Authentication, Authorization, and Public Key Infrastructure (PKI)

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1. Introduction

In today's digital world, securing access to resources and verifying user identities are critical to maintaining trust and integrity in online systems. This report delves into three core aspects of security: Authentication, Authorization, and Public Key Infrastructure (PKI). The purpose of this report is to provide a comprehensive understanding of these concepts, explain their mechanisms, and highlight their role in ensuring the security of modern applications.

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2. Authentication Mechanisms

Authentication is the process of verifying the identity of a user or system before granting access to resources. It confirms that the entity requesting access is indeed who they claim to be. There are two primary types of authentication mechanisms: stateful and stateless.

2.1 Stateful Authentication (Cookie/Session-Based Authentication)

Stateful authentication is the traditional approach used in web applications. It relies on sessions managed by the server to maintain the user's authentication status. The process works as follows:

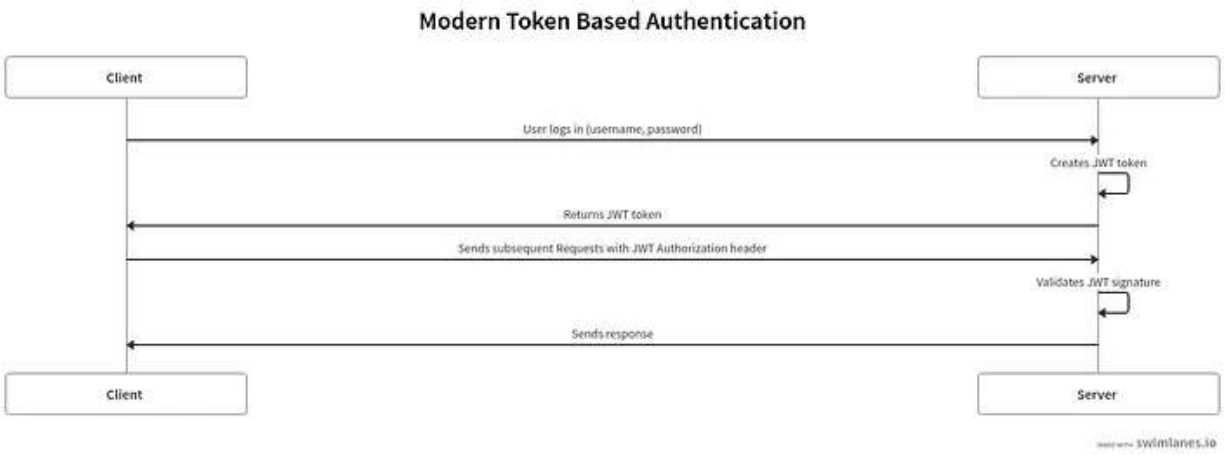
- Session Creation: When a user logs in, the server generates a session ID and stores it either in a database or in memory.
- Cookie Storage: The session ID is sent to the client and stored in a cookie within the user's browser.
- Subsequent Requests: With each subsequent request, the client sends the cookie containing the session ID back to the server. The server validates the session ID against the stored session data to authenticate the user.

Use Case: Stateful authentication is suitable for applications where server-side session management is needed and where scalability is less of a concern. It is commonly used in traditional web applications.

2.2 Stateless Authentication (Token-Based Authentication using JWT)

Stateless authentication eliminates the need for server-side session management, making it highly scalable. JSON Web Tokens (JWT) are a popular mechanism used in stateless authentication.

How JWT Works:



- User Login: Upon a successful login, the server generates a JWT and sends it to the client.
- Token Structure: The JWT consists of three parts:
    1. Header: Specifies the signing algorithm (e.g., HS256) and token type (JWT).
    2. Payload: Contains claims, which are the data to be conveyed, such as user roles, permissions, and other relevant information.
    3. Signature: Created by encoding the header and payload and then encrypting them using the specified algorithm and a secret key.
- Client-Side Storage: The client stores the JWT (often in local storage or a cookie) and includes it in the Authorization header of each subsequent request.
- Server Validation: The server validates the token by checking its signature and expiration before allowing access to the requested resource.

Use Case: JWT is ideal for scalable, distributed applications where server-side session management is impractical. It is commonly used in microservices architectures and single-page applications (SPAs).

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3. Authorization with Spring Security

While authentication verifies a user's identity, authorization determines what resources that authenticated user can access. In Spring Security, both roles and authorities are used to manage access control.

3.1 Understanding Authorities and Roles

- **Roles:** Roles represent groups of privileges. For example, an “ADMIN” role might have permissions to manage users and resources, while a “USER” role might only have access to basic features.
- **Authorities:** Authorities are more granular permissions granted to a user, such as READ_PRIVILEGE or WRITE_PRIVILEGE.

In Spring Security, roles and authorities are managed using the UserDetailsService, which loads user-specific data, including roles and permissions, during authentication.

3.2 CSRF (Cross-Site Request Forgery) Protection

CSRF is a type of attack where an attacker tricks a user into performing actions on a web application without their knowledge. For instance, a logged-in user might be tricked into transferring funds or making changes to their account through a malicious link.

CSRF Tokens: To prevent CSRF attacks, Spring Security generates unique CSRF tokens for each session. These tokens are included in every form submission, and the server verifies them before processing the request.

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4. Method-Level Security in Spring Security

Method-level security in Spring Security allows you to restrict access to specific methods based on roles and permissions. Three key annotations are used:

@PreAuthorize: Checks if a user meets certain conditions before allowing method execution. Example: @PreAuthorize("hasRole('ADMIN')").

@Secured: A simpler way to enforce role-based access control. Example: @Secured("ROLE_ADMIN").

@RolesAllowed: Similar to @Secured, this annotation is used in environments that support JSR-250.

Method-level security is useful for fine-grained access control at the service or controller level.

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5. Public Key Infrastructure (PKI)

Public Key Infrastructure (PKI) is a framework that enables secure communication and authentication over the internet by managing encryption keys and digital certificates. PKI is crucial for establishing trust between entities in a digital environment.

5.1 What is PKI?

PKI uses a pair of cryptographic keys—public and private keys—for encryption and decryption. The public key is shared openly, while the private key is kept secret.

Digital Certificates: Digital certificates bind public keys to entities (individuals, organizations, etc.). These certificates are issued by trusted entities called Certification Authorities (CAs).

5.2 Why Do We Use PKI?

PKI is wide ly used for securing communications, verifying identities, and ensuring the integrity of data in various applications, including:

SSL/TLS: Secure communication over the web (HTTPS).

Email Encryption: Secure email communication using S/MIME.

Digital Signatures: Authenticating documents and transactions.

5.3 Certification Authorities (CAs)

CAs are trusted entities that issue digital certificates after verifying the identity of the certificate requester. Examples include Let's Encrypt, DigiCert, and GlobalSign.

5.4 PKI for the Internet

PKI forms the backbone of secure communication on the internet. It enables HTTPS, which is critical for protecting sensitive information like credit card numbers and personal data during online transactions.

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6. Conclusion

Authentication, authorization, and PKI are essential components of a robust security framework. Authentication mechanisms, whether stateful or stateless, provide the first layer of security by verifying user identities. Authorization ensures that users can only access resources they are permitted to, with Spring Security offering flexible methods to enforce role-based and method-level security. Lastly, PKI establishes trust on the internet by enabling secure communication and verifying identities through cryptographic keys and certificates.

Together, these technologies create a layered defense that protects against unauthorized access, data breaches, and other security threats in today's interconnected world.

References

https://medium.com/@minadev/authentication-and-authorization-with-spring-security-bf22e985f2cb