) → original_password
- Salt = random string (typically up to 16 characters)
  - Concatenated with the password
  - Stored with the password file (it's not secret)
  - Even if you know the salt, you cannot use precomputed hashes to search for a password (because the salt is prefixed)
  - Makes a table of precomputed hashes prohibitively huge

Authentication: CHAP

Challenge-Handshake Authentication Protocol

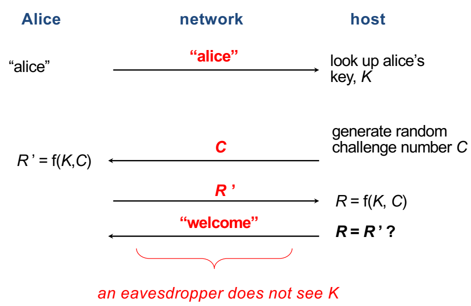


The challenge is a *nonce* (random bits).

We create a hash of the nonce and the secret.

An intruder does not have the secret and cannot do this!

CHAP authentication



Time-Based Authentication

Time-based One-time Password (TOTP) algorithm

- Both sides share a secret key
- User runs TOTP function to generate a one-time password
  one_time_password = hash(secret_key, time)
- User logs in with:
  - *Name*, *password*, and *one_time_password*
- Service generates the same password
  one_time_password = hash(secret_key, time)

Guarding against man-in-the-middle

- Use a covert communication channel
  - The intruder won't have the key
  - Can't see the contents of any messages
  - But you can't send the key over that channel!
- Use signed messages
  - Signed message = { *message* and *encrypted hash of message* }
  - Both parties can reject unauthenticated messages
  - The intruder cannot modify the messages
    - Signatures will fail (they will need to know how to encrypt the hash)

Public Key Authentication

Public key authentication

Demonstrate we can encrypt or decrypt a *nonce*

This shows we have the right key

- Alice wants to authenticate herself to Bob:
- Bob: generates nonce, *S*
  - Sends it to Alice
- Alice: encrypts *S* with her private key (signs it)
  - Sends result to Bob

A random bunch of bits

Public key authentication

Bob:

1. Look up "alice" in a database of public keys
2. Decrypt the message from Alice using Alice's public key
3. If the result is *S*, then Bob is convinced he's talking with Alice

For mutual authentication, Alice has to present Bob with a nonce that Bob will encrypt with his private key and return

Public key authentication

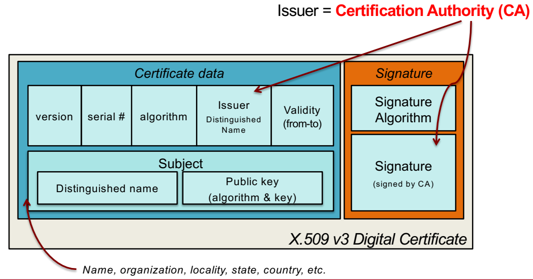
- Public key authentication relies on binding identity to a public key
  - *How do you know it really is Alice's public key?*
- One option:
  get keys from a trusted source
- Problem: requires always going to the source
  - cannot pass keys around
- Another option: *sign the public key*
  - Contents cannot be modified
  - **digital certificate**

X.509 Certificates

ISO introduced a set of authentication protocols

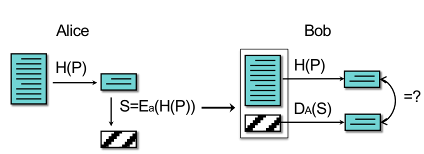
X.509: Structure for public key certificates:

Issuer = **Certification Authority (CA)**



Reminder: What's a digital signature?

Hash of a message encrypted with the signer's private key



X.509 certificates

When you get a certificate

- Verify its signature:
  - hash contents of certificate data
  - Decrypt CA's signature with CA's public key

Obtain CA's public key (certificate) from trusted source

Certificates prevent someone from using a phony public key to masquerade as another person

…if you trust the CA

SSL/TLS

Transport Layer Security

- Provide a transport layer security protocol
- After setup, applications feel like they are using TCP sockets

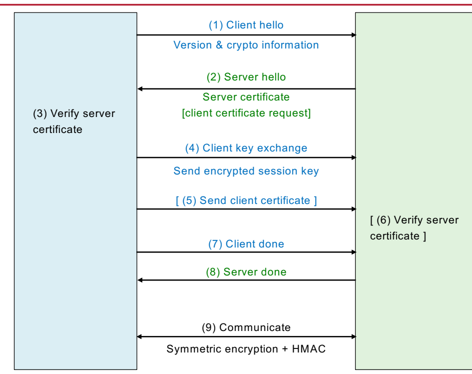
SSL: Secure Socket Layer

- Created with HTTP in mind
  - Web sessions should be secure
  - Mutual authentication is usually not needed
    - Client needs to identify the server but the server won't know all clients
    - Rely on passwords after the secure channel is set up
- SSL evolved to TLS (Transport Layer Security)
  - SSL 3.0 was the last version of SSL … and is considered insecure
  - We use TLS now … but often still call it SSL

Transport Layer Security (TLS)

- *aka* Secure Socket Layer (SSL), which is an older protocol
- Sits on top of TCP/IP
- Goal: provide an encrypted and possibly authenticated communication channel
  - Provides authentication via RSA and X.509 certificates
  - Encryption of communication session via a symmetric cipher
- Hybrid cryptosystem: (usually, but also supports Diffie-Hellman)
  - Public key for authentication
  - Symmetric for data communication
- Enables TCP services to engage in secure, authenticated transfers
  - http, telnet, ntp, ftp, smtp, …

TLS Protocol



OAuth 2.0

Service Authorization

- You want an app to access your data at some service
  - E.g., access your Google calendar data
- But you want to:
  - Not reveal your password to the app
  - Restrict the data and operations available to the app
  - Be able to revoke the app's access to the data

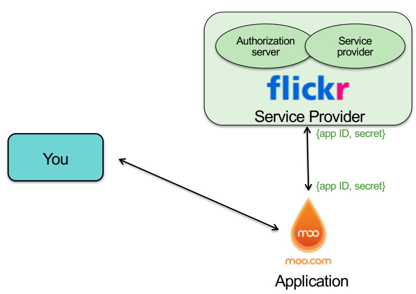
OAuth 2.0: Open Authorization

- OAuth: framework for service authorization
  - Allows you to authorize one website (consumer) to access data from another website (provider) – *in a restricted manner*
  - Designed initially for web services
  - Examples:
    - *Allow the Moo photo printing service to get photos from your Flickr account*
    - *Allow the NY Times to tweet a message from your Twitter account*
- OpenID Connect
  - Remote identification: use one login for multiple sites
  - Encapsulated within OAuth 2.0 protocol

OAuth setup

- OAuth is based on
  - Getting a token from the service provider & presenting it each time an application accesses an API at the service
  - URL redirection
  - JSON data encapsulation
- Register a service
  - Service provider (e.g., Flickr):
    - Gets data about your application (name, creator, URL)
    - Assigns the application (consumer) an ID & a secret
    - Presents list of authorization URLs and scopes (access types)

OAuth Entities

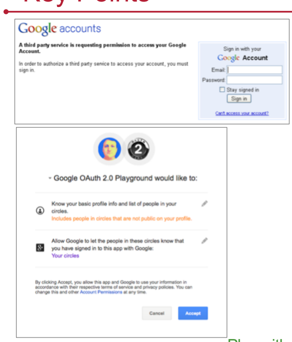


You want moo.com to access your photos on flickr

How does authorization take place?

- Application needs an *Access Token* from the Service (e.g., moo.com needs an *access token* from flickr.com)
  - Application redirects user to Service Provider
    - Request contains: *client ID, client secret, scope* (list of requested APIs)
    - User may need to authenticate at that provider
    - User authorizes the requested access
    - Service Provider redirects back to consumer with a one-time-use authorization code
  - Application now has the *Authorization Code*
    - The previous redirect passed the Authorization Code as part of the HTTP request – therefore not encrypted
  - Application exchanges *Authorization Code* for *Access Token*
    - The legitimate app uses HTTPS (encrypted channel) & sends its secret
    - The application now talks securely & directly to the Service Provider
    - Service Provider returns Access Token
  - Application makes API requests to Service Provider using the **Access Token**

Key Points



- You may still need to log into the Provider's OAuth service when redirected
- You approve the specific access that you are granting
- The Service Provider validates the requested access when it gets a token from the Consumer

Play with it at the ***OAuth 2.0 Playground***: https://developers.google.com/oauthplayground/

Identity Federation: OpenID Connect

Single Sign-On: OpenID Connect

- Designed to solve the problem of
  - Having to get an ID per service (website)
  - Managing passwords per site
  - Layer on top of OAuth 2.0
- Decentralized mechanism for single sign-on
  - Access different services (sites) using the same identity
    - Simplify account creation at new sites
  - User chooses which OpenID provider to use
    - OpenID does not specify authentication protocol – up to provider
  - Website never sees your password
- *OpenID Connect* is a standard but not the only solution
  - Used by Google, Microsoft, Amazon Web Services, PayPal, Salesforce, …
  - Facebook Connect – popular alternative solution (similar in operation but websites can share info with Facebook, offer friend access, or make suggestions to users based on Facebook data)

Sign in with Google

OpenID Connect Authentication

- OAuth requests that you specify a "**scope**"
  - List of access methods that the app needs permission to use
- To enable user identification
  - Specify "openid" as a requested scope
- Send request to server (identity provider)
  - Server requests user ID and handles authentication
- Get back an access token
  - If authentication is successful, the token contains:
    - user ID
    - approved scopes
    - expiration
    - etc.

  same as with OAuth requests for authorization

Cryptographic toolbox

- Symmetric encryption
- Public key encryption
- One-way hash functions
- Random number generators
  - Used for nonces and session keys

Examples

- Key exchange
  - Public key cryptography
- Key exchange + secure communication
  - Random # + Public key + symmetric cryptography
- Authentication
  - Nonce (random #) + encryption
- Message authentication codes
  - Hashes
- Digital signature
  - Hash + encryption with private key

The End