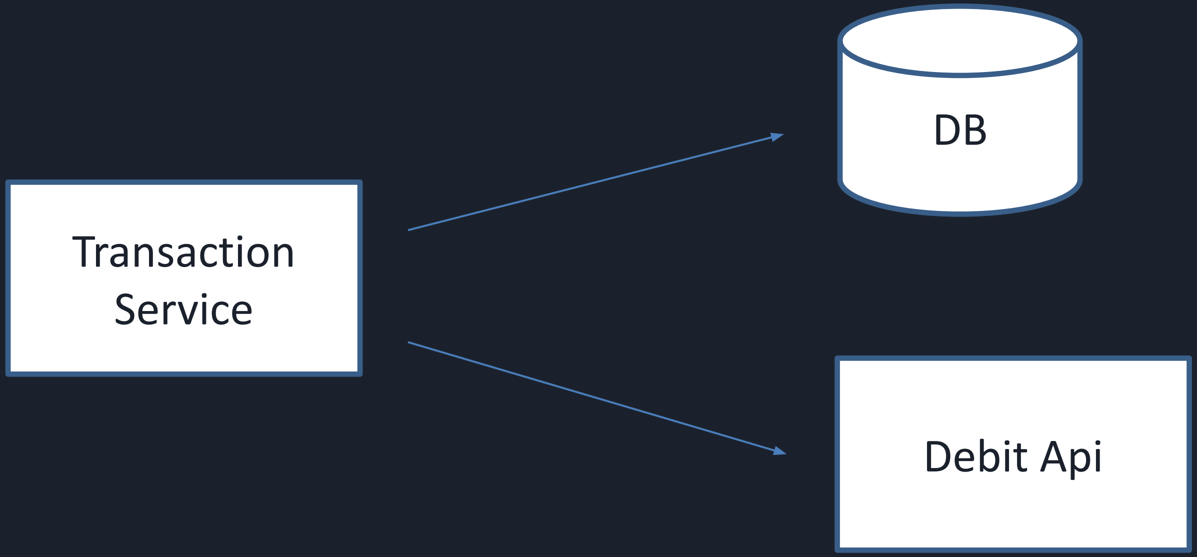
Handling Transactions in Distributed Systems

Agenda

- Context
- Objectives
- Example
- Designing a Debit API
  - Idempotence
- Designing a Transaction flow
  - without compensation
  - with compensation
- Extend
  - 2PC
- In conclusion

Context

1. There is a Transaction service and Debit API
2. Service would call Debit API, and insert a record into DB



Objectives

1. The total transaction amount should eventually match the user’s balance
2. The system can automatically retry failed transactions, reducing manual intervention.

example 1

Step 1: Insert into DB $10

Step 2: Call Debit API $10

-> **transaction: -10 balance: -10**

(Step 2 fail) Step 3: Delete record from Step 1

-> **transaction: 0 balance: 0**

(Step 3 fail)

-> **transaction: -10 balance: 0**

example 2

Step 1: Call Debit API $10

Step 2: Insert into DB $10

-> **transaction: -10 balance: -10**

(Step 2 fail) Step 3: Call Compensate API $10

-> **transaction: 0 balance: 0**

(Step 3 fail)

-> **transaction: 0 balance: -10**

example 3: Transaction

```
Transaction
{
    Step 1: Insert into Db $10
    Step 2: Call Debit API $10
    Step 3: Transaction commit
    (Step 2 fail): Transaction rollback
}
```

Risk of Transaction

1. DB lock (Shared locks, Exclusive locks)
2. If Debit API return slowly, lock will be extended
3. The longer lock time, the more likely deadlock will occur
4. Performance overhead
5. Transaction time out

❖ **If is needed to use transactions, always ensure your transactions completed in shortest time**

Designing a Debit API

Idempotence

- An operation that can be applied multiple times without changing the result

(Idempotent)

Check Balance: /Wallet/GetBalance?userId=123

(Non-Idempotent)

Debit: /Wallet/Debit?userId=123&amount=10

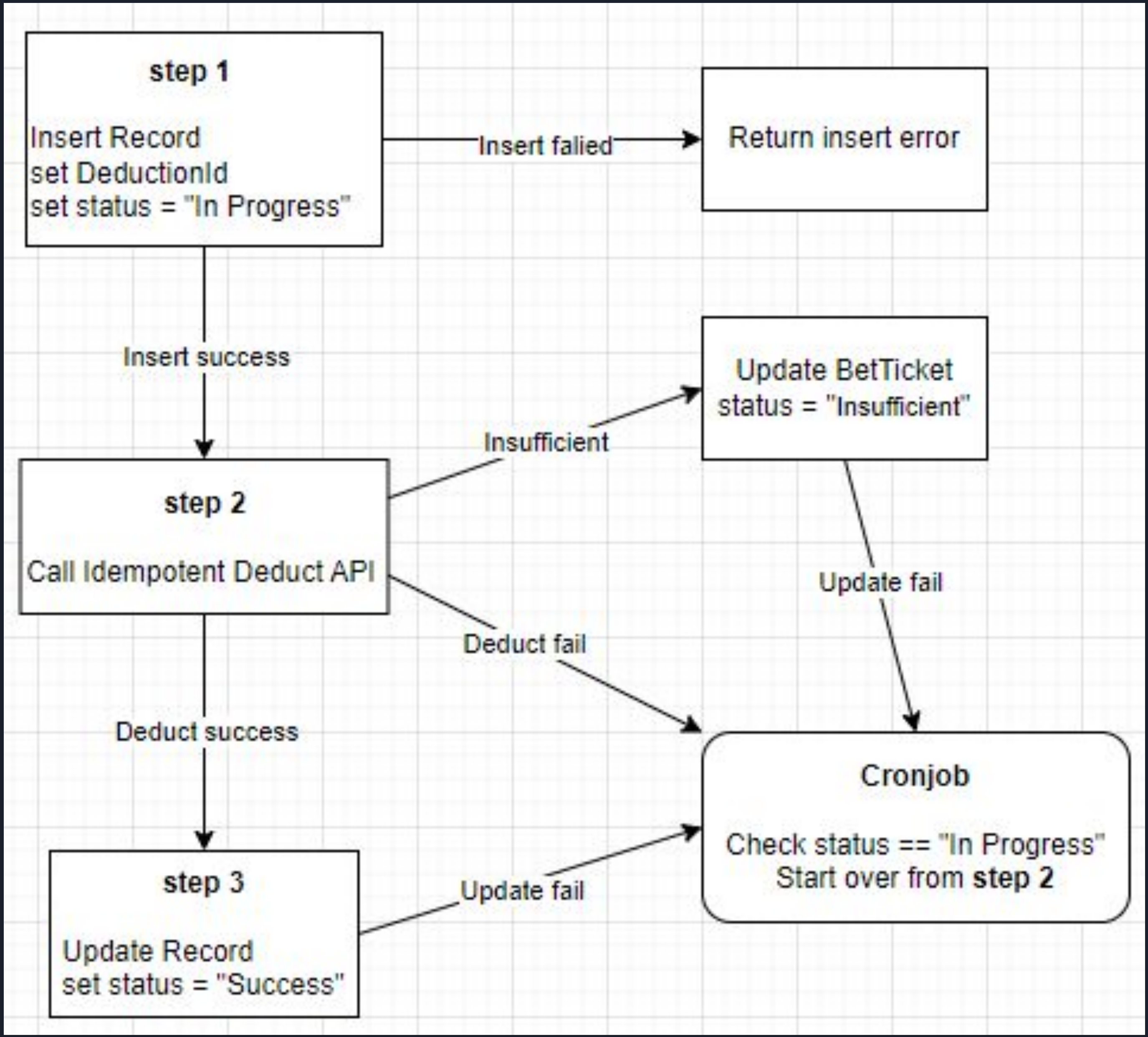
Designing an Idempotent Debit API

- Include a Idempotent Key in the request
- Before debit, check if Idempotent key is exist
- If exist, don’t execute debit
- example:

  /Wallet/Debit?userId=123&amount=10&key=100001

Designing Transaction flow

Solution 1 (without compensation)



step 1

Insert Record
set DeductionId
set status = "In Progress"

Insert falied

Return insert error

Insert success

step 2

Call Idempotent Deduct API

Insufficient

Update BetTicket
status = "Insufficient"

Update fail

Deduct fail

Deduct success

step 3

Update Record
set status = "Success"

Update fail

Cronjob

Check status == "In Progress"
Start over from **step 2**

Solution 1 (without compensation)

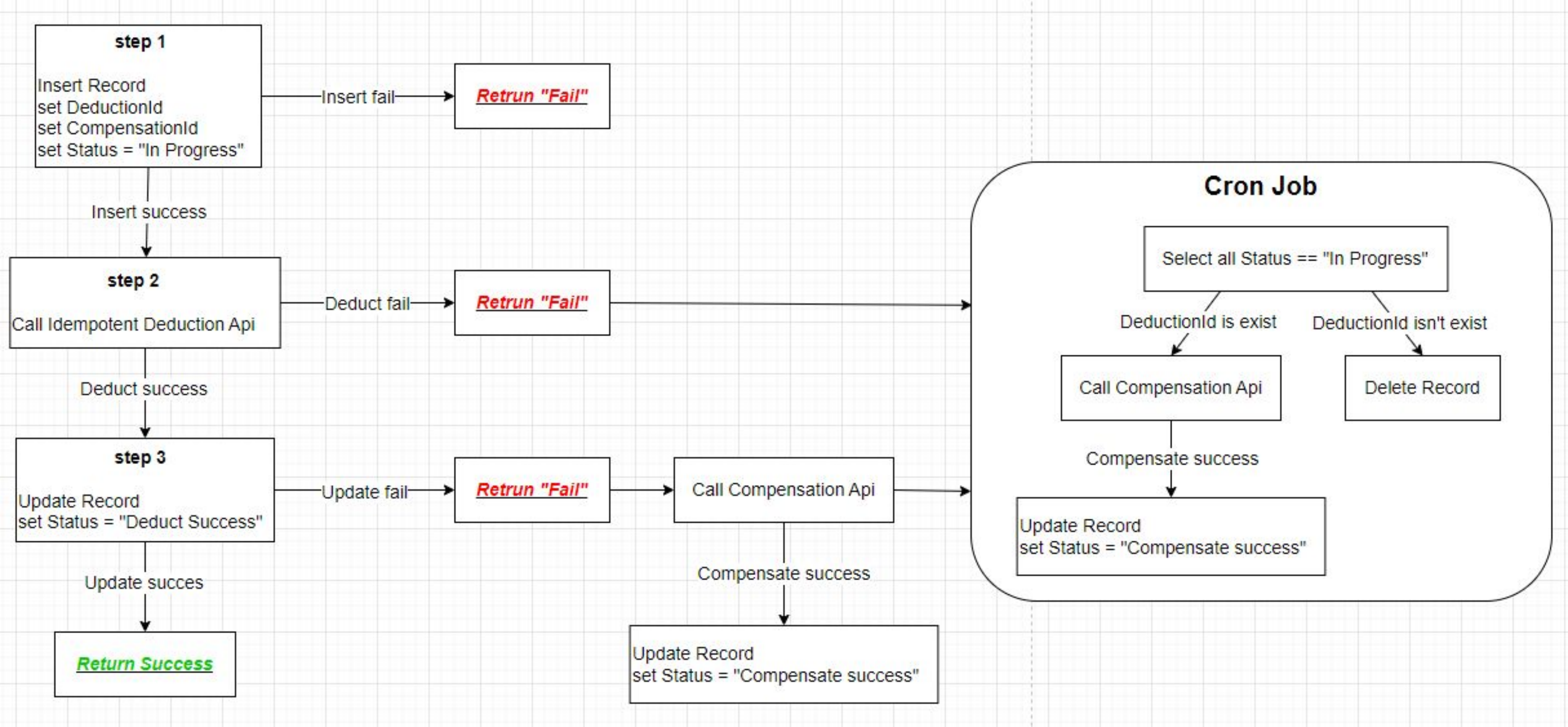
Step 1: Insert into DB with DebitId, set Status = “In Progress”

Step 2: Call Idempotent Debit API

Step 3: Update record, set Status = “Success”

- Cron Job will select all record which Status == “In Progress” and try to call Debit API
- Use DebitId as idempotent key to avoid duplicate debit
- There will only 2 final Status, “Insufficient balance” and “Success”

Solution 2 (with compensation)



step 1

Insert Record
set DeductionId
set CompensationId
set Status = "In Progress"

Insert fail

Retrun "Fail"

Insert success

step 2

Call Idempotent Deduction Api

Deduct fail

Retrun "Fail"

Deduct success

step 3

Update Record
set Status = "Deduct Success"

Update fail

Retrun "Fail"

Call Compensation Api

Compensate success

Update Record
set Status = "Compensate success"

Update succes

Return Success

Cron Job

Select all Status == "In Progress"

DeductionId is exist

DeductionId isn't exist

Call Compensation Api

Delete Record

Compensate success

Update Record
set Status = "Compensate success"

Solution 2 (with compensation)

Step 1: Insert into DB with DebitId, CompensationId, set
Status = “In Progress”

Step 2: Call Idempotent Debit API

Step 3: Update record, set Status = “Debit Success”

- Return success only when all step is successful
- User would only see successful records
- Cron Job will select all record which Status == “In Progress” and try to call Compensation API
- DebitId can also used to check if there is a debit record

Solution 1 vs Solution 2

Solution 1 Pros and Cons

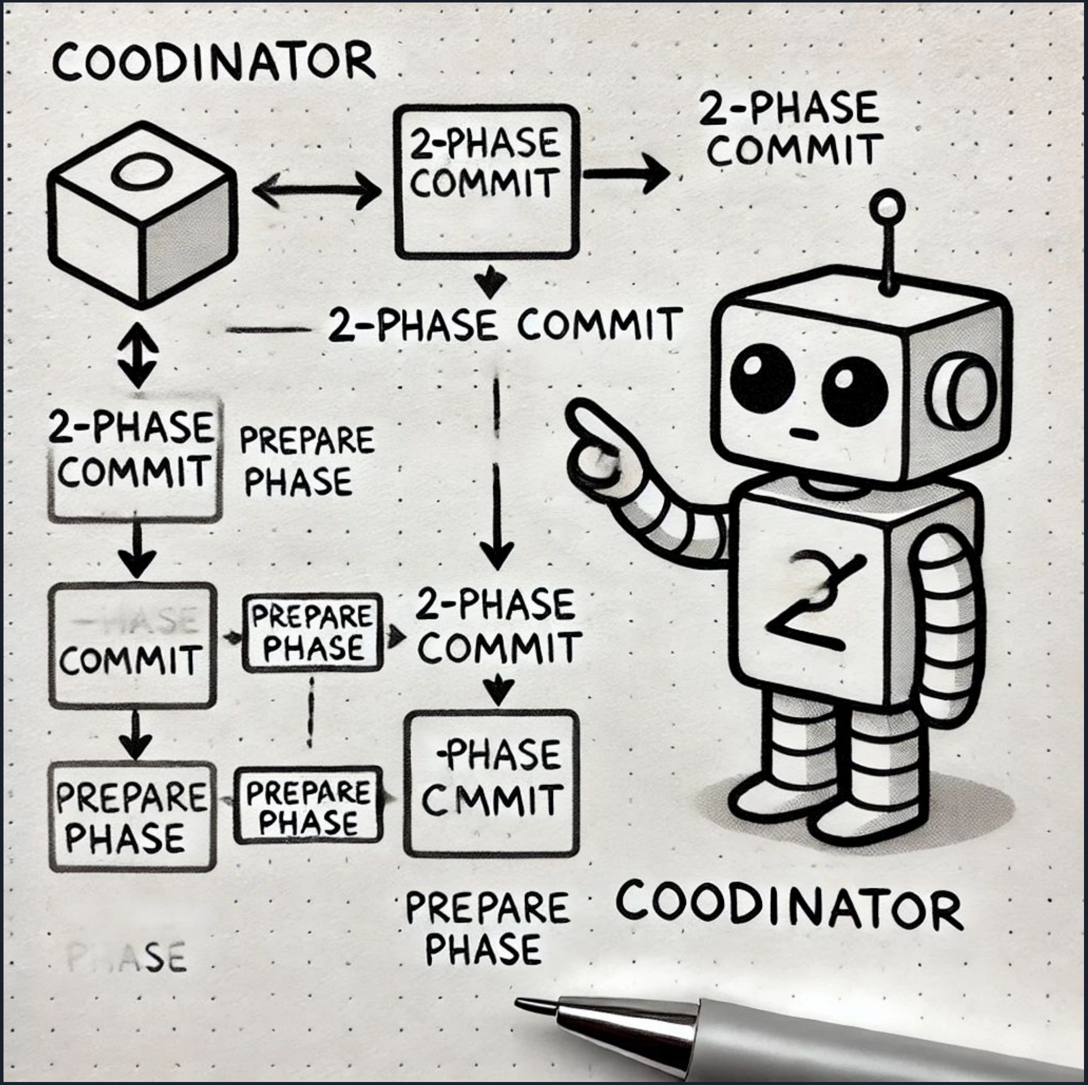
- Pros:
  - Without compensation, design is simpler
- Cons:
  - Worse user experience: If the record is used to show for user(like ticket in a game), the ticket may eventually fail

Solution 2 Pros and Cons

- Pros:
  - Better user experience: If the record is used to show for user(like ticket in a game), the ticket may not fail
- Cons:
  - With compensation, making process is more complex than Solution 1

Extended Topic

2 phase commit (2PC)



2 phase commit (2PC)

- There is a coordinator to handle all transaction process
- Phase 1 is prepare phase, coordinator will prepare all processes in a transaction
- Phase 2 is commit phase, coordinator will commit or abort the process
- If there any process is aborted, do compensation for all other processes

Why didn’t we use 2PC

- Have to maintain an additional coordinator
- Increasing system complexity
- Still need to handle compensation flow if there any step is failed during commit phase

In Conclusion

- If is needed to use transactions, always ensure your transactions completed in shortest time
- Make Debit API idempotent, include idempotent key in the request
- Always make your transaction process can safely redo no matter which step fails
- Simple design, case by case on your requirements

References

- https://chatgpt.com/
- https://en.wikipedia.org/wiki/Idempotence
- https://en.wikipedia.org/wiki/Two-phase_commit_protocol