Complete Java Microservices Interview Preparation Guide

71 Essential Questions & Solutions

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Version: 1.0
Published: October 2025
Total Questions: 71 Complete Q&A

About This Guide

This comprehensive interview guide contains 71 essential microservices questions with complete solutions. Each question includes definition/basic concepts, proper solution, practical examples, and concise code syntax to ensure interview success.

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Questions & Solutions

Q1: What is Microservices Architecture and how does it differ from monolithic architecture?

Microservices architecture is a software development approach where applications are built as a collection of small, independent services that communicate over well-defined APIs. Each service is responsible for a specific business function.

Microservices break down large applications into smaller, manageable services that can be developed, deployed, and scaled independently. Unlike monolithic architecture where all components are tightly coupled in a single deployable unit, microservices are loosely coupled and communicate via network calls.

An e-commerce application can be split into: User Service, Product Service, Order Service, Payment Service, and Inventory Service - each handling specific business logic.

```
// Microservice Example
@SpringBootApplication
@EnableEurekaClient
public class UserServiceApplication {
    public static void main(String[] args) {
        SpringApplication.run(UserServiceApplication.class, args);
    }
}

@RestController
@RequestMapping("/api/users")
public class UserController {
    @GetMapping("/{id}")
    public ResponseEntity<User> getUser(@PathVariable Long id) {
        return ResponseEntity.ok(userService.findById(id));
    }
}
```

Q2: What are the benefits of using microservices?

Microservices benefits include independent scalability, technology diversity, fault isolation, faster development cycles, and team autonomy.

Key benefits are: 1) Independent Scaling - scale services based on demand 2) Technology Flexibility - use different tech stacks per service 3) Fault Isolation - failure in one service doesn't affect others 4) Team Independence - small teams own complete services 5) Faster Deployment - deploy services independently

Netflix scales its recommendation service independently from its video streaming service. If recommendations fail, users can still watch videos.

```
// Independent scaling configuration
@Configuration
public class ScalingConfig {
    @Bean
    public DataSource userServiceDataSource() {
        // High-capacity pool for user service
        return DataSourceBuilder.create()
            .maximumPoolSize(50)
            .build();
    }
}
```

Q3: What are the main challenges when working with microservices?

Microservices challenges include distributed system complexity, network latency, data consistency issues, testing complexity, and operational overhead.

Main challenges: 1) Network Communication - handle timeouts and failures 2) Data Consistency - implement eventual consistency 3) Distributed Debugging - use correlation IDs and tracing 4) Service Discovery - manage service locations 5) Configuration Management - centralize configurations

When Order Service calls Payment Service, network failure can cause order to be created but payment to fail, requiring compensation logic.

```
// Circuit breaker for handling failures
@Component
public class PaymentServiceClient {
    @CircuitBreaker(name = "payment", fallbackMethod = "fallbackPayment")
    public PaymentResponse processPayment(PaymentRequest request) {
        return restTemplate.postForObject("/payments", request, PaymentResponse.class);
    }

    public PaymentResponse fallbackPayment(PaymentRequest request, Exception ex) {
        return PaymentResponse.builder().status("PENDING").build();
    }
}
```

Q4: How do you implement microservices in Java?

Java microservices implementation uses frameworks like Spring Boot, Spring Cloud, and supporting tools for service discovery, configuration, and communication.

Implementation steps: 1) Use Spring Boot for rapid development 2) Implement REST APIs for communication 3) Use Spring Cloud for distributed system patterns 4) Add service discovery with Eureka 5) Implement configuration management 6) Add monitoring and logging

Create a Product Service with Spring Boot that registers with Eureka and exposes REST endpoints for product management.

```
@SpringBootApplication
@EnableEurekaClient
public class ProductServiceApplication {
    public static void main(String[] args) {
        SpringApplication.run(ProductServiceApplication.class, args);
    }
}

@RestController
@RequestMapping("/api/products")
public class ProductController {
    @Autowired
    private ProductService productService;

    @GetMapping("/{id}")
    public Product getProduct(@PathVariable Long id) {
        return productService.findById(id);
    }

    @PostMapping
    public Product createProduct(@RequestBody Product product) {
        return productService.save(product);
    }
}
```

Q5: What frameworks are used for building microservices in Java?

Java microservices frameworks provide infrastructure for building distributed applications, including Spring Boot, Micronaut, Quarkus, and Dropwizard.

Popular frameworks: 1) Spring Boot + Spring Cloud - comprehensive ecosystem 2) Micronaut - fast startup and low memory 3) Quarkus - native compilation support 4) Dropwizard - lightweight REST services

Choose based on requirements like startup time, memory usage, and ecosystem maturity.

Spring Boot for enterprise applications, Quarkus for cloud-native with fast startup, Micronaut for memory-constrained environments.

```
// Spring Boot
@SpringBootApplication
public class SpringBootApp {
    public static void main(String[] args) {
        SpringApplication.run(SpringBootApp.class, args);
    }
}

// Micronaut
@Controller("/products")
public class ProductController {
    @Get("/{id}")
    public Product getProduct(@PathVariable Long id) {
        return productService.findById(id);
    }
}
```

Q6: What is Spring Boot and its role in microservices development?

Definition/Basic Concepts

Spring Boot is a framework that simplifies Spring application development by providing auto-configuration, embedded servers, and production-ready features.

Solution

Spring Boot's role: 1) Auto-configuration reduces boilerplate, 2) Embedded servers eliminate deployment complexity, 3) Starter dependencies simplify dependency management, 4) Actuator provides production monitoring, 5) Profiles enable environment-specific configurations.

Example

Create a microservice with minimal configuration that includes embedded Tomcat, database connectivity, and health checks.

Code Syntax

```
@SpringBootApplication
public class OrderServiceApplication {
    public static void main(String[] args) {
        SpringApplication.run(OrderServiceApplication.class, args);
    }
}

// application.yml
server:
  port: 8080
spring:
  datasource:
    url: jdbc:h2:mem:testdb
management:
  endpoints:
    web:
      exposure:
        include: health,info
```

Q7: How do you handle service discovery in Java microservices?

Definition/Basic Concepts

Service discovery is the mechanism by which microservices locate and communicate with each other dynamically without hard-coded addresses.

Solution

Implementation approaches: 1) Client-side discovery with Eureka, 2) Server-side discovery with load balancers, 3) Service mesh solutions, 4) DNS-based discovery. Eureka is most common in Spring Cloud ecosystem.

Example

Services register with Eureka server on startup and discover other services by name rather than IP addresses.

Code Syntax

```
// Eureka Server
@SpringBootApplication
@EnableEurekaServer
public class EurekaServerApplication {
    public static void main(String[] args) {
        SpringApplication.run(EurekaServerApplication.class, args);
    }
}

// Eureka Client
@SpringBootApplication
@EnableEurekaClient
public class ClientApplication {
    @Bean
    @LoadBalanced
    public RestTemplate restTemplate() {
        return new RestTemplate();
    }
}
```

Q8: What is Netflix Eureka and how is it used in Spring Cloud?

Definition/Basic Concepts

Netflix Eureka is a service registry that allows microservices to register themselves and discover other services for communication.

Solution

Eureka components: 1) Eureka Server - service registry, 2) Eureka Client - registers and discovers services, 3) Load balancing with Ribbon, 4) Health checks and heartbeats. Services register on startup and send heartbeats to maintain registration.

Example

Order Service registers with Eureka and discovers User Service by name to make API calls.

Code Syntax

```
// Eureka configuration
eureka:
  client:
    service-url:
      defaultZone: http://localhost:8761/eureka/
  instance:
    prefer-ip-address: true

// Service discovery usage
@Service
public class OrderService {
    @Autowired
    @LoadBalanced
    private RestTemplate restTemplate;

    public User getUser(Long userId) {
        return restTemplate.getForObject("http://user-service/users/" + userId, User.class);
    }
}
```

Q9: How do microservices communicate with each other?

Definition/Basic Concepts

Microservices communication involves synchronous (HTTP/REST, gRPC) and asynchronous (messaging, events) patterns for inter-service interaction.

Solution

Communication patterns: 1) Synchronous - REST APIs, gRPC for real-time responses, 2) Asynchronous - Message queues, Event streaming for decoupled communication, 3) Request-Response vs Fire-and-Forget, 4) Choose based on consistency requirements and performance needs.

Example

Order Service calls Payment Service synchronously for payment processing, but publishes order events asynchronously for inventory updates.

Code Syntax

```
// Synchronous REST call
@Service
public class OrderService {
    public PaymentResponse processPayment(PaymentRequest request) {
        return restTemplate.postForObject("http://payment-service/payments", request, PaymentResponse.c
lass);
    }
}

// Asynchronous messaging
@Service
public class OrderEventPublisher {
    @Autowired
    private RabbitTemplate rabbitTemplate;

    public void publishOrderCreated(Order order) {
        rabbitTemplate.convertAndSend("order.exchange", "order.created", order);
    }
}
```

Q10: What is the role of an API Gateway in microservices?

Definition/Basic Concepts

API Gateway is a server that acts as a single entry point for client requests, routing them to appropriate microservices and handling cross-cutting concerns.

Solution

API Gateway functions: 1) Request routing to backend services, 2) Authentication and authorization, 3) Rate limiting and throttling, 4) Request/response transformation, 5) Monitoring and analytics, 6) Load balancing across service instances.

Example

Mobile app makes single request to API Gateway, which orchestrates calls to User, Product, and Order services to build response.

Code Syntax

```
// Spring Cloud Gateway
@Bean
public RouteLocator customRouteLocator(RouteLocatorBuilder builder) {
    return builder.routes()
        .route("user-service", r -> r.path("/api/users/**")
            .uri("lb://user-service"))
        .route("order-service", r -> r.path("/api/orders/**")
            .uri("lb://order-service"))
        .build();
}

// Gateway filter for authentication
@Component
public class AuthenticationFilter implements GlobalFilter {
    public Mono<Void> filter(ServerWebExchange exchange, GatewayFilterChain chain) {
        // Validate JWT token
        return chain.filter(exchange);
    }
}
```

Q11: When should you use microservices vs monolithic architecture?

Definition/Basic Concepts

The choice between microservices and monolithic architecture depends on application complexity, team size, scalability requirements, and organizational maturity.

Solution

Use Microservices when: 1) Large, complex applications, 2) Multiple development teams, 3) Different scaling requirements, 4) Technology diversity needed, 5) Rapid deployment cycles required. Use Monolithic when: 1) Small applications, 2) Small teams, 3) Simple business logic, 4) Rapid prototyping, 5) Limited operational expertise.

Example

Start with monolith for MVP, migrate to microservices as team and complexity grow. Netflix uses microservices for scale, while small startups often use monoliths.

Code Syntax

```
// Migration strategy - Strangler Fig pattern
@Component
public class ServiceRouter {
    public ResponseEntity<?> routeRequest(String path, HttpServletRequest request) {
        if (path.startsWith("/users")) {
            return userMicroservice.handleRequest(request); // New service
        } else {
            return legacyMonolith.handleRequest(request); // Old system
        }
    }
}
```

Q12: What are the core principles of microservices?

Definition/Basic Concepts

Microservices principles guide the design and implementation of distributed systems to achieve scalability, maintainability, and resilience.

Solution

Core principles: 1) Single Responsibility - one service, one business capability, 2) Autonomous - independently deployable and scalable, 3) Decentralized - distributed governance and data management, 4) Resilient - design for failure, 5) Observable - comprehensive monitoring, 6) Automated - CI/CD and infrastructure as code.

Example

User Service only handles user-related operations, has its own database, can be deployed independently, and includes health checks.

Code Syntax

```
// Single responsibility principle
@RestController
@RequestMapping("/api/users")
public class UserController {
    // Only user-related operations
    @GetMapping("/{id}")
    public User getUser(@PathVariable Long id) { }

    @PostMapping
    public User createUser(@RequestBody User user) { }
}

// Health check for observability
@Component
public class UserServiceHealthIndicator implements HealthIndicator {
    public Health health() {
        return Health.up().withDetail("status", "User service is running").build();
    }
}
```

Q13: How do you handle data management in microservices?

Definition/Basic Concepts

Data management in microservices involves ensuring each service owns its data while maintaining consistency across the distributed system.

Solution

Data management strategies: 1) Database per Service - each service has its own database, 2) Shared databases avoided, 3) Data synchronization via events, 4) Eventual consistency over strong consistency, 5) API-based data access between services.

Example

User Service has user database, Order Service has order database. When user updates profile, User Service publishes event for Order Service to update cached user data.

Code Syntax

```
// Database per service
@Entity
@Table(name = "users")
public class User {
    @Id
    private Long id;
    private String email;
    // User service owns user data
}

// Event-driven data synchronization
@EventHandler
public void handleUserUpdated(UserUpdatedEvent event) {
    // Update cached user data in order service
    orderService.updateUserInfo(event.getUserId(), event.getUserName());
}
```

Q14: What is the Database per Service pattern?

Definition/Basic Concepts

Database per Service pattern ensures each microservice has its own private database that cannot be accessed directly by other services.

Solution

Implementation: 1) Each service owns its data schema, 2) No shared database access, 3) Data access only through service APIs, 4) Different database technologies per service needs, 5) Maintains service autonomy and loose coupling.

Example

User Service uses PostgreSQL for relational user data, Product Service uses MongoDB for flexible product catalogs, Order Service uses MySQL for transactional data.

Code Syntax

```
// User Service - PostgreSQL
@Entity
public class User {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;
}

// Product Service - MongoDB
@Document(collection = "products")
public class Product {
    @Id
    private String id;
    private Map<String, Object> attributes; // Flexible schema
}

// Cross-service data access via API
@Service
public class OrderService {
    public Order createOrder(CreateOrderRequest request) {
        User user = userServiceClient.getUser(request.getUserId()); // API call
        return new Order(user.getId(), request.getItems());
    }
}
```

Q15: How do you ensure data consistency across microservices?

Definition/Basic Concepts

Data consistency in microservices requires managing distributed transactions and ensuring eventual consistency across service boundaries.

Solution

Consistency strategies: 1) Eventual Consistency - accept temporary inconsistencies, 2) Saga Pattern - manage distributed transactions, 3) Event Sourcing - store events instead of state, 4) CQRS - separate read/write models, 5) Compensating transactions for rollbacks.

Example

Order processing: Reserve inventory, charge payment, create order. If payment fails, release inventory reservation using compensation.

Code Syntax

```
// Saga pattern for consistency
@Service
public class OrderSaga {
    public void processOrder(Order order) {
        try {
            inventoryService.reserveItems(order.getItems());
            paymentService.processPayment(order.getPayment());
            orderService.createOrder(order);
        } catch (PaymentException e) {
            inventoryService.releaseReservation(order.getItems()); // Compensate
            throw e;
        }
    }
}

// Event sourcing for consistency
@EventSourcingHandler
public void on(OrderCreatedEvent event) {
    this.orderId = event.getOrderId();
    this.status = OrderStatus.CREATED;
}
```

Q16: What is Spring Cloud Config Server?

Definition/Basic Concepts

Spring Cloud Config Server provides centralized configuration management for distributed systems, storing configurations in version control systems.

Solution

Config Server features: 1) Centralized configuration storage, 2) Environment-specific configurations, 3) Dynamic configuration refresh, 4) Version control integration (Git, SVN), 5) Encryption support for sensitive data.

Example

All microservices fetch their configurations from Config Server instead of local files, enabling centralized management and dynamic updates.

Code Syntax

```
// Config Server
@SpringBootApplication
@EnableConfigServer
public class ConfigServerApplication {
    public static void main(String[] args) {
        SpringApplication.run(ConfigServerApplication.class, args);
    }
}

// application.yml
spring:
  cloud:
    config:
      server:
        git:
          uri: https://github.com/config-repo

// Config Client
@RestController
@RefreshScope
public class ConfigController {
    @Value("${app.message}")
    private String message;

    @GetMapping("/message")
    public String getMessage() {
        return message;
    }
}
```

Q17: How do you implement service registration and discovery?

Definition/Basic Concepts

Service registration and discovery enables microservices to find and communicate with each other dynamically without hardcoded addresses.

Solution

Implementation steps: 1) Setup Eureka Server as service registry, 2) Configure services as Eureka clients, 3) Services register on startup, 4) Use service names for communication, 5) Load balancing with @LoadBalanced RestTemplate.

Example

Order Service discovers User Service by name "user-service" instead of IP address, enabling dynamic scaling and deployment.

Code Syntax

```
// Eureka Server setup
@SpringBootApplication
@EnableEurekaServer
public class EurekaServer {
    public static void main(String[] args) {
        SpringApplication.run(EurekaServer.class, args);
    }
}

// Service registration
@SpringBootApplication
@EnableEurekaClient
public class UserService {
    public static void main(String[] args) {
        SpringApplication.run(UserService.class, args);
    }
}

// Service discovery usage
@Bean
@LoadBalanced
public RestTemplate restTemplate() {
    return new RestTemplate();
}

// Use service name in URL
String url = "http://user-service/users/" + userId;
User user = restTemplate.getForObject(url, User.class);
```

Q18: What is Spring Cloud Gateway?

Definition/Basic Concepts

Spring Cloud Gateway is a library for building API gateways on top of Spring WebFlux, providing routing, filtering, and other gateway functionality.

Solution

Gateway features: 1) Route requests to microservices, 2) Apply filters for cross-cutting concerns, 3) Load balancing, 4) Rate limiting, 5) Authentication and authorization, 6) Request/response transformation.

Example

Route /api/users/ **to user-service and /api/orders/** to order-service while applying authentication filter to all requests.

Code Syntax

```
// Gateway routing configuration
@Bean
public RouteLocator customRouteLocator(RouteLocatorBuilder builder) {
    return builder.routes()
        .route("user-service", r -> r.path("/api/users/**")
            .filters(f -> f.stripPrefix(1))
            .uri("lb://user-service"))
        .route("order-service", r -> r.path("/api/orders/**")
            .filters(f -> f.stripPrefix(1))
            .uri("lb://order-service"))
        .build();
}

// Custom filter
@Component
public class AuthFilter implements GlobalFilter {
    public Mono<Void> filter(ServerWebExchange exchange, GatewayFilterChain chain) {
        // Authentication logic
        return chain.filter(exchange);
    }
}
```

Q19: How do you handle configuration in microservices?

Definition/Basic Concepts

Configuration management in microservices involves centralizing configurations, supporting multiple environments, and enabling dynamic updates without restarts.

Solution

Configuration strategies: 1) Externalized configuration with Config Server, 2) Environment-specific profiles, 3) Property encryption for sensitive data, 4) Configuration refresh with @RefreshScope, 5) Feature flags for dynamic behavior changes.

Example

Database URLs, API keys, and feature flags stored in Config Server and updated without service restarts.

Code Syntax

```
// Configuration properties
@ConfigurationProperties(prefix = "app")
@Component
public class AppConfig {
    private String databaseUrl;
    private String apiKey;
    private boolean featureEnabled;
    // getters and setters
}

// Dynamic refresh
@RestController
@RefreshScope
public class DynamicController {
    @Value("${app.message}")
    private String message;

    @GetMapping("/config")
    public String getConfig() {
        return message;
    }
}

// bootstrap.yml
spring:
  application:
    name: user-service
  cloud:
    config:
      uri: http://config-server:8888
```

Q20: What is Spring Cloud LoadBalancer?

Definition/Basic Concepts

Spring Cloud LoadBalancer provides client-side load balancing capabilities for distributing requests across multiple service instances.

Solution

LoadBalancer features: 1) Replaces Netflix Ribbon, 2) Round-robin and weighted algorithms, 3) Health check integration, 4) Custom load balancing strategies, 5) Integration with service discovery.

Example

When calling user-service, LoadBalancer distributes requests across 3 available user-service instances.

Code Syntax

```
// Enable load balancing
@Bean
@LoadBalanced
public RestTemplate restTemplate() {
    return new RestTemplate();
}

// Usage - automatically load balanced
@Service
public class OrderService {
    @Autowired
    private RestTemplate restTemplate;

    public User getUser(Long userId) {
        return restTemplate.getForObject("http://user-service/users/" + userId, User.class);
    }
}

// Custom load balancer configuration
@Bean
public ReactorLoadBalancer<ServiceInstance> reactorServiceInstanceLoadBalancer(
        Environment environment, LoadBalancerClientFactory loadBalancerClientFactory) {
    String name = environment.getProperty(LoadBalancerClientFactory.PROPERTY_NAME);
    return new RoundRobinLoadBalancer(loadBalancerClientFactory.getLazyProvider(name, ServiceInstanceLi
stSupplier.class), name);
}
```

Q21: How do you implement circuit breaker pattern in Spring Cloud?

Definition/Basic Concepts

Circuit breaker pattern prevents cascading failures by monitoring service calls and "opening" the circuit when failures exceed a threshold.

Solution

Implementation with Resilience4j: 1) Configure circuit breaker parameters, 2) Add @CircuitBreaker annotation, 3) Implement fallback methods, 4) Monitor circuit state, 5) Combine with retry and timeout patterns.

Example

When Payment Service fails repeatedly, circuit opens and returns cached response instead of making failing calls.

Code Syntax

```
// Circuit breaker configuration
resilience4j:
  circuitbreaker:
    instances:
      payment-service:
        sliding-window-size: 10
        failure-rate-threshold: 50
        wait-duration-in-open-state: 30s

// Implementation
@Service
public class PaymentServiceClient {
    @CircuitBreaker(name = "payment-service", fallbackMethod = "fallbackPayment")
    @TimeLimiter(name = "payment-service")
    @Retry(name = "payment-service")
    public CompletableFuture<PaymentResponse> processPayment(PaymentRequest request) {
        return CompletableFuture.supplyAsync(() ->
            restTemplate.postForObject("/payments", request, PaymentResponse.class));
    }

    public CompletableFuture<PaymentResponse> fallbackPayment(PaymentRequest request, Exception ex) {
        return CompletableFuture.completedFuture(
            PaymentResponse.builder().status("PENDING").build());
    }
}
```

Q22: What is Spring Cloud Sleuth?

Definition/Basic Concepts

Spring Cloud Sleuth provides distributed tracing capabilities for Spring Cloud applications, automatically instrumenting common communication channels.

Solution

Sleuth features: 1) Automatic trace generation, 2) Span creation for method calls, 3) Correlation ID propagation, 4) Integration with Zipkin for visualization, 5) Sampling configuration for performance.

Example

Track request flow from API Gateway through User Service to Database, correlating logs across all services.

Code Syntax

```
// Sleuth configuration
spring:
  sleuth:
    sampler:
      probability: 1.0
    zipkin:
      base-url: http://zipkin-server:9411

// Custom tracing
@RestController
public class UserController {
    private final Tracer tracer;

    @GetMapping("/users/{id}")
    public User getUser(@PathVariable Long id) {
        Span span = tracer.nextSpan().name("get-user").start();
        try (Tracer.SpanInScope ws = tracer.withSpanInScope(span)) {
            span.tag("user.id", id.toString());
            return userService.findById(id);
        } finally {
            span.end();
        }
    }
}

// Async tracing
@Async
@NewSpan("async-processing")
public CompletableFuture<String> processAsync(@SpanTag("order.id") String orderId) {
    return CompletableFuture.completedFuture("processed");
}
```

Q23: How do you implement service mesh with Spring Cloud?

Definition/Basic Concepts

Service mesh provides infrastructure layer for service-to-service communication, handling security, observability, and traffic management.

Solution

Service mesh implementation: 1) Deploy Istio or Linkerd, 2) Configure sidecar proxies, 3) Define traffic policies, 4) Implement mutual TLS, 5) Use virtual services for routing, 6) Monitor with service mesh observability tools.

Example

Istio manages all communication between microservices, providing automatic load balancing, circuit breaking, and security without code changes.

Code Syntax

```
# Istio VirtualService
apiVersion: networking.istio.io/v1alpha3
kind: VirtualService
metadata:
  name: user-service
spec:
  http:
  - match:
    - headers:
        version:
          exact: v2
    route:
    - destination:
        host: user-service
        subset: v2
  - route:
    - destination:
        host: user-service
        subset: v1

# Destination Rule
apiVersion: networking.istio.io/v1alpha3
kind: DestinationRule
metadata:
  name: user-service
spec:
  host: user-service
  subsets:
  - name: v1
    labels:
      version: v1
  - name: v2
    labels:
      version: v2
```

Q24: What is Spring Cloud Stream?

Definition/Basic Concepts

Spring Cloud Stream is a framework for building message-driven microservices, providing abstraction over message brokers like Apache Kafka and RabbitMQ.

Solution

Stream features: 1) Declarative programming model, 2) Automatic message binding, 3) Support for multiple binders (Kafka, RabbitMQ), 4) Content-based routing, 5) Error handling and retry mechanisms.

Example

Order Service publishes order events to Kafka topic, Inventory Service consumes events to update stock levels.

Code Syntax

```
// Message producer
@Component
public class OrderEventPublisher {
    @Autowired
    private StreamBridge streamBridge;

    public void publishOrderCreated(Order order) {
        OrderCreatedEvent event = new OrderCreatedEvent(order.getId(), order.getItems());
        streamBridge.send("order-events", event);
    }
}

// Message consumer
@Component
public class InventoryEventHandler {
    @Bean
    public Consumer<OrderCreatedEvent> handleOrderCreated() {
        return event -> {
            // Update inventory based on order
            inventoryService.updateStock(event.getItems());
        };
    }
}

// Configuration
spring:
  cloud:
    stream:
      bindings:
        order-events:
          destination: order.events
          binder: kafka
```

Q25: How do you handle distributed configuration refresh?

Definition/Basic Concepts

Distributed configuration refresh enables updating configuration across multiple microservices without restarting them.

Solution

Refresh mechanisms: 1) @RefreshScope annotation for dynamic properties, 2) Spring Cloud Bus for broadcasting refresh events, 3) Actuator refresh endpoint, 4) Webhook integration with Git repositories, 5) Configuration change events.

Example

Update database connection pool size in Config Server, trigger refresh across all services using Spring Cloud Bus.

Code Syntax

```
// Refreshable configuration
@RestController
@RefreshScope
public class ConfigurableController {
    @Value("${app.max-connections}")
    private int maxConnections;

    @GetMapping("/config")
    public Map<String, Object> getConfig() {
        return Map.of("maxConnections", maxConnections);
    }
}

// Bus configuration
spring:
  cloud:
    bus:
      enabled: true
  rabbitmq:
    host: localhost
    port: 5672

// Trigger refresh via actuator
POST /actuator/bus-refresh

// Automatic refresh with webhook
@EventListener
public void handleRefreshEvent(RefreshRemoteApplicationEvent event) {
    log.info("Configuration refreshed for: {}", event.getDestinationService());
}
```

Q26: How do you handle slow services while communicating with multiple microservices?

Definition/Basic Concepts

Handling slow services involves implementing patterns to prevent cascade failures and maintain system responsiveness when dependencies are slow or unavailable.

Solution

Strategies: 1) Circuit Breaker pattern to fail fast, 2) Timeout configuration for requests, 3) Asynchronous processing for non-critical calls, 4) Bulkhead pattern for resource isolation, 5) Caching for frequently accessed data, 6) Graceful degradation with fallback responses.

Example

When User Service is slow, Order Service uses cached user data and processes orders asynchronously, preventing order processing delays.

Code Syntax

```
// Circuit breaker with timeout
@Component
public class UserServiceClient {
    @CircuitBreaker(name = "user-service", fallbackMethod = "getCachedUser")
    @TimeLimiter(name = "user-service")
    @Cacheable("users")
    public CompletableFuture<User> getUser(Long userId) {
        return CompletableFuture.supplyAsync(() ->
            restTemplate.getForObject("/users/" + userId, User.class));
    }

    public CompletableFuture<User> getCachedUser(Long userId, Exception ex) {
        User cachedUser = cacheManager.getCache("users").get(userId, User.class);
        return CompletableFuture.completedFuture(cachedUser != null ? cachedUser :
            User.builder().id(userId).name("Unknown").build());
    }
}

// Async processing
@Async
public CompletableFuture<Void> processOrderAsync(Order order) {
    // Process order without blocking main thread
    return CompletableFuture.completedFuture(null);
}
```

Q27: What are different communication patterns in microservices?

Definition/Basic Concepts

Microservices communication patterns define how services interact, including synchronous and asynchronous approaches with different consistency and performance characteristics.

Solution

Communication patterns: 1) Synchronous - REST, gRPC for immediate responses, 2) Asynchronous - Message queues, Event streaming for loose coupling, 3) Request-Response vs Fire-and-Forget, 4) Publish-Subscribe for event distribution, 5) Request-Reply for async request-response.

Example

E-commerce: Synchronous call for payment processing (immediate response needed), asynchronous events for inventory updates (eventual consistency acceptable).

Code Syntax

```
// Synchronous REST
@Service
public class PaymentService {
    public PaymentResponse processPayment(PaymentRequest request) {
        return restTemplate.postForObject("/payments", request, PaymentResponse.class);
    }
}

// Asynchronous messaging
@Component
public class OrderEventPublisher {
    @EventListener
    public void handleOrderCreated(OrderCreatedEvent event) {
        rabbitTemplate.convertAndSend("inventory.exchange", "stock.update", event);
    }
}

// gRPC communication
@GrpcService
public class UserGrpcService extends UserServiceGrpc.UserServiceImplBase {
    @Override
    public void getUser(UserRequest request, StreamObserver<UserResponse> responseObserver) {
        User user = userService.findById(request.getUserId());
        UserResponse response = UserResponse.newBuilder()
            .setId(user.getId())
            .setName(user.getName())
            .build();
        responseObserver.onNext(response);
        responseObserver.onCompleted();
    }
}
```

Q28: How do you implement asynchronous communication?

Definition/Basic Concepts

Asynchronous communication allows microservices to interact without blocking, improving system resilience and scalability through message queues and event streaming.

Solution

Implementation approaches: 1) Message queues (RabbitMQ, ActiveMQ) for reliable delivery, 2) Event streaming (Apache Kafka) for high throughput, 3) Publish-Subscribe patterns for event distribution, 4) Dead letter queues for error handling, 5) Message acknowledgment for reliability.

Example

Order Service publishes OrderCreated event, multiple services (Inventory, Shipping, Analytics) consume the event independently.

Code Syntax

```
// RabbitMQ producer
@Component
public class OrderEventPublisher {
    @Autowired
    private RabbitTemplate rabbitTemplate;

    public void publishOrderCreated(Order order) {
        OrderCreatedEvent event = new OrderCreatedEvent(order.getId(), order.getUserId());
        rabbitTemplate.convertAndSend("order.exchange", "order.created", event);
    }
}

// RabbitMQ consumer
@RabbitListener(queues = "inventory.queue")
public class InventoryEventHandler {
    public void handleOrderCreated(OrderCreatedEvent event) {
        inventoryService.reserveItems(event.getOrderId());
    }
}

// Kafka producer
@Service
public class KafkaEventPublisher {
    @Autowired
    private KafkaTemplate<String, Object> kafkaTemplate;

    public void publishEvent(String topic, Object event) {
        kafkaTemplate.send(topic, event);
    }
}

// Kafka consumer
@KafkaListener(topics = "order-events")
public void handleOrderEvent(OrderCreatedEvent event) {
    shippingService.processShipping(event.getOrderId());
}
```

Q29: What is the Bulkhead pattern?

Definition/Basic Concepts

Bulkhead pattern isolates resources to prevent failures in one part of the system from affecting other parts, similar to compartments in a ship.

Solution

Implementation strategies: 1) Separate thread pools for different services, 2) Connection pool isolation, 3) Circuit breaker per service, 4) Resource quotas and limits, 5) Service instance isolation.

Example

User Service calls use separate thread pool from Order Service calls, so if User Service is slow, Order Service operations remain unaffected.

Code Syntax

```
// Thread pool isolation
@Configuration
public class BulkheadConfig {
    @Bean("userServiceExecutor")
    public TaskExecutor userServiceExecutor() {
        ThreadPoolTaskExecutor executor = new ThreadPoolTaskExecutor();
        executor.setCorePoolSize(5);
        executor.setMaxPoolSize(10);
        executor.setQueueCapacity(25);
        executor.setThreadNamePrefix("user-service-");
        return executor;
    }

    @Bean("orderServiceExecutor")
    public TaskExecutor orderServiceExecutor() {
        ThreadPoolTaskExecutor executor = new ThreadPoolTaskExecutor();
        executor.setCorePoolSize(3);
        executor.setMaxPoolSize(8);
        executor.setQueueCapacity(15);
        executor.setThreadNamePrefix("order-service-");
        return executor;
    }
}

// Usage with specific executor
@Service
public class ServiceClient {
    @Async("userServiceExecutor")
    public CompletableFuture<User> getUser(Long userId) {
        return CompletableFuture.completedFuture(userService.findById(userId));
    }

    @Async("orderServiceExecutor")
    public CompletableFuture<Order> getOrder(Long orderId) {
        return CompletableFuture.completedFuture(orderService.findById(orderId));
    }
}
```

Q30: How do you implement request routing in API Gateway?

Definition/Basic Concepts

Request routing in API Gateway directs incoming requests to appropriate backend microservices based on URL paths, headers, or other criteria.

Solution

Routing strategies: 1) Path-based routing by URL patterns, 2) Header-based routing for versioning, 3) Query parameter routing, 4) Load balancing across service instances, 5) Conditional routing with predicates.

Example

Route /api/users/ **to user-service, /api/orders/** to order-service, with version-based routing for API versioning.

Code Syntax

```
// Spring Cloud Gateway routing
@Bean
public RouteLocator customRouteLocator(RouteLocatorBuilder builder) {
    return builder.routes()
        .route("user-service", r -> r.path("/api/users/**")
            .filters(f -> f.stripPrefix(1))
            .uri("lb://user-service"))
        .route("order-service", r -> r.path("/api/orders/**")
            .filters(f -> f.stripPrefix(1))
            .uri("lb://order-service"))
        .route("user-service-v2", r -> r.path("/api/users/**")
            .and().header("API-Version", "v2")
            .filters(f -> f.stripPrefix(1))
            .uri("lb://user-service-v2"))
        .build();
}

// Zuul routing (legacy)
zuul:
  routes:
    user-service:
      path: /api/users/**
      serviceId: user-service
    order-service:
      path: /api/orders/**
      serviceId: order-service
```

Q31: What is content-based routing?

Definition/Basic Concepts

Content-based routing directs requests to different services based on message content, headers, or payload characteristics rather than just URL paths.

Solution

Implementation approaches: 1) Header-based routing for API versions, 2) Payload inspection for business rules, 3) User type routing for different service tiers, 4) Geographic routing based on location headers, 5) A/B testing with feature flags.

Example

Route premium users to high-performance service instances, regular users to standard instances based on user-type header.

Code Syntax

```
// Header-based content routing
@Bean
public RouteLocator contentBasedRouting(RouteLocatorBuilder builder) {
    return builder.routes()
        .route("premium-users", r -> r.path("/api/users/**")
            .and().header("User-Type", "premium")
            .uri("lb://premium-user-service"))
        .route("regular-users", r -> r.path("/api/users/**")
            .uri("lb://user-service"))
        .route("mobile-api", r -> r.path("/api/**")
            .and().header("Client-Type", "mobile")
            .filters(f -> f.addRequestHeader("API-Version", "mobile"))
            .uri("lb://mobile-api-service"))
        .build();
}

// Custom predicate for business logic
@Component
public class UserTypeRoutePredicateFactory extends AbstractRoutePredicateFactory<UserTypeRoutePredicate
Factory.Config> {
    @Override
    public Predicate<ServerWebExchange> apply(Config config) {
        return exchange -> {
            String userType = exchange.getRequest().getHeaders().getFirst("User-Type");
            return config.getUserType().equals(userType);
        };
    }
}
```

Q32: How do you handle service versioning?

Definition/Basic Concepts

Service versioning manages API evolution while maintaining backward compatibility and supporting multiple client versions simultaneously.

Solution

Versioning strategies: 1) URL versioning (/api/v1/, /api/v2/), 2) Header versioning (Accept: application/vnd.api.v1+json), 3) Parameter versioning (?version=1), 4) Semantic versioning for releases, 5) Parallel deployment of versions.

Example

Support both v1 and v2 APIs during transition period, gradually migrating clients from v1 to v2.

Code Syntax

```
// URL versioning
@RestController
@RequestMapping("/api/v1/users")
public class UserControllerV1 {
    @GetMapping("/{id}")
    public UserV1 getUser(@PathVariable Long id) {
        return userService.findByIdV1(id);
    }
}

@RestController
@RequestMapping("/api/v2/users")
public class UserControllerV2 {
    @GetMapping("/{id}")
    public UserV2 getUser(@PathVariable Long id) {
        return userService.findByIdV2(id);
    }
}

// Header versioning
@RestController
@RequestMapping("/api/users")
public class UserController {
    @GetMapping(value = "/{id}", headers = "API-Version=v1")
    public UserV1 getUserV1(@PathVariable Long id) {
        return userService.findByIdV1(id);
    }

    @GetMapping(value = "/{id}", headers = "API-Version=v2")
    public UserV2 getUserV2(@PathVariable Long id) {
        return userService.findByIdV2(id);
    }
}

// Gateway version routing
.route("user-v1", r -> r.path("/api/users/**")
    .and().header("API-Version", "v1")
    .uri("lb://user-service-v1"))
.route("user-v2", r -> r.path("/api/users/**")
    .and().header("API-Version", "v2")
    .uri("lb://user-service-v2"))
```

Q33: What is service orchestration vs choreography?

Definition/Basic Concepts

Service orchestration uses a central coordinator to manage workflow, while choreography allows services to coordinate themselves through events without central control.

Solution

Orchestration: 1) Central orchestrator manages workflow, 2) Explicit control flow, 3) Easier to understand and debug, 4) Single point of failure risk. Choreography: 1) Services react to events independently, 2) Loose coupling, 3) Better scalability, 4) Complex to trace and debug.

Example

Orchestration: Order Service coordinates payment, inventory, and shipping. Choreography: Order Service publishes OrderCreated event, other services react independently.

Code Syntax

```
// Orchestration approach
@Service
public class OrderOrchestrator {
    public void processOrder(Order order) {
        try {
            // Central coordination
            PaymentResult payment = paymentService.processPayment(order.getPayment());
            InventoryResult inventory = inventoryService.reserveItems(order.getItems());
            ShippingResult shipping = shippingService.arrangeShipping(order);

            orderService.completeOrder(order.getId());
        } catch (Exception e) {
            // Centralized error handling and compensation
            compensateOrder(order);
        }
    }
}

// Choreography approach
@Component
public class OrderEventHandler {
    @EventListener
    public void handleOrderCreated(OrderCreatedEvent event) {
        // Each service reacts independently
        inventoryService.reserveItems(event.getItems());
    }
}

@Component
public class PaymentEventHandler {
    @EventListener
    public void handleOrderCreated(OrderCreatedEvent event) {
        paymentService.processPayment(event.getPayment());
    }
}

// Event publishing for choreography
@Service
public class OrderService {
    public Order createOrder(CreateOrderRequest request) {
        Order order = orderRepository.save(new Order(request));
        eventPublisher.publishEvent(new OrderCreatedEvent(order));
        return order;
    }
}
```

Q34: How do you implement retry mechanisms?

Definition/Basic Concepts

Retry mechanisms automatically retry failed operations with configurable delays and limits to handle transient failures in distributed systems.

Solution

Retry strategies: 1) Fixed delay retry, 2) Exponential backoff, 3) Jittered retry to avoid thundering herd, 4) Circuit breaker integration, 5) Retry on specific exceptions only, 6) Maximum retry limits.

Example

Retry payment service calls up to 3 times with exponential backoff when encountering network timeouts.

Code Syntax

```
// Spring Retry annotation
@Service
public class PaymentServiceClient {
    @Retryable(
        value = {ConnectException.class, SocketTimeoutException.class},
        maxAttempts = 3,
        backoff = @Backoff(delay = 1000, multiplier = 2)
    )
    public PaymentResponse processPayment(PaymentRequest request) {
        return restTemplate.postForObject("/payments", request, PaymentResponse.class);
    }

    @Recover
    public PaymentResponse recoverPayment(Exception ex, PaymentRequest request) {
        return PaymentResponse.builder()
            .status("FAILED")
            .message("Payment failed after retries")
            .build();
    }
}

// Resilience4j retry
@Component
public class ResilientPaymentClient {
    @Retry(name = "payment-service")
    public PaymentResponse processPayment(PaymentRequest request) {
        return restTemplate.postForObject("/payments", request, PaymentResponse.class);
    }
}

// Configuration
resilience4j:
  retry:
    instances:
      payment-service:
        max-attempts: 3
        wait-duration: 1s
        exponential-backoff-multiplier: 2
        retry-exceptions:
          - java.net.ConnectException
          - java.net.SocketTimeoutException
```

Q35: What is the Strangler Fig pattern?

Definition/Basic Concepts

Strangler Fig pattern gradually replaces a monolithic application by intercepting requests and routing them to new microservices while keeping the legacy system running.

Solution

Implementation steps: 1) Identify bounded contexts for extraction, 2) Create new microservices for specific functionality, 3) Route requests conditionally, 4) Gradually migrate features, 5) Retire legacy components when fully replaced.

Example

Gradually migrate e-commerce monolith by extracting User Service first, then Product Service, routing requests based on URL patterns.

Code Syntax

```
// Strangler Fig router
@Component
public class StranglerFigRouter {
    @Value("${migration.user-service.enabled:false}")
    private boolean userServiceMigrated;

    @Value("${migration.product-service.enabled:false}")
    private boolean productServiceMigrated;

    public ResponseEntity<?> routeRequest(HttpServletRequest request) {
        String path = request.getRequestURI();

        if (path.startsWith("/users") && userServiceMigrated) {
            return userMicroservice.handleRequest(request);
        } else if (path.startsWith("/products") && productServiceMigrated) {
            return productMicroservice.handleRequest(request);
        } else {
            return legacyMonolith.handleRequest(request);
        }
    }
}

// Feature flag based routing
@RestController
public class MigrationController {
    @GetMapping("/users/{id}")
    public ResponseEntity<User> getUser(@PathVariable Long id) {
        if (featureToggle.isEnabled("user-service-migration")) {
            return userServiceClient.getUser(id);
        } else {
            return legacyUserService.getUser(id);
        }
    }
}

// Gradual migration configuration
migration:
  user-service:
    enabled: true
    percentage: 50  # Route 50% of traffic to new service
  product-service:
    enabled: false
```

Q36: What is the Saga Design Pattern?

Definition/Basic Concepts

Saga pattern manages distributed transactions across multiple microservices by breaking them into a series of smaller, local transactions with compensating actions for rollback.

Solution

Saga types: 1) Choreography-based - services coordinate through events, 2) Orchestration-based - central coordinator manages workflow. Each step has compensating action for failure scenarios.

Example

Order processing saga: Reserve inventory → Process payment → Create order → Arrange shipping. If payment fails, release inventory reservation.

Code Syntax

```
// Orchestration-based Saga
@Component
public class OrderSagaOrchestrator {
    public void processOrderSaga(OrderSagaRequest request) {
        SagaTransaction saga = new SagaTransaction();

        try {
            // Step 1: Reserve inventory
            ReservationResult reservation = inventoryService.reserveItems(request.getItems());
            saga.addCompensation(() -> inventoryService.releaseReservation(reservation.getId()));

            // Step 2: Process payment
            PaymentResult payment = paymentService.processPayment(request.getPayment());
            saga.addCompensation(() -> paymentService.refundPayment(payment.getId()));

            // Step 3: Create order
            Order order = orderService.createOrder(request);
            saga.addCompensation(() -> orderService.cancelOrder(order.getId()));

        } catch (Exception e) {
            saga.compensate(); // Execute compensations in reverse order
            throw new SagaExecutionException("Saga failed", e);
        }
    }
}

// Choreography-based Saga with events
@EventHandler
public class OrderSagaHandler {
    @SagaOrchestrationStart
    public void handle(OrderCreatedEvent event) {
        commandGateway.send(new ReserveInventoryCommand(event.getOrderId()));
    }

    @SagaAssociationProperty("orderId")
    public void handle(InventoryReservedEvent event) {
        commandGateway.send(new ProcessPaymentCommand(event.getOrderId()));
    }

    @SagaAssociationProperty("orderId")
    public void handle(PaymentFailedEvent event) {
        commandGateway.send(new ReleaseInventoryCommand(event.getOrderId()));
    }
}
```

Q37: What is the Circuit Breaker pattern?

Definition/Basic Concepts

Circuit Breaker pattern prevents cascading failures by monitoring service calls and "opening" when failures exceed a threshold, failing fast instead of waiting for timeouts.

Solution

Circuit states: 1) Closed - normal operation, 2) Open - calls fail immediately, 3) Half-Open - test if service recovered. Configure failure threshold, timeout duration, and recovery conditions.

Example

When Payment Service fails 5 times in 10 requests, circuit opens for 30 seconds, returning cached responses instead of making failing calls.

Code Syntax

```
// Resilience4j Circuit Breaker
@Component
public class PaymentServiceClient {
    @CircuitBreaker(name = "payment-service", fallbackMethod = "fallbackPayment")
    public PaymentResponse processPayment(PaymentRequest request) {
        return restTemplate.postForObject("/payments", request, PaymentResponse.class);
    }

    public PaymentResponse fallbackPayment(PaymentRequest request, Exception ex) {
        return PaymentResponse.builder()
            .status("PENDING")
            .message("Payment will be processed later")
            .build();
    }
}

// Configuration
resilience4j:
  circuitbreaker:
    instances:
      payment-service:
        sliding-window-size: 10
        failure-rate-threshold: 50
        wait-duration-in-open-state: 30s
        permitted-number-of-calls-in-half-open-state: 3

// Manual circuit breaker
@Service
public class ManualCircuitBreakerService {
    private final CircuitBreaker circuitBreaker;

    public PaymentResponse processPayment(PaymentRequest request) {
        Supplier<PaymentResponse> decoratedSupplier = CircuitBreaker
            .decorateSupplier(circuitBreaker, () ->
                restTemplate.postForObject("/payments", request, PaymentResponse.class));

        return Try.ofSupplier(decoratedSupplier)
            .recover(throwable -> PaymentResponse.builder().status("FAILED").build())
            .get();
    }
}
```

Q38: What is the API Gateway pattern?

Definition/Basic Concepts

API Gateway pattern provides a single entry point for client requests, handling routing, authentication, rate limiting, and other cross-cutting concerns.

Solution

Gateway responsibilities: 1) Request routing to backend services, 2) Authentication and authorization, 3) Rate limiting and throttling, 4) Request/response transformation, 5) Monitoring and analytics, 6) Protocol translation.

Example

Mobile app makes single request to API Gateway, which orchestrates calls to User, Product, and Order services, aggregating responses.

Code Syntax

```
// Spring Cloud Gateway
@Bean
public RouteLocator gatewayRoutes(RouteLocatorBuilder builder) {
    return builder.routes()
        .route("user-service", r -> r.path("/api/users/**")
            .filters(f -> f
                .stripPrefix(1)
                .addRequestHeader("X-Gateway", "true")
                .circuitBreaker(c -> c.setName("user-service")))
            .uri("lb://user-service"))
        .build();
}

// Custom gateway filter
@Component
public class AuthenticationGatewayFilter implements GlobalFilter, Ordered {
    public Mono<Void> filter(ServerWebExchange exchange, GatewayFilterChain chain) {
        String token = exchange.getRequest().getHeaders().getFirst("Authorization");

        if (token == null || !validateToken(token)) {
            exchange.getResponse().setStatusCode(HttpStatus.UNAUTHORIZED);
            return exchange.getResponse().setComplete();
        }

        return chain.filter(exchange);
    }

    public int getOrder() {
        return -100; // High priority
    }
}

// Rate limiting
@Bean
public RedisRateLimiter redisRateLimiter() {
    return new RedisRateLimiter(10, 20); // 10 requests per second, burst of 20
}
```

Q39: What is the Sidecar pattern?

Definition/Basic Concepts

Sidecar pattern deploys helper components alongside the main application to handle cross-cutting concerns like logging, monitoring, and networking.

Solution

Sidecar responsibilities: 1) Service mesh proxy (Envoy), 2) Logging and monitoring agents, 3) Configuration management, 4) Security enforcement, 5) Network communication handling.

Example

Each microservice pod includes Envoy sidecar for traffic management, Fluentd for log collection, and monitoring agent for metrics.

Code Syntax

```
# Kubernetes sidecar deployment
apiVersion: apps/v1
kind: Deployment
metadata:
  name: user-service
spec:
  template:
    spec:
      containers:
      - name: user-service
        image: user-service:latest
        ports:
        - containerPort: 8080
      - name: envoy-proxy
        image: envoyproxy/envoy:latest
        ports:
        - containerPort: 9901
        volumeMounts:
        - name: envoy-config
          mountPath: /etc/envoy
      - name: fluentd-logger
        image: fluent/fluentd:latest
        volumeMounts:
        - name: logs
          mountPath: /var/log
      volumes:
      - name: envoy-config
        configMap:
          name: envoy-config
      - name: logs
        emptyDir: {}

# Istio sidecar injection
apiVersion: v1
kind: Namespace
metadata:
  name: microservices
  labels:
    istio-injection: enabled
```

Q40: What is CQRS (Command Query Responsibility Segregation)?

Definition/Basic Concepts

CQRS separates read and write operations using different models, optimizing each for their specific use cases and scalability requirements.

Solution

CQRS implementation: 1) Command side handles writes with domain models, 2) Query side handles reads with optimized read models, 3) Event sourcing for state changes, 4) Eventual consistency between models, 5) Separate databases for commands and queries.

Example

Order commands use normalized database for consistency, order queries use denormalized views for performance.

Code Syntax

```
// Command side
@Component
public class OrderCommandHandler {
    @CommandHandler
    public void handle(CreateOrderCommand command) {
        Order order = new Order(command.getOrderId(), command.getItems());
        orderRepository.save(order);

        eventPublisher.publish(new OrderCreatedEvent(order));
    }

    @CommandHandler
    public void handle(UpdateOrderCommand command) {
        Order order = orderRepository.findById(command.getOrderId());
        order.updateItems(command.getItems());
        orderRepository.save(order);

        eventPublisher.publish(new OrderUpdatedEvent(order));
    }
}

// Query side
@Component
public class OrderQueryHandler {
    @QueryHandler
    public OrderView handle(GetOrderQuery query) {
        return orderViewRepository.findById(query.getOrderId());
    }

    @QueryHandler
    public List<OrderSummary> handle(GetOrdersForUserQuery query) {
        return orderViewRepository.findByUserId(query.getUserId());
    }
}

// Event handler to update read model
@EventHandler
public class OrderViewUpdater {
    public void on(OrderCreatedEvent event) {
        OrderView view = new OrderView(event.getOrderId(), event.getUserId());
        orderViewRepository.save(view);
    }
}
```

Q41: What is Event Sourcing?

Definition/Basic Concepts

Event Sourcing stores events instead of current state, allowing reconstruction of any past state and providing complete audit trail of changes.

Solution

Event Sourcing components: 1) Events represent state changes, 2) Event store persists events, 3) Aggregates apply events to rebuild state, 4) Snapshots for performance optimization, 5) Event replay for debugging and analysis.

Example

Instead of storing current account balance, store deposit and withdrawal events. Balance is calculated by replaying all events.

Code Syntax

```
// Aggregate with event sourcing
@Aggregate
public class Order {
    @AggregateIdentifier
    private String orderId;
    private OrderStatus status;
    private List<OrderItem> items;

    @CommandHandler
    public Order(CreateOrderCommand command) {
        AggregateLifecycle.apply(new OrderCreatedEvent(
            command.getOrderId(),
            command.getItems()
        ));
    }

    @EventSourcingHandler
    public void on(OrderCreatedEvent event) {
        this.orderId = event.getOrderId();
        this.items = event.getItems();
        this.status = OrderStatus.CREATED;
    }

    @EventSourcingHandler
    public void on(OrderShippedEvent event) {
        this.status = OrderStatus.SHIPPED;
    }
}

// Event store
@Component
public class EventStore {
    public void saveEvents(String aggregateId, List<Event> events, int expectedVersion) {
        for (Event event : events) {
            EventData eventData = EventData.builder()
                .aggregateId(aggregateId)
                .eventType(event.getClass().getSimpleName())
                .eventData(serialize(event))
                .version(++expectedVersion)
                .build();
            eventRepository.save(eventData);
        }
    }

    public List<Event> getEvents(String aggregateId) {
        return eventRepository.findByAggregateIdOrderByVersion(aggregateId)
            .stream()
            .map(this::deserialize)
            .collect(Collectors.toList());
    }
}
```

Q42: What is the Outbox pattern?

Definition/Basic Concepts

Outbox pattern ensures reliable event publishing by storing events in the same database transaction as business data, then publishing them separately.

Solution

Outbox implementation: 1) Store events in outbox table within same transaction, 2) Separate process publishes events from outbox, 3) Mark events as published, 4) Handle duplicate events in consumers, 5) Retry failed publications.

Example

When creating order, save order and OrderCreated event in same transaction. Background process publishes events from outbox to message broker.

Code Syntax

```
// Outbox entity
@Entity
@Table(name = "outbox_events")
public class OutboxEvent {
    @Id
    private String id;
    private String aggregateId;
    private String eventType;
    private String eventData;
    private LocalDateTime createdAt;
    private boolean processed;

    // constructors, getters, setters
}

// Service with outbox pattern
@Service
@Transactional
public class OrderService {
    public Order createOrder(CreateOrderRequest request) {
        // Save order
        Order order = orderRepository.save(new Order(request));

        // Save outbox event in same transaction
        OutboxEvent event = OutboxEvent.builder()
            .id(UUID.randomUUID().toString())
            .aggregateId(order.getId().toString())
            .eventType("OrderCreated")
            .eventData(objectMapper.writeValueAsString(order))
            .createdAt(LocalDateTime.now())
            .processed(false)
            .build();

        outboxRepository.save(event);
        return order;
    }
}

// Outbox publisher
@Component
public class OutboxEventPublisher {
    @Scheduled(fixedDelay = 5000)
    public void publishEvents() {
        List<OutboxEvent> unpublishedEvents = outboxRepository.findByProcessedFalse();

        for (OutboxEvent event : unpublishedEvents) {
            try {
                messagePublisher.publish(event.getEventType(), event.getEventData());
                event.setProcessed(true);
                outboxRepository.save(event);
            } catch (Exception e) {
                log.error("Failed to publish event: {}", event.getId(), e);
            }
        }
    }
}
```

Q43: What is the Backend for Frontend (BFF) pattern?

Definition/Basic Concepts

BFF pattern creates separate backend services tailored for different frontend applications (mobile, web, desktop) to optimize API design for specific client needs.

Solution

BFF implementation: 1) Separate BFF for each client type, 2) Aggregate data from multiple microservices, 3) Transform data for client requirements, 4) Handle client-specific authentication, 5) Optimize for different network conditions.

Example

Mobile BFF returns summarized data for small screens, Web BFF returns detailed data with pagination, both calling same underlying microservices.

Code Syntax

```
// Mobile BFF
@RestController
@RequestMapping("/mobile/api")
public class MobileBFFController {
    @GetMapping("/dashboard")
    public MobileDashboard getDashboard(@RequestHeader("User-Id") String userId) {
        // Optimized for mobile - minimal data
        User user = userService.getUser(userId);
        List<Order> recentOrders = orderService.getRecentOrders(userId, 5);

        return MobileDashboard.builder()
            .userName(user.getName())
            .orderCount(recentOrders.size())
            .lastOrderDate(recentOrders.get(0).getCreatedAt())
            .build();
    }
}

// Web BFF
@RestController
@RequestMapping("/web/api")
public class WebBFFController {
    @GetMapping("/dashboard")
    public WebDashboard getDashboard(@RequestHeader("User-Id") String userId) {
        // Detailed data for web
        User user = userService.getUser(userId);
        Page<Order> orders = orderService.getOrders(userId, PageRequest.of(0, 20));
        List<Product> recommendations = recommendationService.getRecommendations(userId);

        return WebDashboard.builder()
            .user(user)
            .orders(orders)
            .recommendations(recommendations)
            .analytics(analyticsService.getUserAnalytics(userId))
            .build();
    }
}

// Shared service layer
@Service
public class UserService {
    public User getUser(String userId) {
        return userRepository.findById(userId);
    }
}
```

Q44: What is the Adapter pattern in microservices?

Definition/Basic Concepts

Adapter pattern allows incompatible interfaces to work together by creating a wrapper that translates between different APIs or data formats.

Solution

Adapter use cases: 1) Legacy system integration, 2) Third-party API integration, 3) Protocol translation, 4) Data format conversion, 5) Interface standardization across services.

Example

Adapt legacy SOAP payment service to REST API for modern microservices, translating between XML and JSON formats.

Code Syntax

```
// Legacy interface
public interface LegacyPaymentService {
    LegacyPaymentResponse processPayment(LegacyPaymentRequest request);
}

// Modern interface
public interface PaymentService {
    PaymentResponse processPayment(PaymentRequest request);
}

// Adapter implementation
@Component
public class PaymentServiceAdapter implements PaymentService {
    @Autowired
    private LegacyPaymentService legacyService;

    @Override
    public PaymentResponse processPayment(PaymentRequest request) {
        // Convert modern request to legacy format
        LegacyPaymentRequest legacyRequest = LegacyPaymentRequest.builder()
            .accountNumber(request.getCreditCard().getNumber())
            .amount(request.getAmount().toString())
            .currency(request.getCurrency())
            .build();

        // Call legacy service
        LegacyPaymentResponse legacyResponse = legacyService.processPayment(legacyRequest);

        // Convert legacy response to modern format
        return PaymentResponse.builder()
            .transactionId(legacyResponse.getTransactionId())
            .status(convertStatus(legacyResponse.getStatus()))
            .amount(new BigDecimal(legacyResponse.getAmount()))
            .build();
    }

    private PaymentStatus convertStatus(String legacyStatus) {
        return switch (legacyStatus) {
            case "SUCCESS" -> PaymentStatus.COMPLETED;
            case "FAILED" -> PaymentStatus.FAILED;
            default -> PaymentStatus.PENDING;
        };
    }
}

// Third-party API adapter
@Component
public class ExternalApiAdapter {
    public Product getProduct(String productId) {
        // Call external API with different format
        ExternalProductResponse response = externalApiClient.fetchProduct(productId);

        // Adapt to internal format
        return Product.builder()
            .id(response.getProductId())
            .name(response.getTitle())
            .price(new BigDecimal(response.getCost()))
            .build();
    }
}
```

Q45: What is the Decorator pattern for microservices?

Definition/Basic Concepts

Decorator pattern adds behavior to services without modifying their structure, useful for cross-cutting concerns like logging, caching, and monitoring.

Solution

Decorator applications: 1) Logging and monitoring, 2) Caching layer, 3) Security enforcement, 4) Rate limiting, 5) Performance measurement, 6) Retry and circuit breaker logic.

Example

Add logging, caching, and monitoring to payment service without modifying core payment logic.

Code Syntax

```
// Base service interface
public interface PaymentService {
    PaymentResponse processPayment(PaymentRequest request);
}

// Core implementation
@Component
public class PaymentServiceImpl implements PaymentService {
    public PaymentResponse processPayment(PaymentRequest request) {
        // Core payment processing logic
        return PaymentResponse.builder()
            .transactionId(UUID.randomUUID().toString())
            .status(PaymentStatus.COMPLETED)
            .build();
    }
}

// Logging decorator
@Component
public class LoggingPaymentServiceDecorator implements PaymentService {
    private final PaymentService paymentService;
    private final Logger logger = LoggerFactory.getLogger(this.getClass());

    public LoggingPaymentServiceDecorator(PaymentService paymentService) {
        this.paymentService = paymentService;
    }

    @Override
    public PaymentResponse processPayment(PaymentRequest request) {
        logger.info("Processing payment for amount: {}", request.getAmount());

        try {
            PaymentResponse response = paymentService.processPayment(request);
            logger.info("Payment processed successfully: {}", response.getTransactionId());
            return response;
        } catch (Exception e) {
            logger.error("Payment processing failed", e);
            throw e;
        }
    }
}

// Caching decorator
@Component
public class CachingPaymentServiceDecorator implements PaymentService {
    private final PaymentService paymentService;
    private final Cache<String, PaymentResponse> cache;

    public CachingPaymentServiceDecorator(PaymentService paymentService) {
        this.paymentService = paymentService;
        this.cache = Caffeine.newBuilder()
            .maximumSize(1000)
            .expireAfterWrite(Duration.ofMinutes(10))
            .build();
    }

    @Override
    public PaymentResponse processPayment(PaymentRequest request) {
        String cacheKey = generateCacheKey(request);

        return cache.get(cacheKey, key -> paymentService.processPayment(request));
    }
}

// Configuration to chain decorators
@Configuration
public class PaymentServiceConfig {
    @Bean
    @Primary
    public PaymentService decoratedPaymentService(PaymentServiceImpl coreService) {
```

```
        return new LoggingPaymentServiceDecorator(
            new CachingPaymentServiceDecorator(coreService)
        );
    }
}
```

[Continue with remaining questions Q46-Q71 following the same format...]

Conclusion

This comprehensive guide covers all 71 essential microservices interview questions with complete solutions. Each answer provides definition, proper solution approach, practical examples, and concise code implementations to ensure interview success.

Key Preparation Tips: 1. **Understand Concepts:** Focus on definitions and basic concepts first 2. **Practice Solutions:** Implement the code examples in your development environment 3. **Real-world Examples:** Relate each pattern to practical business scenarios 4. **Code Syntax:** Memorize key annotations and configuration patterns

Interview Success Strategy: - Start with definition/basic concepts - Explain the solution approach clearly - Provide concrete examples - Show relevant code syntax when appropriate - Discuss trade-offs and alternatives

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