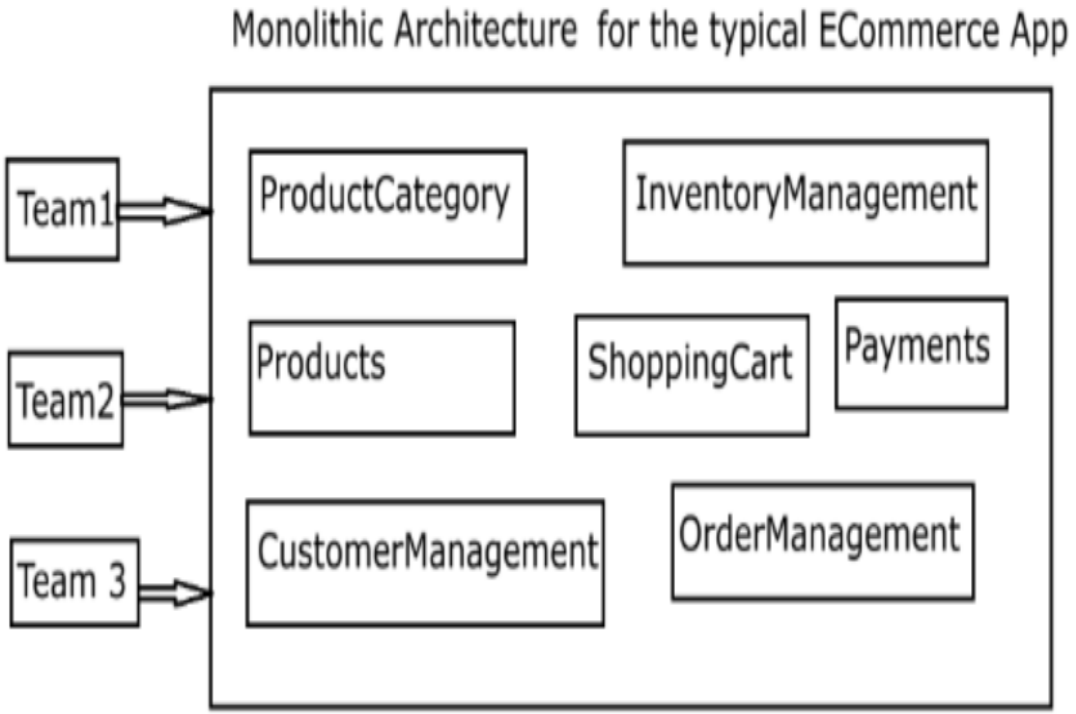
Building MicroServices using Spring Cloud

From Basics To Advanced ….

Before Microservices

- **Monolithic Architecture**
- What is it ?
- Disadvantages
  - **Brittle architectur**e
  - Scalability costly
  - Single Technology Stack
  - Huge Codebase deployed in single artifact
  - Tougher re deployment
  - Tight coupling

Visualization of Monolith Architecture



Single Huge codebase

Deployed as single artifact

Single Tech Stack

Must redeploy on every single smallest change

Enter Microservices

- What is it ?
  - It is a smaller (micro) , independent application(RESTful web service) , which can be developed , tested , deployed and scaled independently on separate technologies.
  - Has its own Database (SQL / NO SQL based)

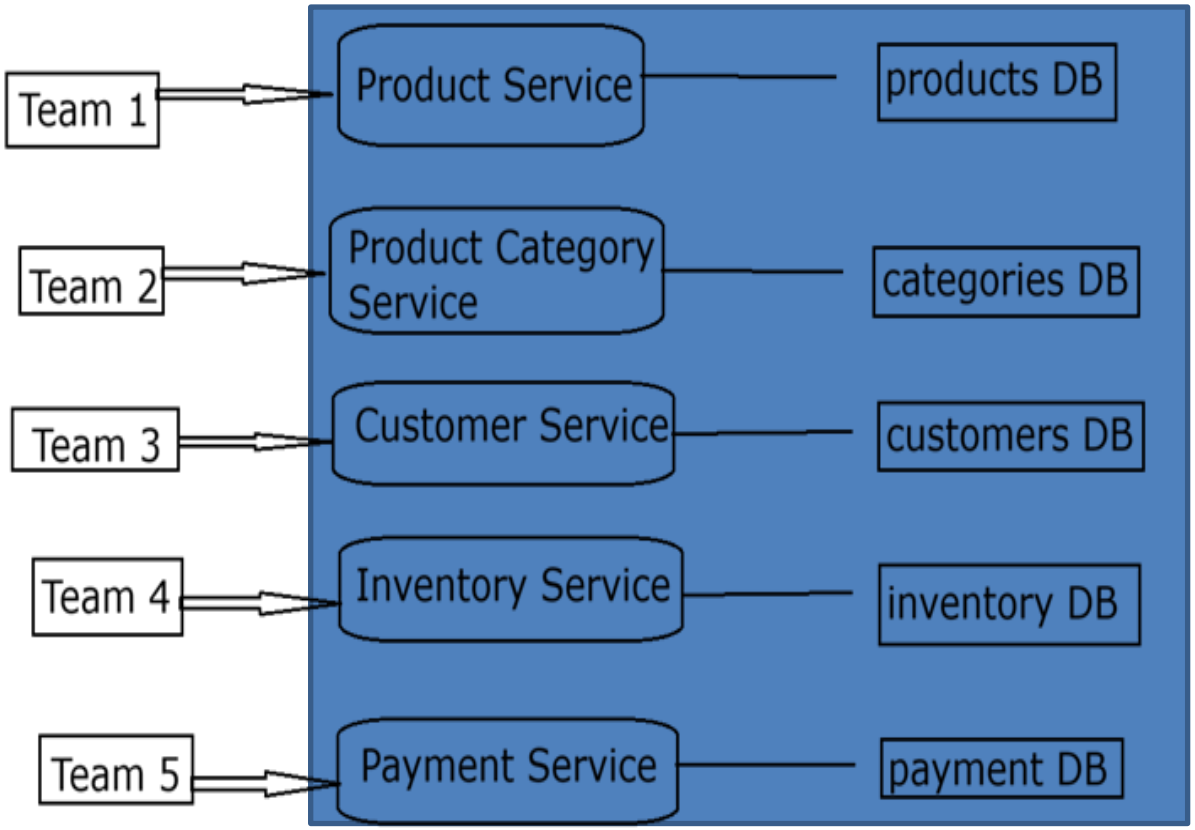
More Details About Microservices

- It is an architectural approach to building software applications that helps both developers and businesses
  - to achieve faster delivery cycles, faster innovation, improve scalability, and help teams to work independently.
- The entire application is broken into a smaller independent services
- Each of this service is self-contained that performs a dedicated function and links with other services through APIs and protocols.
- Different programming languages, frameworks, and technologies are used to develop these services.

Benefits of Microservices

- 30% Higher customer satisfaction/retention
- 29% Faster time to market/ responding to changes in the marketplace
- 28% Improved application quality/performance
- 29% Better security of company/customer data

Microservices Based Architecture



Highlights
Loose Coupling

Developed , Tested , Deployed independently

Scaled independently

Product Release cycle faster

Service Registry

API Gateway

Config Server

Message Broker

Circuit Breaker

Distributed Tracing

Challenges in Designing Microservices based application

- How to identify the break down of the entire application ?
- How many separate services to create ?
- How to keep track of different services, their host names and port numbers ?
- How to communicate between different services ?
- Debugging , monitoring and many more concerns….

Best Practices

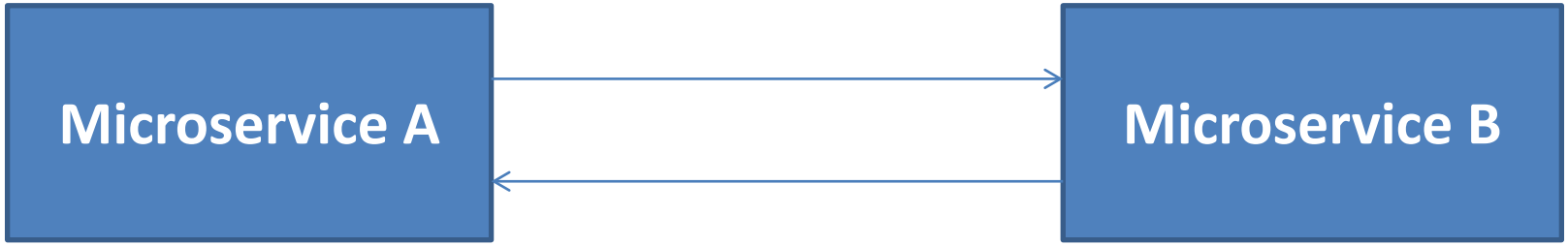
- Each Microservice has its own database.
- Client (API or Frontend) interacts only through the API gateway,
  - Do not have direct access to the services.
- Each service will be registered to the discovery server. The discovery server keeps track of all the Microservices available in the system.
- Configuration server contains all the configurations for the Microservices.
- Each Microservice is built as a separate Spring Boot application, which can be developed, deployed, and scaled independently.

Communication between Services

- 2 ways of communication
  - Synchronous communication
    - HTTP client sends a request and awaits its response , causing blocking of the invoker thread.
    - Can use RestTemplate or Web Client or Open Feign client
  - Asynchronous communication
    - The client sends a request to the Middleman (message broker) and does not wait for the response
    - Can use RabbitMq or Apache Kafka

Synchronous Communication

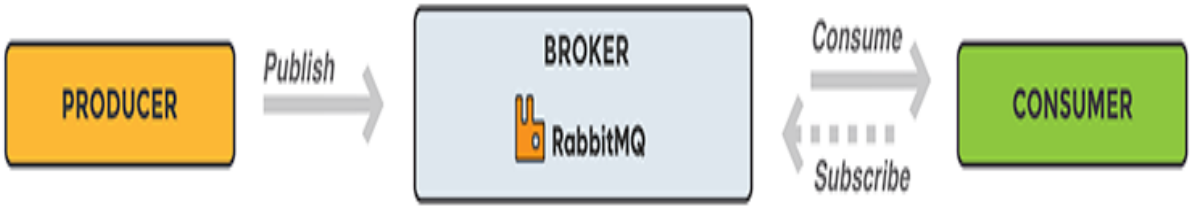
- HTTP Request and Response based communication



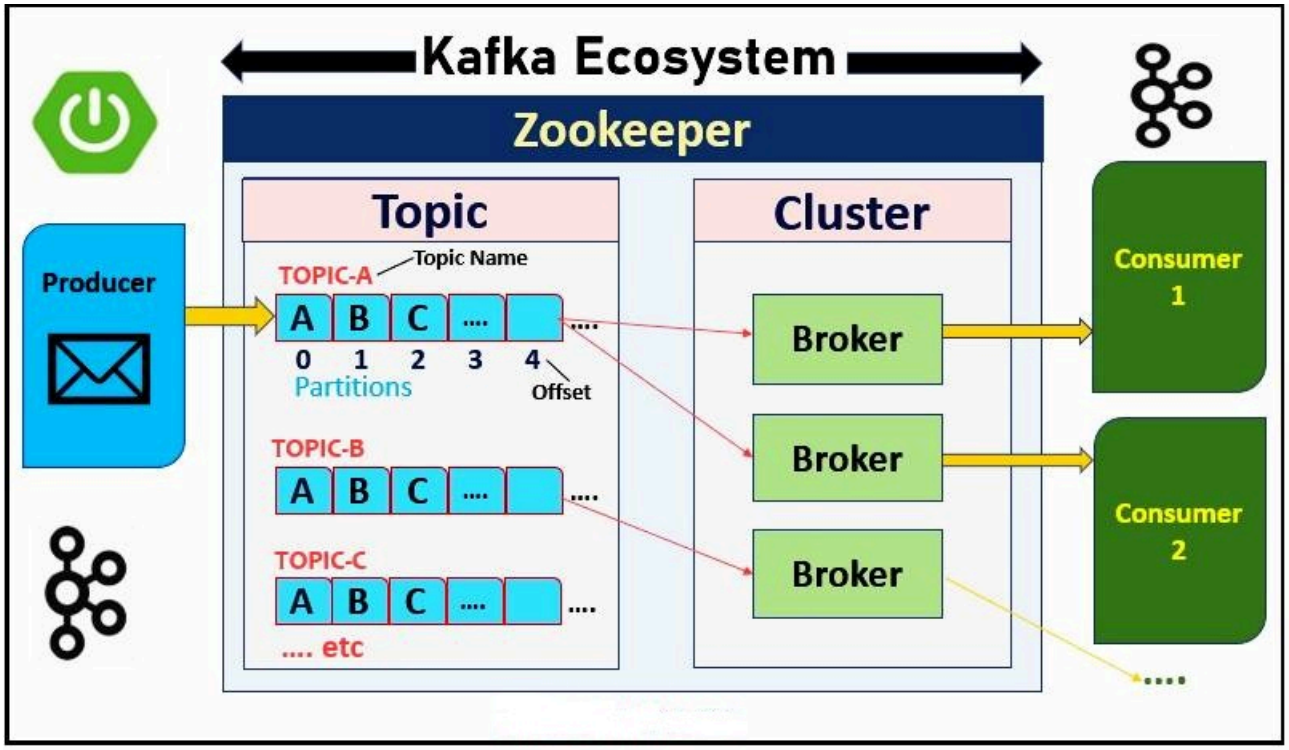
- REST API call (Blocking)

Asynchronous Communication

- Complete de coupling of producer from the consumer
- Based upon MoM (Message Oriented Middleware)



Kafka Based Asynchronous communication



More challenges and their solutions

- Client has to remember the host name and port numbers of different micro services and its instances.
- Solution
  - Design common entry point , where the client sends all the requests. This entry point will further delegate the requests to actual microservice.
  - Design Pattern – **API Gateway**

Continued with Problem and Solution

- Problem
  - In case of increased or reduced load , individual micro services will be scaled up or down . How to dynamically locate these services in a distributes environment ?
- Solution
  - Different services can register to centralized registry n can discover each other dynamically
- Service Registry and Discovery Pattern

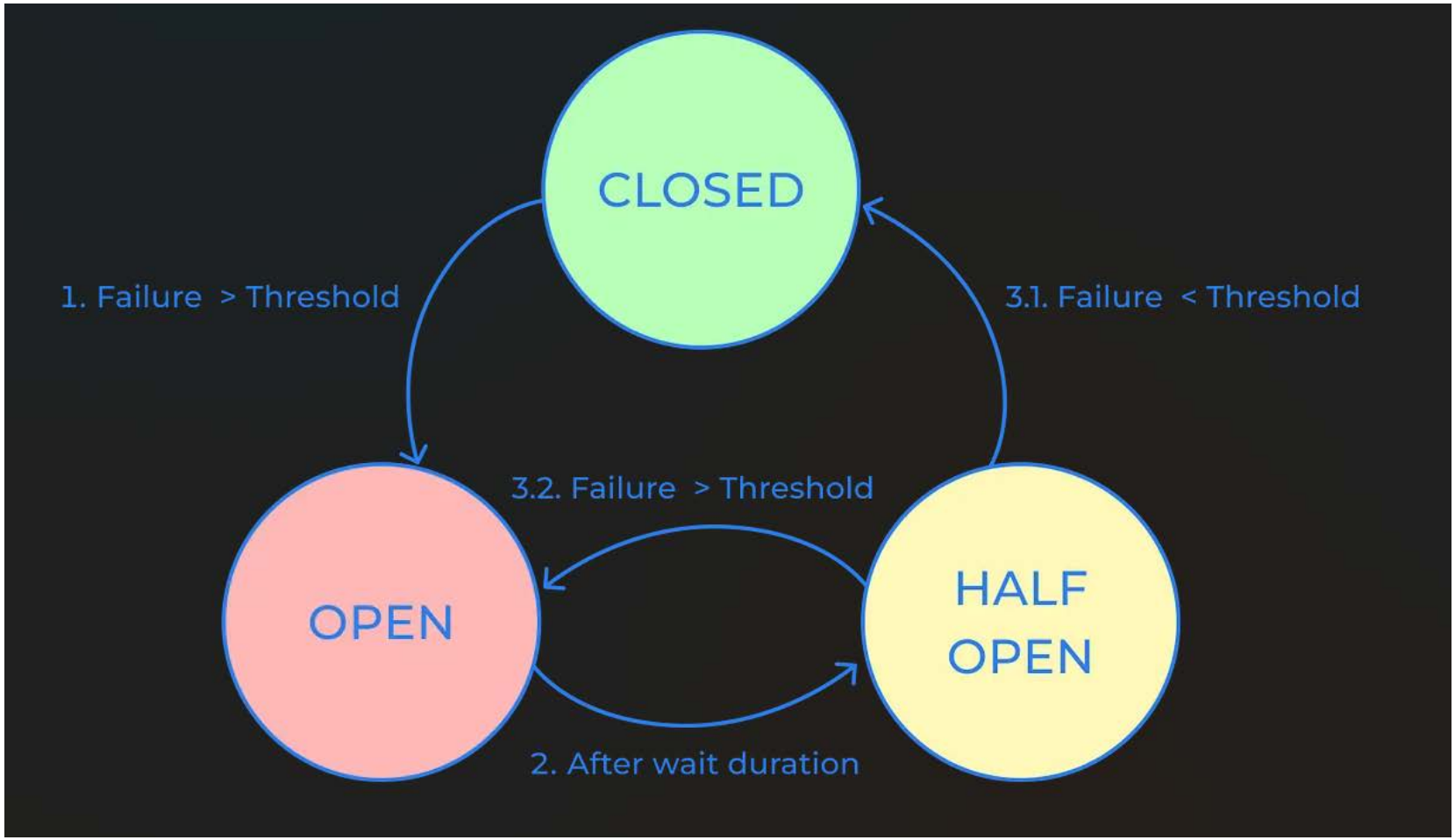
Continued

- In case of one micro service instance down or busy , the call should be redirected to another instance
- Solution
  - Load Balancing
- Server side or Client Side Load Balancing

Continued

- In case of synchronous communication between the services, when a particular service is showing high latency or is completely unresponsive, then that failure is spread across multiple systems causing Cascading of failures.
- To build fault toleant system
- **Circuit breaker design pattern**

Circuit Breaker Pattern



Problem and solution

- Different micro services will have their separate configuration. If its tightly coupled within the service , anytime config changes , all of the instances will have to be restarted
- Solution
  - Externalize the configuration
- **Centralized Configuration** Pattern

Continued

- In a distributed application where , multiple services communicate with each other over the network , it challenging to diagnose and debug issues when they arise.
- Solution
- Distributed Tracing Pattern

Spring Cloud

- Provides ready made implementation for earlier mentioned design patterns
- **Example Patterns and Implementations**
- *The API Gateway Pattern -* ***Spring Cloud Gateway***
- *The Circuit Breaker Pattern -* ***Resilience4j Integration***
- *The Service Registry and Discovery Pattern –* ***Spring Cloud Eureka Server n Client***
- *The Config Server Pattern –* ***Spring Cloud Config , Spring Cloud Bus***
- *Additionally Saga Pattern , Event Driven architecture pattern n many more..*

Case Study

- Food Ordering Distributed Application
- Microservices used
  - Restaurant Service
  - Restaurant food menu Service
  - User Service
  - FoodOrder Service

Food Ordering App Requirements

- Admin can add restaurants
- Admin can add food items (menu) for specific restaurant
- Customers can sign up n sign in
- Customer can get list of all restaurants
- Customer can get specific restaurant n its menu details
- Get specific customer details by its ID
- Customer can place food order , from specific restaurant , containing list of food items

Restaurant Use Case

- Add New Restaurant
  - **URL** http://localhost:8080/restaurants
  - **Method** POST
  - **Payload** RestaurantDTO
    - Name , address , city , description
  - **Response Status** 201
  - **Response Body** Restaurant DTO

Restaurant Use Case

- Fetch Details of All Restaurants
  - **URL** http://localhost:8080/restaurants
  - **Method** GET
  - **Payload none**
  - **Response Status** 204 (empty response) or 200
  - **Response Body** List<Restaurant DTO>

Restaurant Use Case

- Fetch Details of specific Restaurant by ID
  - **URL** http://localhost:8080/restaurants/{restaurantId}
  - **Method** GET
  - **Payload path variable** restaurantId
  - **Response Status** 404 (with error message) or 200
  - **Response Body** Restaurant DTO

Development steps for Restaurant Service

- Create Spring boot project
  - STS 4 , Spring Boot 3.4.1 ,Jakarta EE 9
- Add Dependencies
  - Web , JPA , MySql , swagger , model mapper , validation,lombok
- Configure application.properties
- Create Entity , Repository , Service and controller.
- DTO , custom exceptions and global exception handler

Testing of Restaurant MS

- Either use swagger
  - http://localhost:8080/swagger-ui/index.html
- OR import postman collection
  - Food Ordering MS
  - Run the end points from the folder
    - Food Ordering MS /restaurants

Restaurant Menu Use Case (Uses **MS communication using RestTemplate**)

- Add New Food Item to the Menu
  - **URL** http://localhost:7070/menu
  - **Method** POST
  - **Payload** FoodItemDTO
    - Food item Name , description, is veg , price , restaurant id
  - **Response Status** 201 or 400 (in case of invalid restaurant id)
  - **Response Body** FoodItemDTO or error message
- **Highlight** – RestTemplate based communication between MS , for validating restaurant

Restaurant Menu Use Cases

- Fetch Details of specific Food Item by ID
  - **URL** http://localhost:7070/menu/{foodItemId}
  - **Method** GET
  - **Payload path variable** foodItemId
  - **Response Status** 404 (with error message) or 200
  - **Response Body** FoodItem DTO , with ID

Restaurant Menu Use Case (Uses **MS communication using RestTemplate**)

- Get Restaurant n menu details
  - **URL** http://localhost:7070/menu /restaurant/{restaurantId}
  - **Method** GET
  - **Payload** path variable restaurantId
  - **Response Status** 200 or 400 (in case of invalid restaurant id)
  - **Response Body** RestaurantMenuDetails DTO or error message
    - RestaurantMenuDetails – RestaurantDTO + List<FoodItemDTO>

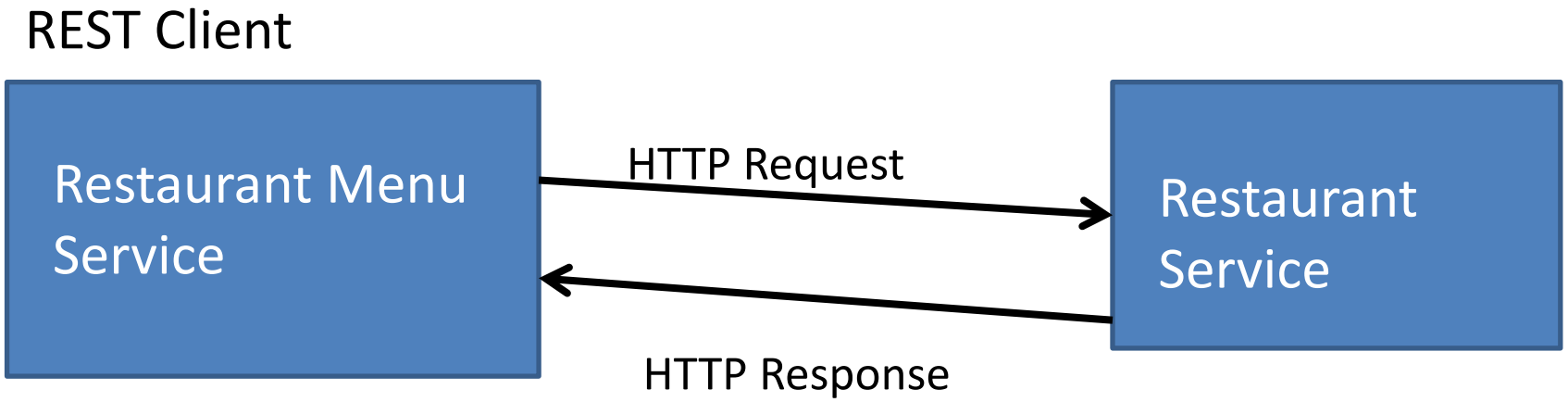
- **Highlight** – RestTemplate based communication between MS , for getting restaurant details
- (no load balancing yet)

Development steps for RestaurantMenu Service

- Create Spring boot project
  - STS 4 , Spring Boot 3.4.1 ,Jakarta EE 9
- Add Dependencies
  - Web , JPA , MySql , swagger , model mapper , validation,lombok
- Configure application.properties , with additional property for getting Restaurant details
  - restaurant.get=http://localhost:8080/restaurants/{restaurantId}
- Create Entity , Repository , Service and controller,
  DTO , custom exceptions and global exception handler

Inter communication between Micro services using RestTemplate

Validate | Get Restaurant Details by ID



Dev steps for using RestTemplate in RestaurantMenu Service

- Configure RestTemplate bean in Spring boot application class
  - Represents the abstraction of synchronous REST client
  - Not yet using load balancer !
- Inject value of GET URL , using SpEL , in Service class
  - @Value("${restaurant.get}")

    private String url;

Microservice Communication using RestTemplate

- Inject RestTemplate in FoodMenuService implementation class
- Make REST call , using RestTemplate API

  <T> T getForObject(String url, Class<T> responseTypeCls, Object... uriVariables) throws RestClientException

- It gets representation of the rsouces by doing a GET call on the specified URL. The response is converted and returned.
- Can pass URI variables , if needed

Testing of RestaurantMenu MS

- Either use swagger
  - http://localhost:7070/swagger-ui/index.html
- OR import postman collection n Run the end points from the folder , Food Ordering MS /menu
  - Add new food item
  - Get details of specific food item
  - Get restaurant n its complete menu

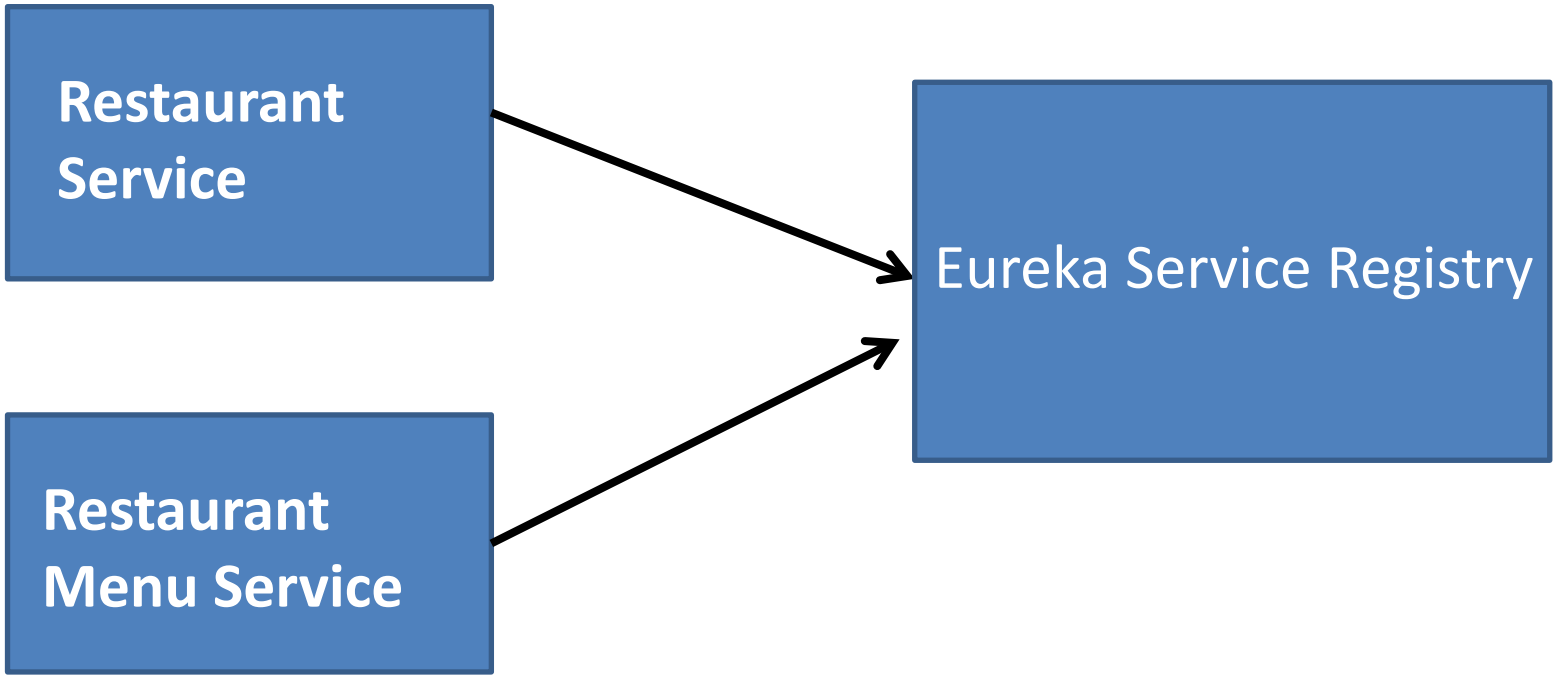
Why Service Registry and Discovery?

- Problem
  - In microservices inter communication , hard coding of hostnames , port numbers required
    - Eg GET URL for getting Restaurant details specified by id from Restaurant Menu service
    - http://localhost:8080/restaurants/{restaurantId}
  - Load balancing unavailable

Service Registry and Discovery Pattern

- Multiple Microservices will register to a centralized registry.
- Centralized registry maintains track of all of registered services n their instances
- While making a call from one MS to another , use Spring application name instead of hard coded details.
- Enables dynamic discovery of the available MS instance n performs the call.
- Analogy – Telephone Directory

Spring Cloud Eureka Server (Netflix)



Spring Cloud Service Registry Development Steps

- Create Spring boot project
- Add dependency
  - spring-cloud-starter-netflix-eureka-server
- Configure application.properties(or yml) for this Eureka Server
  - eureka.client.fetch-registry=false
    - Disable Fetch registry from Eureka Server
  - eureka.client.register-with-eureka=false
    - Disable register with Eureka
  - server.port=8761 (Default port for Eureka Server)
- Add @EnableEurekaServer annotation on Spring Boot Application class

Test Service Registry

- Build (Maven Goals – clean n package) Spring Boot app
- Run Service Registry JAR from cmd prompt
  - java -jar ServiceRegistry-0.0.1.jar
- Launch Eureka dashboard
- From web browser
  - http://localhost:8761
- Should display Eureka dashboard , with no current instances registered.

Register RestaurantService As Eureka client

Development Steps

- Add Eureka Client dependency in pom.xml

- Add the property , to register Restaurant Service as Eureka client with Eureka server
  - eureka.client.serviceUrl.defaultZone= http://localhost:8761/eureka/
- Build n run Spring Boot app.

Register Restaurant Menu Service As Eureka client

Development Steps

- Add Eureka Client dependency in pom.xml

- Add the property , to register Restaurant Menu Service as Eureka client with Eureka server
  - eureka.client.serviceUrl.defaultZone= http://localhost:8761/eureka/
- Build n run Spring Boot app.

Testing Service Registry

- Refresh Eureka Console
- Should display 2 instances registered with Eureka
  - Restaurant-Service
  - Restaurant-Menu-Service

Eureka Client Dynamic Discovery

- Add @LoadBalanced over RestTemplate Bean , in spring boot application class
  - It enables client side load balancing
- Replace hard coded host name n port no by Service Name , in the configuration file
  - restaurant.get=http://Restaurant-service/restaurants/{restaurantId}

- Re build , run n test microservice communication as earlier , using swagger or postman
- Eg Get Restaurant n List of Food Item Details by restaurant id (postman collection)

Customer Sign Up use Case

- Add New Customer
  - **URL** http://localhost:8080/users/signup
  - **Method** POST
  - **Payload** UserReqDTO
    - Name , email, password, dob
  - **Response Status** 201 or 400 in case of validation fialures or in case of dup email
  - **Response Body** error mesg or Restaurant DTO

Customer Sign in Use Case

- Customer Sign in
  - **URL** http://localhost:8080/users/signin
  - **Method** POST
  - **Payload** AuthRequest
    - Email n password
  - **Response Status** 401 or 200
  - **Response Body** error message for invalid email | password or User response DTO

User(Customer) Use Case

- Get User Details
  - **URL** http://localhost:8080/users/{userId}
  - **Method** GET
  - **Payload** path variable userId
  - **Response Status** 404 or 200
  - **Response Body** error message or User resp DTO , with generated User ID

Development steps for User Service

- Create Spring boot project
  - STS 4 , Spring Boot 3.4.1 ,Jakarta EE 9
- Add Dependencies
  - Web , JPA , MySql , swagger , model mapper , validation,lombok , **Eureka Client**
- Configure application.properties
  - DB , JPA n **Eureka client properties**

  eureka.client.serviceUrl.defaultZone=http://localhost:8761/eureka/

- Create Entity , Repository , Service and controller.
- DTO , custom exceptions and global exception handler

Testing User MicroService

- Insert admin record
  - insert into users values (default,'1990-10-20','admin@gmail.com','admin','admin',
- Refresh Eureka dashboard , to confirm running of User Service instance
- Test end points either using swagger | postman collection
  - Sign up
  - Sign in
  - Get customer Details by ID

Place Food Order Use Case

- Place Food Order
  - **URL** http://localhost:8080/orders
  - **Method** POST
  - **Payload** OrderRequestDTO
  - **Response Status** 201 or 400 |404 in case of validation failures or in invalid customer | restaurant
  - **Response Body** error mesg or OrderRespDTO

Schemas of Request DTO

- Order Request DTO
    - List<FoodOrderItem>
    - Customer ID
    - Restaurant ID
    - Delivery Address DTO
- FoodOrderItem
  - Food Item Id
  - Quantity

Schemas of Response DTO

- **Order Response DTO**
  - Order ID
  - Order Status (*NEW*, *PROCESSING*, *DELIVERED*, *CANCELLED)*
  - *Order Amount (total bill)*
  - *Order placing Date Time*
  - *Promised delivery Date Time*
  - *Delivery charges*
  - List<OrderLineDTO>
  - Restaurant Name
  - Customer Name

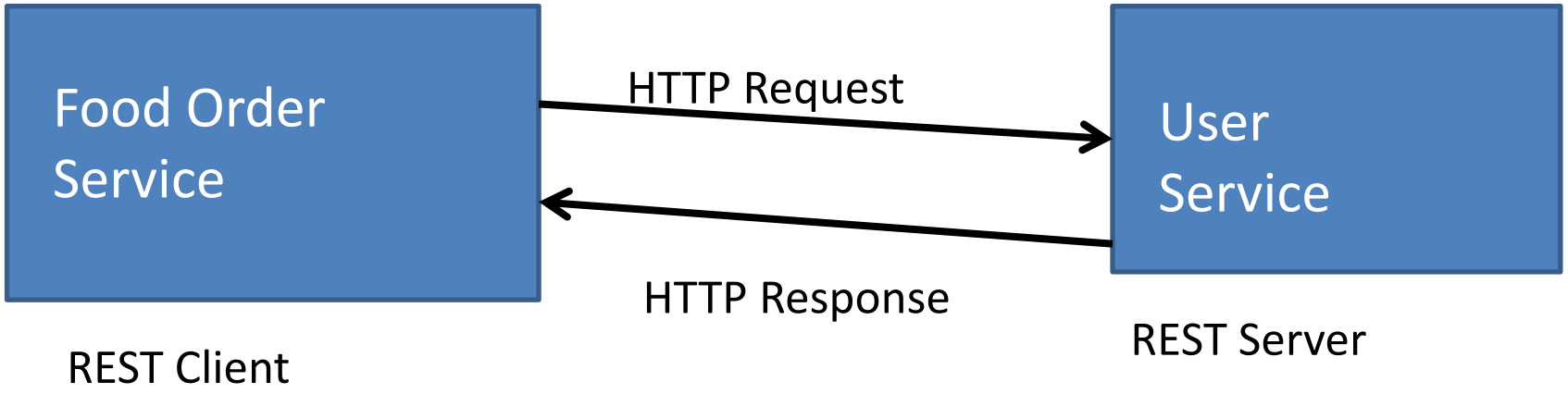
Schema of OrderLineDTO

- OrderLineDTO
  - Food Item Name
  - Quantity
  - Sub total

Inter communication between Micro services using WebClient

RestTemplate – Maintenance mode – to be Deprecated API (Replaced by WebClient)

Validate | Get User Details by ID



Web Client Supports synchronous , asynchronous and streaming communication between micro services

Dev Steps for using Web Client

- Since WebClient is a part of Rective Spring web , add new dependency
  - spring-boot-starter-webflux
- Configure WebClient.Builder as a Spring bean , in spring boot application class
  - Add @LoadBalanced for client side load balancing
- Inject WebClient.Builder in the Service layer , build WebClient
- Use WebClient methods for synchronous communication between microservices.

Intercommunication between MicroServices using OpenFeign Client

- Why OpenFeign ?
  - With RestTemplate or WebClient , programmer has to write lot of boiler plate code for making the REST call.
- What is OpenFeign ?
  - It is an open-source project developed by Netflix and currently managed by Spring Cloud.
  - It is a declarative synchronous REST client
  - It creates a dynamic implementation of the interfaces , declared as FeignClient.
  - Lot easier than any of the earlier approaches

Development Steps in using OpenFeign Client

- Add dependency in pom.xml
  - spring-cloud-starter-openfeign
- Add @EnableFeignClients , to enable OpenFeign clients
- Create Client interface annotated with
  - @FeignClient(name = “Service-Name")
  - Declare interface methods
  - Eg - @GetMapping("/restaurants/{restaurantId}")
  - **public** RestaurantDTO findRestaurantById(@PathVariable Long restaurantId);
- OpenFeign library will automatically generate the implementation logic for making a REST call
- **Does it remind you of anything learnt earlier ?**

Business Logic Steps for Placing Order in Service Layer

- Validate n get Customer details by customer Id from User MicroService , via WebClient
- Validate n get Restaurant details by restaurant Id from Restaurant MicroService , via OpenFeign client
- Create Order entity , with order status – NEW
- Establish uni directional association between Order and DeliveryAddress
  - Order HAS-A Delivery Address

Steps Continued

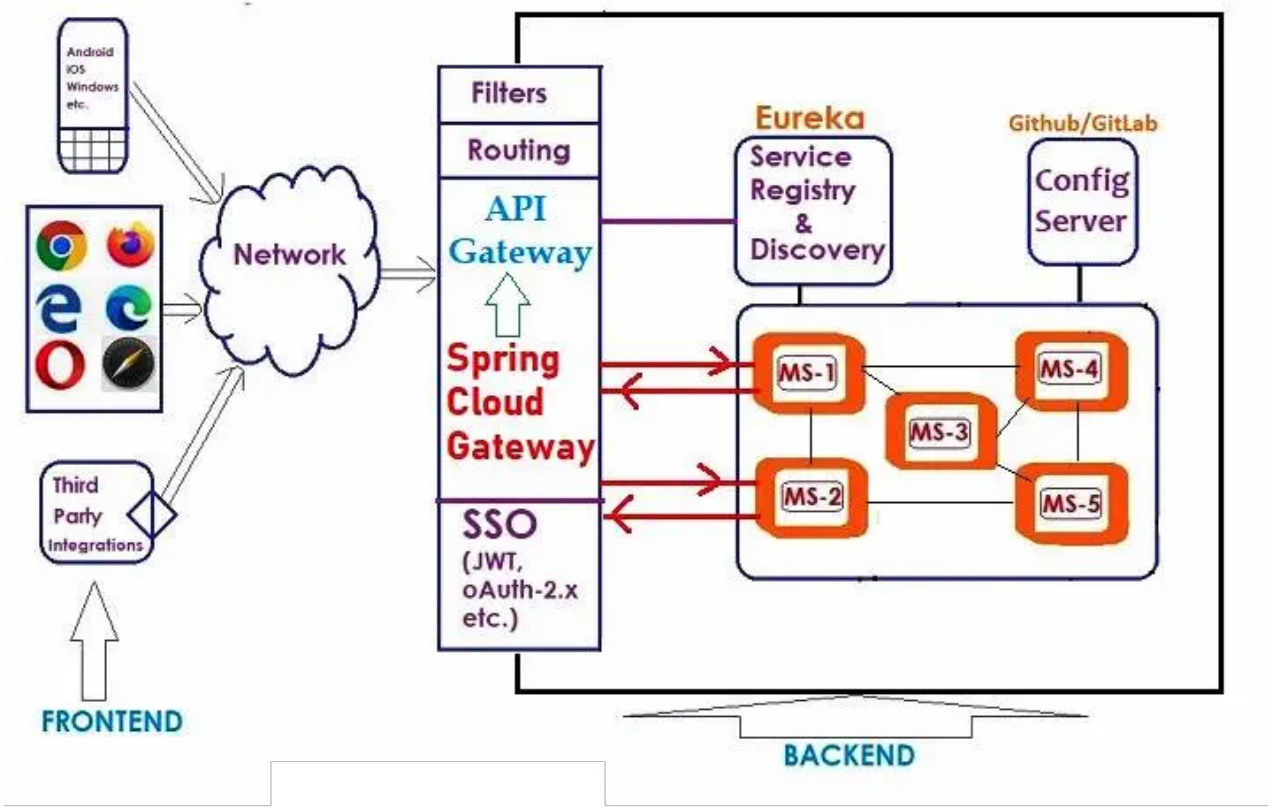
- Assign customer id n restaurant id in Order Entity
- Set Promised delivery time (30 minutes , after placing the order)
- Save order entity , using Order Repository
- Create order lines using ordered food items
- Assign order lines to current Order
  - Establish bi directional association between Order 1 ←→ * OrderLine
  - Single Order HAS-A multiple OrderLines
- Generate Order Response DTO with
  - Order details
  - Order line details
  - Restaurant name
  - Customer name

Testing Of Place Order

API Gateway

- Why ?
  - It simplifies the communication between a client and a service (i.e frontend application and the backend application)
  - In its absence Client will have to know details about each n every microservice running in the back end.
  - **It acts as a single entry point to access any micro service from the distributed application.**
  - It is a non-blocking and reactive gateway that provides several features like routing, filtering, load balancing, circuit breaking n cross cutting conerns like Security

Spring Cloud API Gateway



API Gateway Implementation Steps

- Create Spring boot project with dependencies
  - spring-cloud-starter-gateway
  - spring-cloud-starter-netflix-eureka-client
- Register API Gateway as Eureka client with Eureka server
- Configure routes for individual micro service
  - Id – unique ID
  - uri - lb://Service-Name
  - Predicates : Path – URL pattern of the micro service

Testing

- Run Api Gateway Service
- Run postman client , for
  - Placing Food Order
  - Get Restaurant n Menu Details
- Refer to postman collection
- Concludes Microservices V3 here