Advisory Report

Windesheim

Spark! Living Lab Conditioned Goods

Version 0.8



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# Abstract

A cold chain is a temperature-controlled supply chain, where the cargo is cooled throughout the chain. These cold chains are arranged traditionally. There is minimal insight into the delivery times, conditions, and origin of the goods within the chain. Lamb Weston, a major producer of French fries, uses a cold chain to transport their fries from the factory to a cooled warehouse. They want to measure the temperature during the transport from their factory to the cold store to guarantee that the fries are cooled correctly, and the conditions are as stated by the provider for the cold chain’s entirety. These sensor data need to be stored without any entity being able to alter the information.   
A previous project group advised Spark! Living Lab that a blockchain, specifically Hyperledger Fabric, could provide these functionalities. Because of this advice Spark! Living Lab commissioned this project. The goal of this project was to build a Proof of Concept to show if Hyperledger Fabric meets the requirements for this use case.

Hyperledger Fabric is a very extensive blockchain framework. This means it takes a lot of time and experience to fully understand the framework. The framework also has almost no low-level infrastructure documentation available. This combined with unclear error messages, that could be interpreted in different ways, makes Hyperledger Fabric especially difficult to implement. Because of this our advice would be to ask the question ‘Do the benefits weigh up against the complexity of Hyperledger Fabric, and how important is the integrity of the data collected?’ before choosing the Hyperledger framework. We believe that if integrity of data is not that important, but the idea of transparency and insight is, other options might be a better solution. For example, a simple database could be used to store the measurement data. However, this option does not guarantee data integrity to the extend a blockchain does.

Nonetheless, if Spark! Wants to continue with Hyperledger Fabric it might be wise to hire an expert to assist with the project. This may not be necessary, but it will majorly decrease the development time. IBM’s blockchain platform might also be an option to extend the proof of concept to a fully production ready solution.

Index

[1 Abstract 2](#_Toc73538147)

[2 Introduction 4](#_Toc73538148)

[2.1 Context 4](#_Toc73538149)

[2.2 Companies 4](#_Toc73538150)

[2.3 Problem statement 4](#_Toc73538151)

[2.4 Goal 4](#_Toc73538152)

[3 The product 5](#_Toc73538153)

[3.1 Infrastructure 5](#_Toc73538154)

[3.2 Software 5](#_Toc73538155)

[4 Findings 6](#_Toc73538156)

[4.1 Extensive 6](#_Toc73538157)

[4.2 No low-level documentation infrastructure 6](#_Toc73538158)

[4.3 Code samples available 6](#_Toc73538159)

[4.4 Unclear errors 7](#_Toc73538160)

[4.5 Rumored IBM withdrawal from Hyperledger Fabric 7](#_Toc73538161)

[5 Improvements 8](#_Toc73538162)

[5.1 Software Error logging 8](#_Toc73538163)

[5.2 Avoid query operators. 8](#_Toc73538164)

[5.3 Use an off-chain database for the dashboard. 8](#_Toc73538165)

[5.4 Access control 8](#_Toc73538166)

[5.5 Generify 8](#_Toc73538167)

[5.6 Pre-generated certificates 9](#_Toc73538168)

[6 Advice 10](#_Toc73538169)

[7 References 12](#_Toc73538170)

[8 Appendix 13](#_Toc73538171)

# Introduction

This document contains advice for Spark! Living Lab about the use of Hyperledger Fabric in the conditioned goods use case.

## Context

Companies that need their cargo cooled during transport make use of a ‘cold chain’. A cold chain is a temperature-controlled supply chain, where the cargo is cooled throughout the chain (Wikipedia, 2021). When a customer purchases a cold chain service, both parties' conditions and quality are agreed upon; this is stated in a Service Level Agreement (SLA) (wikipedia, 2020). There is a chance of a cold break in the cold chain, which means there was an undetermined time that the cargo was not cooled. This cold chain is arranged traditionally, documenting events on paper and manually measuring temperatures. Which means that the customer has no concrete evidence that the provider has met the SLA. This causes to be minimal insight into the delivery times, conditions, and origin of the goods within the chain.

## Companies

Lamb Weston is one of the world’s largest processors of potato products founded in Weston, Oregon, with over 1300 employees (Lamb Weston, n.d.). They produce frozen fries and other potato products in all shapes and sizes for any occasion. Lamb Weston wants to produce fries in a sustainable way by using methods such as sustainable cultivation, smart processing of their products and supply chain innovation [1]. Lamb Weston is the owner of this projects supply chain.

## Problem statement

Lamb Weston uses a cold chain to cool their fries during transport. This cold chain starts at the factory of Lamb Weston where the fries are produced. After frying the fries, they are cooled down to -7 degrees Celsius in their factory. These fries are then transported to another location where they are cooled down to -18 degrees Celsius. Lamb Weston wants to measure the temperature during the transport from their factory to the cold store to guarantee that the fries are cooled correctly, and the conditions are as stated by the provider for the cold chain’s entirety. These sensor data need to be stored without any entity being able to alter the information.

## Goal

This project aims to provide a solution that monitors and captures the temperature of the fries during transport from Lamb Weston’s factory to the cold store. All this data must have the integrity to provide the needed information to confirm that the SLA has been met. To make sure that the data stays unaltered, blockchain (Hyperledger Fabric) will be used. The final goal is a prototype in the form of a proof of concept (PoC).

Based on the results of the PoC and discoveries made during the project this advisory report was written.

# The product

This chapter will briefly describe the final product. The final product consists of two parts. The first part is the infrastructure that is used to run the Hyperledger Fabric blockchain. The second part is the software that runs on top of the blockchain infrastructure and controls the business logic, connection to the blockchain and visual representation of the blockchain data.

## Infrastructure

The infrastructure part of this project and PoC consists of three Ubuntu 20.04 servers, one for each company (Lamb Weston, DLG and Lineage). All Hyperledger Fabric services are run on top of the servers using Docker containers.   
All steps needed to deploy a Hyperledger Fabric production network consisting of three companies are combined in scripts. These scripts can be used to deploy the complete network in a few simple steps.

## Software

The software for the Hyperledger Fabric Network is split into three different application that work together to give the optimal experience. They can also work independently from each other for example the chaincode could be assessed without the API. So that one application does not affect everything. The software is split into the following applications:

* **Chaincode (smart contracts):** the chaincode handles the business logics by allowing applications to retrieve and insert data in to the blockchain. This is achieved by defining smart contracts.
* **Application Programmer Interface (API):** the API handles the communication between the sensors, dashboard, and the blockchain through the chaincode. This allows us to have one central endpoint to communicate to, instead of having multiple application accessing the chaincode with their own gateway.
* **Dashboard (front-end):** the dashboard application’s primary task is to visualize the data inside the blockchain for the user. In this dashboard it will also be possible to add additional shipments and attach sensors to shipments.

# Findings

This chapter will describe all findings the project group made during the project and the realization of the PoC.

## Extensive

Hyperledger Fabric contains plenty of features and functionalities, this makes it an extremely extensive framework for creating blockchain applications and networks. This means it takes a lot of time and experience to fully understand what Hyperledger Fabric entails. Because Hyperledger is so extensive there is a lot of different documentation about multiple versions, which sometimes can be confusing and a little bit overwhelming to find the correct documentation. It takes a lot of knowledge about blockchain and Hyperledger Fabric and a considerable amount of manpower to create a production ready application in a short time. This will probably be the case with every other blockchain framework too.

## No low-level documentation infrastructure

While Hyperledger Fabric has a lot of extensive documentation, almost none of the documentation about the infrastructure is low-level. This means that there is a lot of documentation on how Hyperledger Fabric is supposed to work, however there is almost no technical documentation describing how the Hyperledger Fabric services are supposed to be implemented. Almost the whole infrastructure part of the Proof of Concept is based on third party documentation. Because there is not a lot of official low-level documentation these third-party documents cannot really be verified to check if they are correct. This makes implementing Hyperledger Fabric in a production environment especially difficult.

## Code samples available

Hyperledger Fabric offer plenty of coding samples in their fabric-samples repository or IBM‘s repositories from basic to advanced usages using different languages including JavaScript (TypeScript), Go and Java. These examples could provide a developer with knowledge about building chaincodes and applications to connect with the blockchain. Also, contributors such as IBM are offering tooling to make developing Hyperledger Fabric applications a lot easier. IBM’s Visual Studio Code extension allows developers to create Hyperledger Fabric Networks and create and deploy smart contracts with a few clicks. This is a major time save while developing applications.

## Unclear errors

The messages that are produced when commands or processes go wrong are interpretable in multiple ways. For example, when an orderer cannot connect to Kafka (ordering service) it only gives a connection timeout error. This error can be generated by a lot of different issues. Searching on the internet, you come to find many others that have difficulty deciphering the error messages. These unclear errors contribute to the difficulty in implementing Hyperledger Fabric without purchasing services from IBM (IBM blockchain platform).

## Rumored IBM withdrawal from Hyperledger Fabric

There are rumors that IBM is going to withdraw from the Hyperledger Fabric project. It is being said that IBM does not make enough money from the blockchain department. On 28th of May two key developers have left the company that where key developers of the Hyperledger fabric platform which suggests that the rumor might be true (Ledger Insights, 2021). If these rumors are true and the main driving force behind Hyperledger Fabric leaves, it could mean that the development of Hyperledger Fabric slows down. New features and bug fixes could take longer to implement which impacts the longevity and stability of the blockchain. Of course these are still rumors and nothing is confirmed yet.

# Improvements

This chapter will describe all improvements that could be made to the final product.

## Software Error logging

To improve the current applications when an error occurs a monitoring and error logging software such as Sentry or Datadog can be used. This would beneficial because this would give insights in when and where an error occurred and where it went wrong. This information is helpful when recreating an error. Which could lead to a higher and faster solving rate.

## Avoid query operators.

The Hyperledger Fabric documentation recommends to not use query operators such as ‘$or’, ‘$in’ and ‘$regex’ to improve performance. Because query operators will lead to full database scans, which decrease the performance of the network and will give longer response time. Currently, there is only one query using an ‘$regex’ operator. This would not hurt performance much but changing this could improve performance in the future.

## Use an off-chain database for the dashboard.

The Hyperledger Fabric documentation also recommends using an off-chain database for applications such as a dashboard. This is a replica set of the data stored in the blockchain. This allows to query and analyze the data from the blockchain in a data store optimize for the specific case without impacting the performance of the network. Submitting data to an off-chain database can be achieved by using the chaincode events. For every block, the application receives it will iterate through the transactions and build a replica data store based on the key and values of every transaction.

## Access control

Hyperledger Fabric offers support for access control in the networks. This can be achieved on channel level or chaincode level. Access control can be used to define which client can perform which action. Only the clients with the right identity and permissions can perform the action. Hyperledger Fabric offers extension APIs for extracting client identity that can be used for access control decisions.

## Generify

Currently, parts of the applications are specifically tailored to this use case. For example, temperature measurement or validating the SLA. To make it smoother to implement additional measurements or features It would be beneficial to make this process more generic to also make it fit other use cases easier if this POC would be reused as a basis for future projects. This would also make this project more valuable for companies that do not have the resources to develop this from scratch. Because their application could be based on this current POC.

## Pre-generated certificates

The scripts used to deploy the Hyperledger Fabric infrastructure use certificates to have a secure connection between the Hyperledger Fabric services. These certificates are pre-generated and publicly available, which means that they are not secure enough for a production network. If these scripts are to be used in a production environment, other certificates need to be used.

# Advice

This chapter will describe the project group’s advice based on findings made during the project and the realization of the PoC.

During the project, the team quickly became aware of the size and complexity of Hyperledger Fabric. The complexity is one of the main downsides of using Hyperledger Fabric and the main source of the issues found.

As the project group had no previous experience with blockchain development, the development heavily relied on documentation. This documentation was often very high level and did not provide a lot of information about the infrastructure on a technical level. This made development, designing, and deploying of the network remarkably harder, and slowed down the progression significantly. This combined with the time constraints on the project caused some issues. When others, such as an IT-department, try to implement a Hyperledger fabric network without previous experience with blockchain or Hyperledger Fabric the lack of infrastructure technical documentation will almost certainly impact the development duration and quality.

To overcome this problem a team of Hyperledger Fabric experts could be hired to design and deploy the network, or the IBM’s blockchain platform could be used. Both options will ensure a shorter implementation period and full usability of the platform.

Another possible solution is to use other platforms for blockchain or use other methods of deploying Hyperledger Fabric. Due to the lack of time the project team did not test alternatives to Hyperledger Fabric or all the deployment methods within Hyperledger Fabric to solve the problems such as the lack of technical documentation. Alternatives could be a viable option however these are not researched thoroughly enough to recommend this at the moment.

There are also some improvements that could be made to improve the current proof of concept. For example, the PoC right now uses pre-generated certificates, which is not safe in a production environment. These certificates need to be generated by the companies themselves. It is also wise to use an off-chain database for the dashboard to improve performance and limit the number of queries to the blockchain. Query operators should be avoided if possible because they scan the whole state database which will decrease the performance. Finally access control should also be implemented to have a level of authorization and authentication.

An important question to ask before choosing Hyperledger Fabric blockchain network is: “Do the benefits weigh up against the complexity of Hyperledger Fabric, and how important is the integrity of the data collected?” The research team believes that when the integrity of data is not that important, but the idea of transparency and insight is, other options might be a better solution. For only insight in the transport a simpler solution with a standard database and sensors is an easier solution to implement. This option will also reduce the implementation cost and time of the sensor infrastructure. However, this option does not guarantee the integrity to the extend a blockchain does.

The project team believes that using blockchain could be a viable solution when implemented by experts and the integrity of data is of great importance. This would be especially true when an existing blockchain solution could be used as a base.

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# Appendix

This document contains no annexes.