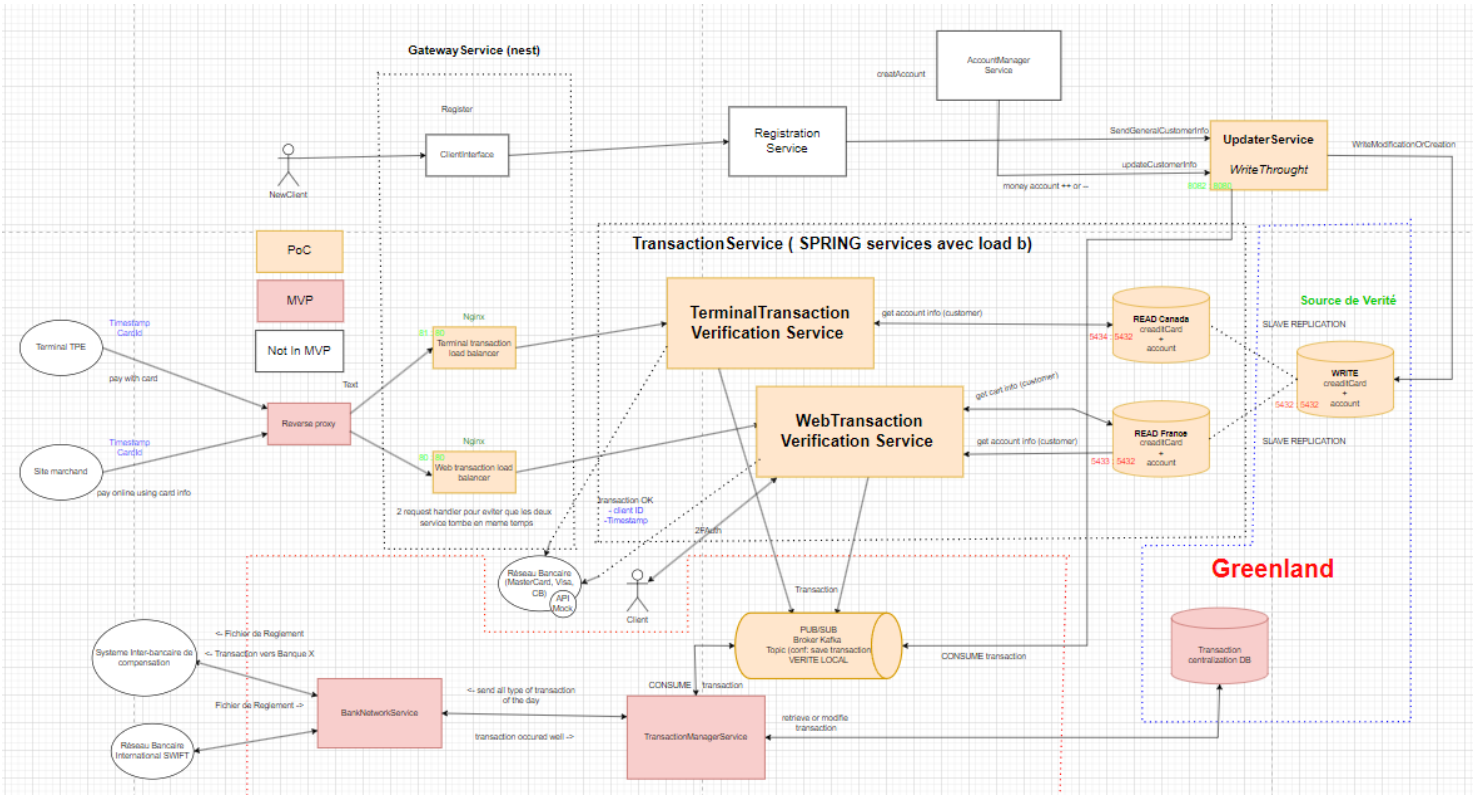
Follow-up Architecture Report
AL Néo-Bank

Final Week :

Final state of the services architecture :



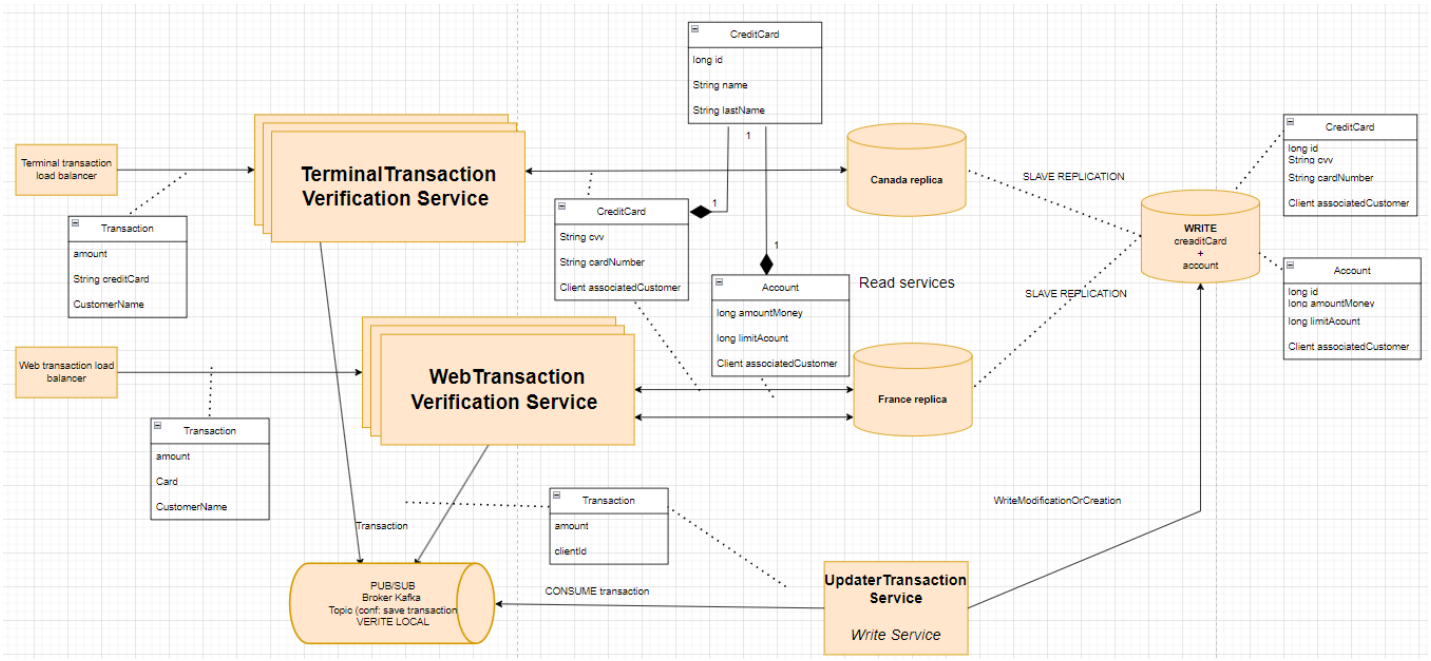
In orange, you can see the implemented components used to present the PoC. In red, the components needed to finish the complete execution flow of a transaction validation in the context of the MVP. In white, services provide additional understanding of the deletion of services in the event of any additions after the MVP.

Our architecture was created in the context of a bank, to conceptualize an architecture that could meet a fundamental need in a bank, which is to resolve a transaction to validate it. Added to this main need is the inclusion in the architecture of an initiative to take a stance on the obvious problem of heavy use in different parts of the world.

Our architecture has been designed to meet the following requirements:

- Each transaction is validated in the shortest possible time
- Multiple transactions can be handled by our system (scalability)
- Several regions can have their own system.

Proof of Concept :



Our PoC was therefore designed to address the above problem.

CQRS Service part:

The first solution we implemented to address the scalability issue was to separate the write logic from the read logic. Indeed, in the context of transaction verification, we don't need to modify the data, because once the transaction has been validated, after only the customer data, the amount of money in the bank can be reduced by a payment. So there's the pre-transaction part and the post-transaction part.
Each with its own data-related needs:

- In the first case, we need to retrieve the data in order to check that it's correct and that the customer is able to proceed with payment.
- In the second case, modify the data to ensure that it remains consistent with the system.

This separation of functions led us to build a CQRS model.

So we had our validation services, which only validated, and another service that modified the customer account afterwards. All in all, the transaction validation flow should be able to handle our problem. However, the validation services (in read mode) must also respond quickly, so to meet the high demand, we decided to set up a load balancer, using the Round Robin algo, to several potential instances of our validation services. We also decided to split the validation services into two, one validating transactions from a payment terminal, the other validating transactions via a WEB payment form.

In the first case, it's a matter of validating the account, whereas in the second, it's a matter of validating the card supplied. We'll then have one service running faster than the other, and

we've deduced that this would be better than having one service do all the validations even if the case doesn't require it, and also so as not to have any internal mapping of the service to determine.

But there's cons to this approach. Indeed, in terms of deployment, this will mean that we will potentially be arranging several instances of two different services, and this may represent an overconsumption of resources when the requests are not numerous enough for this approach to represent a real monetary advantage.

CQRS Database part :

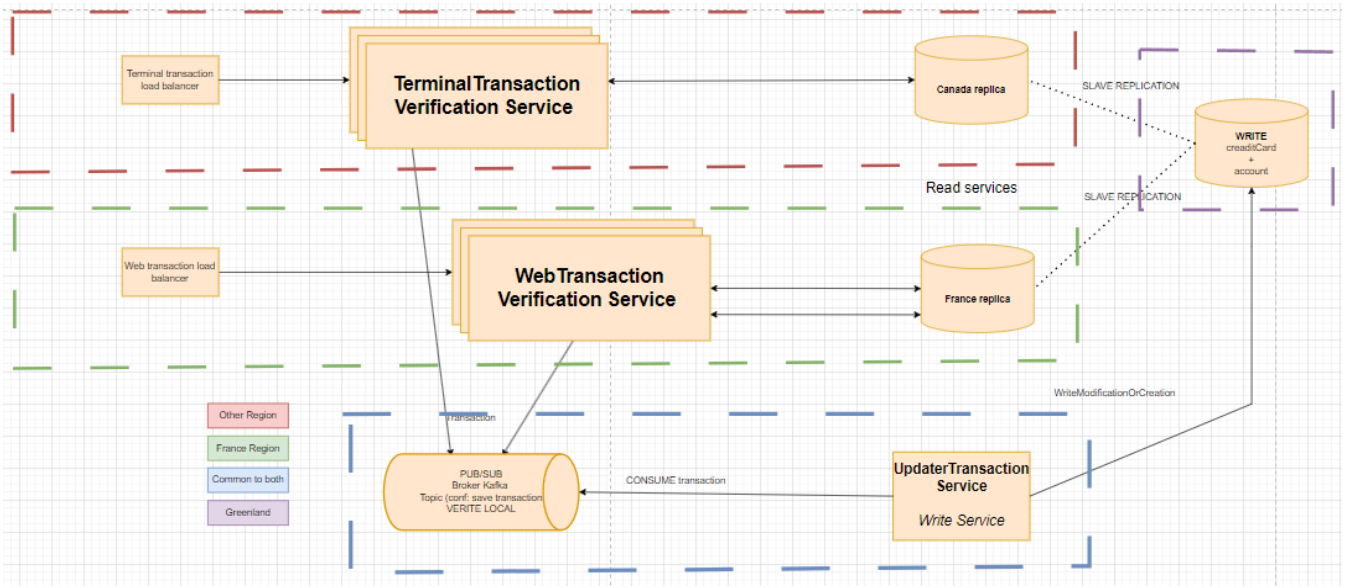
Still in the context of our CQRS approach, we decided to do the same with our databases, separating them in a master-slave data replication model. We were obliged to have our databases in Greenland, so we decided to place our main master DB in Greenland, containing the latest data modifications, which would then be replicated to our slaves in read-only mode. Our different slaves will be specific to different regions of the world.

Update flow :

After the transaction has been validated, a new transaction object is created and added to the kafka broker. In fact we do beside of sending the request directly to the update service because of two things :

- First, we need to temporarily save the validated transaction as we dont want to lose those important information. In fact if the update service is down for a reason, we can store transactions in the broker during the laps of time needed by the update service to goes up against, and then to treat all the transactions to update the client account.
- Second, we need the update service to treat all the triggers to modification but with one instance, as for the moment, we didn't put in place a multiple instance solution using load balancer for this solution.

PoC Context :



In this section, we'll explain the context of our PoC in order to address the problem of diverse regions and their specification.

First of all, in order to open up to several regions, we need to diversify our deployment. So we thought of setting up farms by region, where we'd have a replication of our system excluding the Greenland database.

To explain the diagram above, in our poc we have separated one part of our architecture as pseudo belonging to the French farm, and the other to the farm in the other region. In fact, all the elements shown in the diagram are contained within a farm, but for the purposes of demonstration we've made this separation.

There are advantages to this design, two to be precise:

- the first is that having farms deployed by region allows us to be "relatively" close to our customers, and thus have relatively better throughput. In this way, we'll be able to reduce the time it takes to make a request, because the network is slow.

- the second is in the context of the "diverse regulations" requirement. Indeed, in the immediate future, in this PoC, having diverse regulations possible by region is not taken into account because it could not be implemented. But the idea would be to have a configurable file that would be the same for all regions, where administrators could add new rules, translated into permissions that would be added to the transaction validation flow. For example, a rule describing the fact that non-French people in France can't have a negative balance on their account.

Architecture weakness :

Asynchronous Issues :

The fact that we use a CQRS model includes some asynchronous action that occurs when we are actually trying to update a client account on the greenland database side.

Indeed, as our subject is about a bank systeme, we have to really be careful on the data that we use to validate a transaction. In fact, asynchronous bring with it some weak consistency issues, which in our case is bad because we really need to be highly consistante. Otherwise a client without money could pay for something. We can't have an elapsed time where the data could be inconsistent.

In our case, we decided to make a hypothesis : " A customer cannot make two payments in a row in less than 5 minutes ". This lets our systeme the time, for one transaction request, if she is validated, to update the client account. In real life, it's rare to make two payments with a card two times in a row in less than 5 minutes, but it's possible.

The only solution that we have is to add a mutex on the data that is in the update process, so no one can retrieve this client related data until the update is finished.

Replication master - slave :

In our actual systeme, we replicate all the databases in each slave. The thing is that it has a cost in terms of deployment because the database will be as heavy as the one in Greenland. The solution could be to replicate data based on each customer region. Or in the greenland to have a different Database for each region, and to replicate it in the region.

The first solution add a new layer of complexity as we replicate a value to a replica based on a value of this data. It can slow the update process.
The second solution is to segregate our database in the greenland side into multiple databases based on the region. And so we will have each customer in his region and each database will replicate its entire self in its related region. In this case, the update process is not impacted but it could be possible to have a much bigger Database that another one and to fall against in the initial problematic.

Missing points :

Business side :

Our version of the project was : "From France to Europe and beyond, Mastering heavy loads and diverse regulations", the biggest part has been taken, concluding in our MVP, but there are some scenarios for which it hasn't been the case.
The first one is for a client that pays in a foreign country. Indeed this scenario presents a thing that we didn't think about, how to detect a client when he is not in his country. In fact as

we are an online bank, it wasn't the priority in the MVP, but it's something that is missing in the case of our version.
The second one is to have rules specific to each region. As we explained, that is something which we thought about but didn't implement it in the PoC.

Resilience side :

The fact is that if a service goes down, there are other instances to take his job, even if we have a Round Robin algo which is dumb (don't check the health of the service, cost time). But if a slave replica of the database goes down, we didn't implement a kind of service or configuration that is going to rebuild it, so if the database goes down for a x reason, the request will just fail over.

Difficulty encountered :

Complex architecture, in fact, in the context of the realization of this architecture, we had to set up a huge number of technological tools, and deal with a huge number of configurations linked to them, which was no easy task.

We also spread ourselves too thin in the course of the project, having to revisit our architecture every week as new methods were discovered. We wanted to have a good starting point to avoid factoring as much as possible, so we fell into the problem of design paralysis.

Finally, creating a prototype to demonstrate the PoC was also complicated, as we had to populate the database with a large number of different values (account and customer card), in order to have a "realistic" database on which to demonstrate a heavy load of requests.

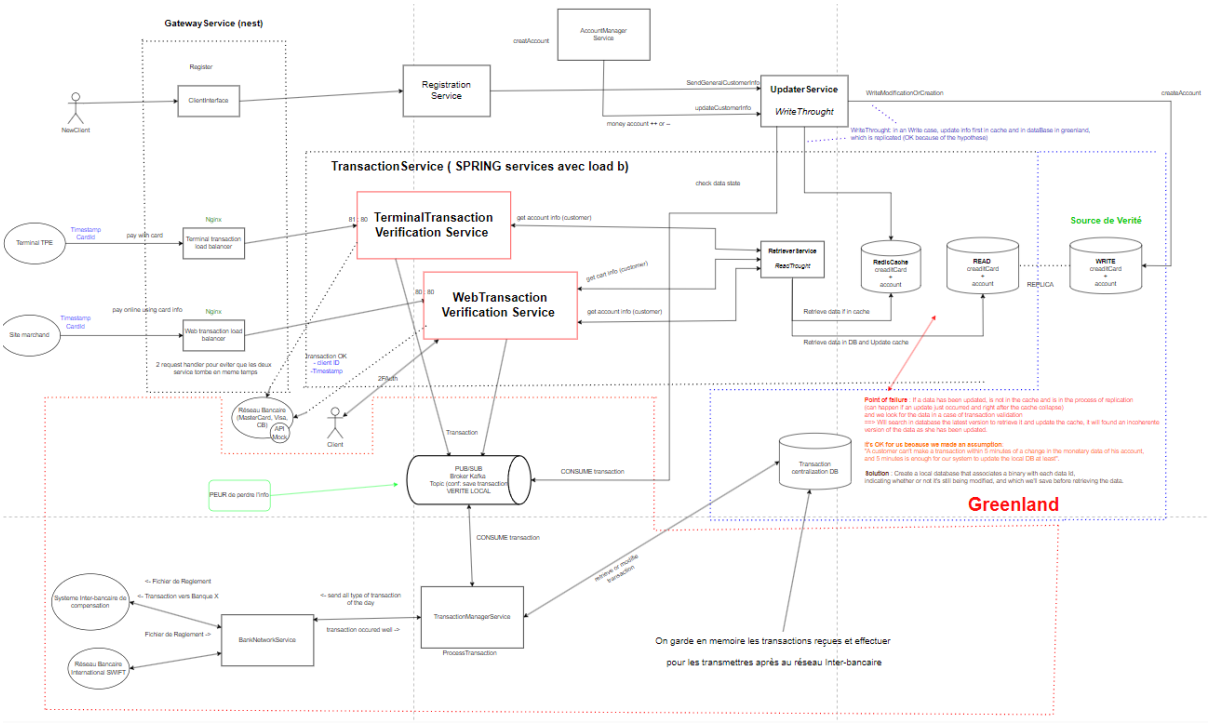
Auto-Évaluation (Francais) :

Chaque membre du projet à travailler de manière équitable dans ce projet. Des propositions étaient faites et ajoutées à l'architecture, puis l'on trouve un timing pour discuter de la chose et conclure sur une architecture et de nouveaux scénarios. Nous avons tous contribué à l'implémentation du projet, à sa documentation dans le rapport et à sa configuration notamment dans le cadre d'ajout de nouvelle technologie, ainsi, voici la répartitions des points :

- Ayman Bassy : 100 pts
- Tobias Bonifay : 100 pts
- Mathieu Schalkwijk: 100 pts
- Igor Melnyk : 100 pts

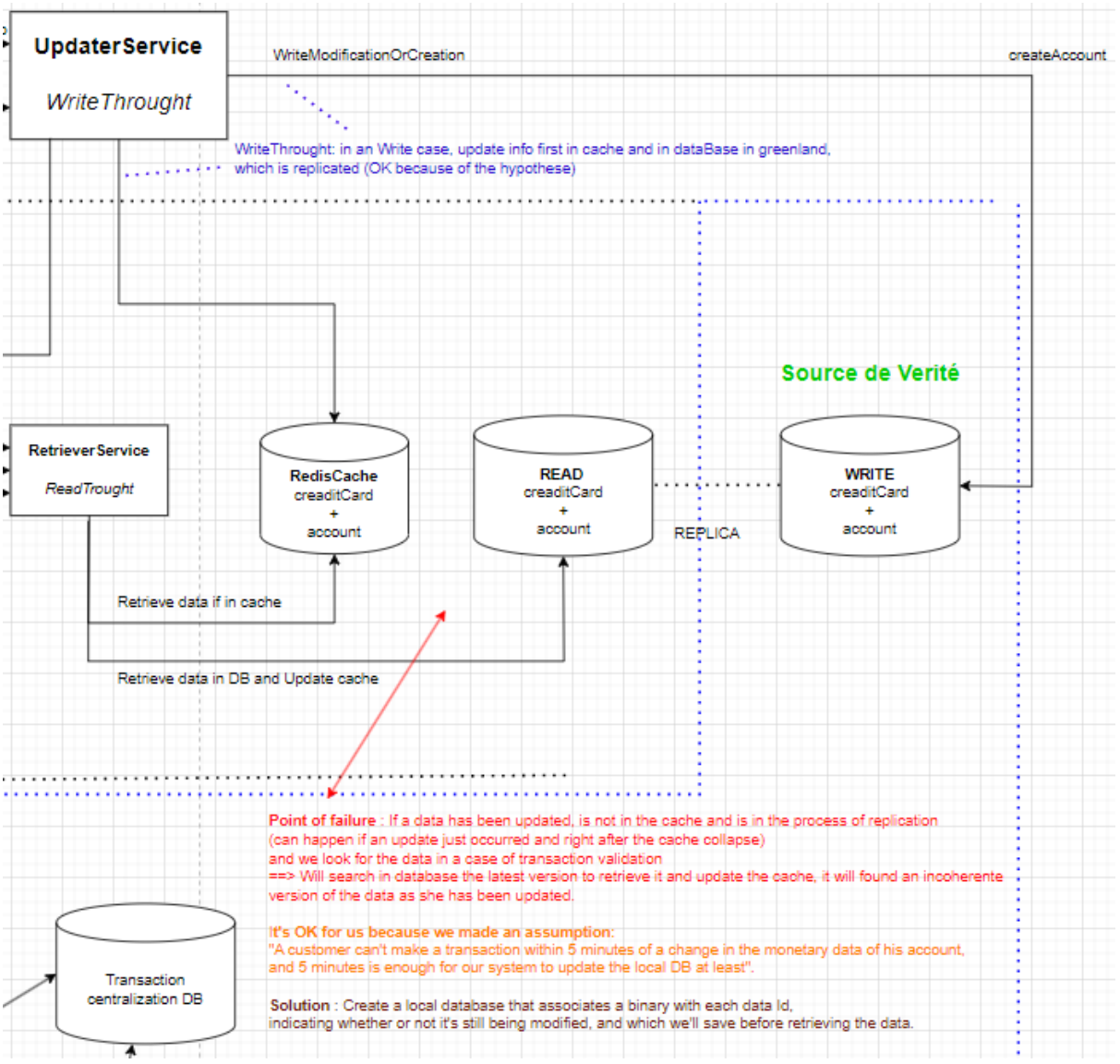
Week 44 (after vacation) :

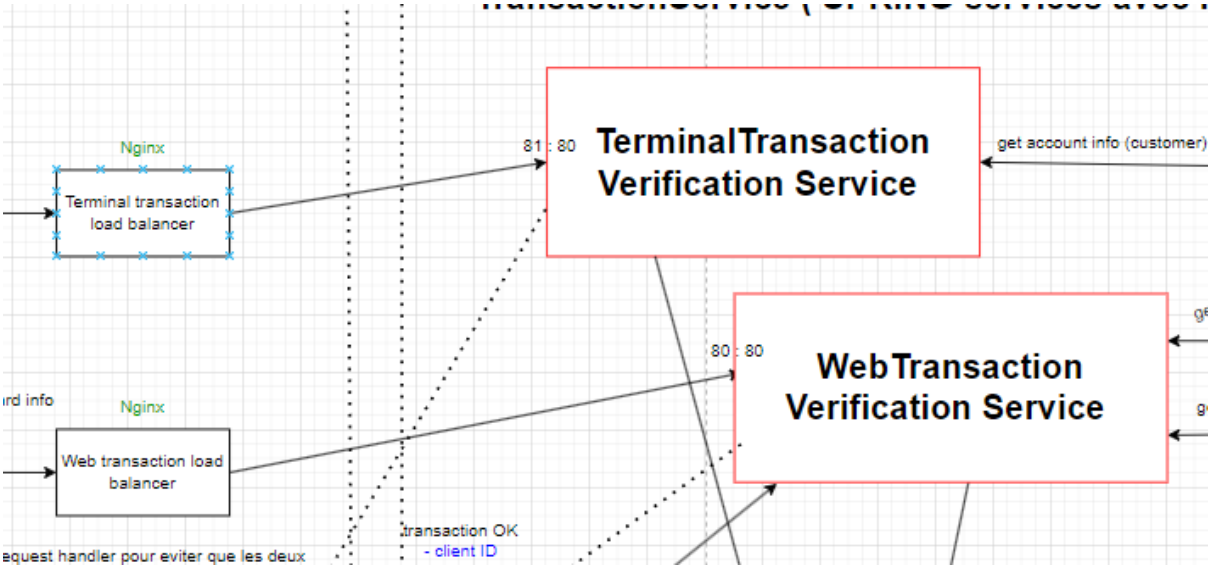
Current Structure of the services architecture :



The latest changes were made to the database, following the various studies carried out on the previous models, implemented or not. We deduced a data model that combines data consistency, high availability and speed.
In effect, we've decided to read and write to the database via a cache, so that the data is replicated on the cache, which will respond rapidly to the request. If the data is present in the cache, we retrieve it, if not, we retrieve it from the database and duplicate it on the cache. We only duplicate exactly what we need in our context of use, not all the values. We can do this because it's through a service that we'll perform persistence on the cache.

We'll have two services, one for writes and one for reads. This way, these services can respond quickly and perform CRUD. In fact, we've decided to separate the CRUD logic from our request verification services in order to make them more accountable. In the context of this POC, our resources are limited, so we can't perform a perfect verification, but this one embeds more complexity, especially as this CRUD deporter logic could also be used by other persistent services in our application. (See image below)


UpdaterService
WriteThrought
WriteModificationOrCreation
createAccount
WriteThrought: in an Write case, update info first in cache and in dataBase in greenland,
which is replicated (OK because of the hypothese)
Source de Verité
RetrieverService
ReadTrought
RedisCache
creaditCard
+
account
READ
creaditCard
+
account
REPLICA
WRITE
creaditCard
+
account
Retrieve data if in cache
Retrieve data in DB and Update cache
Point of failure : If a data has been updated, is not in the cache and is in the process of replication
(can happen if an update just occurred and right after the cache collapse)
and we look for the data in a case of transaction validation
==> Will search in database the latest version to retrieve it and update the cache, it will found an incoherente
version of the data as she has been updated.
It's OK for us because we made an assumption:
"A customer can't make a transaction within 5 minutes of a change in the monetary data of his account,
and 5 minutes is enough for our system to update the local DB at least".
Transaction
centralization DB
Solution : Create a local database that associates a binary with each data Id,
indicating whether or not it's still being modified, and which we'll save before retrieving the data.


Nginx
Terminal transaction
load balancer
81 : 80
TerminalTransaction
Verification Service
get account info (customer)
80 : 80
WebTransaction
Verification Service
Nginx
Web transaction load
balancer
transaction OK
- client ID

We've also decided to add load balancers via Ngix before the transaction verification services, as this allows loads to be distributed between several instances, thus managing greater demand. To do this, we use a Round Robin algorithm, so we don't need any further optimization. (See image above).

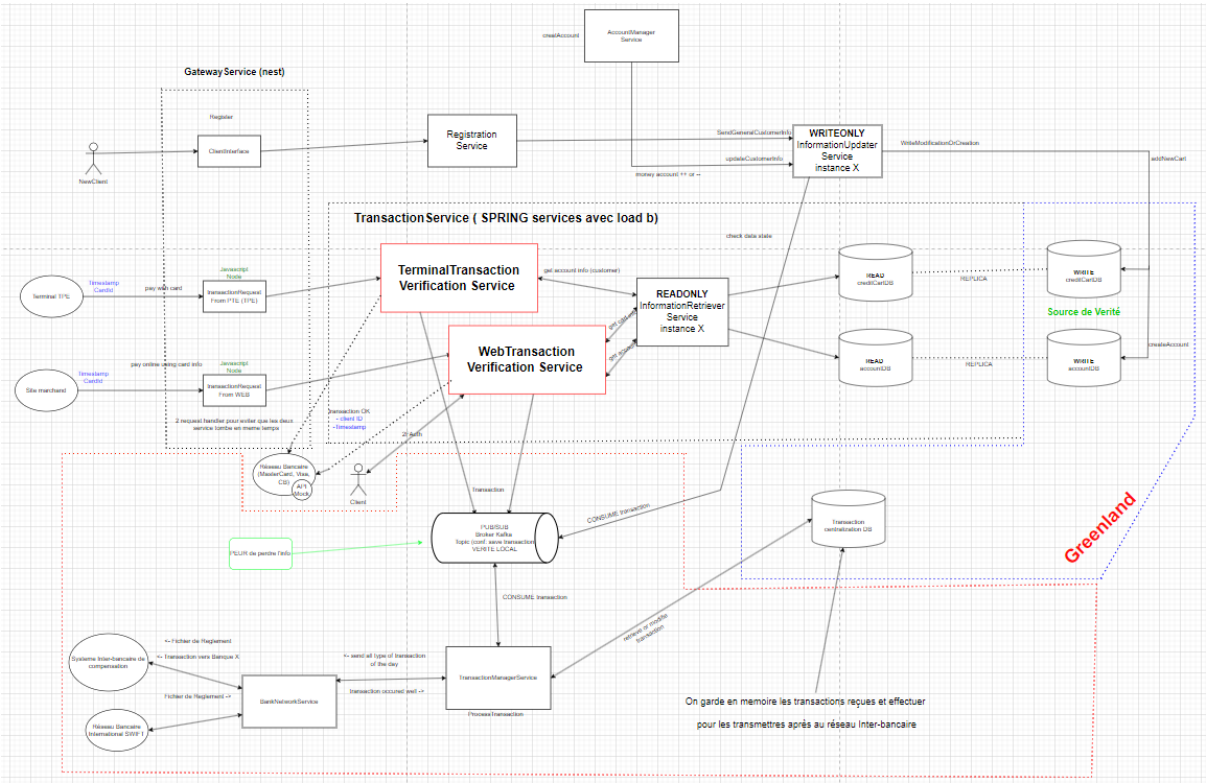
We're thinking of adding a load balancer in front of multiple instances of our new solution's crud services, but since we're only doing CRUD, we're thinking that using Spring Web Flux for asynchronous and concurrent code, for example, might enable us to fill the equivalent demand at service level. In fact, time constraints are holding us back, as the configuration steps are very time-consuming.

Scenario of the week :

To test all the first transaction validation par using everything but the caches, indeed time remaining to configure cache may take time, and we want to have the main flow before.

Week 42 :

Current Structure of the services architecture :



- Some change at the level of the databases has been made. The following hypothesis has been put forward: *a customer who is in the process of making a paying transaction (which means a transaction involving a change to his money in his bank account) cannot at the same time make a major change to his account, at least in the category linked to his money in the bank*.
  With these hypotheses in mind, we decided to reduce the complexity of the architecture at the database level. In effect, we would have a CQRS architecture with databases in master script at the Greenland level, which replicated their data at the level of the local Slavs read only in the region.

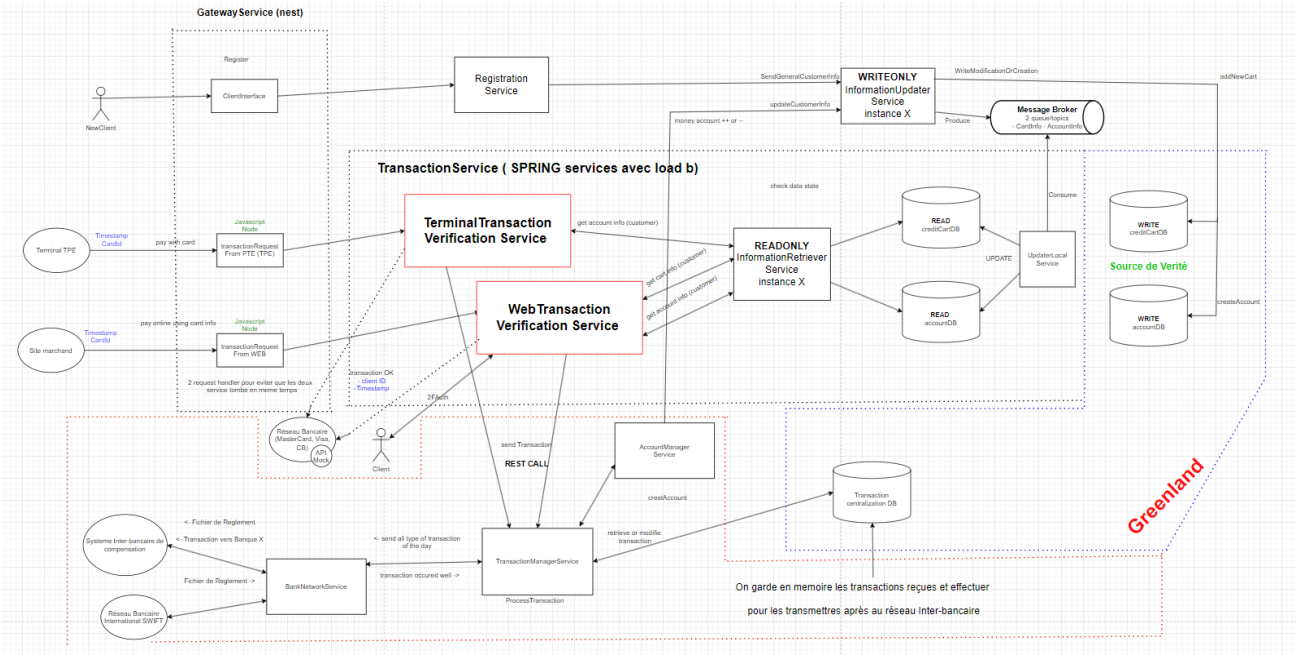
- Also at the level of resilience of a validated transaction data that has to go and modify the database. We've found that it doesn't pass through too many services, which increases the risk of losing the data in the event of a breakdown or other failure of a service that doesn't have much interest in being present in the flow. That's why we've removed the AccoutManager service, and set up a data bus to work more on an event-driven basis, with a "transaction validated" event that will be stored in memory on the bus, then consumed by our database write service.

Scenario of the Week :

We're still in the same scenario as last week, but in parallel we're also developing a load balancing solution on several instances of our transaction services. Indeed, in the case of a basic implementation, with the service retrieving the values to be checked from the database, and those in a case of large demand, the services may struggle, hence this initial implementation to see how it would work with a load balancer.

Week 41 :

Current Structure of the services architecture :



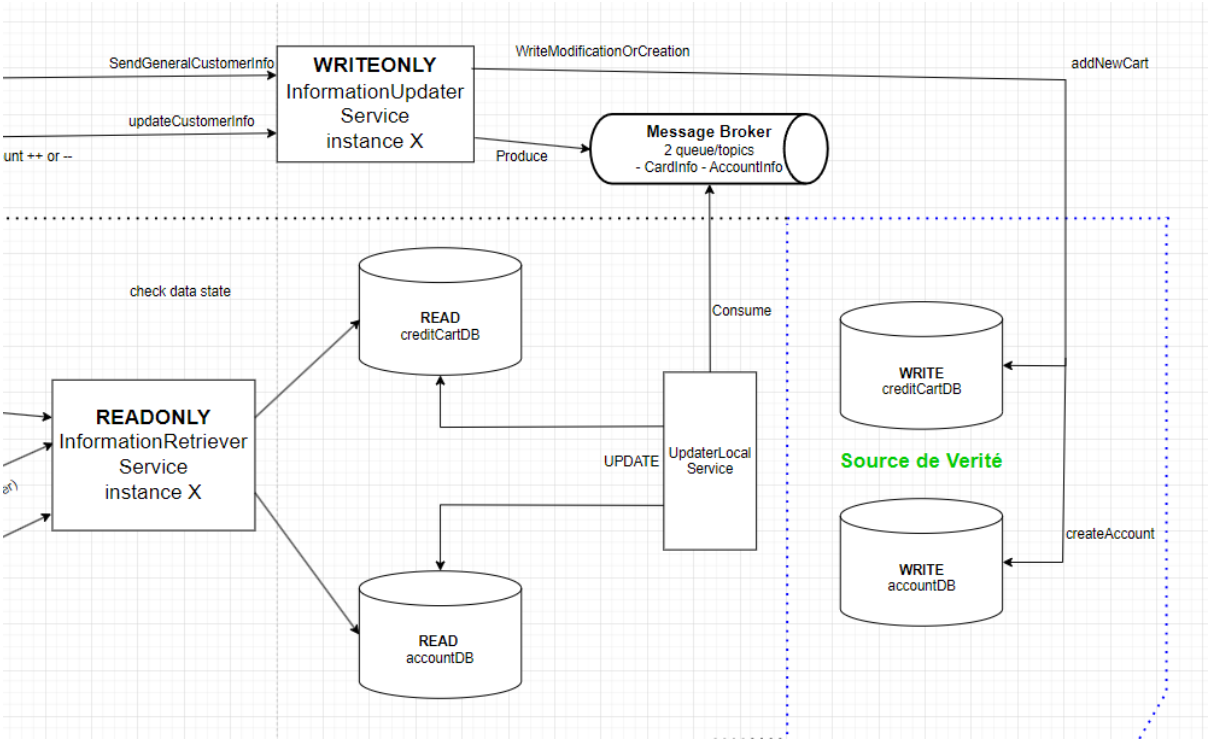
In our new service architecture, we haven't really changed the logic in terms of how transactions work or anything else - everything is still faithful to what we did the week before. But we did look at what we were going to do about the databases.

The challenge for us was not only to reduce database costs, but also to be able to retrieve data as quickly as possible. So we absolutely had to have databases that were always available and with consistent data, since the account information from which we validated a transaction had to be the same after updating. In order to avoid verification on biased data.

So, put in perspective with the CAP theorem, here we would give priority to consistency and availability. For partitioning tolerance, we assume that each time data is modified or added, it is duplicated between the Greenland database and the local database. Local databases are read-only, but in the event that they are no longer available, following a 50x server-side error for example, we'll send the request to Greenland so that we can still access the data.

The bottom line is that: the validation of a banking transaction must, in as many cases as possible, return a rapid response, whether or not it has been validated; a read transaction to a database must always be able to do this, and must return data consistent with the latest state of the data.

Architecture ZOOM :



Here is the part of the architecture that has really changed within a week. Indeed for this one, we have implemented a solution based on the CQRS model. We would have two services, one to write and the other to read. We would also have two databases in Greenland, and two others locally depending on where we are deploying. We would have a Broker that will notify the update service of the incoming modification sent to Greenland.

We thought of this solution only for this part without including the transaction database one because for now, we don't feel that we will need it as the real fast part is where, and in the context of validation of a bank transaction, we want it to be fast. For what comes next, it can be slower.

New Service Serving CQRS :

ReadOnly service : this service is here to retrieve data from a local database for each type of data that we would want. If an update and read action occurs at the same time, the update one occurs first. This service is the one that will increase its instance in case of a big scale request.

WriteOnly service : This service is here to modify any type of information. It accesses the Greenland database and through the broker sends the update to the UpdateService which only Job is to perform an update of the data in the readOnlyDatabase.

Why CQRS :

We thought of the CQRS pattern because in our case, we, from the beginning, were doing things on two different levels. The first one being action that occurs but only needs to read things from the database, the second one being all other cases that will involve account management.

The second reason for this choice was that, in terms of data recovery, we needed a model that would enable us to recover data quickly. We couldn't make a request all the way to the greenland, as this would potentially take too long, and could quickly load the databases, knowing that other actions would be taking place.

So this model allows us to distinguish between reading and writing, and if other functionality involving fast reading arises, the solution would be to add an uptade service on the duplicate of a new database.

The last point is that, based on our current knowledge, this solution seems more suitable and general, rather than having databases with a master-slave relationship of data replication. But this approach can be used as an alternative depending on our results.

Persona (no change):

- Fabrice : technician at the new neo-bank "IgorBanque", his job is to keep BNP IgorBanque's servers up and running.
- Philippe : A merchant who recently opened a cookie-shop in Nice, he offers customers a means of paying by card, or on the internet via click and collect.

User Stories (no change):

- As Fabrice, I need to know from the cardNetwork which kind of transaction is coming
- As Phillipe, I need to know from my TPE terminal if the client transaction have succeeded
- As Phillipe, I need to be notified if a transaction have succeeded if the purchase of the click and collect have been made on my website
- As Fabrice, I need to know in the bank systeme if any kind of transaction have succeeded

Scenario for this week :

Phillipe second scenario, but with one customer (phillipe), and multiple customers, in order to explore what could happen if in the case of a naive approach we try to handle a really large amount of bank transaction.

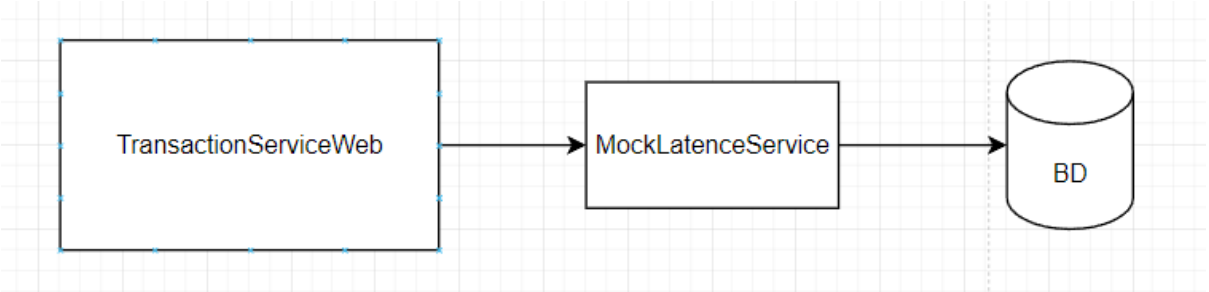


Image of what could be the first naive implementation

In this scenario, we will suppose that our service in requesting data directly from greenland, and to do so, we will have a service that will retrieve data with latency to explore what happens when :

- the transaction service request data from database
- the transaction service request data from database with latency

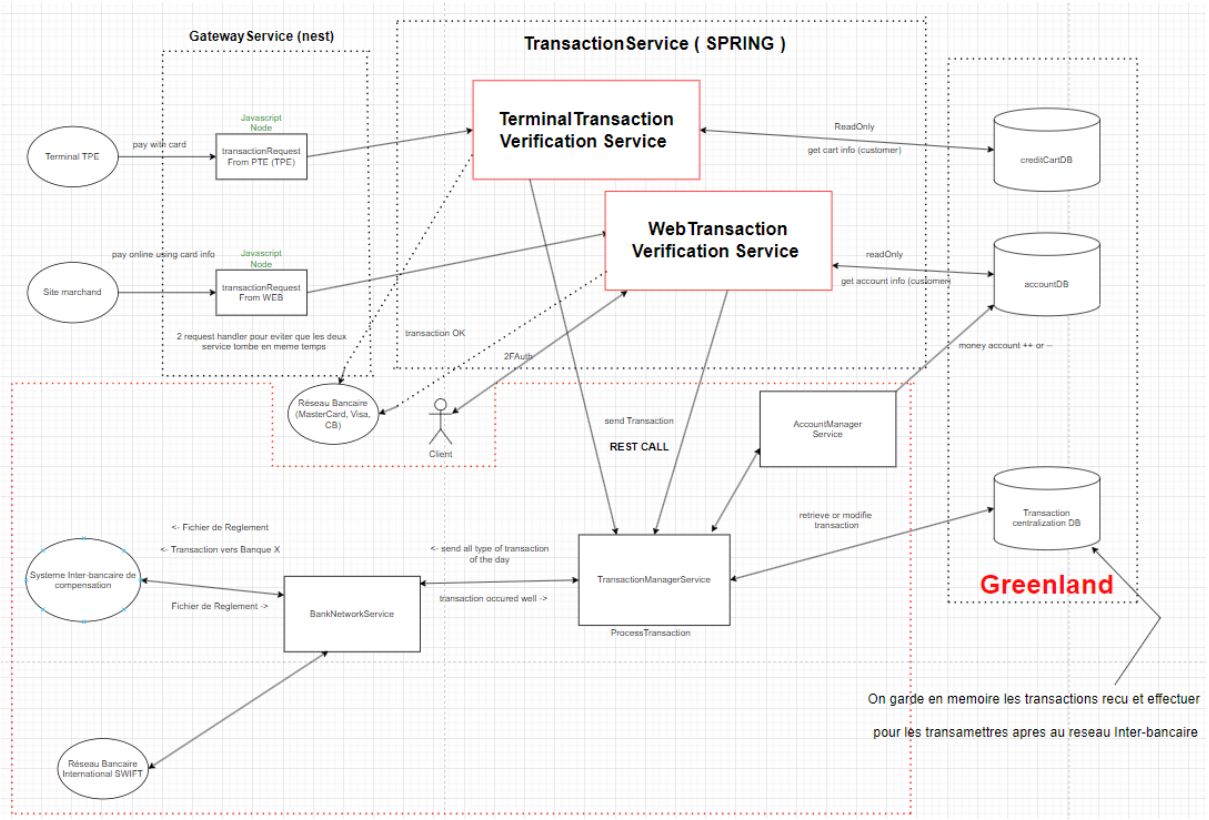
this two scenario will have multiple test with different amount of data to treat

For the intermediar latency service, it will be implemented using some optimisation so it don't crash while simulating, indeed we just want to simulate what could happens to the transaction service if a too big amount of transaction object are created to validate it, in the case where we could wait 0 second or 2-3 second.

So we can test resiliency and also the performance of this naive solution (it also give us a first implementation of our main service for this iteration)

Week 40 :

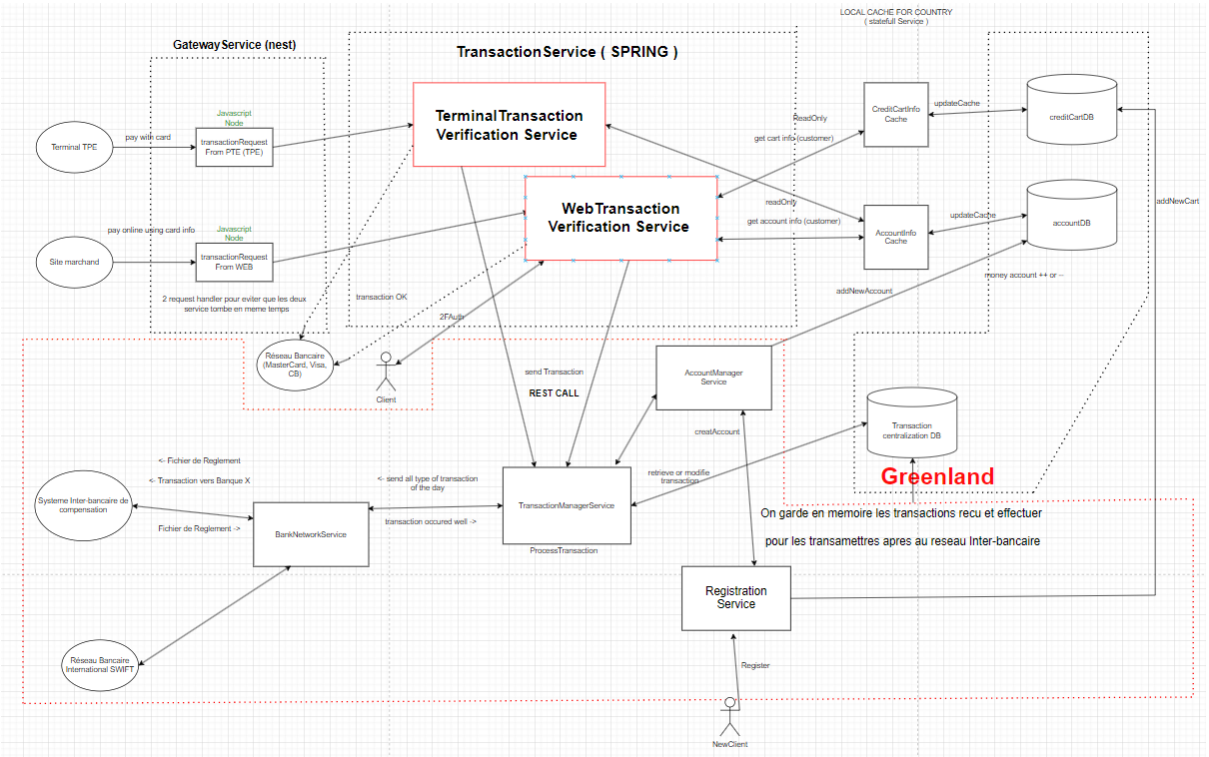
Current Structure of the services architecture :



Our architecture has been designed to meet a primary need: the scalability of our banking system. Indeed, the first type of service provided will be the banking transaction, so we decided to focus on this one.

In this diagram, we've separated the former large transactionService block into two services, one responsible for transactions issued from a TER and the other for transactions issued from another type of terminal, in our case a CB, Visa or other web-based banking transaction service. We have decided to leave bank transfers aside, as they are not a priority for the moment. This separation allows us to better manage a large flow of transaction requests. There will indeed be a certain amount of repetition in the verification process, but this will enable us to have a faster verification service in the TER case..

As far as the databases are concerned, at first we thought of a read-only solution. But given that we'll have to process a large number of requests in several countries in the future. With databases located in Greenland, this can be very slow. So we've come up with a kind of caching solution that would be set up on the servers in each country. Each time the databases undergo an update via a modification, they notify the caches that change their data. This solution would be even more feasible for credit cards, given that this information changes very little. Here's what the diagram would look like:



The parts circled in red are part of the transaction system (apart from customer registration, which is there to populate the databases). In fact, the most important thing is to create a simple transaction schema with the various rules and verifications linked to it. Then we'll add the system for notifying the banking network of successful transactions, and the processing of settlement files. These are logs of all the transactions carried out during the day, and it is on the basis of this file that we add or withdraw money from the various customers.

Note also that in the real world, a transaction comes from the credit card network and is then processed, so we've chosen to distinguish two types of transaction, rather than abstracting one from the credit card network.

Services :

TransactionRequestFromTPE:

- His role is to process the transaction for a TPE on client side, and to send only needed info to the service

TransactionRequestFromWEB:

- His role is to process the transaction coming from an NetworkCard API, such as Master, Visa or CB, and to send only needed info to the service

TransactionManagerService:

- Its role is to process a transaction when this one is validated by the validators services, it sends the transaction to the AccountManagerService so this service can process the impact of the recent transaction on account. He also added the transaction to the list of transactions of the day in the TransactionCentralisationDB. When the daily cycle has finished, he takes the list of transactions that occurred during this time and sends them to the BankNetwork. He can also be notified that transaction coming from other bank have arrived and he notify the AccountManager (in future implementation, will store those information so client can seed an historique of transaction)

AccountManagerService:

- Manage client's account. Create a new account for clients. Depending on the invoked action, can modify a new client balance depending on the transaction regarding him.
- Scaling point : this service is invoked only if needed, and for scale needs, can have just before a bus that content all the action that he have to archive (like add or retire money), those action can be done in the background as they don't have an immediate impact

BankNetworkService:

- Service that is linked to the outside, when a transaction comes from the systeme, it changes it into a reglementation file understandable by the banking network.
  When a file comes from the outside, I change it into a transactional JSON understandable by the TransactionManagerService.

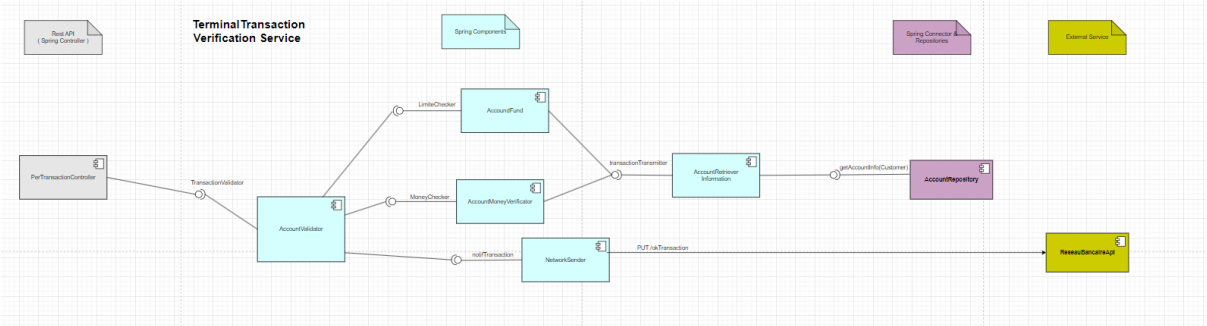
RegistrationService:

- Not importante service in this scope, here to fill DB. This service is here to manage the step in a new client registration. Treat a JSON with all client info and create his account and generate him a new neo-card.

TerminalTransactionVerificationService :

- Its role is to check if a wanted transaction can be done. It then sends a REST Call to the transactionManagerService so it continues the process.

Component Diagram :



Components :

ComponentAccountValidator **:**

- receives a transaction and validates it or not

AccountFund **:**

- manages the verification linked to the account ceiling
  - checks if the account has reached the payment limit

AccountMoneyVerificator **:**

- handles verification related to account money, check if the account has enough money.If false: checks whether the account can or may still go into the red

NetworkSender **:**

- if transaction is marked as successful, notifies the card network

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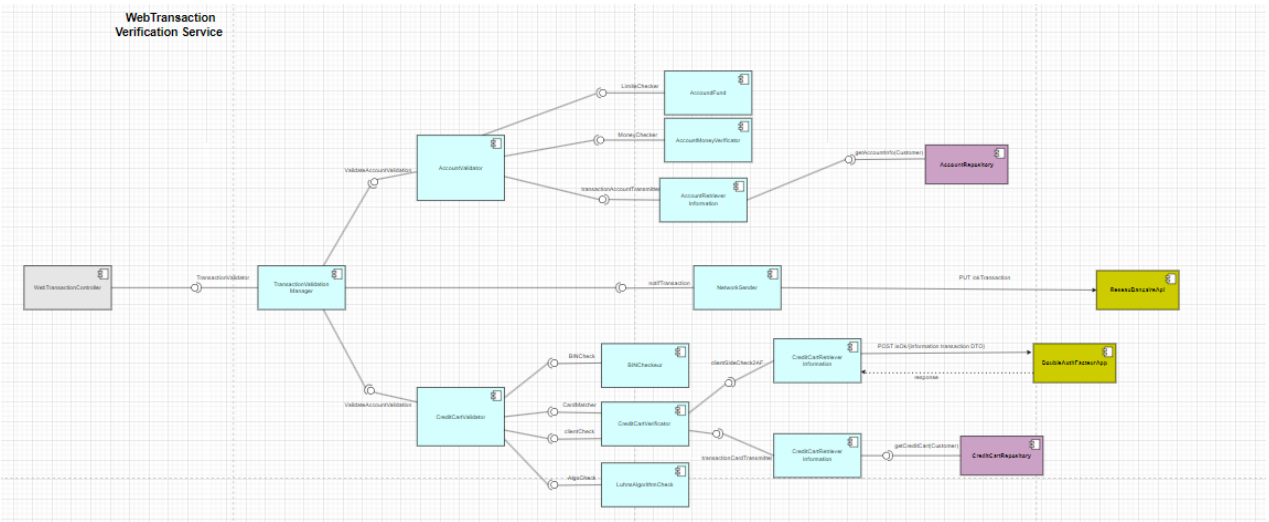

Components :

TransactionValidationManager:

- checks that all verifications have been carried out correctly, and is responsible for the order in which transactions are carried out.

CreditCartValidator:

- performs verification of credit card information

BINChecker:

- verifies regex format of card information submitted for verification

LuhnsAlgorithmCheck:

- checks the 16-digit code provided to verify the validity of the number

CreditCartVerificator:

- verifies that the information given by the customer corresponds to the object in BD

Persona :

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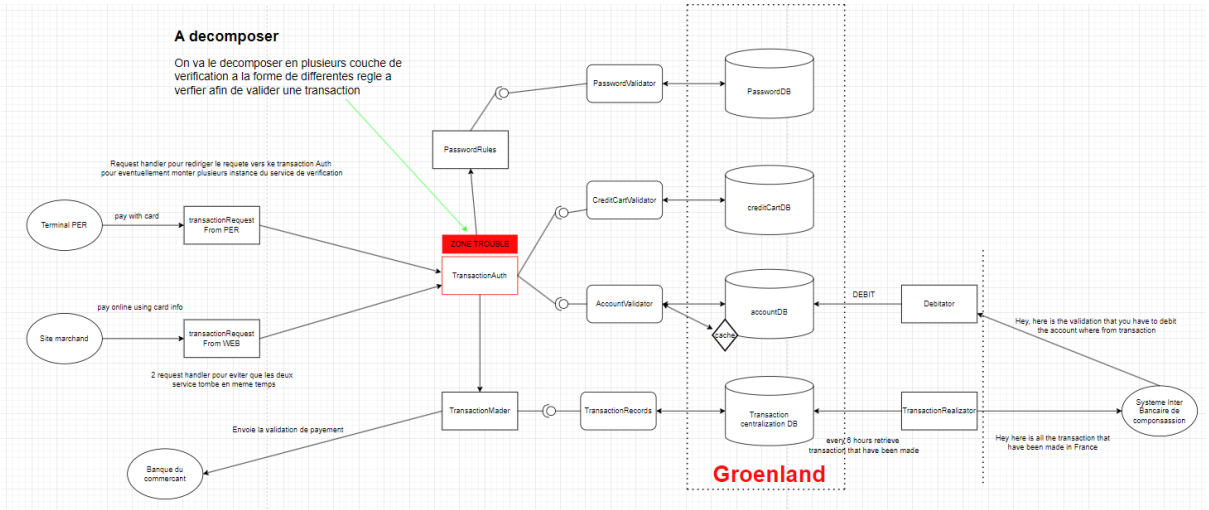
- As Fabrice, I need to know in the bank systeme if any kind of transaction have succeeded

Week 39 :

Current Structure of the architecture :



In our current architecture, we only support transactions for the moment, but we'd like to concentrate on them so that we can consider applications of version 7 of the bank, i.e. large-scale scaling.

In our schema, we have the following external services: the terminal, a merchant's site, his bank and the interbank clearing system, which manages money exchanges between banks.

We then have a verification layer which retransmits transaction requests to the central transaction verification system. We've imagined it this way in order to potentially isolate the transaction verification service, which could be the part most in demand during a scale-up, so we can raise several instances of this service.

In our verification service, we'd have a set of components that verify each part of the request, which must comply with a set of established rules (ceiling limit, sufficient balance, valid credit card, valid transmitted information, correct passwords, etc.). Most of the information will be stored in Greenland databases, with which we will interact to retrieve this information. A caching solution could also be deployed to speed up retrieval in the event of scaling.

A broadcast component will then be called if the transaction can go through. The money is then frozen on the account, and the new transaction is added to all those already processed. The customer's bank, if external, is notified of the pending transfer.

Every 6 hours (according to the Internet), the SIT will retrieve all the transactions carried out and, once all the transfers have been made, will tell the bank to withdraw the frozen money from the accounts. Given that the action of debiting the money happens every 6 hours in our conception of the thing, the debiting component may not be asynchronous in the immediate future, but in a scaling perspective, it probably will be.

In the end, we'll have 4 layers: transaction reception, verification, communication with external services and databases.

Ideally, what would be most feasible would be to group external management into a single service, which would also include functionality not required for transactions, and to output transaction verification processing in a single service.

Sequence Diagram Flow :