

# Section 1

## Understanding Microservices

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# Introduction

- ▶ Microservices is a hot trend in the technology section
- ▶ Netflix, Google, Twitter have been used microservices-based architecture
- ▶ It can be extremely daunting to start, however, for the larger enterprise, each modules can be developed with their own history and purpose

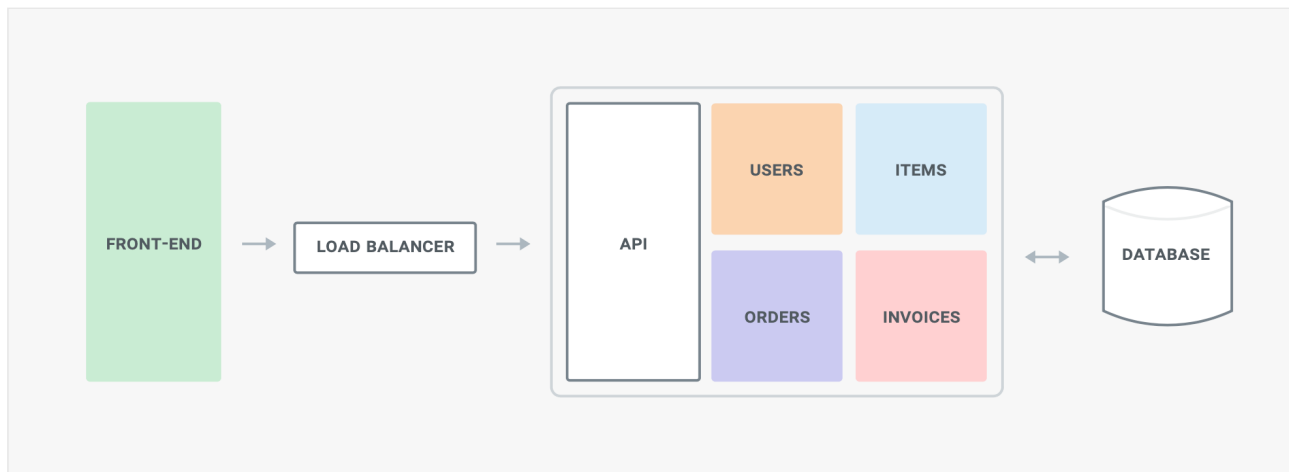
# Advantages of Microservices

1. **Agility:** Componentization and distributed functionality empower developers to iterate and deploy continuously, autonomous of other business units and application teams.
2. **Freedom of Options:** Developers can independently pick their preferred framework (language, structure) to construct and convey functionality more rapidly.
3. **Resiliency:** Microservices are designed for failure with redundancy and isolation in mind, which in turn makes applications more robust.
4. **Efficiency:** There can be significant savings for the enterprise that decouples functionality and adopts microservices.

# Monolithic vs Microservices

## ► Monolithic:

- Easy to understand
- It's great when the codebase and the team working on it are both relatively small
- A fast way to develop a product and get it into market quickly
- No other dependencies.



# Microservices

- ▶ Able to be **built independently**
- ▶ Able to be **deployed independently**
- ▶ Implementation detail will be taken care by the specific team working on that specific feature.
- ▶ Implementations of other components (services) work with interfaces, or APIs.
- ▶ One “big” specific thing tend to become much smaller => “microservices”

# Microservices

A **monolithic** application puts all its functionality into a single process...



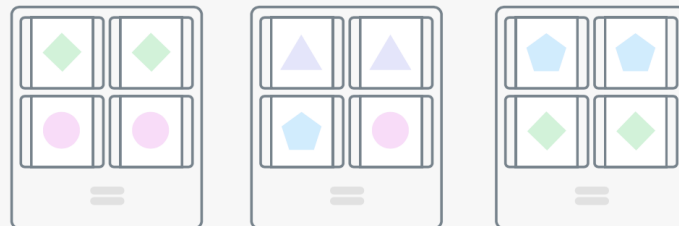
... and scales by replicating the monolith on multiple servers.



A **microservice** architecture puts each element of functionality into a separate service...



... and scales by distributing these services across servers, replicating as needed.



# Microservices Pros and Cons

## ► Pros:

- Better architecture for large applications
- Better agility in the long term
- Easy to learn
- Isolation for scalability and damage control

## ► Cons:

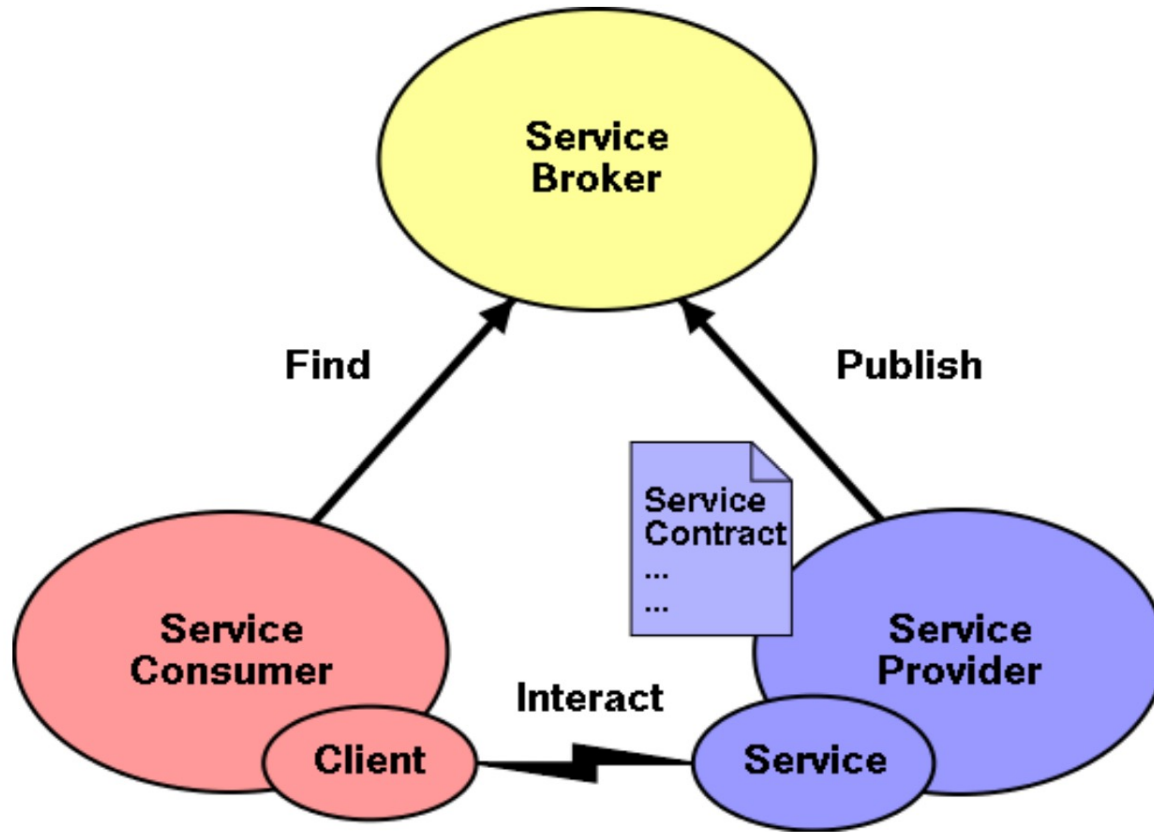
- More moving parts
- Complex infrastructure requirements
- Consistency and availability
- Harder to test

# Service-oriented architecture (SOA)

- ▶ *“Service-oriented architecture (SOA) is a type of software design that makes software components reusable using service interfaces that use a common communication language over a network.”*
- ▶ In briefly, SOA integrates software components that have been separately deployed and maintained and allows them to communicate and work together to form software applications across different systems.



# Service-oriented architecture (SOA)



# Microservices architecture principles

## 1. A microservices has a single concern.

- ▶ Should do one thing and one thing only = Single object responsibility
- ▶ Easier to maintain and scale

## 2. A microservice is a discrete

- ▶ Must clear boundaries separating it from its environment.
- ▶ Must be well-encapsulated
- ▶ Development: Isolated from all other microservices
- ▶ Production: It becomes part of a larger application after deployment

# Microservices architecture principles

## 3. A microservices is transportable.

- ▶ Can be moved from one runtime environment to another
- ▶ Easier to use in an automated or declarative deployment process.

## 4. A microservice carries its own data

- ▶ Should have its own data storage that is isolated from all other microservices.
- ▶ Shared with other microservices by a public interface
- ▶ The common problem is data redundancy.

# Microservices architecture principles

## 5. A microservice is ephemeral

- ▶ It can be created, destroyed, and replenished on demand
- ▶ The standard operating expectation is that microservices come and go all the time, sometimes due to system failure and sometimes due to scaling demands.

# Microservice communication

## 1. Synchronous protocol

- ▶ HTTP/HTTPS
- ▶ The client sends a request and waits for a response from the service
- ▶ Thread is blocked
- ▶ The client code can only continue its task when it receives the HTTP server response.

## 2. Asynchronous protocol

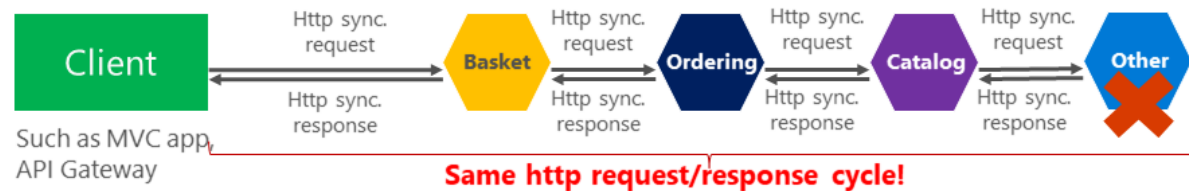
- ▶ AMQP (a protocol supported by many OS and cloud environments)
- ▶ Asynchronous messages
- ▶ The client send message and doesn't wait for a response.
- ▶ RabbitMQ or Kafka is a message queue

# Microservice communication

## Synchronous vs. async communication across microservices

### Anti-pattern

**Synchronous**  
all request/response cycle



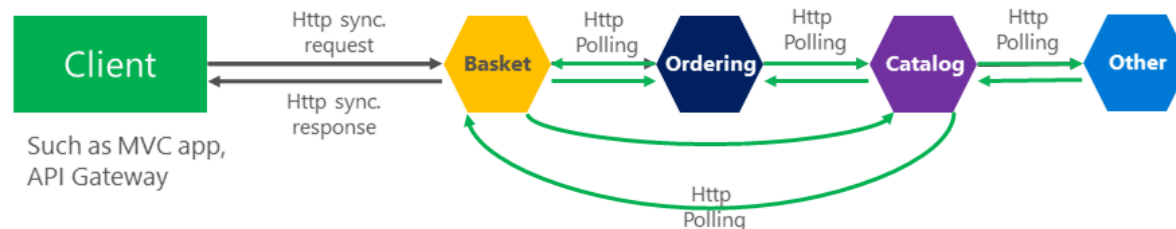
### Asynchronous

Comm. across internal microservices  
(EventBus: like **AMQP**)

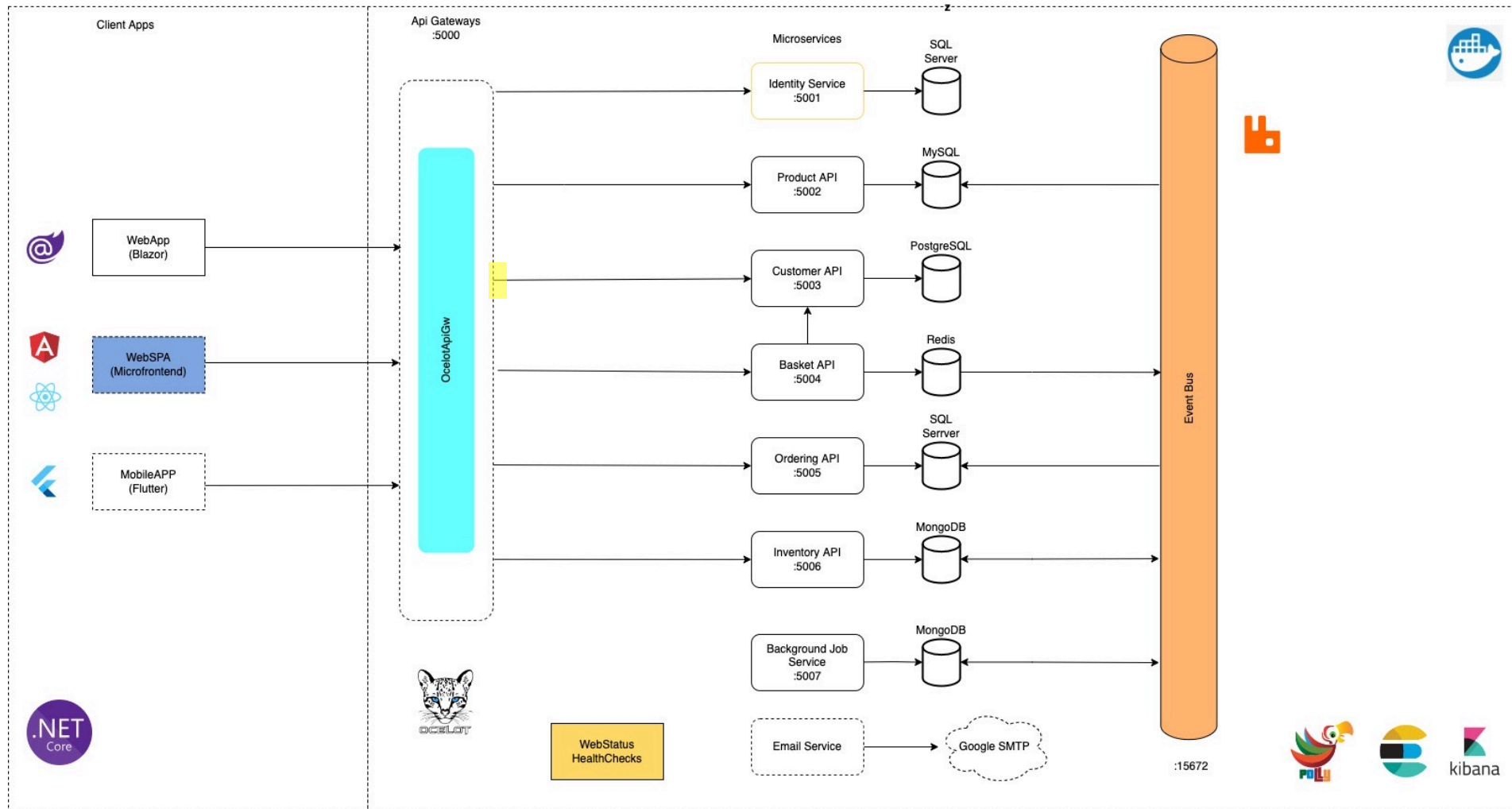


### "Asynchronous"

Comm. across internal microservices  
(Polling: **Http**)



# Tedu aspnetcore Microservices project



aspnetcore-microservices.sln

Solution

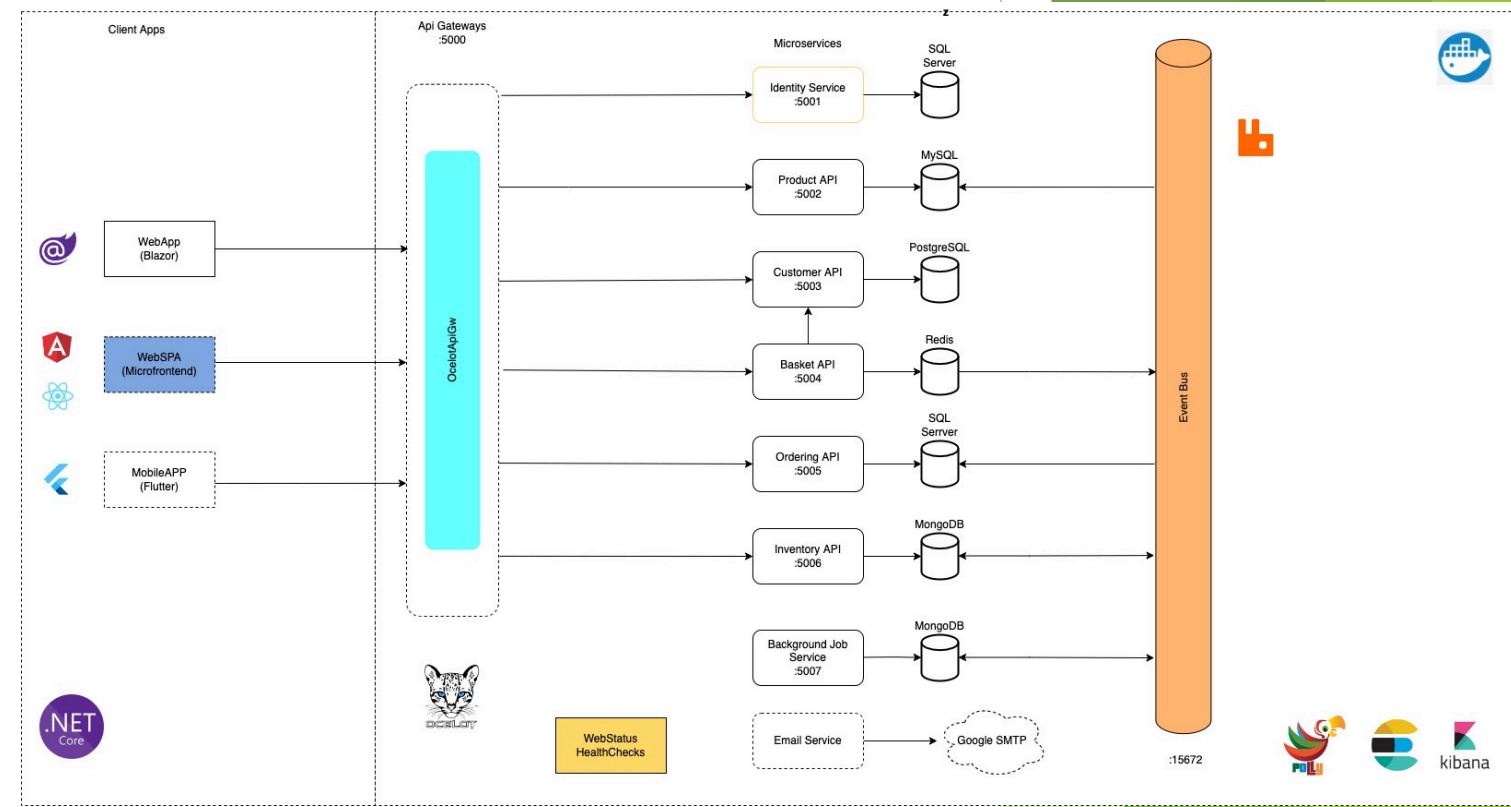
aspnetcore-microservices · 16 projects

Solution Items

- .dockerignore
- docker-compose.yml
- docker-compose.override.yml
- global.json
- README.md
- Tedu-Microservices-Solution\_Architect.jpg

src · 16 projects

- ApiGateways · 1 project
  - OcelotApiGw
- BuildingBlocks · 5 projects
  - Common.Logging
  - Contracts
  - EventBus.Messages
  - Infrastructure
  - Shared
- Services · 9 projects
  - Basket · 1 project
  - Customer · 1 project
  - Inventory · 1 project
  - Ordering · 4 projects
  - Product · 1 project
  - ScheduledJob · 1 project
- WebApps · 1 project





# Solution exploration

- ▶ **Building Blocks:** Including class libraries which defines interfaces, contracts, shared and common methods.
  - ▶ **Common.Logging:** Logging system with Serilog and elasticsearch.
  - ▶ **Contracts:** The blue print of the system, where we can define the common interfaces as: Repository, UnitOfWork... to define our contracts for the whole system.
  - ▶ **EventBus.Message:** Event Bus Message system, AMQP, standardize communication across microservices.
  - ▶ **Infrastructure:** Class library implements from Contracts interface.
  - ▶ **Shared:** Sharing resources, common variables, configurations across microservices.

# Solution exploration

- ▶ Services: Including the microservices of the system.
  - ▶ Basket: Basket API with Redis
  - ▶ Customer: Customer Minimal API with PostgreSQL
  - ▶ Ordering: Ordering API with Clean Architecture and SQL Server
  - ▶ Product: Product API with MySQL
  - ▶ Inventory: Inventory API with MongoDB
  - ▶ ScheduledJob: Hangfire API with MongoDB, background tasks

# Solution exploration

- ▶ WebApps:
  - ▶ WebHealthStatus MVC, presentation health check system.
  - ▶ Microfrontend Client App (not included in this course)

# Section 2

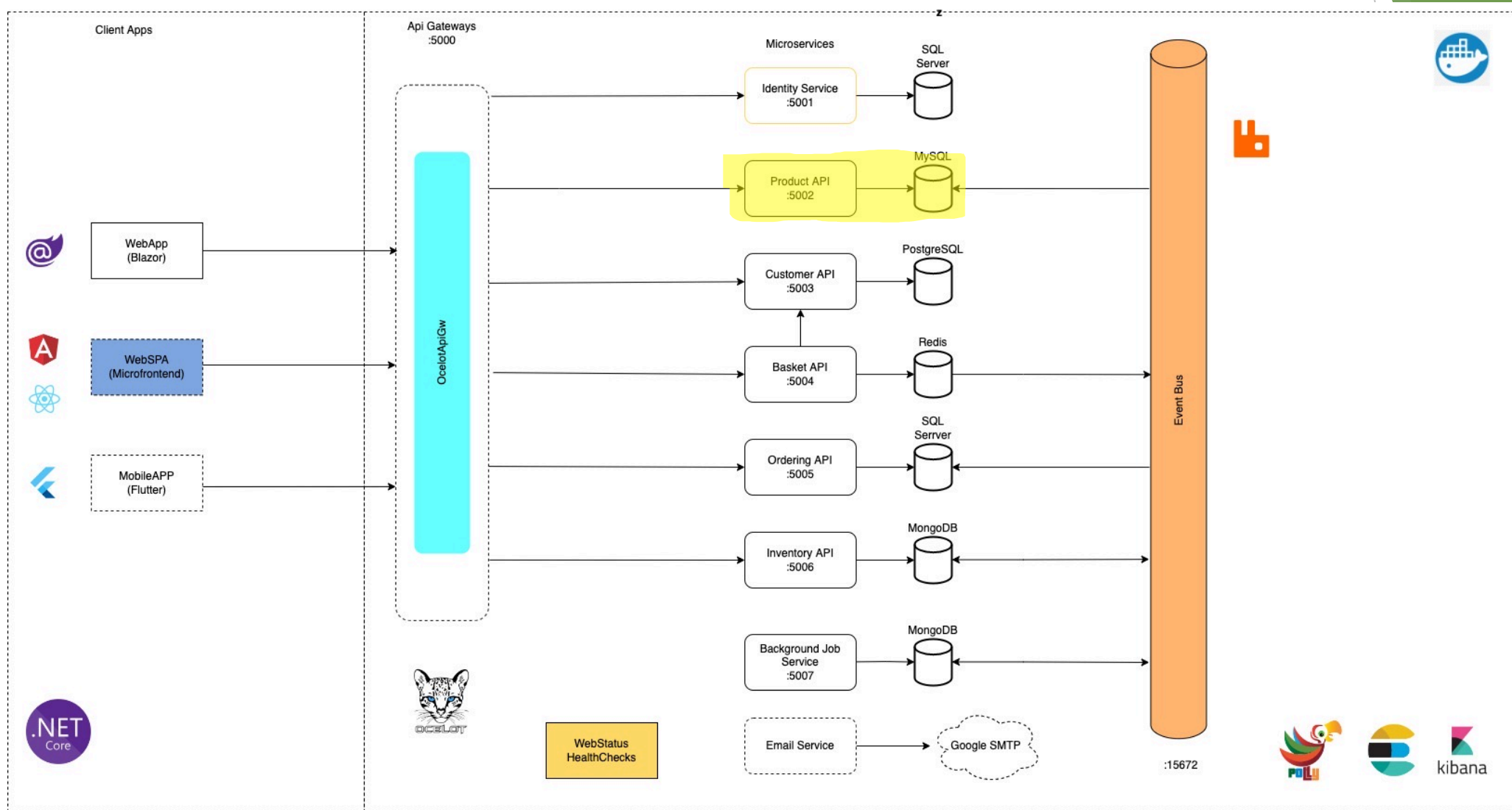
## Product API with MySQL

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# Section 3

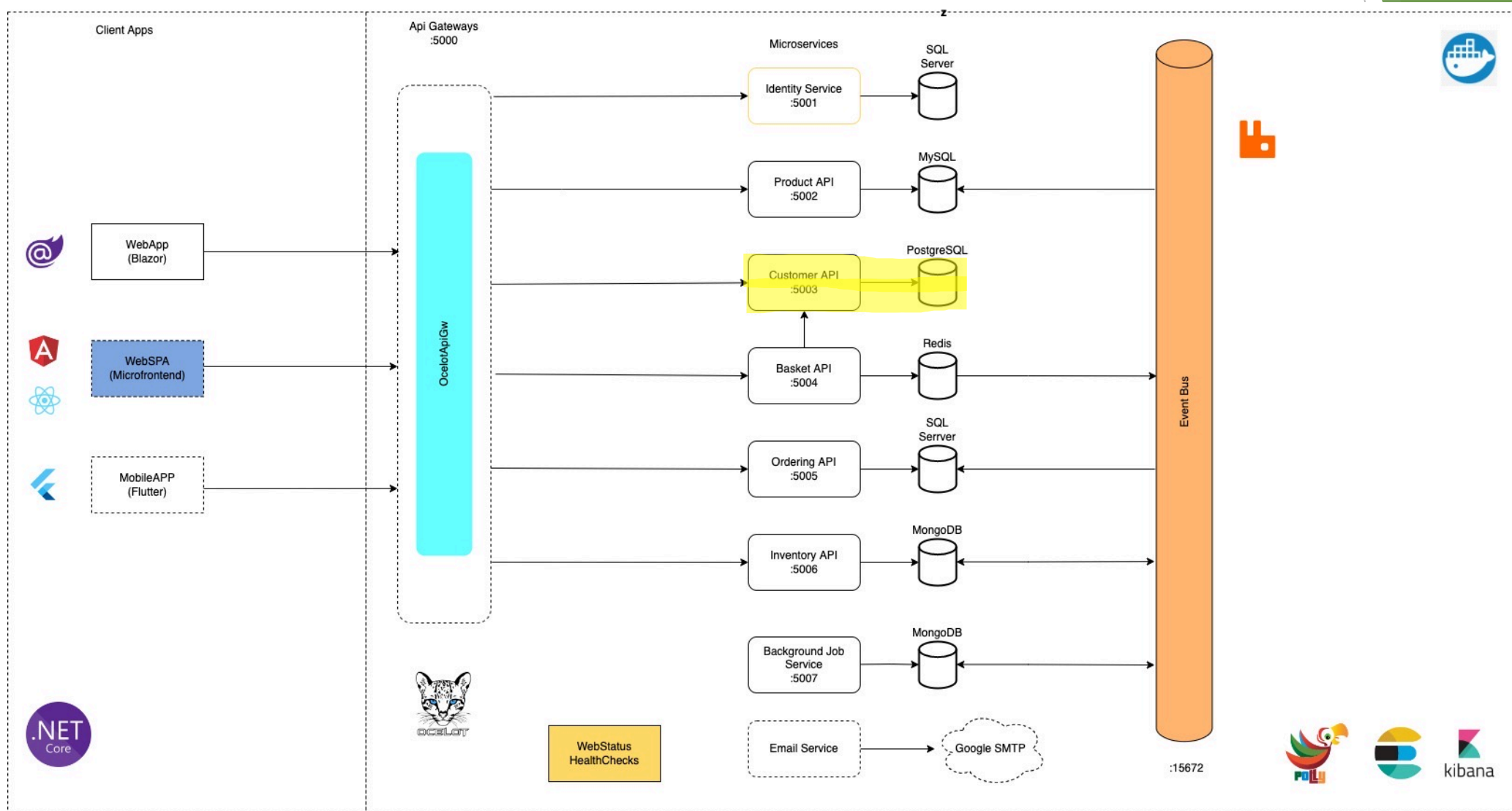
## Customer API with Minimal API & PostgreSQL

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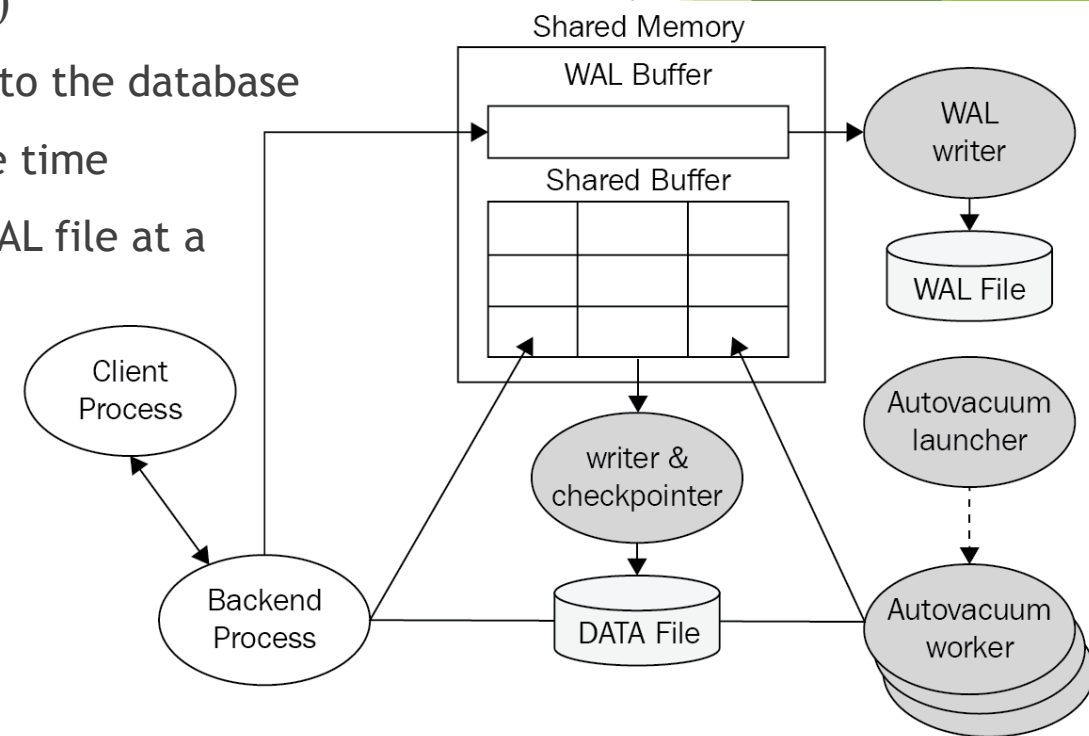
# An overview of PostgreSQL

- ▶ Released in 1994
- ▶ PostgreSQL is an **object-relational database management system (ORDBMS)**
- ▶ A popular **Database as a Service (DBaaS)**
- ▶ PostgreSQL can be delivered as DBaaS on many clouds, such as **Amazon Web Services (AWS)**, Google Cloud SQL, Microsoft Azure, Heroku, and EnterpriseDB Cloud.
- ▶ Open source **license is free**, so developers can easily operate as many databases as they wish without any cost.



# The PostgreSQL architecture

- ▶ Shared memory:
  - ▶ Minimize DISK I/O
  - ▶ Access very large buffers (tens or hundreds of gigabytes) worth) quickly.
  - ▶ The reduction of **write-ahead log (WAL)** (Nhật ký ghi trước)
  - ▶ The WAL buffer is a buffer that temporarily stores changes to the database
  - ▶ Minimize contention when many users access it at the same time
  - ▶ The contents stored in the WAL buffer are written to the WAL file at a predetermined point in time.



# Standout Features:

- ▶ Complex query
- ▶ Trigger
- ▶ View
- ▶ Integrity transactions
- ▶ Multi-version concurrency control (Kiểm tra truy cập đồng thời đa phiên bản)
- ▶ Parallel query
- ▶ Types: JSON/JSONB, XML, Key-Value
- ▶ Point-in-time-recovery - PITR)
- ▶ Authentication: GSSAPI, SSPI, LDAP, SCRAM-SHA-256, Certificate
- ▶ Columns/Rows security
- ▶ Index: B-tree, Multicolumn, Expression, Partial
- ▶ Advanced Index: GiST, SP-Gist, KNN Gist, GIN, BRIN, Bloom filters

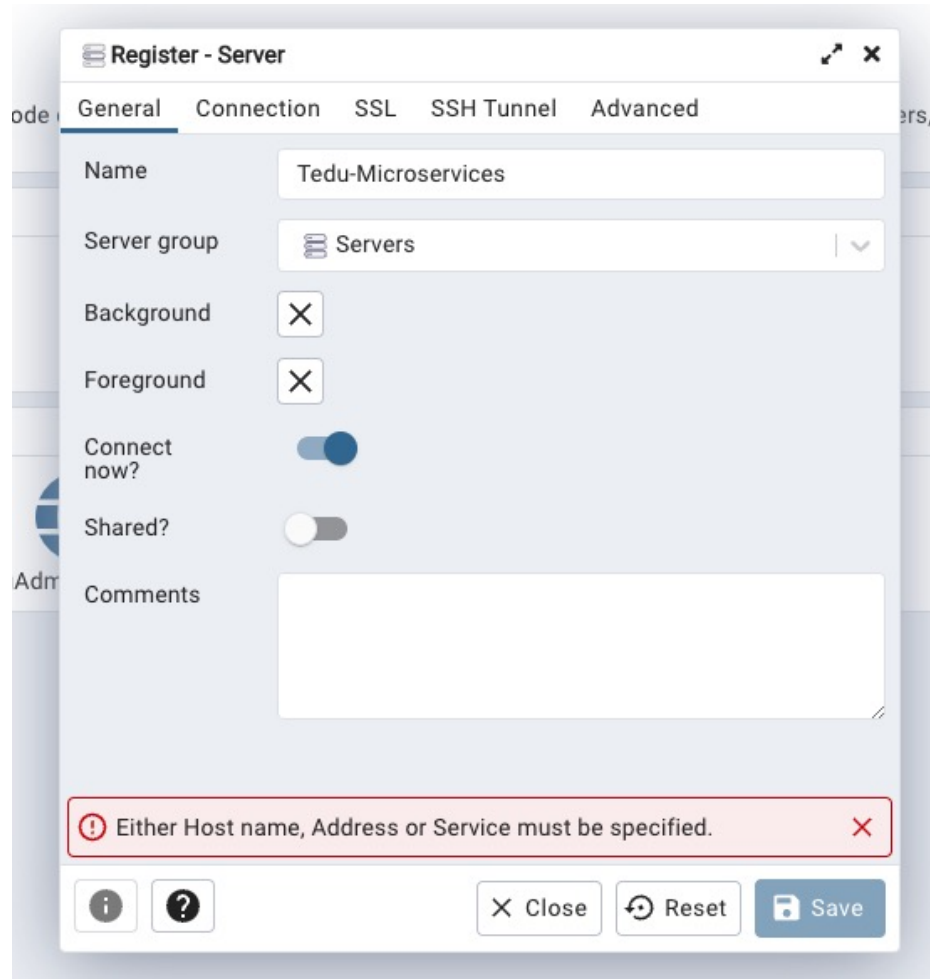
# PgAdmin4

- ▶ <https://www.pgadmin.org/>
- ▶ Download desktop version at: <https://www.pgadmin.org/download/>
- ▶ Or using docker at: <http://localhost:5050> (docker-compose-override.yml file)

```
pgadmin:
  container_name: pgadmin
  environment:
    - PGADMIN_DEFAULT_EMAIL=admin@tedu.com.vn
    - PGADMIN_DEFAULT_PASSWORD=admin1234
  restart: always
  ports:
    - "5050:80"
  volumes:
    - pgadmin_data:/root/.pgadmin
```

# PgAdmin4

- Add new Server



The screenshot shows the 'Register - Server' dialog box in PgAdmin4. The 'General' tab is selected, showing fields for 'Name' (Tedu-Microservices), 'Server group' (Servers), 'Background' (unchecked), 'Foreground' (unchecked), 'Connect now?' (checked), 'Shared?' (unchecked), and 'Comments'. A red error message at the bottom states: 'Either Host name, Address or Service must be specified.' The dialog has buttons for 'Close', 'Reset', and 'Save'.

Register - Server

General Connection SSL SSH Tunnel Advanced

Name Tedu-Microservices

Server group Servers

Background ☐

Foreground ☐

Connect now? ☒

Shared? ☐

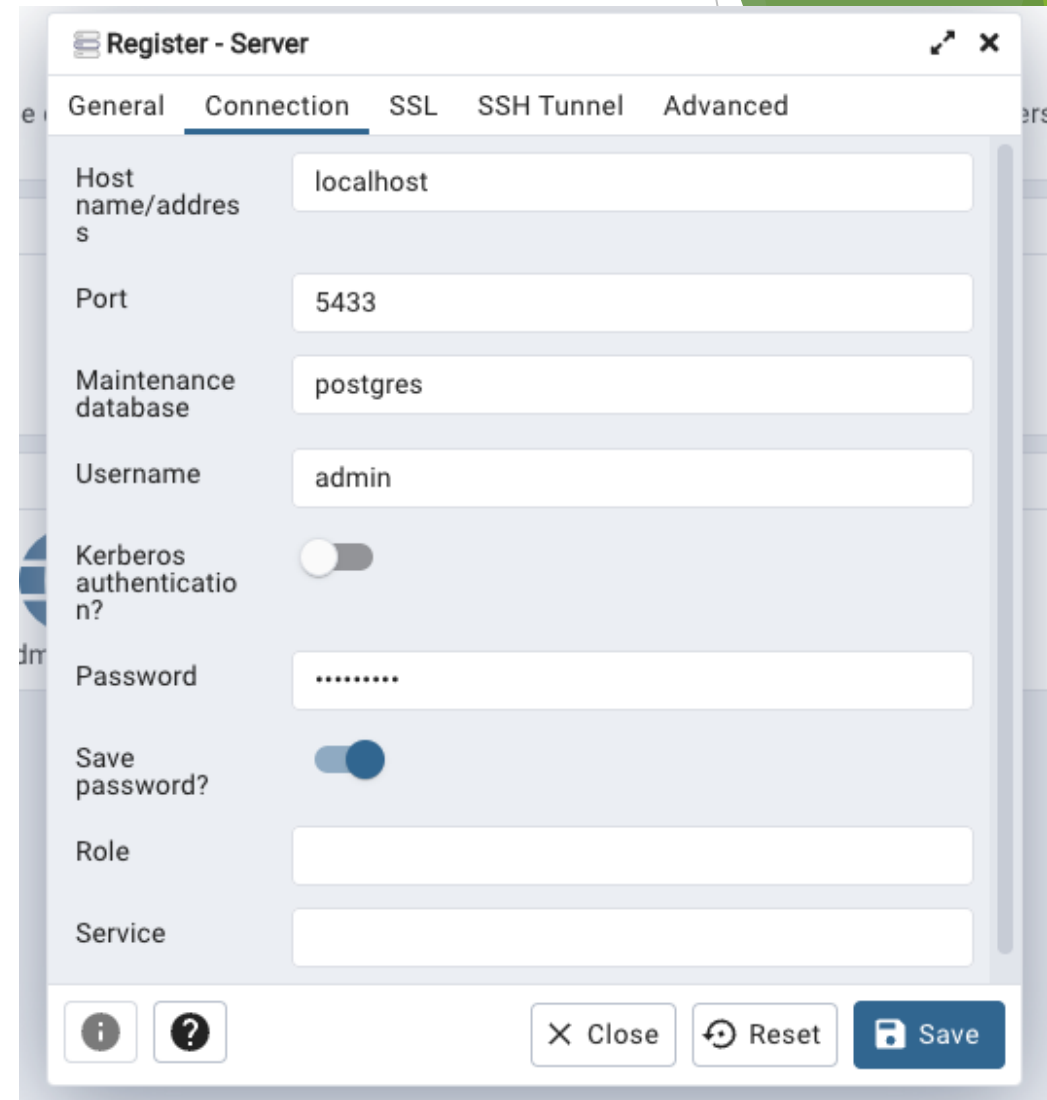
Comments

Either Host name, Address or Service must be specified.

Close Reset Save

# PgAdmin4

- ▶ Connection (docker-compose.override.yml)
- ▶ Username: admin
- ▶ Password: admin1234



The image shows the 'Register - Server' dialog box in PgAdmin4, with the 'Connection' tab selected. The dialog contains the following fields and controls:

- Host name/address:** localhost
- Port:** 5433
- Maintenance database:** postgres
- Username:** admin
- Kerberos authentication?:** ☐
- Password:** ..... (masked)
- Save password?:** ☒
- Role:** (empty field)
- Service:** (empty field)

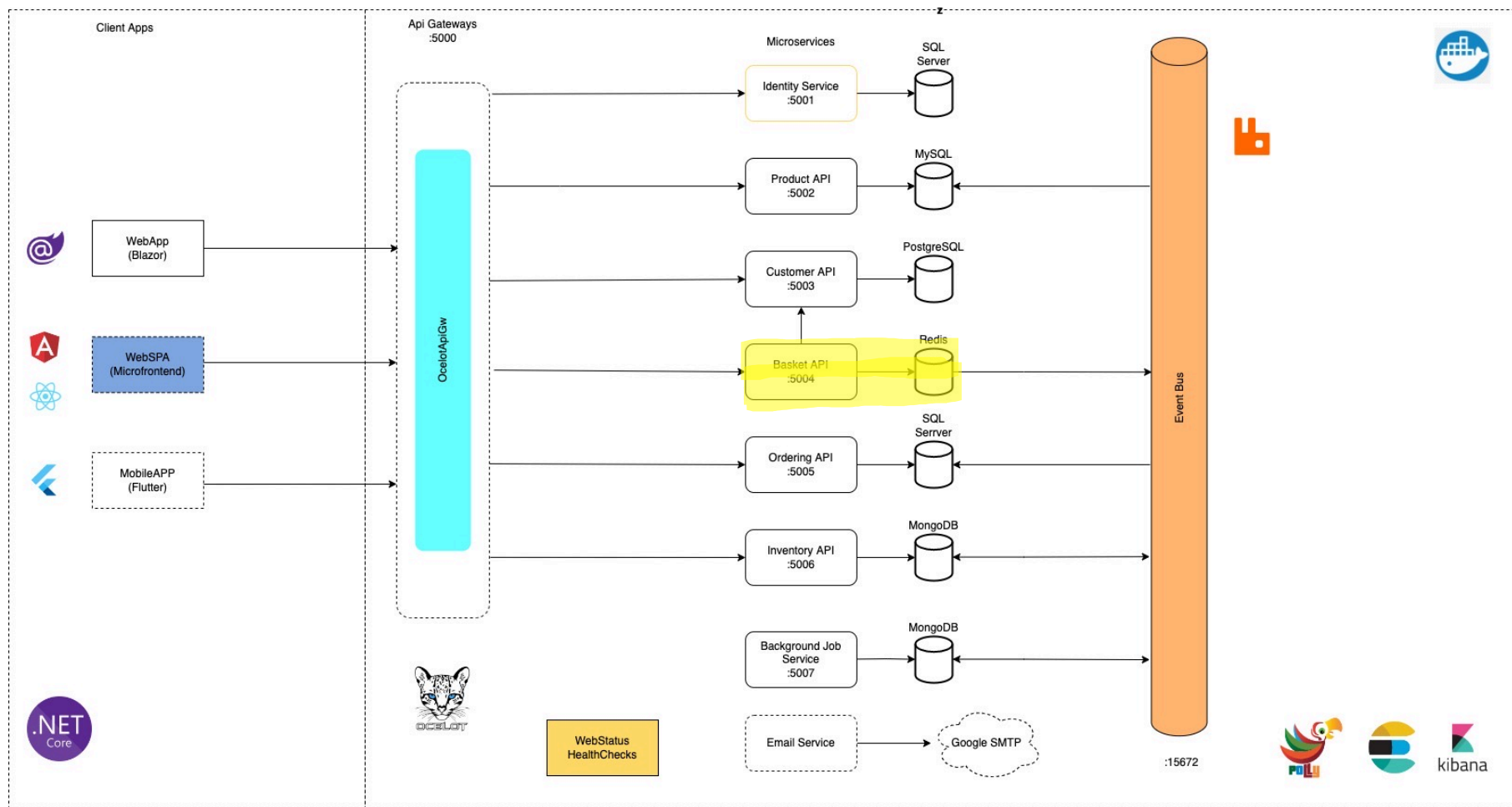
At the bottom of the dialog, there are three buttons: 'Close' (with an 'X' icon), 'Reset' (with a circular arrow icon), and 'Save' (with a floppy disk icon). There are also information and help icons on the left.

# Section 4

## Basket API with Redis



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# An overview of Redis

- ▶ Redis' name comes from “**RE**mote **D**ictionary **S**erver”.
- ▶ a fast in-memory database and cache
- ▶ Open source
- ▶ Redis is often called a data structure server because its core data types are similar to those found in programming languages like: strings, lists, dictionaries (or hashes), sets, and sorted sets.
- ▶ Ideal for rapid development and fast applications, as core data structures are easily shared between processes and services.



# Primarily Use cases

## ▶ **Intelligent Caching**

- ▶ Redis is commonly used as a cache to store frequently accessed data in memory so that applications can be responsive to users.
- ▶ You can easily to configure: how long you want to keep data, and which data to evict first,

## ▶ **Data Expiration and Eviction Policies**

- ▶ Data structures in Redis can be marked with a Time To Live (TTL) set in seconds, after which they will be removed.

## ▶ **Publication and Subscription Messaging (Pub/Sub)**

- ▶ Pub/Sub messaging allows for messages to be passed to channels and for all subscribers to that channel to receive that message.

# Primarily Use cases

## ▶ Session Management

- ▶ Session state is data that captures the current status of user interaction with applications such as a website or a game.
- ▶ Session state is how apps remember user identity, login credentials, personalization information, recent actions, shopping cart, and more.
- ▶ The session state is cached data for a specific user or application that allows fast response to user actions.
- ▶ While the session is live, the application reads from and writes to the in-memory session store exclusively.

# Exploring Redis with the CLI

- ▶ Start redis server: “**redis-server**”
- ▶ Start redis cli: “**redis-cli**”
- ▶ check redis with ping command: “ping”
- ▶ Set key: “**SET** {key} {value}”
- ▶ Get key: “**GET** {key}”
- ▶ Increase value of key to 1: “**INCR** {key}”
- ▶ Decrease value of key to 1: “**DECR** {key}”
- ▶ Create a list: “**LPUSH** {key} {value1 value2 ...}”
- ▶ Retrieve the value of list index: “**LINDEX** {key} {index}”
- ▶ Retrieve the range of items: “**LRANGE** {key} 0 -1” (The -1 means ”to the end of the list”)

# Section 5

## Order API with SQL Server Clean Architecture & CQRS

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# SOLID

- ▶ What is SOLID?
  - ▶ **S**: Single Responsibility Principle
  - ▶ **O**: Open/Closed Principle
  - ▶ **L**: Liskov Substitution Principle
  - ▶ **I**: Interface Segregation Principle
  - ▶ **D**: Dependency Inversion Principle

# Single Responsibility Principle (SRP)

- ▶ A class should have one and only one responsibility.
- ▶ SRP makes the classes compact and neat where each one is responsible for a single problem, task, or concern.



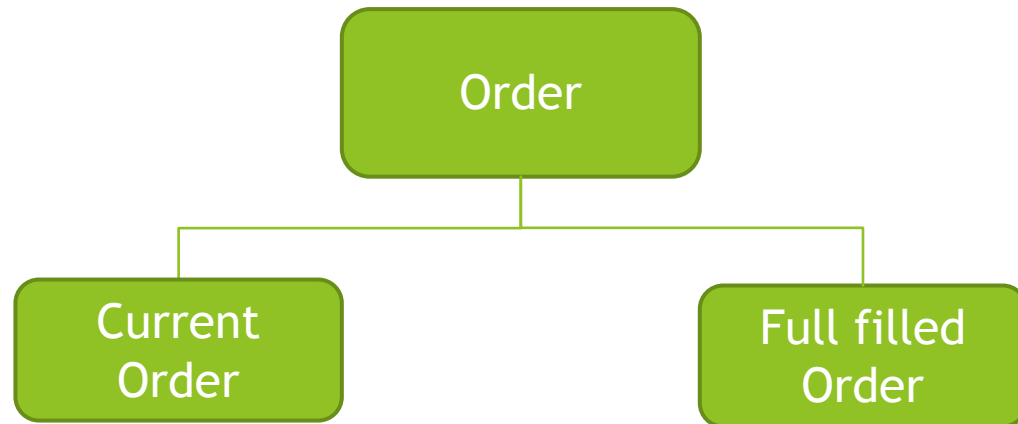
Basket

Logging

Order

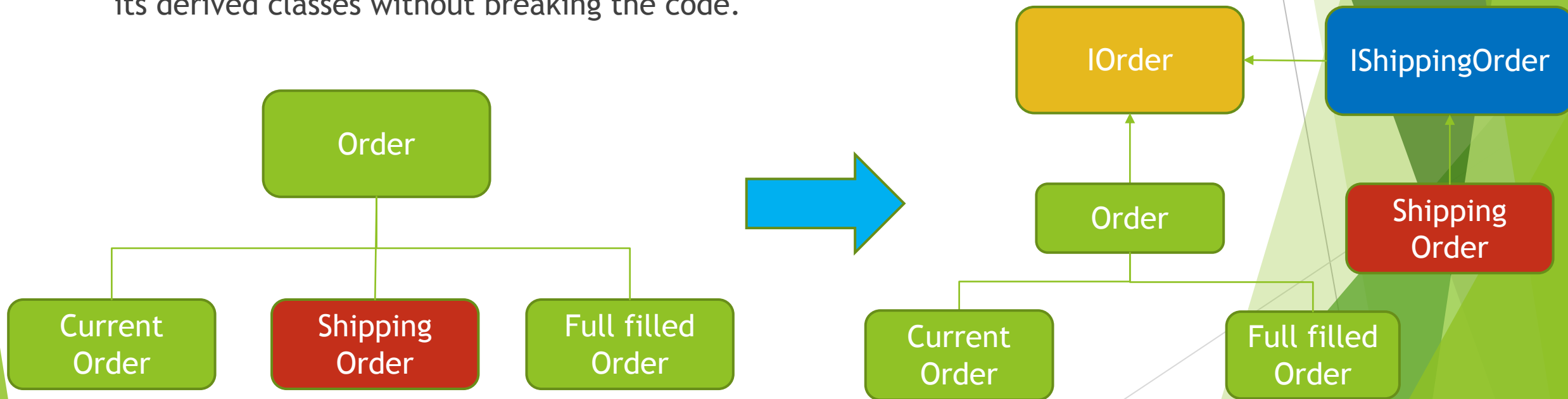
# Open/Closed Principle (OCP)

- ▶ Open for extension but closed for modification.
- ▶ CLOSED => once a class has been developed and tested, the code should only be changed to correct bugs.
- ▶ OPEN => a class should be able to extend to introduce new functionalities. In this way, you need to test only the newly created class.



# Liskov Substitution Principle (LSP)

- ▶ Derived classes must be able to substitute any object for their base classes.
- ▶ To be more simpler, objects of a parent class can be replaced with objects of its derived classes without breaking the code.





# Interface Segregation Principle (ISP)

- ▶ Clients of your class should not be forced to depend on methods they do not use.
- ▶ Similar to the SRP, the goal of ISP is to reduce the side effects and frequency of required changes by splitting the code into multiple, independent parts.

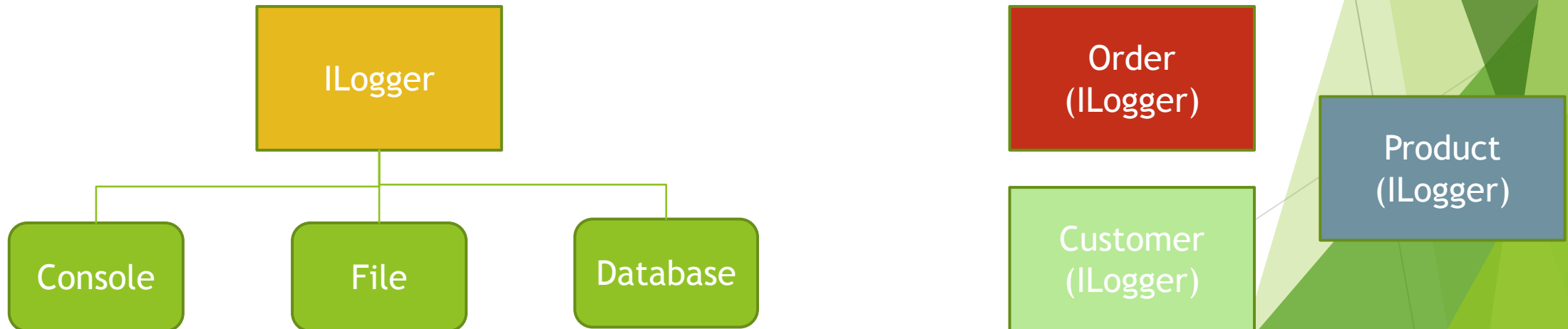
```
interface OrderService {  
    void orderBurger(int quantity);  
    void orderFries(int fries);  
    void orderCombo(int quantity, int fries);  
}
```



```
interface BurgerOrderService {  
    void orderBurger(int quantity);  
}  
  
interface FriesOrderService {  
    void orderFries(int fries);  
}
```

# Dependency Inversion Principle (DIP)

- ▶ High-level modules should not depend on low-level modules. They should depend on abstract classes or interfaces instead.
- ▶ Splits the dependency between the high-level and low-level modules by introducing abstraction between them.
- ▶ => The Dependency Injection pattern is an implementation of this principle.

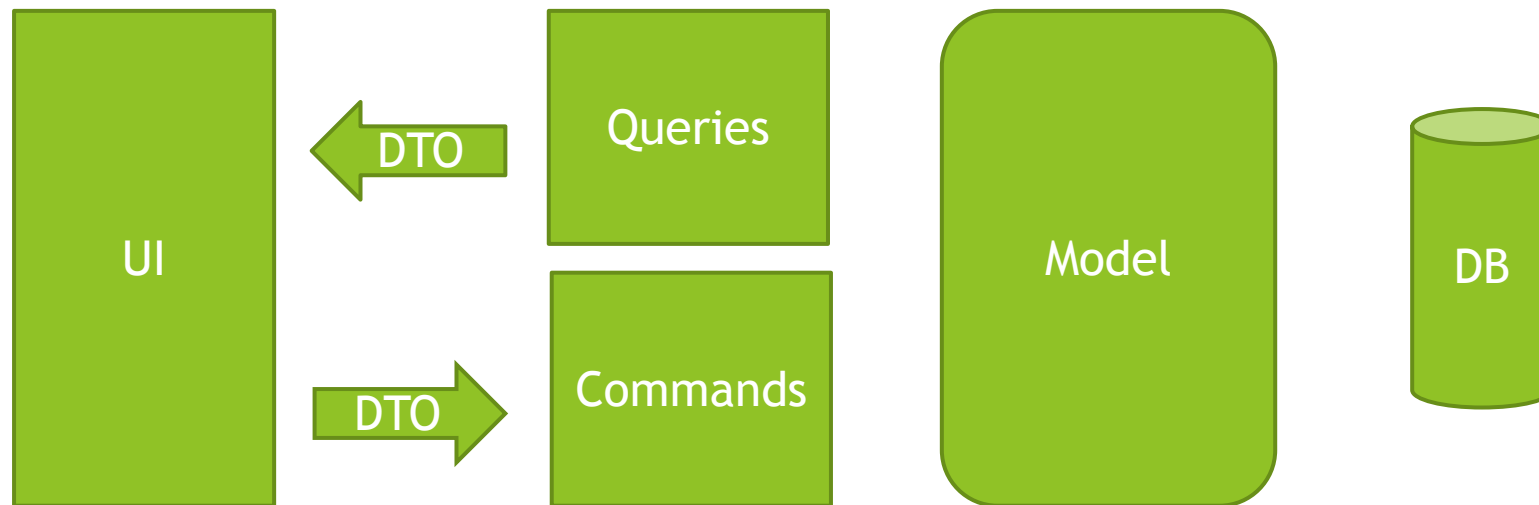


# Command Query Responsibility Segregation (CQRS)

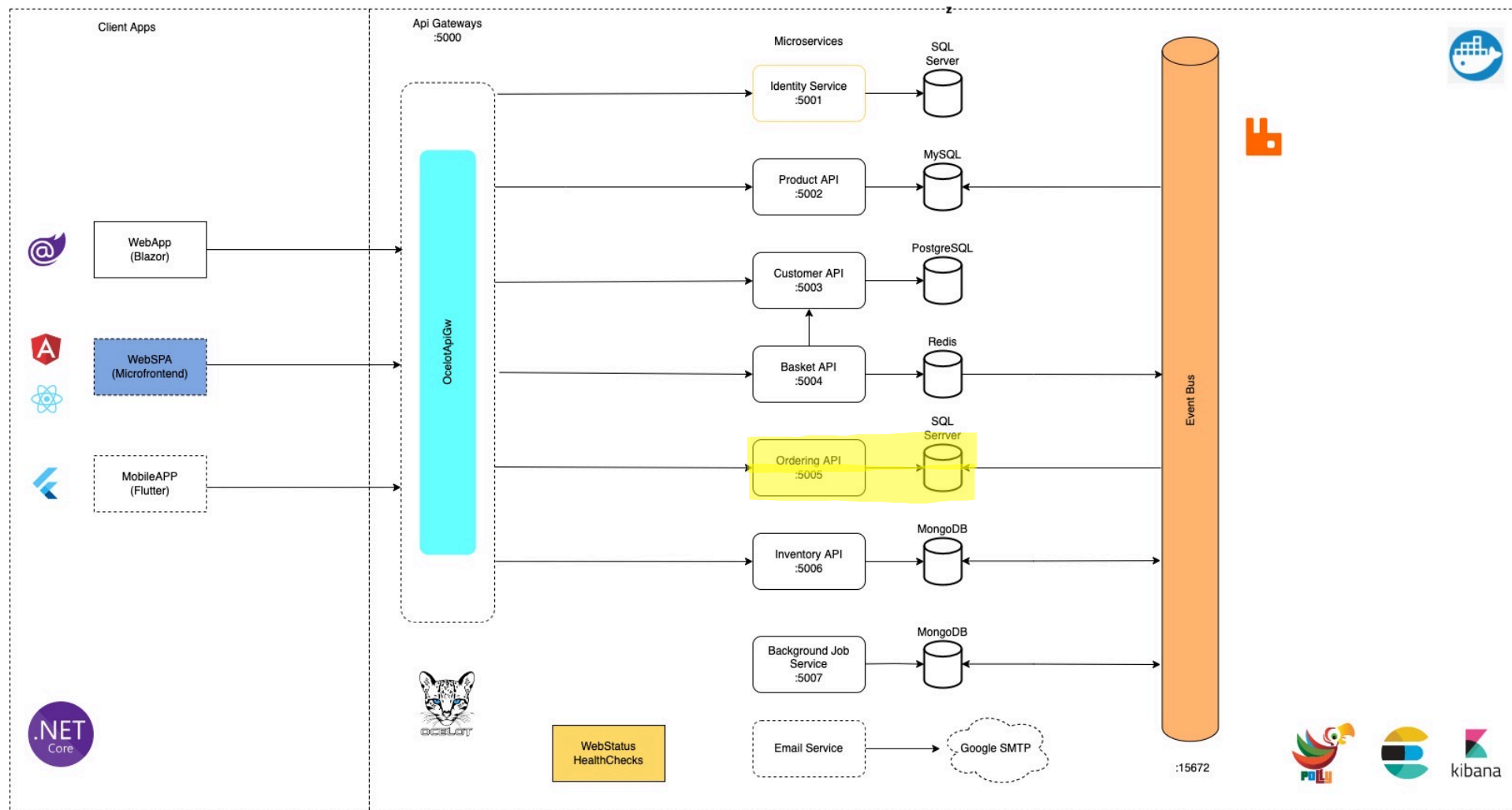
- ▶ Command: Write data (CREATE, UPDATE, DELETE)
- ▶ Query: Read data (READ)



# Command Query Responsibility Segregation (CQRS)



# Command Query Responsibility Segregation (CQRS)



# Section 6

## Microservices Communication

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# Microservice communication

## 1. Synchronous protocol

- ▶ HTTP/HTTPS
- ▶ The client sends a request and waits for a response from the service
- ▶ Thread is blocked
- ▶ The client code can only continue its task when it receives the HTTP server response.

## 2. Asynchronous protocol

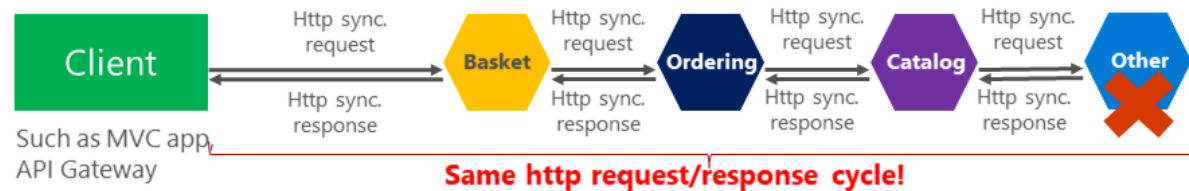
- ▶ AMQP (a protocol supported by many OS and cloud environments)
- ▶ Asynchronous messages
- ▶ The client send message and doesn't wait for a response.
- ▶ RabbitMQ or Kafka is a message queue

# Microservice communication

## Synchronous vs. async communication across microservices

### Anti-pattern

**Synchronous**  
all request/response cycle



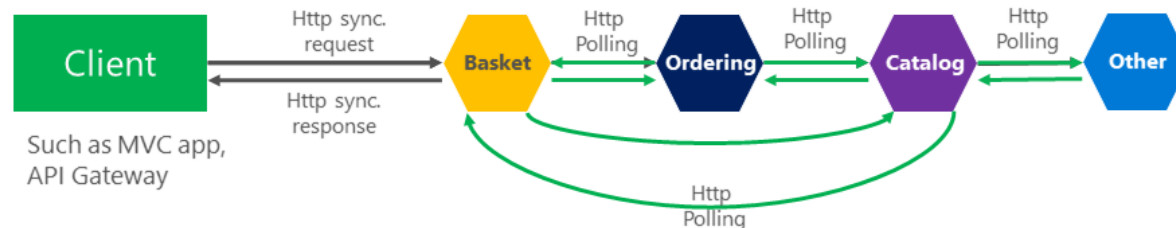
### Asynchronous

Comm. across internal microservices  
(EventBus: like **AMQP**)



### "Asynchronous"

Comm. across internal microservices  
(Polling: **Http**)





# MassTransit

- ▶ MassTransit is a free, open-source distributed application framework for .NET
- ▶ MassTransit makes it easy to create applications and services that leverage message-based, loosely-coupled asynchronous communication for higher availability, reliability, and scalability.
- ▶ => To build durable asynchronous services.



# MassTransit

- ▶ Simple yet Sophisticated
  - ▶ Easy to use and understand API allowing you to focus on solving business problems
- ▶ Transport Liquidity
  - ▶ Deploy your solution using RabbitMQ, Azure Service Bus, ActiveMQ, and Amazon SQS/SNS without having to rewrite it
- ▶ Powerful Message Patterns
  - ▶ Including message consumers, persistent sagas and event-driven state machines, and routing-slip based distributed transactions with compensation
- ▶ End-to-End Solution
  - ▶ Handles message serialization, headers, broker topology, message routing, exceptions, retries, concurrency, connection and consumer lifecycle management



# MassTransit

- ▶ A **Message** in MassTransit is just a Plain Old CLR Object or POCO for short. These can be a Class, Interface, or a Record.
- ▶ A **Consumer** is a .Net class that implements `IConsumer<T>` and is somewhat similar to an ASP.Net Controller but with only a single action. These are registered using the `AddConsumer` method on the MassTransit Configuration Builder. The consumer is added as a Scoped Lifetime.



# MassTransit

- ▶ Transport:
  - ▶ In Memory: A dependency free way to get started, but not for production use
  - ▶ RabbitMQ: A high performance transport that allows both cloud based and local development
  - ▶ Azure Service Bus: Use the power of Azure
  - ▶ SQS: Use the power of AWS



# RabbitMQ



- ▶ The most widely deployed open source message broker.
- ▶ RabbitMQ is lightweight and easy to deploy on premises and in the cloud.
- ▶ It supports multiple messaging protocols.
- ▶ RabbitMQ can be deployed in distributed and federated configurations to meet high-scale, high-availability requirements.

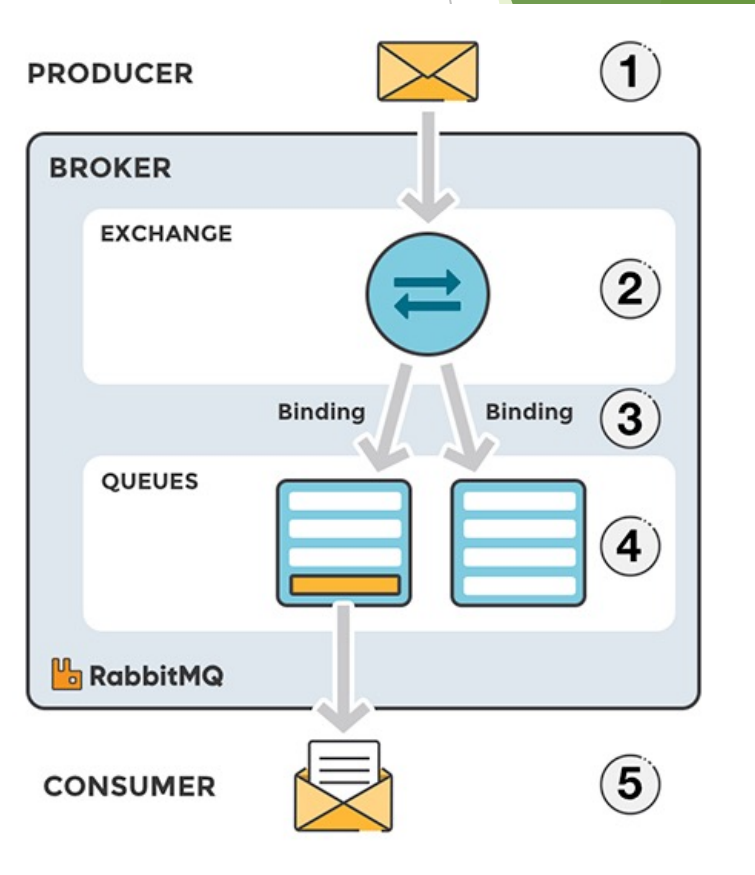
# Common Concepts



- ▶ **Producer:** producer is no more than an user application that produces message(s)
- ▶ **Consumer:** similarly, consumer is also an user application that consumes message(s)
- ▶ **Message:** information that is sent from producers to consumers.
- ▶ **Queue:** a place to store message until consumer(s) can process
- ▶ **Exchange:** a place that receives message(s) published by producer(s) and push to the queue(s) depending on rules of each queue.
- ▶ **Binding:** responsible for creating link between **exchange** and **queue**
- ▶ **Routing key:** a kind of key that exchange uses which queue to send message to.
- ▶ **Vhost:** provides a way to segregate applications using the same RabbitMQ instance. RabbitMQ vhosts creates a logical group of connections, exchanges, queues, bindings, user permissions, etc. within an instance.

# Standard RabbitMQ message flow

1. The producer publishes a message to the exchange.
2. The exchange receives the message and is now responsible for the routing of the message.
3. Binding must be set up between the queue and the exchange. In this case, we have bindings to two different queues from the exchange. The exchange routes the message into the queues.
4. The messages stay in the queue until they are handled by a consumer.
5. The consumer handles the message.

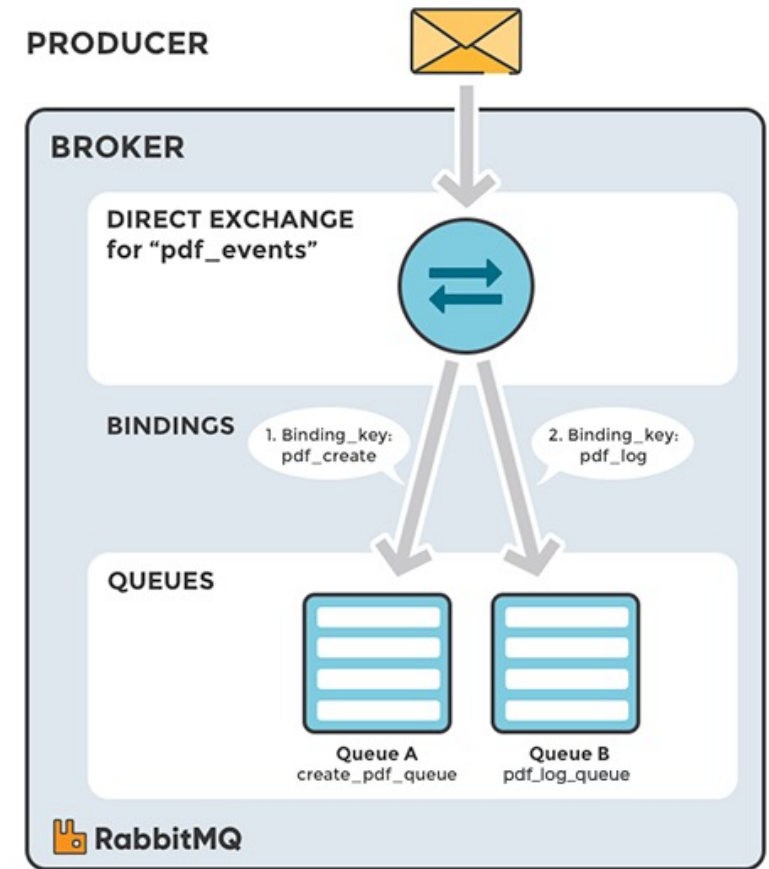


# Exchange types

## ► Direct Exchange

- A direct exchange delivers messages to queues based on a message routing key.
- The routing key is a message attribute added to the message header by the producer.
- Think of the routing key as an "address" that the exchange is using to decide how to route the message. **A message goes to the queue(s) with the binding key that exactly matches the routing key of the message.**

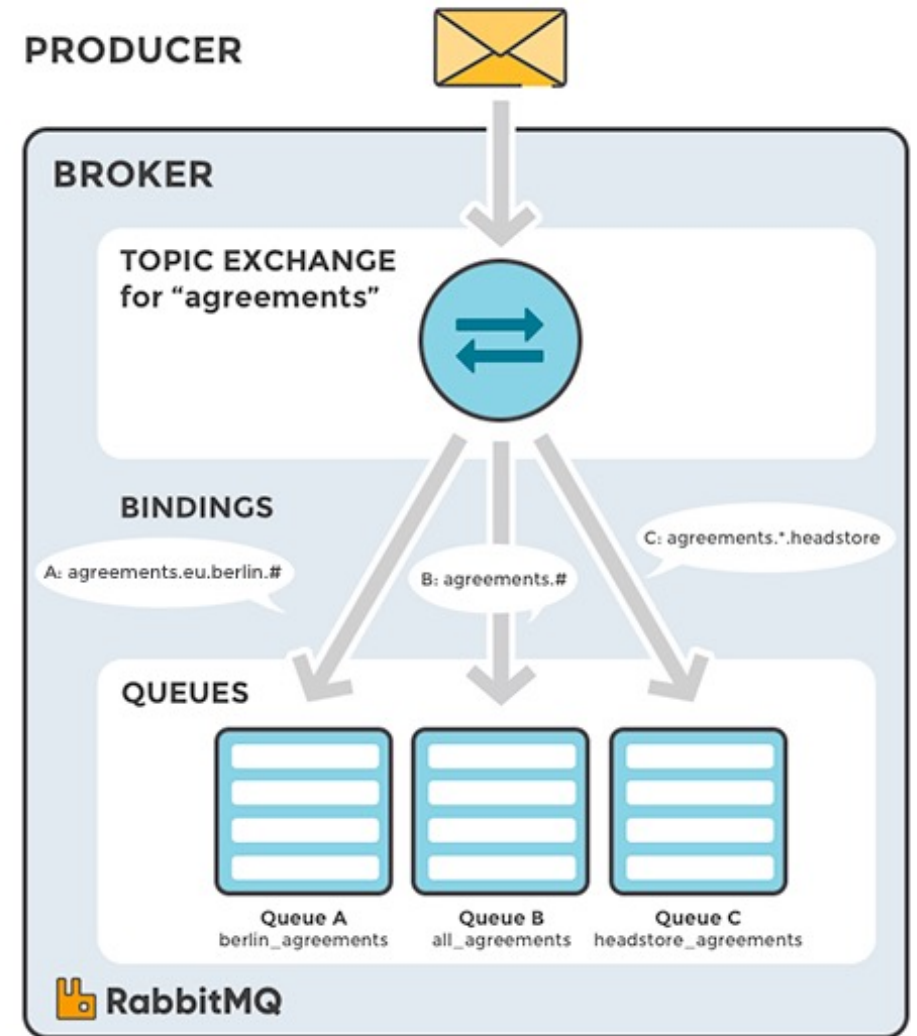
=> "The direct exchange type is useful to distinguish messages published to the same exchange using a simple string identifier."





# Exchange types

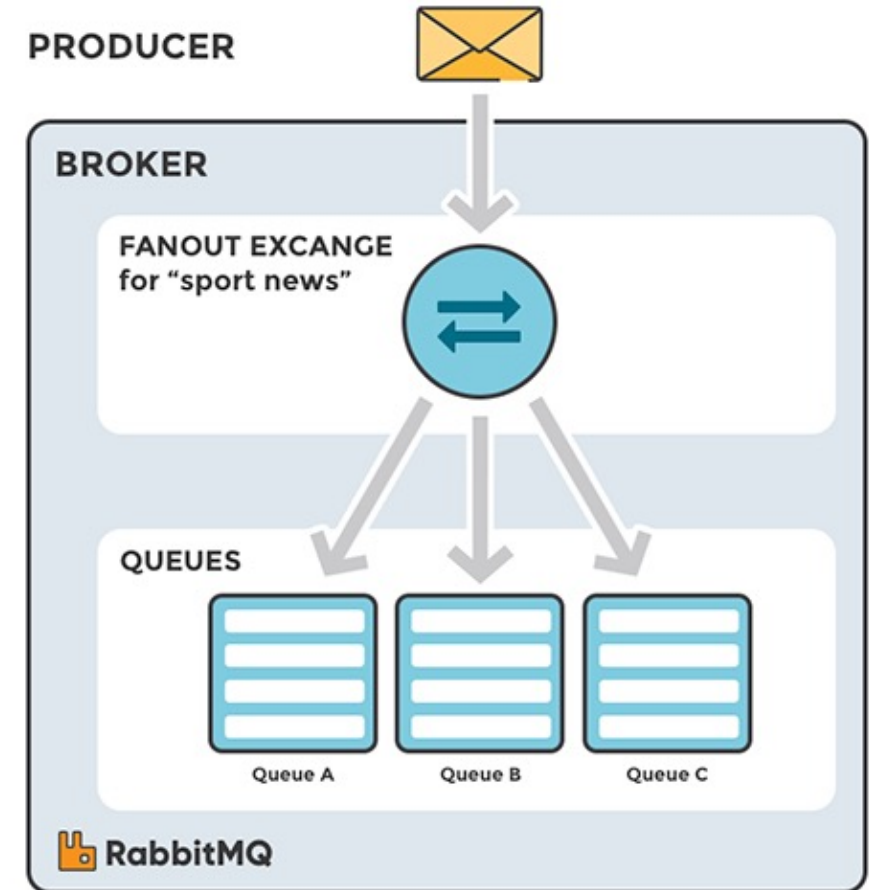
- **Topic Exchange**
  - Route messages to queues based on wildcard matched between the **routing key** and the **routing pattern**
  - The routing patterns may contain an asterisk ("\*")



# Exchange types

## ► Fanout Exchange

- Copies and routes a received message to all queues that are bound to it regardless of routing keys or pattern matchings as with direct and topic exchanges.
- The same message needs to be sent to one or more queues



# Exchange types

## ► Headers Exchange

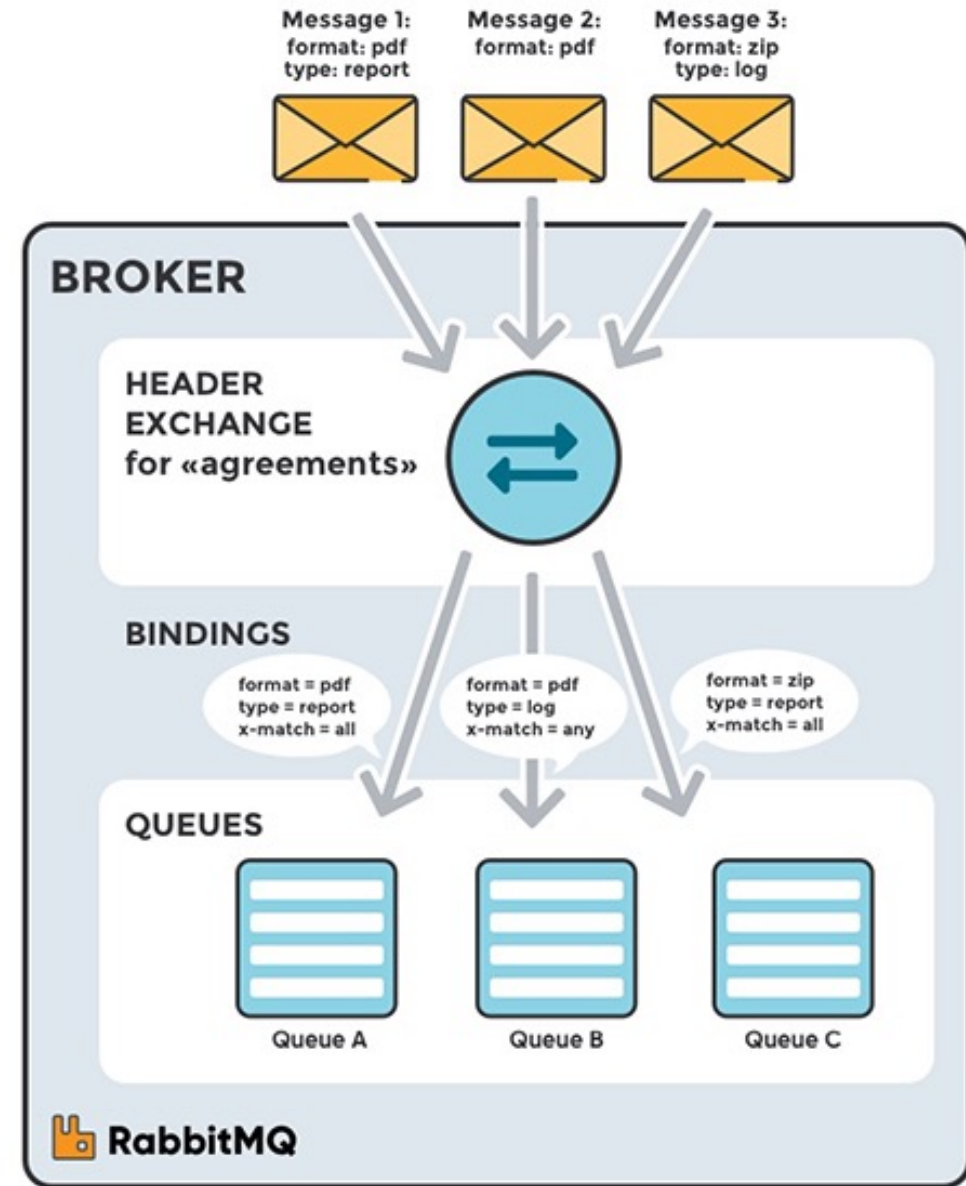
- Based on arguments containing headers and optional values.
- Very similar to topic exchanges, but route messages based on header values instead of routing keys.

Message 1: Delivered to Queue A and Queue B

Message 2: Delivered to Queue B

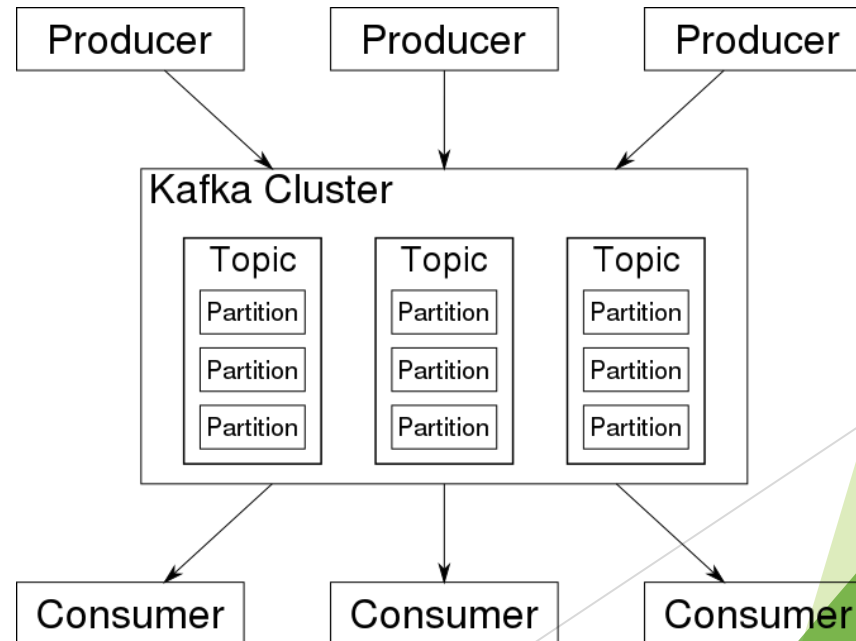
Message 3: Delivered to Queue B

Queue C doesn't receive any of the messages



# Apache Kafka

- What is Apache Kafka?
  - Kafka is a message bus developed for high-ingress data replay and streams. Kafka is a durable message broker that enables applications to process, persist, and re-process streamed data. Kafka has a straightforward routing approach that uses a routing key to send messages to a topic.



# Apache Kafka vs RabbitMQ

Tool	Apache Kafka	RabbitMQ
Message ordering	provides message ordering thanks to its partitioning. Messages are sent to topics by message key.	Not supported.
Message lifetime	Kafka is a log, which means that it retains messages by default. You can manage this by specifying a retention policy.	RabbitMQ is a queue, so messages are done away with once consumed, and acknowledgment is provided.
Delivery Guarantees	Retains order only inside a partition. In a partition, Kafka guarantees that the whole batch of messages either fails or passes.	Doesn't guarantee atomicity, even in relation to transactions involving a single queue.
Message priorities	N/A	In RabbitMQ, you can specify message priorities and consume message with high priority first.