Microservice Architecture (/index.html)

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Pattern: Saga

Context

You have applied the Database per Service (database-per-service.html) pattern. Each service has its own database. Some business transactions, however, span multiple service so you need a mechanism to implement transactions that span services. For example, let's imagine that you are building an e-commerce store where customers have a credit limit. The application must ensure that a new order will not exceed the customer's credit limit. Since Orders and Customers are in different databases owned by different services the application cannot simply use a local ACID transaction.

Problem

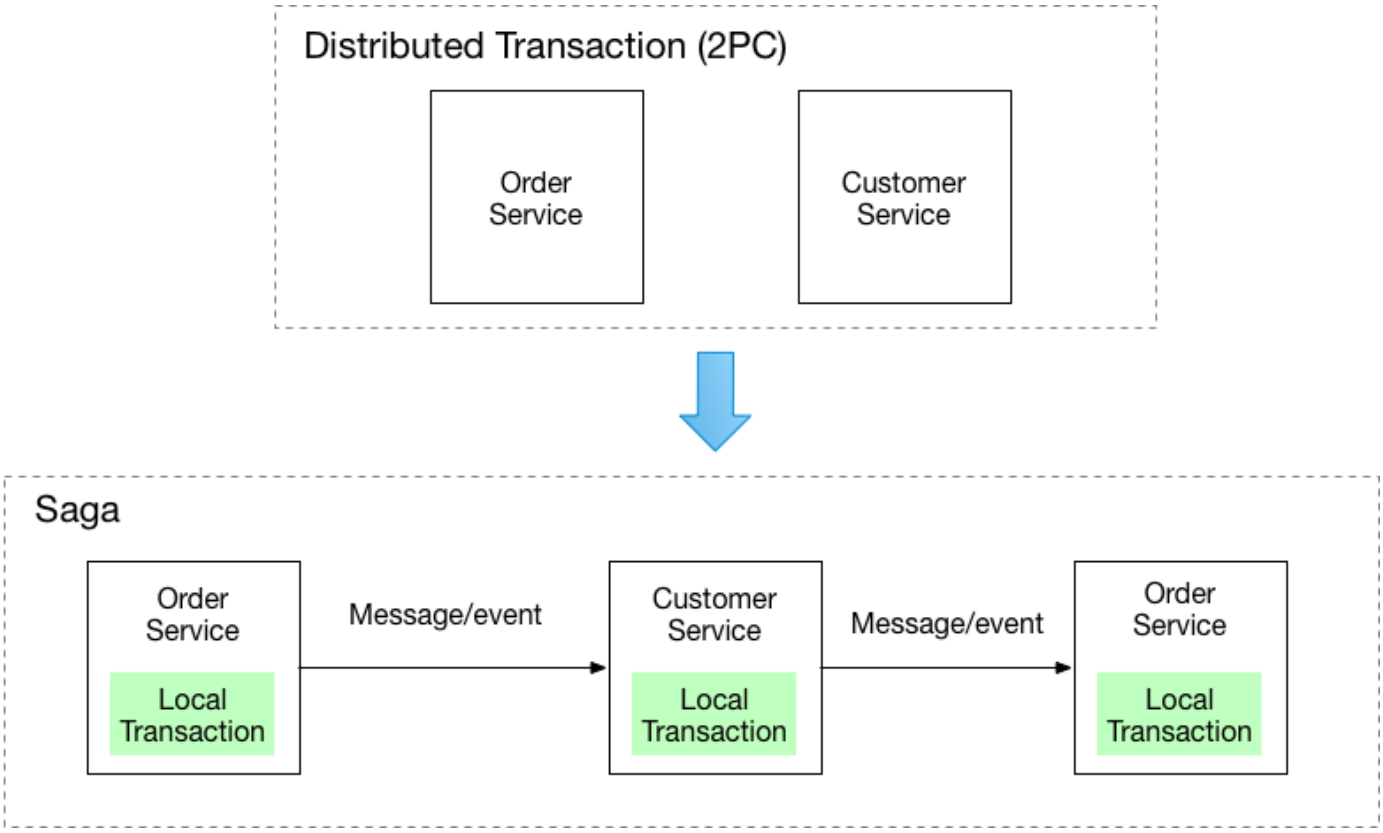
How to implement transactions that span services?

Forces

- 2PC is not an option

Solution

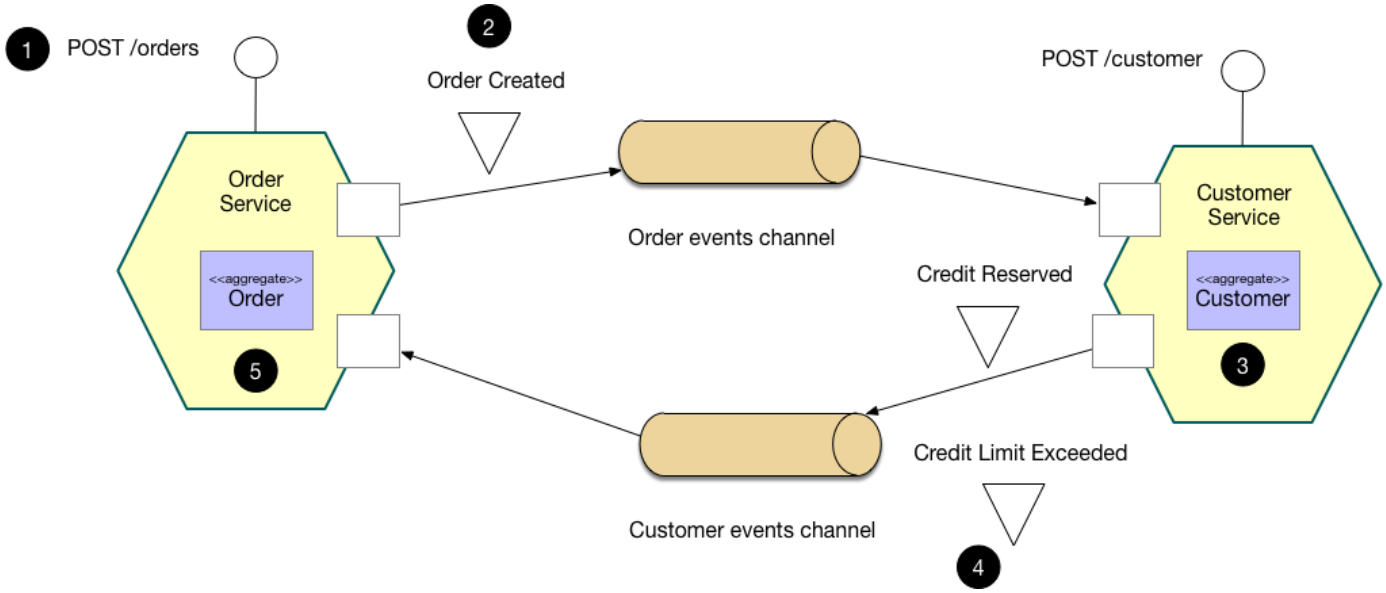
Implement each business transaction that spans multiple services is a saga. A saga is a sequence of local transactions. Each local transaction updates the database and publishes a message or event to trigger the next local transaction in the saga. If a local transaction fails because it violates a business rule then the saga executes a series of compensating transactions that undo the changes that were made by the preceding local transactions.



There are two ways of coordination sagas:

- Choreography - each local transaction publishes domain events that trigger local transactions in other services
- Orchestration - an orchestrator (object) tells the participants what local transactions to execute

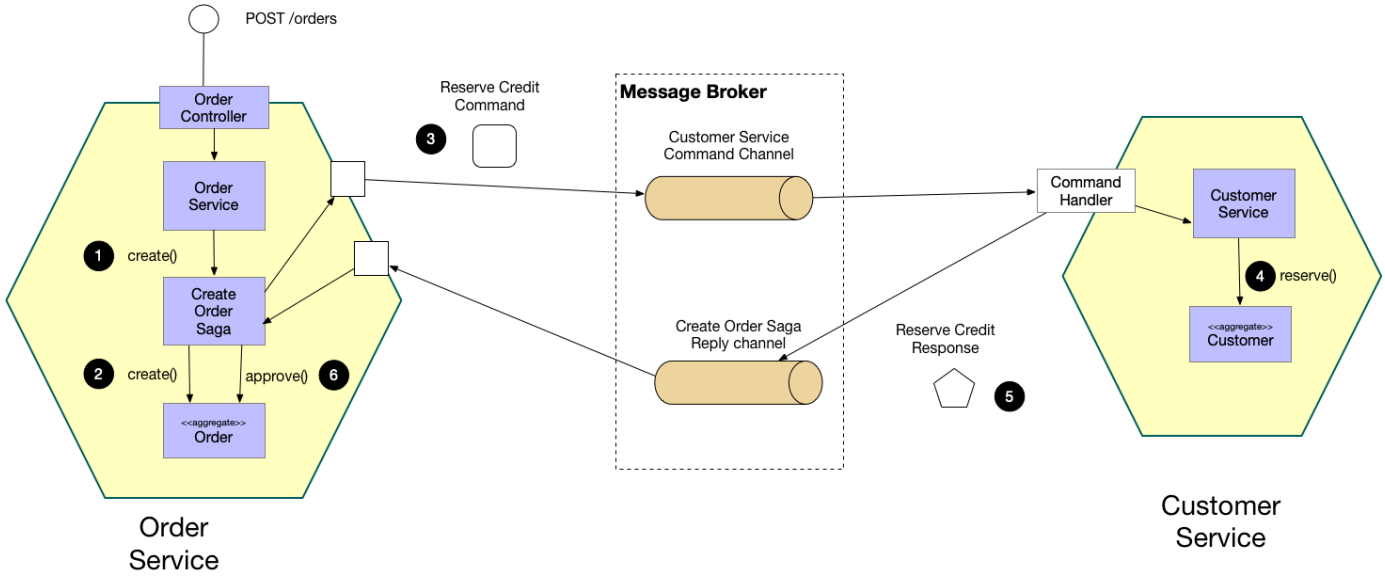
Example: Choreography-based saga



An e-commerce application that uses this approach would create an order using a choreography-based saga that consists of the following steps:

1. The `Order Service` receives the `POST /orders` request and creates an `Order` in a `PENDING` state
2. It then emits an `Order Created` event
3. The `Customer Service` 's event handler attempts to reserve credit
4. It then emits an event indicating the outcome
5. The `OrderService` 's event handler either approves or rejects the `Order`

Example: Orchestration-based saga



An e-commerce application that uses this approach would create an order using an orchestration-based saga that consists of the following steps:

1. The `Order Service` receives the `POST /orders` request and creates the `Create Order` saga orchestrator
2. The saga orchestrator creates an `Order` in the `PENDING` state

3. It then sends a `Reserve Credit` command to the `Customer Service`
4. The `Customer Service` attempts to reserve credit
5. It then sends back a reply message indicating the outcome
6. The saga orchestrator either approves or rejects the `Order`

Resulting context

This pattern has the following benefits:

- It enables an application to maintain data consistency across multiple services without using distributed transactions

This solution has the following drawbacks:

- The programming model is more complex. For example, a developer must design compensating transactions that explicitly undo changes made earlier in a saga.

There are also the following issues to address:

- In order to be reliable, a service must atomically update its database *and* publish a message/event. It cannot use the traditional mechanism of a distributed transaction that spans the database and the message broker. Instead, it must use one of the patterns listed below.
- A client that initiates the saga, which an asynchronous flow, using a synchronous request (e.g. HTTP `POST /orders`) needs to be able to determine its outcome. There are several options, each with different trade-offs:
    - The service sends back a response once the saga completes, e.g. once it receives an `OrderApproved` or `OrderRejected` event.
    - The service sends back a response (e.g. containing the `orderID`) after initiating the saga and the client periodically polls (e.g. `GET /orders/{orderID}`) to determine the outcome
    - The service sends back a response (e.g. containing the `orderID`) after initiating the saga, and then sends an event (e.g. websocket, web hook, etc) to the client once the saga completes.

Related patterns

- The Database per Service pattern (database-per-service.html) creates the need for this pattern
- The following patterns are ways to *atomically* update state *and* publish messages/events:
    - Event sourcing (event-sourcing.html)
    - Transactional Outbox (transactional-outbox.html)
- A choreography-based saga can publish events using Aggregates (aggregate.html) and Domain Events (domain-event.html)

Learn more

- Read these blog posts on the Saga pattern:
    - overview of sagas (https://chrisrichardson.net/post/antipatterns/2019/07/09/developing-sagas-part-1.html)
    - saga coordination mechanisms: choreography and orchestration (https://chrisrichardson.net/post/sagas/2019/08/04/developing-sagas-part-2.html)
    - implementing choreography-based sagas (https://chrisrichardson.net/post/sagas/2019/08/15/developing-sagas-part-3.html)
    - implementing orchestration-based sagas (https://chrisrichardson.net/post/sagas/2019/12/12/developing-sagas-part-4.html)
- My book Microservices patterns (/book) describes this pattern in a lot more detail. The book's example application (https://github.com/microservice-patterns/ftgo-application) implements orchestration-based

sagas using the Eventuate Tram Sagas framework (https://github.com/eventuate-tram/eventuate-tram-sagas)
- My presentations (/presentations) on sagas and asynchronous microservices.

Example code

The following examples implement the customers and orders example in different ways:

- Choreography-based saga (https://github.com/eventuate-tram/eventuate-tram-examples-customers-and-orders) where the services publish domain events using the Eventuate Tram framework (https://github.com/eventuate-tram/eventuate-tram-core)
- Orchestration-based saga (https://github.com/eventuate-tram/eventuate-tram-sagas-examples-customers-and-orders) where the `Order Service` uses a saga orchestrator implemented using the Eventuate Tram Sagas framework (https://github.com/eventuate-tram/eventuate-tram-sagas)
- Choreography and event sourcing-based saga (https://github.com/eventuate-examples/eventuate-examples-java-customers-and-orders) where the services publish domain events using the Eventuate event sourcing framework (http://eventuate.io/)
