1. Definition

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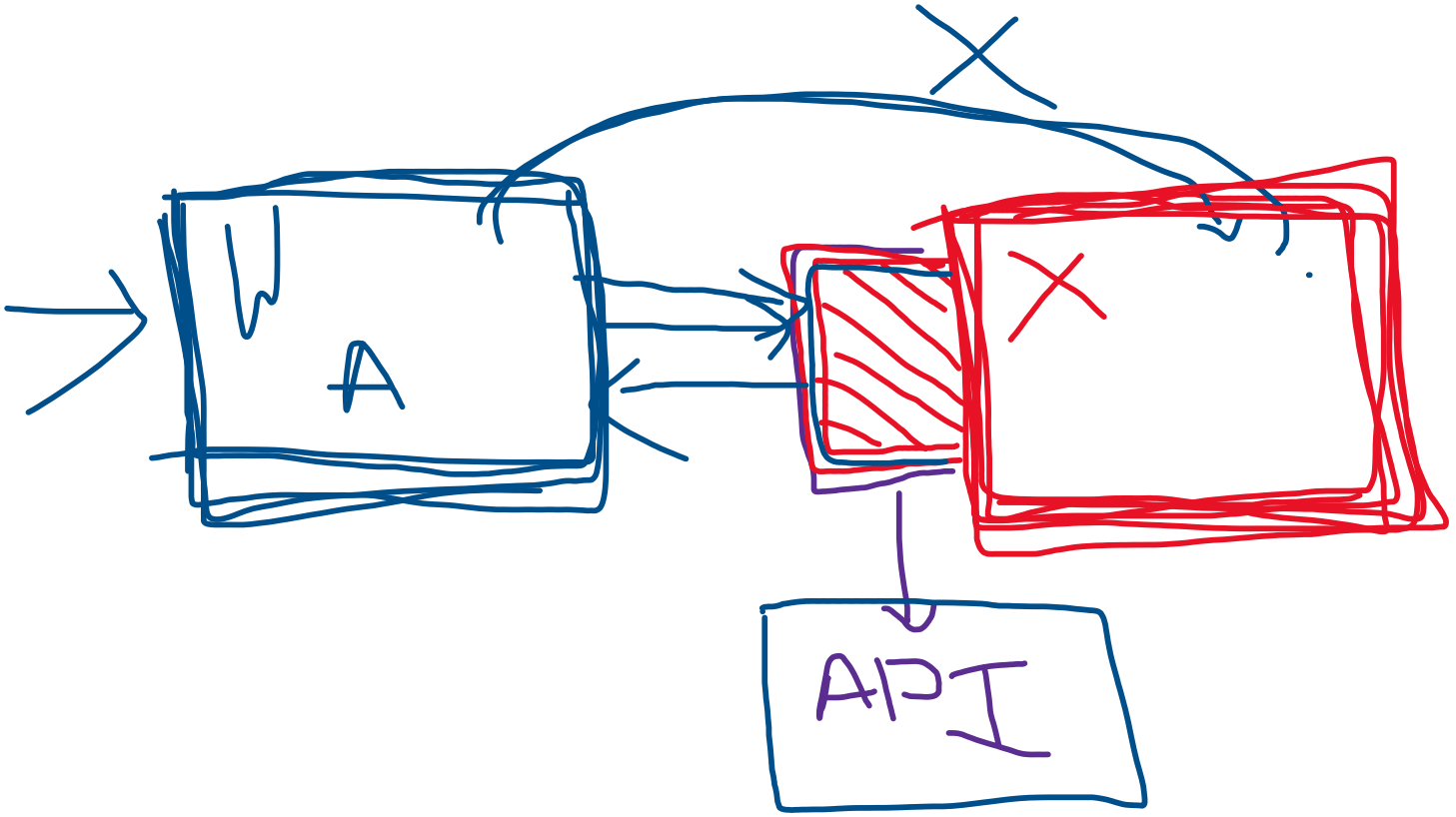
- An API (Application Programming Interface) is essentially a set of rules and protocols that allows different software applications to communicate with each other
- It can be thought of as a bridge that connects different systems or services, enabling them to share data and functionalities without directly interacting with each other's underlying code
- Ex: Weather app



2. Key Features

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- Enable different systems, platforms, and applications to communicate and share data effortlessly
- Significantly reduce the time and effort required to develop applications by leveraging pre-built functionalities
- Enable systems to scale and adapt to growing or changing requirements
- APIs contribute to creating dynamic and responsive applications that offer better user experiences
- Allow organizations to expand their ecosystem and collaborate with external developers and partners
- APIs provide controlled and secure access to data, allowing organizations to share information with clients, partners, or the public
- APIs provide mechanisms to enforce security policies and ensure compliance with industry standards
- APIs can help organizations reduce operational and development costs

3. Types of APIs

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1. **Web API:**
   - APIs that are accessible over the web using HTTP/HTTPS protocols
   - Allow applications to communicate over the internet
   - Data is usually shared in JSON/XML formats
   - Examples:
     - *Fetching weather data from OpenWeather API*
     - *Embedding Google Maps on a website*

2. **Library API:**
   - APIs provided by libraries or frameworks to expose specific functionality for developers
   - Allow developers to utilize predefined functions or methods without implementing them from scratch
   - Examples:
     - *NumPy API: Provides functions for numerical computations*
     - *TensorFlow API: Offers tools for building and training ML/DL models*
     - *Matplotlib API: Allows creating visualizations programmatically*

3. **Remote API:**
   - APIs designed to interact with systems located on a different network or server, often through the internet or intranet
   - Web API is a subset of Remote API, i.e., all Web APIs are Remote APIs, but not all Remote APIs are Web APIs
   - Makes use of Intranet APIs, which can only be accessible within a private network
   - Examples:
     - *Deploying virtual machines using AWS EC2 API*
     - *Retrieving remote files stored in Google Drive through its API*

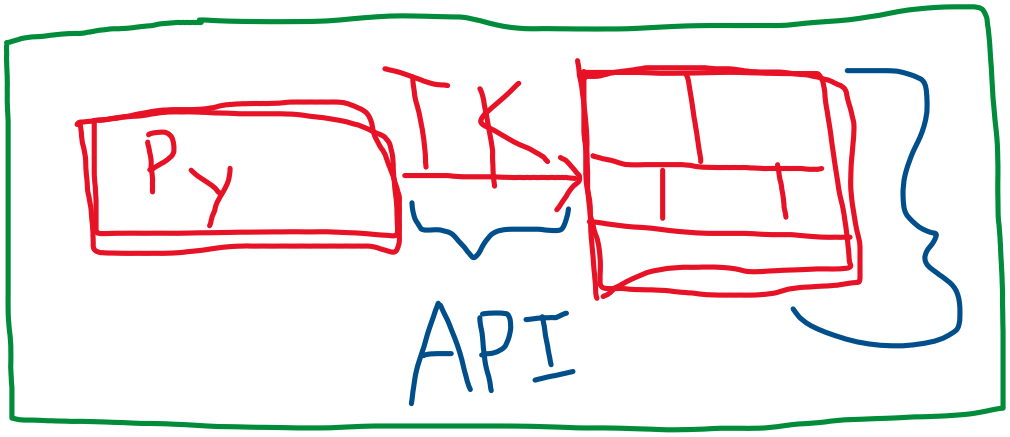
4. **Database API:**
   - APIs that allow applications to interact with databases
   - Provide a structured way to perform CRUD (Create, Read, Update, Delete) operations on a database
   - Examples:
     - *MySQL Connector API: Enables interaction with MySQL databases*
     - *MongoDB API: Allows CRUD operations on NoSQL data*
     - *Firebase Realtime Database API: Facilitates real-time database interactions*

5. **Hardware API:**
   - APIs that enable software to interact with physical hardware devices

- Provide an abstraction layer to control and retrieve data from devices without needing low-level programming
- Examples:
  - *GPU APIs like CUDA or OpenCL for performing parallel computations*
  - *APIs for IoT devices such as sensors or smart appliances*
  - *Using APIs to control drones or robots programmatically*

6. GUI API:

- APIs designed for building and interacting with graphical user interfaces
- Allow developers to create and manage GUI components programmatically
- Examples:
  - *Java Swing API: Provides tools to create desktop GUIs in Java*
  - *Tkinter: A Python library for creating GUI applications*
  - *Android SDK: Enables developers to build mobile app interfaces*



4. API Protocols

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1. **REST:**
   - Abbreviation for Representational State Transfer
   - It's a lightweight architectural style that uses HTTP for communication
   - Follow a set of principles, such as statelessness and resource representation using URLs
   - Each API call is independent of the other
   - Common HTTP methods: GET, POST, PUT, DELETE
   - Use Cases: Web applications, mobile applications, and public APIs (e.g., Twitter API, GitHub API)

```
GET /users/123 HTTP/1.1
Host: example.com
```

```
{
  "id": 123,
  "name": "John Doe",
  "email": "john.doe@example.com"
}
```

2. **SOAP:**
   - Abbreviation for Simple Object Access Protocol
   - A protocol that relies on XML messaging for communication
   - Designed for more structured and secure interactions
   - Has built-in error handling and security (e.g., WS-Security)

```
<soap:Envelope xmlns:soap="http://schemas.xmlsoap.org/soap/envelope/">
  <soap:Body>
    <GetUserDetails>
      <UserId>123</UserId>
    </GetUserDetails>
  </soap:Body>
</soap:Envelope>
```

3. **GraphQL:**
   - Allows clients to request only the data they need, reducing over-fetching and under-fetching
   - Clients specify the structure of the response
   - All queries are handled at one endpoint

```
{
  user(id: "123") {
    name
    email
    posts {
      title
      comments {
        text
      }
    }
  }
}
```

4. **gRPC:**
   - Abbreviation for Google Remote Procedure Call
   - A high-performance RPC framework by Google using Protocol Buffers (Protobuf) for message serialization
   - Operates over HTTP/2, providing bi-directional streaming
   - Works across various programming languages and minimizes payload size

```
service UserService {
  rpc GetUserDetails (UserRequest) returns (UserResponse);
}
message UserRequest {
  int32 user_id = 1;
}
message UserResponse {
  int32 user_id = 1;
  string name = 2;
  string email = 3;
}
```

5. **WebSocket:**
   - A protocol providing full-duplex communication over a single TCP connection
   - Enables continuous exchange of data without re-establishing the connection
   - Ideal for real-time use cases due to its low latency
   - Use Cases: Chat applications, online gaming, live data feeds

```
const socket = new WebSocket("ws://example.com/stocks");
socket.onmessage = (event) => {
  console.log("Stock update:", event.data);
};
```

Feature	REST	SOAP	GraphQL
Data Format	JSON, XML, etc.	XML only	JSON only
Flexibility	High	Low	Very High

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Data Format	JSON, XML, etc.	XML only	JSON only
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Performance	Fast	Slower	Efficient
Use Case	Modern web APIs	Enterprise applications	Dynamic client needs

5. Working

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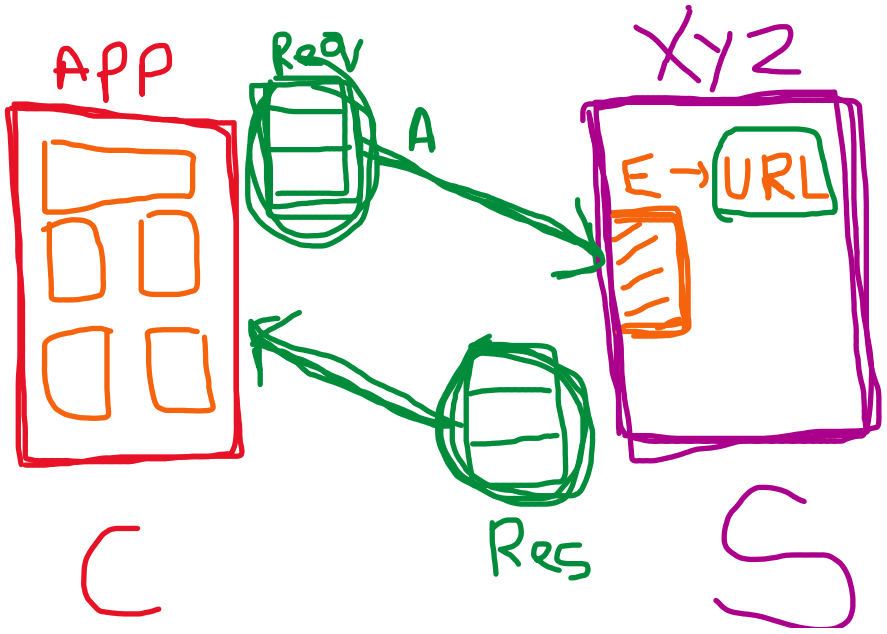
1. **Request Initiation:**
   - The process begins when a client (like a web browser, mobile app, etc.) initiates a request to the API
   - This request is usually made using HTTP methods such as GET, POST, PUT, or DELETE

2. **API Endpoint:**
   - The request is sent to a specific URL known as an API endpoint
   - This endpoint is like a door that the API has opened for requests

3. **Request Processing:**
   - The server receives the request and processes it
   - This involves verifying the request parameters, checking authentication, and accessing databases, etc.

4. **Response Generation:**
   - After processing the request, the server generates a response
   - This response typically includes the requested data or a confirmation of the action performed

5. **Response Delivery:**
   - The response is sent back to the client
   - The client receives the response and uses the data to perform the desired action or display information to the user



6. API Components

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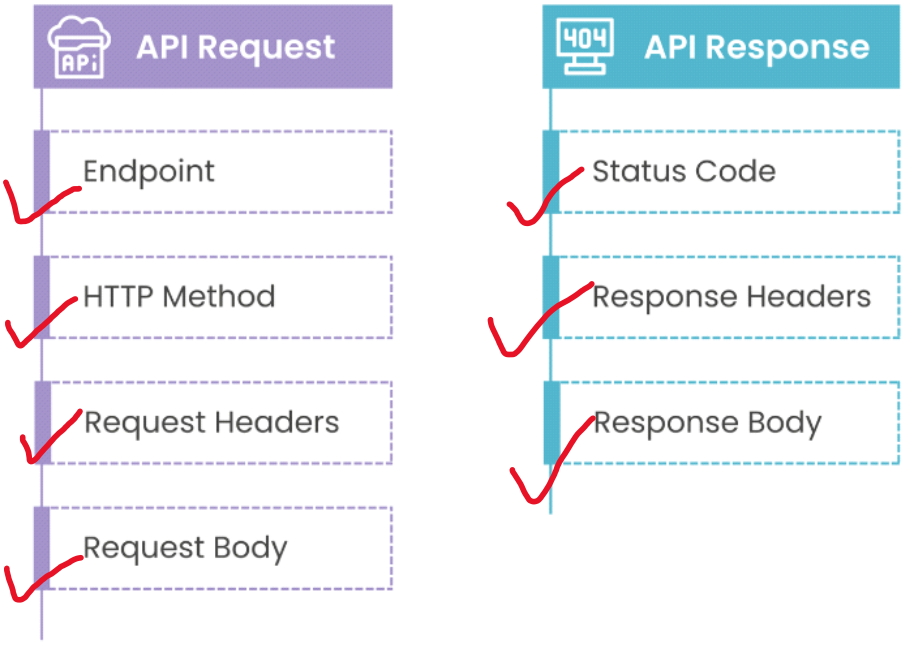
1. **Endpoint:**
   - It's a specific URL where the API can be accessed by a client to perform a certain action
   - Acts as the communication touchpoint between the client and the server
   - Usually include path parameters and query parameters

2. **Request:**
   - Message sent by a client to the API to ask for information or perform an operation
   - Key components of a request:
     - Method: Specifies the type of operation (e.g., GET, POST, PUT, DELETE)
     - Headers: Provide metadata about the request, such as content type
     - Body: Contains the data being sent to the server

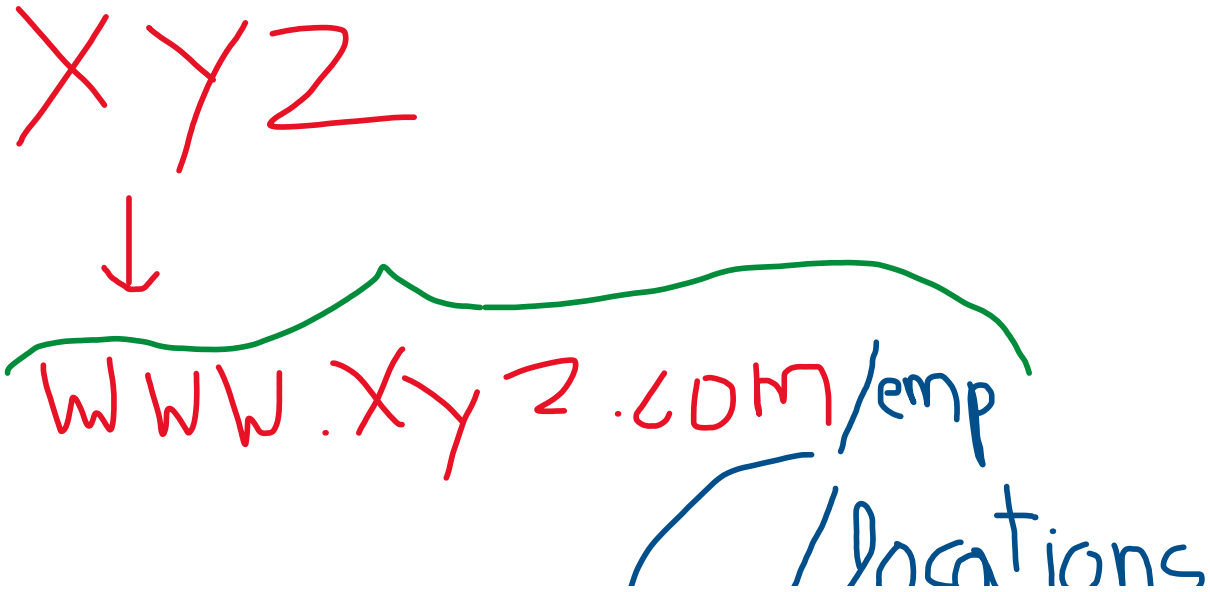
```
POST /users HTTP/1.1
Host: api.example.com
Content-Type: application/json
Authorization: Bearer token123
Body:
{
  "name": "John Doe",
  "email": "john.doe@example.com"
}
```

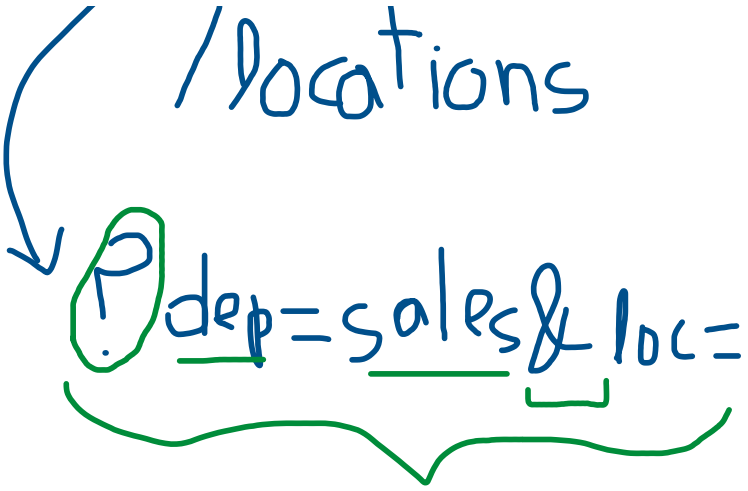
3. **Response:**
   - message sent back by the API after processing a client's request
   - Key components of a response:
     - Status Code: Indicates the outcome of the request (e.g., success, error)
     - Headers: Metadata about the response, such as content type or caching instructions
     - Body: The actual data being returned, typically in JSON, XML

```
HTTP/1.1 200 OK
Content-Type: application/json
Body:
{
  "id": 123,
  "name": "John Doe",
  "email": "john.doe@example.com"
}
```



4. **Rate Limiting and Quotas:**
   - Mechanisms to control the number of requests a client can make within a specified time
   - Mainly to prevent abuse and ensure fair usage
   - Headers for implementation:
     - X-RateLimit-Limit: Maximum requests allowed
     - X-RateLimit-Remaining: Requests remaining in the current window
     - Retry-After: Time to wait before retrying




/locations
?dep=sales&loc=

7. API Lifecycle

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- The API lifecycle refers to the comprehensive process of designing, developing, deploying, managing, and eventually retiring an API
- It is a structured framework that ensures APIs are effective, scalable, secure, and meet business objectives
- Understanding the API lifecycle is critical for maintaining high-quality API products and enhancing the user experience

1. **Planning and Design:**
   - Identify business goals, user needs, and the problems the API will solve
   - Determine the target audience: developers, partners, or internal teams
   - Define endpoints, request/response formats, and data models
   - Follow design methodologies like REST, GraphQL, or gRPC
   - Ensure adherence to API design best practices, such as intuitive endpoints, consistent naming, and proper versioning
   - **Tools:** Postman, SwaggerHub, and Stoplight for API design and documentation

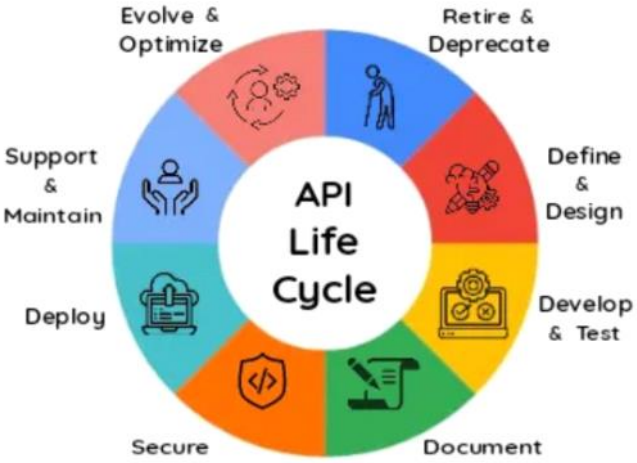
2. **Development:**
   - The development phase involves implementing the API's backend logic and infrastructure
   - Write the server-side code using programming frameworks like Flask, FastAPI, or Express.js
   - Integrate authentication and security mechanisms
   - Perform unit testing to validate individual functions and methods
   - **Tools:** Git, Jenkins, Docker, or Kubernetes for CI/CD pipelines

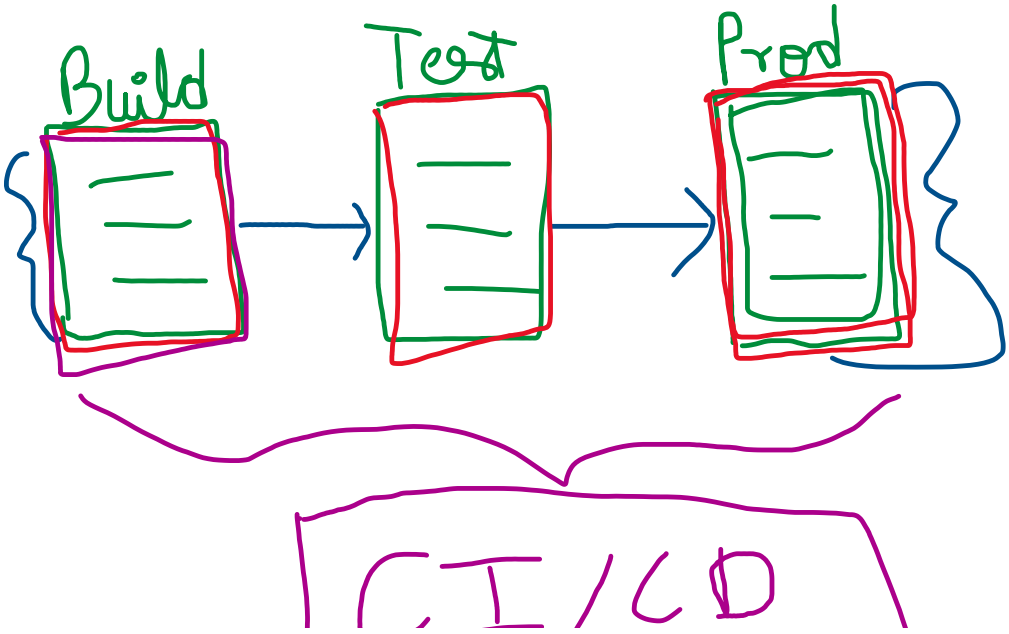
3. **Deployment:**
   - Involves releasing the API into a production environment where users can access it
   - Deploy the API to staging, testing, and production environments
   - Use cloud services like AWS, Azure, or GCP for scalability and reliability
   - Set up an API gateway to manage routing, caching, and load balancing
   - Popular gateways include AWS API Gateway, Kong, and Apigee

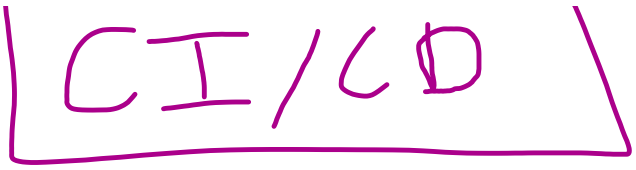
4. **Monitoring and Management:**
   - Track performance metrics like response times, uptime, and error rates
   - Gather usage data to understand traffic patterns, popular endpoints, and user behavior
   - Identify areas for improvement or optimization
   - Enforce rate limiting to prevent abuse
   - **Tools:** Datadog, New Relic, and Grafana

5. **Updates and Versioning:**
   - Ensure new updates do not break existing clients
   - Provide clear migration paths if breaking changes are unavoidable
   - Notify users in advance of deprecated features or versions
   - Provide timelines and guidelines for transition

6. **Retirement:**
   - When an API no longer serves its purpose, it is retired or deprecated
   - Inform stakeholders and users about the API's retirement well in advance
   - Provide tools or resources to help users transition to newer APIs
   - Archive or securely dispose of any stored data associated with the API






CI/CD

8. Authentication & Authorization

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- When building an API, especially one that will be exposed to the public or clients, managing who can access it and ensuring t he security of data is paramount
- Authentication and authorization are two critical concepts that help in securing APIs and ensuring that only legitimate users can access resources

Authentication:

- Process of verifying the identity of a user or system
- It answers the question: ***Who are you?***

Authorization:

- process of determining what an authenticated user is allowed to do
- It answers the question: ***What can you do?***

Types of Authentication Mechanisms:

1. **API Keys:**
   - They work by sending a key (usually a long string of characters) with each request to identify the client
   - Typically used for public APIs or services where the user is not required to log in manually
   - Easy to implement and widely supported
   - Can be intercepted if not transmitted over HTTPS and does not provide strong user verification
2. **OAuth (Open Authorization):**
   - Open standard for access delegation commonly used for third-party authentication
   - Allows a user to grant a third-party application access to their resources without sharing their credentials
   - Secure and allows fine-grained permissions
   - Comparatively more complex to implement
3. **JWT (JSON Web Tokens):**
   - JWT is a compact and self-contained method for securely transmitting information between parties as a JSON object
   - It's commonly used for handling user authentication in stateless applications
   - No need to store session information server-side
   - Tokens can become stale or vulnerable if not properly managed
4. **Bearer Tokens:**
   - They are a form of access token commonly used in API requests to authorize access to protected resources
   - These tokens are typically provided by an OAuth server or after a successful login
   - Secure and stateless authentication method

Types of Authorization Mechanisms:

1. **Role-Based Access Control (RBAC):**
   - Common authorization method used to assign permissions based on user roles
   - The system defines roles (e.g., Admin, User, Manager) and each role has certain permissions associated with it
   - After a user is authenticated, the API checks the user's role and grants or denies access based on predefined role permissions
   - Simple to manage when there are clear roles

2. **OAuth 2.0 and OpenID Connect (OIDC):**
   - OAuth 2.0 is a widely used framework for authorization
   - OIDC is an identity layer on top of OAuth 2.0, which provides authentication features, in addition to OAuth's authorization features
   - OAuth 2.0 is typically used for delegating access to APIs on behalf of a user

Best Practices for API Authentication and Authorization:

- Ensure all authentication and authorization requests are transmitted over HTTPS to prevent **man-in-the-middle (MITM)** attacks
- Use hashing algorithms (e.g., bcrypt, Argon2) to store user passwords
- Set appropriate expiration times for tokens and use refresh tokens to allow users to renew their sessions without needing to re-authenticate
- Implement **multi-factor authentication (MFA)** where possible to increase the security of APIs
- Return generic error messages for failed authentication or authorization attempts to avoid exposing sensitive information
- Regularly review API logs to detect suspicious activity and to identify potential security breaches