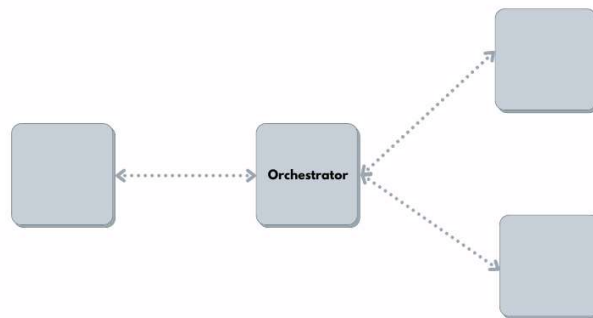


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Saga Pattern



Orchestration Saga Pattern With Spring Boot

27 Comments / Architectural Design Pattern, Architecture, Articles, Data Stream / Event Stream, Design Pattern, Java, Kafka, Kubernetes Design Pattern, MicroService, Reactive Programming, Reactor, Spring, Spring Boot, Spring WebFlux / By vlns / January 30, 2022

Overview:

In this tutorial, I would like to show you a simple implementation of **Orchestration Saga Pattern with Spring Boot**.

Over the years, Microservices have become very popular. Microservices are distributed systems. They are smaller, modular, easy to deploy and scale etc.

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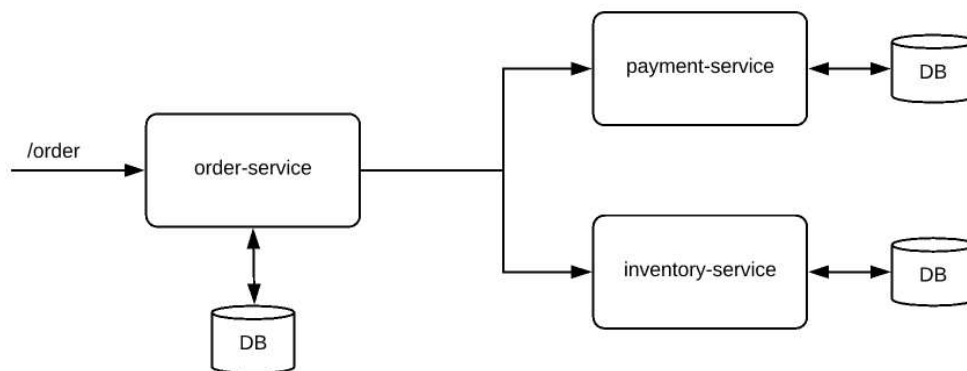
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Developing a single Microservice application might be interesting! But handling a business transaction which spans across multiple Microservices is not fun! In order to complete an application workflow / a task, multiple Microservices might have to work together.

Let's see how difficult it could be in dealing with transactions / data consistency in the distributed systems in this article & how **Orchestration Saga Pattern** could help us.

A Simple Transaction:

Let's assume that our business rule says, when a user places an order, order will be fulfilled if the product's price is within the user's credit limit/balance & the inventory is available for the product. Otherwise it will not be fulfilled. It looks really simple. This is very easy to implement in a monolith application. The entire workflow can be considered as 1 single transaction. It is easy to commit / rollback when everything is in a single DB. With distributed systems with multiple databases, It is going to be very complex! Let's look at our architecture first to see how to implement this.



We have below Microservices with its own DB.

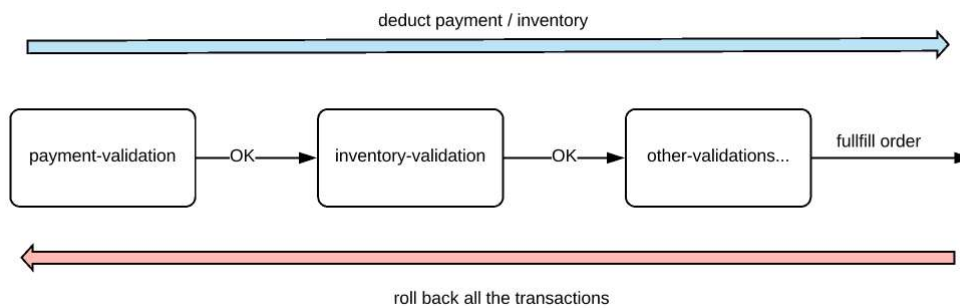
- **order-service**
- **payment-service**
- **inventory-service**

When the order-service receives the request for the new order, It has to check with the payment-service & inventory-service. We deduct the payment, inventory and fulfill the order finally! What will happen if we

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deducted payment but if inventory is not available? How to roll back? It is difficult when multiple databases are involved.



Saga Pattern:

Each business transaction which spans multiple microservices are split into micro-service specific local transactions and they are executed in a sequence to complete the business workflow. It is called Saga. It can be implemented in 2 ways.

- **Choreography approach**
- **Orchestration approach**

In this article, we will be discussing the Orchestration based saga. For more information on Choreography based saga, check [here](#).

Orchestration Saga Pattern:

In this pattern, we will have an orchestrator, a separate service, which will be coordinating all the transactions among all the Microservices. If things are fine, it makes the order-request as complete, otherwise marks that as cancelled.

Let's see how we could implement this. Our sample architecture will be more or less like this.!

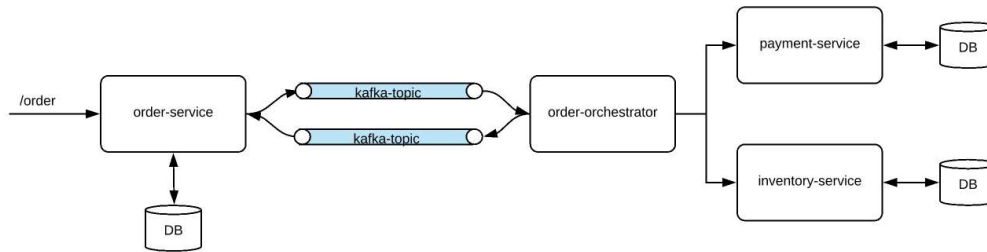
- In this demo, communication between orchestrator and other services would be a simple HTTP in a non-blocking asynchronous way to make this stateless.

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- We can also use Kafka topics for this communication. For that we have to use [scatter/gather pattern](#) which is more of a stateful style.



Common DTOs:

- First I create a Spring boot multi module maven project as shown below.



- I create common DTOs/models which will be used across all the microservices. (I would suggest you to follow [this approach](#) for DTOs)

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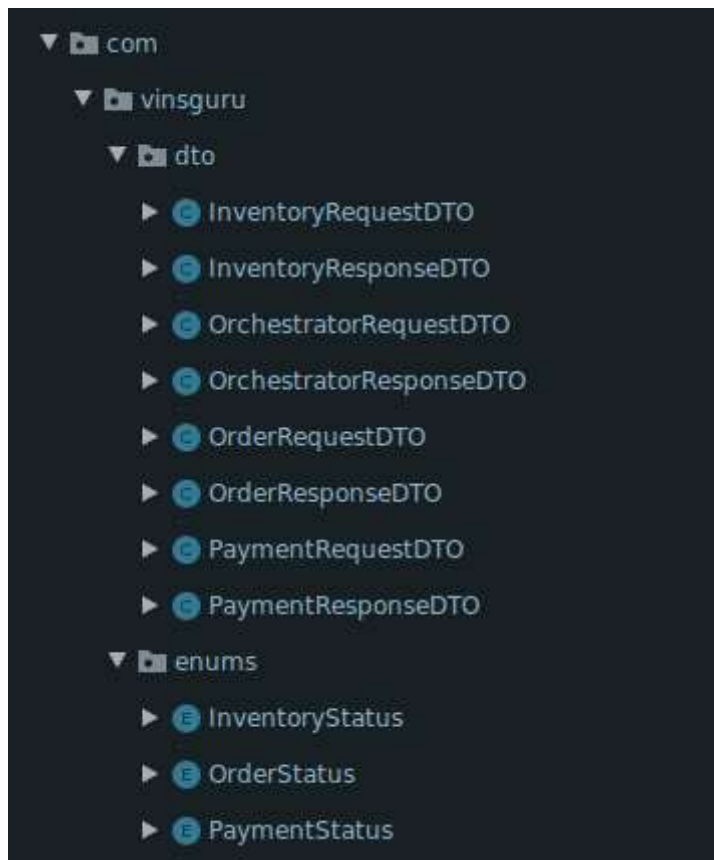
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ral Design..



Inventory Service:

Each microservice which will be coordinated by orchestrator is expected to have at least 2 endpoints for each entity! One is deducting and other one is for resetting the transaction. For example, if we deduct inventory first and then later when we come to know that insufficient balance from payment system, we need to add the inventory back.

Note: I used a map as a DB to hold some inventory for few product IDs.

```
@Service
public class InventoryService {

    private Map<Integer, Integer> productInventoryMap;

    @PostConstruct
    private void init(){
        this.productInventoryMap = new HashMap<>();
        this.productInventoryMap.put(1, 5);
        this.productInventoryMap.put(2, 5);
        this.productInventoryMap.put(3, 5);
    }
}
```

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```

    }

    public InventoryResponseDTO deductInventory(final In
        int quantity = this.productInventoryMap.getOrDef
        InventoryResponseDTO responseDTO = new Inventory
        responseDTO.setOrderId(requestDTO.getOrderId());
        responseDTO.setUserId(requestDTO.getUserId());
        responseDTO.setProductId(requestDTO.getProductId
        responseDTO.setStatus(InventoryStatus.UNAVAILABL
        if(quantity > 0){
            responseDTO.setStatus(InventoryStatus.AVAILA
            this.productInventoryMap.put(requestDTO.getP
        }
        return responseDTO;
    }

    public void addInventory(final InventoryRequestDTO r
        this.productInventoryMap
            .computeIfPresent(requestDTO.getProductI
    }

}

```

- controller

```

@RestController
@RequestMapping("inventory")
public class InventoryController {

    @Autowired
    private InventoryService service;

    @PostMapping("/deduct")
    public InventoryResponseDTO deduct(@RequestBody fina
        return this.service.deductInventory(requestDTO);
    }

    @PostMapping("/add")
    public void add(@RequestBody final InventoryRequestD
        this.service.addInventory(requestDTO);
    }
}

```

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}

}

Payment Service:

It also exposes 2 endpoints like inventory-service. I am showing only the important classes. For more details please check the github link at the end of this article for the complete project source code.

```
@Service
public class PaymentService {

    private Map<Integer, Double> userBalanceMap;

    @PostConstruct
    private void init(){
        this.userBalanceMap = new HashMap<>();
        this.userBalanceMap.put(1, 1000d);
        this.userBalanceMap.put(2, 1000d);
        this.userBalanceMap.put(3, 1000d);
    }

    public PaymentResponseDTO debit(final PaymentRequest
        double balance = this.userBalanceMap.getOrDefault
        PaymentResponseDTO responseDTO = new PaymentResp
        responseDTO.setAmount(requestDTO.getAmount());
        responseDTO.setUserId(requestDTO.getUserId());
        responseDTO.setOrderId(requestDTO.getOrderId());
        responseDTO.setStatus(PaymentStatus.PAYMENT_REJE
        if(balance >= requestDTO.getAmount()){
            responseDTO.setStatus(PaymentStatus.PAYMENT_
            this.userBalanceMap.put(requestDTO.getUserId
        }
        return responseDTO;
    }

    public void credit(final PaymentRequestDTO requestDT
        this.userBalanceMap.computeIfPresent(requestDTO.
```

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}

}

- controller

```

@RestController
@RequestMapping("payment")
public class PaymentController {

    @Autowired
    private PaymentService service;

    @PostMapping("/debit")
    public PaymentResponseDTO debit(@RequestBody Payment
        return this.service.debit(requestDTO);
    }

    @PostMapping("/credit")
    public void credit(@RequestBody PaymentRequestDTO re
        this.service.credit(requestDTO);
    }

}

```



Order Service:

Our order service receives the create order command and raises an **order-created** event using spring boot kafka binder. It also listens to **order-updated** channel/kafka topic and updates order status.



```

@RestController
@RequestMapping("order")
public class OrderController {

```

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```

@Autowired
private OrderService service;

@PostMapping("/create")
public PurchaseOrder createOrder(@RequestBody OrderR
    requestDTO.setOrderId(UUID.randomUUID());
    return this.service.createOrder(requestDTO);
}

@GetMapping("/all")
public List<OrderResponseDTO> getOrders(){
    return this.service.getAll();
}
}

```

- service

```

@Service
public class OrderService {

    // product price map
    private static final Map<Integer, Double> PRODUCT_PR
        1, 100d,
        2, 200d,
        3, 300d
    );

    @Autowired
    private PurchaseOrderRepository purchaseOrderReposit

    @Autowired
    private FluxSink<OrchestratorRequestDTO> sink;

    public PurchaseOrder createOrder(OrderRequestDTO ord
        PurchaseOrder purchaseOrder = this.purchaseOrder
        this.sink.next(this.getOrchestratorRequestDTO(or
        return purchaseOrder;
    }
}

```

^

```

public List<OrderResponseDTO> getAll() {
    return this.purchaseOrderRepository.findAll()
        .stream()
        .map(this::entityToDto)
        .collect(Collectors.toList());
}

private PurchaseOrder dtoToEntity(final OrderRequest
    PurchaseOrder purchaseOrder = new PurchaseOrder(
    purchaseOrder.setId(dto.getOrderId());
    purchaseOrder.setProductId(dto.getProductId());
    purchaseOrder.setUserId(dto.getUserId());
    purchaseOrder.setStatus(OrderStatus.ORDER_CREATE
    purchaseOrder.setPrice(PRODUCT_PRICE.get(purchas
    return purchaseOrder;
}

private OrderResponseDTO entityToDto(final PurchaseO
    OrderResponseDTO dto = new OrderResponseDTO();
    dto.setOrderId(purchaseOrder.getId());
    dto.setProductId(purchaseOrder.getProductId());
    dto.setUserId(purchaseOrder.getUserId());
    dto.setStatus(purchaseOrder.getStatus());
    dto.setAmount(purchaseOrder.getPrice());
    return dto;
}

public OrchestratorRequestDTO getOrchestratorRequest
    OrchestratorRequestDTO requestDTO = new Orchestr
    requestDTO.setUserId(orderRequestDTO.getUserId())
    requestDTO.setAmount(PRODUCT_PRICE.get(orderRequ
    requestDTO.setOrderId(orderRequestDTO.getOrderId
    requestDTO.setProductId(orderRequestDTO.getProdu
    return requestDTO;
}
}

```

Order Orchestrator:



This is a microservice which is responsible for coordinating all the transactions. It listens to order-created topic. As and when a new order is created, It immediately builds separate request to each service like payment-service/inventory-service etc and validates the responses. If they are OK, fulfills the order. If one of them is not, cancels the order. It also tries to reset any of local transactions which happened in any of the microservices.

We consider all the local transactions as 1 single workflow. A workflow will contain multiple workflow steps.

- Workflow step

```
public interface WorkflowStep {  
  
    WorkflowStepStatus getStatus();  
    Mono<Boolean> process();  
    Mono<Boolean> revert();  
  
}
```

- Workflow

```
public interface Workflow {  
  
    List<WorkflowStep> getSteps();  
  
}
```

- In our case, for the Order workflow, we have 2 steps. Each implementation should know how to do local transaction and how to reset.
- Inventory step

```
public class InventoryStep implements WorkflowStep {  
  
    private final WebClient webClient;
```

^

```
private final InventoryRequestDTO requestDTO;
private WorkflowStepStatus stepStatus = WorkflowStep

public InventoryStep(WebClient webClient, InventoryR
    this.webClient = webClient;
    this.requestDTO = requestDTO;
}

@Override
public WorkflowStepStatus getStatus() {
    return this.stepStatus;
}

@Override
public Mono<Boolean> process() {
    return this.webClient
        .post()
        .uri("/inventory/deduct")
        .body(BodyInserters.fromValue(this.reque
        .retrieve()
        .bodyToMono(InventoryResponseDTO.class)
        .map(r -> r.getStatus().equals(Inventory
        .doOnNext(b -> this.stepStatus = b ? Wor
    }

@Override
public Mono<Boolean> revert() {
    return this.webClient
        .post()
        .uri("/inventory/add")
        .body(BodyInserters.fromValue(this.r
        .retrieve()
        .bodyToMono(Void.class)
        .map(r -> true)
        .onErrorReturn(false);
    }
}
```

- Payment step



```
public class PaymentStep implements WorkflowStep {

    private final WebClient webClient;
    private final PaymentRequestDTO requestDTO;
    private WorkflowStepStatus stepStatus = WorkflowStep

    public PaymentStep(WebClient webClient, PaymentReque
        this.webClient = webClient;
        this.requestDTO = requestDTO;
    }

    @Override
    public WorkflowStepStatus getStatus() {
        return this.stepStatus;
    }

    @Override
    public Mono<Boolean> process() {
        return this.webClient
            .post()
            .uri("/payment/debit")
            .body(BodyInserters.fromValue(this.r
            .retrieve()
            .bodyToMono(PaymentResponseDTO.class
            .map(r -> r.getStatus().equals(Payme
            .doOnNext(b -> this.stepStatus = b ?
        }

    @Override
    public Mono<Boolean> revert() {
        return this.webClient
            .post()
            .uri("/payment/credit")
            .body(BodyInserters.fromValue(this.reque
            .retrieve()
            .bodyToMono(Void.class)
            .map(r -> true)
            .onErrorReturn(false);
    }
}
```

^

```
}
```

- service / coordinator

```
@Service
public class OrchestratorService {

    @Autowired
    @Qualifier("payment")
    private WebClient paymentClient;

    @Autowired
    @Qualifier("inventory")
    private WebClient inventoryClient;

    public Mono<OrchestratorResponseDTO> orderProduct(fi
        Workflow orderWorkflow = this.getOrderWorkflow(r
        return Flux.fromStream(() -> orderWorkflow.getSt
            .flatMap(WorkflowStep::process)
            .handle(((aBoolean, synchronousSink) ->
                if(aBoolean)
                    synchronousSink.next(true);
                else
                    synchronousSink.error(new Workfl
            )))
            .then(Mono.fromCallable(() -> getRespons
            .onErrorResume(ex -> this.revertOrder(or

    }

    private Mono<OrchestratorResponseDTO> revertOrder(fi
        return Flux.fromStream(() -> workflow.getSteps()
            .filter(wf -> wf.getStatus().equals(Work
            .flatMap(WorkflowStep::revert)
            .retry(3)
            .then(Mono.just(this.getResponseDTO(requ

    }

    private Workflow getOrderWorkflow(OrchestratorReques
```

^

```
WorkflowStep paymentStep = new PaymentStep(this.  
WorkflowStep inventoryStep = new InventoryStep(t  
return new OrderWorkflow(List.of(paymentStep, in  
}  
  
private OrchestratorResponseDTO getResponseDTO(Orche  
OrchestratorResponseDTO responseDTO = new Orches  
responseDTO.setOrderId(requestDTO.getOrderId());  
responseDTO.setAmount(requestDTO.getAmount());  
responseDTO.setProductId(requestDTO.getProductId)  
responseDTO.setUserId(requestDTO.getUserId());  
responseDTO.setStatus(status);  
return responseDTO;  
}  
  
private PaymentRequestDTO getPaymentRequestDTO(Orche  
PaymentRequestDTO paymentRequestDTO = new Paymen  
paymentRequestDTO.setUserId(requestDTO.getUserId  
paymentRequestDTO.setAmount(requestDTO.getAmount  
paymentRequestDTO.setOrderId(requestDTO.getOrd  
return paymentRequestDTO;  
}  
  
private InventoryRequestDTO getInventoryRequestDTO(0  
InventoryRequestDTO inventoryRequestDTO = new In  
inventoryRequestDTO.setUserId(requestDTO.getUser  
inventoryRequestDTO.setProductId(requestDTO.getP  
inventoryRequestDTO.setOrderId(requestDTO.getOrd  
return inventoryRequestDTO;  
}  
  
}
```

I have provided only high level details here. For the complete source, check [here](#).

Orchestration Saga Pattern – Demo:



-

- The user 1 with this available balance \$100, he can buy product id 1 as it costs only \$100.



Summary:

We were able to successfully demonstrate the **Orchestration Saga Pattern with Spring Boot**. Handling transactions and maintaining data consistency among all the microservices are difficult in general. When multiple services are involved like payment, inventory, fraud check, shipping check...etc it would be very difficult to manage such a complex workflow with multiple steps without a coordinator. By introducing a separate service for orchestration, order-service is freed up from these responsibilities.

Check the project source code [here](#).

Learn more about Microservices Patterns.

- [Bulkhead Pattern – Microservice Design Patterns](#)
- [Circuit Breaker Pattern – Microservice Design Patterns](#)
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Happy coding 😊

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27 thoughts on “Orchestration Saga Pattern With Spring Boot”



Sambhav Dave

August 12, 2020 at 4:38 PM

Wonderful sir. I am your youtube and udemy subscriber. Please keep on teaching students like me. I am working as test automation engineer at Tcs Nagpur. I love your way of teaching, and especially bringing new topics out of the traditional scenarios that we face. #BigFan

Reply

vlns

August 14, 2020 at 1:59 PM

Thanks Sambhav.

Reply

Sankar

August 26, 2020 at 8:53 PM

great article on spring boot and kafka. Thanks Vinoth.

Reply

Milton Chapilliquen

September 1, 2020 at 10:26 AM

Hello dear,

I have a couple of questions about your excellent post:

I have my client API, which I have created 3 spring boot projects

(independent): customer (GET /customers/{id-customer}, POST, PUT, etc),

addresses (GET /{id-customer}/addresses, POST, PUT , etc) and contacts

(GET /{id-customer}/contacts, POST, PUT, etc). Could you use Stream, Flux

and kafka so that when I request GET /customers/{id} it returns the complete



'customers' information, including the 'address' and 'contacts' service information in parallel? It means that the request must wait for the data of each service to be obtained and return all the information of a customer. Do you have any suggestions or examples?

About the display of orders, payments and products, is there a way that the response from the execution of the POST /order/create returns the ORDER_CANCELLED status? I mean does the POST request "wait" for the process to finish completely and the updated status to be sent when an error occurs? Currently the POST /order/create returns only ORDER_CREATED, and the status changes it in the background.

Reply

vlns

September 1, 2020 at 2:07 PM

Hi,

You have multiple questions here.

Most of the applications are more read heavy than write. So when you need customer info, you could avoid calling multiple services internally to join all the info. Because when you need to query 3 services, when one service is down, the entire application becomes kind of down! not accessible. There is a separate pattern for this. Event carried state transfer – Check this **one**.

If you check the screenshots, order-service always keeps the order in pending status first as soon as it gets a request. The orchestraor service is the one which coordinates all the activities and decides it can be fulfilled or cancelled. So, order-service does not wait. It is asynchronous.

Thanks.

Reply



Hien HOANG

October 26, 2020 at 2:46 AM

Hi Vins,

I followed your blog for really long time, and I saw that you had several topic related to Kafka. I am just curious about how do you perform the testing for streaming application using Kafka. May you create a post about each testing level for Kafka?

Many thanks in advanced.

Reply

Leclerc HOUNMENOU

November 23, 2020 at 5:04 AM

Just say thanks you!!

Very satisfied!

You are a master!

Never give up!!

Reply

vlns

November 23, 2020 at 3:13 PM

spam?

Reply

jagadeesh

December 11, 2020 at 10:03 AM

Hi ..good one..plz provide ur udemy details and you tube..are u providing any tutorial for microservices?..



Reply

Rajugaru

January 2, 2021 at 4:02 AM

after reading a dozen stuff over the internet and tried and got tired. This is one of the most satisfying among all other. and thank you very much for all the explanation. Loved it. Looking forward to read some more interesting stuff.

Reply

Akash

January 19, 2021 at 6:44 PM

Awesome tutorial. I struggled a lot to find distributed transaction examples and tutorials. This article is my destination!

Reply

Martin

January 23, 2021 at 10:28 AM

I wonder, what will happen when during the reverting process – let's say after revert payment but before revert inventory (or vice versa) – the coordinator failed and go down. With this implementation we will leave our system in inconsistent state.

Reply

vlns

January 24, 2021 at 4:40 PM

Yes, It could happen. For that we could use Kafka topics for the communication between the orchestrator and other services.

Or this orchestrator will be maintaining its own DB for the state. That

^

is – It has to get the confirmation for the reverting process. Otherwise it will retry.

Reply

K

March 5, 2021 at 2:33 AM

Is this orchestration approach recommended if we have one service calling 7-8 micro services?

Also, we could call the inventory and payment service using Test template. Is a message broker or Kafka mandatory?

Could you please let me know? Thanks

Reply

vlns

March 5, 2021 at 3:35 AM

Each approach has its own advantage!

RestTemplate is simple and easy. Using message brokers helps with async processing and calling service does not have to worry about service unavailability. I would not say it is recommended. It just a demo wherever this pattern will be useful.

Reply

Raj

February 21, 2022 at 8:17 AM

Hello vlns

Nice article.

I am just wondering where in the code you invoke the orchestration service.

If you could direct me to that code snippet?



Thanks

Raj

Reply

vlns

February 26, 2022 at 3:24 PM

Check here for the complete source code.

Reply

Camilo Cortes

March 28, 2022 at 12:23 AM

Hi vlns

excellent article.

I have a question.

I Can implement the project dont using Kafka? only calling the order-orchestration service with a HTTP request?

Reply

vlns

June 26, 2022 at 8:22 PM

Yes. Please check this – <https://www.vinsguru.com/spring-webflux-aggregation/>

Reply

Neha

June 16, 2022 at 2:53 AM

LI:

I see your current code don't return correct "status": "ORDER_CANCELLED" on 4th attempts. Could you please double check?

Reply

vlns

June 26, 2022 at 7:32 PM

Thanks a lot. Looks like it broke with recent version of Spring. I have updated the code as few things got deprecated as well. It seems to work now.

Reply

Neha

July 11, 2022 at 4:13 PM

Hey, I do see code still not working with the latest code, I double check many times. Something weird happening. Would you want to double check again ?

Reply

Neha

July 11, 2022 at 5:53 PM

I think there is confusion with the Status - it always return ORDER_CREATED irrespective of success or failure. Its happening because you've hardcoded in OrderService.java dtoToEntity method need some correction. Please do the needful and inform back.

Reply

vlns

July 11, 2022 at 8:01 PM



Yes, it is ORDER CREATED. Not Completed or
Failed. The status will get updated eventually!!

sai

June 20, 2022 at 10:31 AM

same me too, Wondering why the flow is not going to order -orchestrator
processor.

Reply

vlns

June 26, 2022 at 7:33 PM

It works fine now as I had to update few things for latest version of
Spring.

Reply

sai

June 20, 2022 at 10:51 AM

I just Found, Using rest end point we can see cancelled order as shown in the
below images.

<http://localhost:8080/order/all>

Thanks For the article @Vinsguru

Reply

^

Leave a Reply

Your email address will not be published. Required fields are marked *

Comment *

Name *

Email *

Website

☐ Save my name, email, and website in this browser for the next time I comment.

☐ Notify me of follow-up comments by email.

☐ Notify me of new posts by email.

Post Comment

