API Gateway - Interview Questions & Detailed Answers

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1. What is an API Gateway, and why is it used?
An API Gateway is a server that acts as an intermediary between clients and backend services. It handles request routing, authentication, rate limiting, caching, and response transformation. It is used to manage API traffic efficiently, improve security, reduce backend load, and ensure scalability.

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2. How does an API Gateway differ from a Load Balancer?
An API Gateway provides additional features beyond load balancing, such as authentication, rate limiting, caching, and API composition. A Load Balancer simply distributes network traffic among multiple backend servers to improve availability and scalability. While Load Balancers operate at the network or transport layer (Layer 4/7), API Gateways operate at the application layer (Layer 7), enabling more advanced request handling.

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3. What are the key benefits of using an API Gateway?

- **Security:** Protects backend services by enforcing authentication and authorization.
- **Rate Limiting & Throttling:** Controls traffic to prevent abuse and maintain system stability.
- **Load Balancing:** Distributes requests across multiple services to improve scalability.
- **Caching:** Reduces backend load and speeds up response times.
- **Request Transformation:** Converts API requests between different formats (e.g., JSON to XML).
- **Monitoring & Logging:** Tracks API performance, usage, and security threats.

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4. How does an API Gateway handle authentication and authorization?
API Gateways enforce security through authentication (verifying user identity) and authorization (checking user permissions). Common methods include:

- **API Keys:** Unique identifiers required for API access.
- **OAuth 2.0 & JWT (JSON Web Tokens):** Used for secure access management.

- **mTLS (Mutual TLS):** Ensures encrypted communication between clients and APIs.
- **LDAP & SAML:** Used for enterprise authentication.

When a request reaches the API Gateway, it verifies the credentials/token before forwarding the request to backend services. If authentication fails, the request is denied.

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5. Explain rate limiting and throttling in API Gateways.
Rate limiting and throttling control how many requests a client can make within a specified time to prevent API abuse.

- **Rate Limiting:** Restricts the number of API calls per user/IP per second, minute, or hour. Example: A user can make only 100 requests per minute.
- **Throttling:** Allows excess requests but slows down response times instead of rejecting them immediately. Useful for handling high-traffic scenarios.
- **Burst Limits:** Temporary high limits that adjust dynamically based on usage patterns.

Common rate-limiting algorithms include:

- **Token Bucket Algorithm:** Requests consume tokens from a fixed bucket; new tokens are added periodically.
- **Leaky Bucket Algorithm:** Requests are processed at a fixed rate, preventing traffic spikes.
- **Fixed Window & Sliding Window Counters:** Limit requests per time window.

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6. What caching strategies can be implemented in an API Gateway?
Caching improves performance by storing frequently accessed responses to reduce redundant backend calls. Common caching strategies include:

- **In-memory Caching:** Stores responses in memory (e.g., Redis, Memcached).
- **Response Caching:** Stores API responses and serves cached results for repeated requests.
- **Edge Caching (CDN):** Uses Content Delivery Networks to cache API responses globally.

- **Per-Route Caching:** Different endpoints have different caching rules (e.g., caching GET but not POST requests).
- **Time-to-Live (TTL):** Sets expiration times for cached responses to ensure freshness.

Example: A product details API can cache responses for 5 minutes to reduce database queries.

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7. How does an API Gateway improve security against DDoS attacks?
An API Gateway protects against Distributed Denial of Service (DDoS) attacks by:

- **Rate Limiting & Throttling:** Prevents excessive requests from overwhelming backend services.
- **IP Whitelisting & Blacklisting:** Blocks requests from suspicious or unauthorized IP addresses.
- **Web Application Firewall (WAF) Integration:** Filters malicious traffic based on predefined security rules.
- **Bot Detection & CAPTCHA:** Identifies automated bots and requires human verification.
- **TLS Termination:** Encrypts and decrypts traffic to prevent man-in-the-middle attacks.

Example: If an attacker floods an API with millions of requests per second, the API Gateway enforces rate limiting to block excess traffic.

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8. When should you use an API Gateway in a microservices architecture?
An API Gateway is useful in microservices architectures when:

- **Multiple services need a unified entry point.** Instead of clients calling each service directly, an API Gateway routes requests efficiently.
- **Security and authentication are required.** API Gateways enforce access controls to protect microservices.
- **Rate limiting and caching are necessary.** This ensures performance and system stability.

- **Request transformation is needed.** API Gateways can convert between formats like REST, GraphQL, and gRPC.

- **API monitoring and analytics are important.** It enables logging, tracing, and monitoring API usage.

Example: In an e-commerce system, an API Gateway can route requests to separate microservices for authentication, product catalog, and payments.

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9. How would you design an API Gateway for a large-scale system with millions of users?
For a high-traffic system, an API Gateway must be designed for **scalability, reliability, and security**:

- **Deploy in a Distributed Architecture:** Use multiple API Gateway instances behind a Load Balancer to handle traffic spikes.

- **Enable Auto-Scaling:** Dynamically adjust resources based on demand (e.g., Kubernetes-based deployment).

- **Use Rate Limiting & Throttling:** Prevent excessive API calls from overloading the system.

- **Implement Caching:** Reduce backend workload by caching frequently requested responses.

- **Ensure High Availability:** Use multi-region deployment with failover mechanisms.

- **Monitor & Log API Traffic:** Track errors, response times, and security threats with observability tools.

Example: A **global video streaming service** (like Netflix) would use a CDN-enabled API Gateway to route requests to the nearest data center, improving latency.

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10. What challenges might arise when implementing an API Gateway, and how would you address them?

- **Single Point of Failure:** API Gateway failure can disrupt all API traffic. Solution: Deploy multiple API Gateway instances with failover support.

- **Increased Latency:** Extra processing (authentication, transformation, logging) can slow down requests. Solution: Optimize configurations, enable caching, and minimize request overhead.

- **Complexity in Microservices:** Managing API routes, security policies, and monitoring can be challenging. Solution: Use an API Gateway management platform (e.g., Kong, Apigee).
- **Scalability Issues:** A poorly designed API Gateway can become a performance bottleneck. Solution: Use horizontal scaling with distributed API Gateway nodes.
- **Versioning & Backward Compatibility:** Managing API versions can be complex. Solution: Implement versioning strategies (e.g., `/v1/resource`, `/v2/resource`).

Example: If an **API Gateway becomes a bottleneck in an IoT system**, scaling it with a **Kubernetes-based deployment** ensures high availability.