The Lifecycle of a User Transaction in a Hyperledger Fabric Blockchain Network Part 2: Order and Validate

Sjir Nijssen[1] and Peter Bollen[2](✉)

[1] Heerlen, The Netherlands
Sjir.Nijssen@pna-group.com
[2] Maastricht University, Maastricht, The Netherlands
p.bollen@maastrichtuniversity.nl

Abstract. The paper describes the second part of the happy path of a user transaction through a Hyperledger Fabric Blockchain Network. The full cycle of a user transaction originates from the Client Application (an actor outside the Hyperledger Ledger Network but inside an organization that is part of a set of organizations that jointly run the Hyperledger Fabric Blockchain Network). In the process of making the Hyperledger Fabric Blockchain network knowledge explicit, essential parts of FBM were applied in cooperation with the developers of the Fabric Blockchain platform.

1 Introduction

In this paper the second part of a high level conceptual overview of the life cycle of an end user transaction is described, from its birth in a client application that is part of an organization that is part of a Hyperledger Fabric Blockchain business network to its eternal "life" in the immutable blockchain. In [1] the first stage in the transaction life cycle was explained: *proposing* and *endorsing*.

In this article we will explain the second and third stage of this transaction life cycle: *Ordering* and *Validating*. In [1] the endorsing stage was discussed. The endorsing strategy (a part of the channel strategies) is important for the final outcome of the endorsing stage and hence the transition to the next stage in the transaction life cycle. In a distributed decision making process like Fabric an endorsement policy prescribes how many and which kind of actors need to endorse a transaction proposal.

The architecture of Fabric and design decisions are described in [2–5]. Reference [6] has some general information about permissioned blockchains, while [7] has the focus on the unique aspects of Fabric.

How useful the endorsement policies are will depend on the application, on the desired resilience of the solution against failures or misbehavior of endorsers, and on various other properties. Examples of these endorsing policies are given in Appendix A.

S. Nijssen—Retired from PNA, the Netherlands.

C. Debruyne et al. (Eds.): OTM 2018 Workshops, LNCS 11231, pp. 150–158, 2019.
https://doi.org/10.1007/978-3-030-11683-5_16

In Sects. 2 and 3 we will address the ordering and validating stages respectively. In Sect. 4 we will finally conclude that the transaction process will lead to an updated Ledger that consists of a new world state (in case of a valid transaction) and the updated blockchain (irrespective of transaction is classified as valid or not valid).

2 The Life Cycle of a User Transaction Part 2: The Ordering Phase

In this chapter we will discuss the next steps that together complete the ‘happy path’ of a user transaction through a Hyperledger Fabric (HLF) Network. In the HLF documentation this entire process is divided into 3 phases, the (proposing and) endorsing phase, the ordering phase and the validation-committing phase. In this section we will illustrate the 2nd main phase in the happy path of a Fabric user transaction life cycle by continuing from the 1st main stage: endorsing and the possible results of this stage to the description of the 2nd stage in the transaction life cycle: ordering.

2.1 The Possible Outcomes of the Endorsing Transaction Stage

In this section we will show what happens when the outcome of the endorsing stage is either *sufficient*, *not sufficient* or *inconsistent*.

2.1.1 With Sufficient Endorsements

As soon as the Client application has decided it has obtained a sufficient number of endorsements from the endorsing peers for a given submitted transaction instance, it sends the transaction message (= proposed transaction by client application, the Read-write sets and the signatures of the Endorsing peers) to the Orderers, of course properly signed and *encrypted.*

2.1.2 Not Sufficient Endorsements After a Set Time

When the Client application comes to the conclusion that there are not a sufficient number of endorsements, the Client application will decide to stop this proposed transaction as it will anyway be later rejected by the Committers, would it be sent to the orderers and from there packaged into a block to the Committers.

2.1.3 Client Application Detects That There Are Inconsistent Transaction Responses

If the client application detects that not all endorsed responses are consistent, it may decide to stop the transaction workflow early. Should the client application in such a situation nevertheless decide to forward the inconsistent set of responses to the ordering service, the transaction will be declared invalid during the committing process.

2.2 The Client Application Sends the Responses of the Endorsers to the Orderers

The next step in the business transaction flow is to have the Client Application send the answers by the Endorsing peers to the ordering service (see Fig. 1).

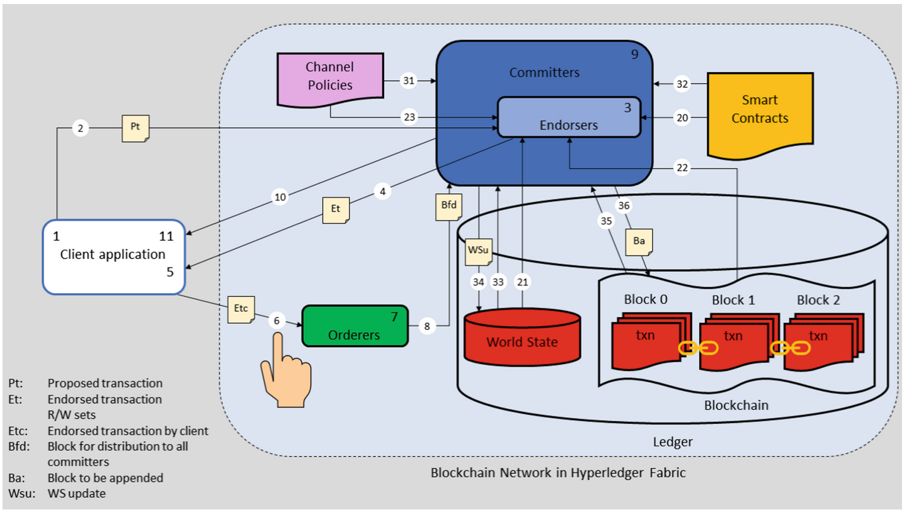


Fig. 1. Conceptual transaction flow architecture

2.3 The Orderers Prepare a Block to Be Included in the Block Chain

The next step in the transaction flow is to have the orderers prepare a package of transactions, called proposed block (see Fig. 2).

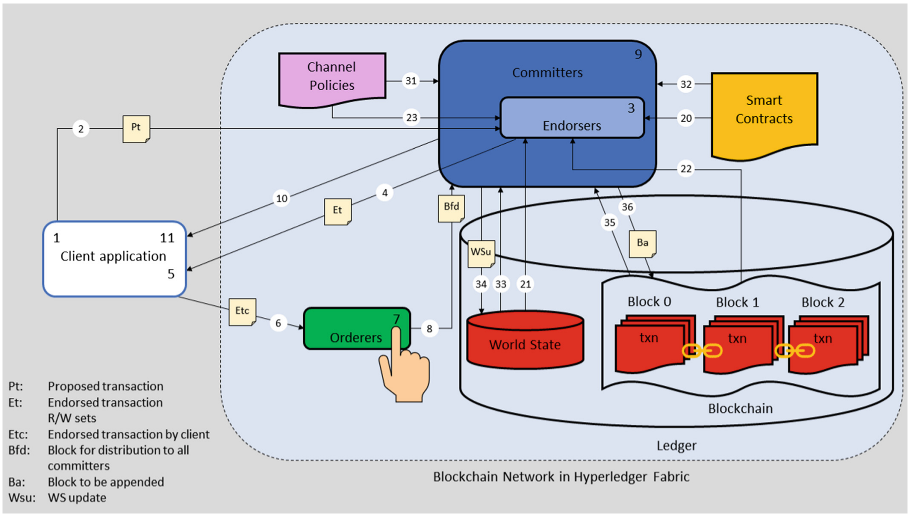


Fig. 2. Conceptual transaction flow architecture

The ordering peers receive transactions from all channels and from potentially *different* Client Applications. The ordering service brings the transactions in a strict order. Please recall that each channel in the Hyperledger Fabric business network has its own blockchain and its own World State, for privacy reasons. Different channels may use different ordering strategies.

When the new block that was in the process of being formed by the orderers, has reached the desired block size, or the endorsing process of the new block has reached the time limit, (and those two parameters can be different in different channels), the orderers have to submit the newly formed block to the Committers (see Fig. 3).

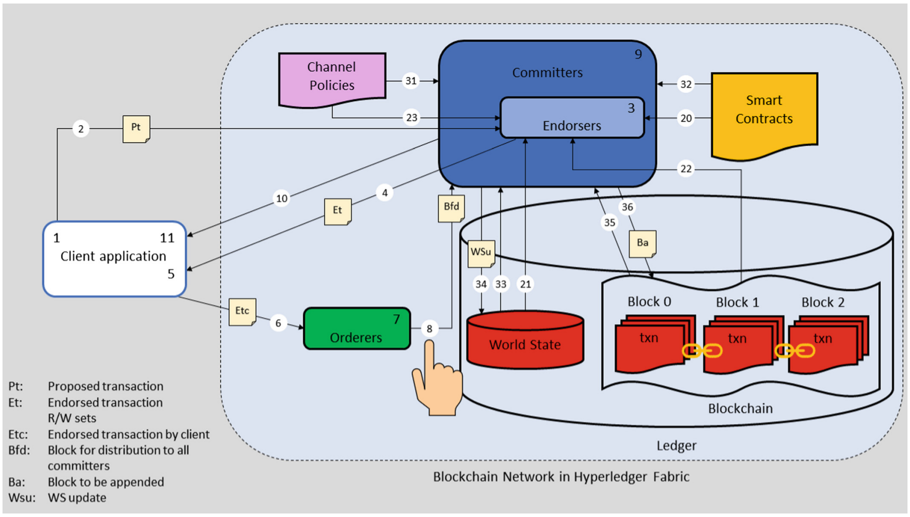


Fig. 3. Conceptual transaction flow architecture

3 The Life Cycle of a User Transaction Part 3: The Validating Phase

In this section we will illustrate the 3rd main stage in the happy path of the Fabric user transaction life cycle by continuing from the 2nd stage: ordering to the description of the 3rd stage in the transaction life cycle: validating and committing.

The committing peers receive the proposed block from the orderers (see Fig. 4). Each committer checks that each transaction in a proposed block satisfies the associated endorsement policy, using information flow 31. If not, the transaction will be marked as invalid, yet will be left in the block, but it has no effect on the World State.

Each committer uses the Read set of a proposed transaction to check that that Read set used by the endorsing peers in the simulation (during the endorsing phase) is still the same as now is available in the World set. If not the same, the transaction will be marked as invalid by the committer as invalid in the block, and has no effect on the World State.

The committers append the proposed block to the blockchain and update the World State for all the valid transactions in the block.

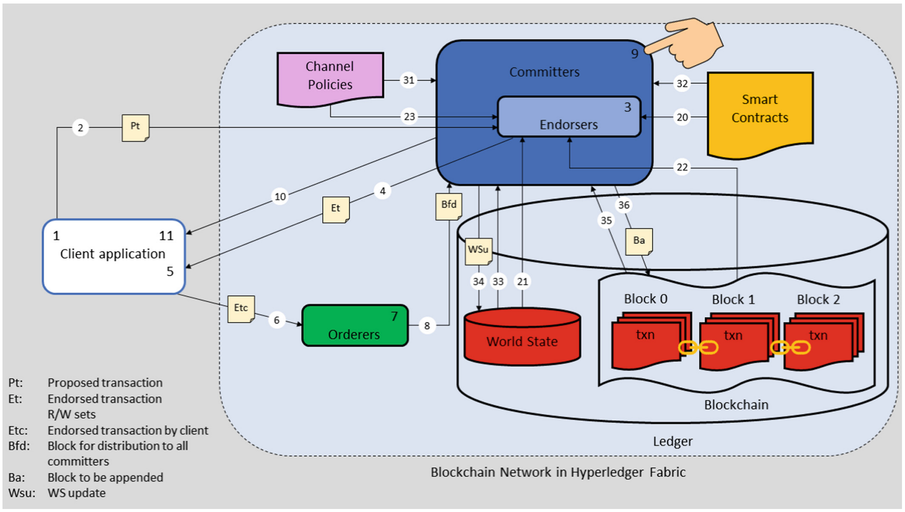


Fig. 4. Conceptual transaction flow architecture

3.1 The Committing Peers Inform Each Client Application for Each Transaction Instance Submitted

When the committing peers have added a new block to the blockchain and have updated the World State (in case there is at least one valid transaction in the block), they inform the Client application that the proposed transaction is included in a new block, either as valid, or invalid, and in case of invalid, the reason why a proposed transaction is invalid (see Fig. 5).

Hence the Client application can receive one of the following two messages.

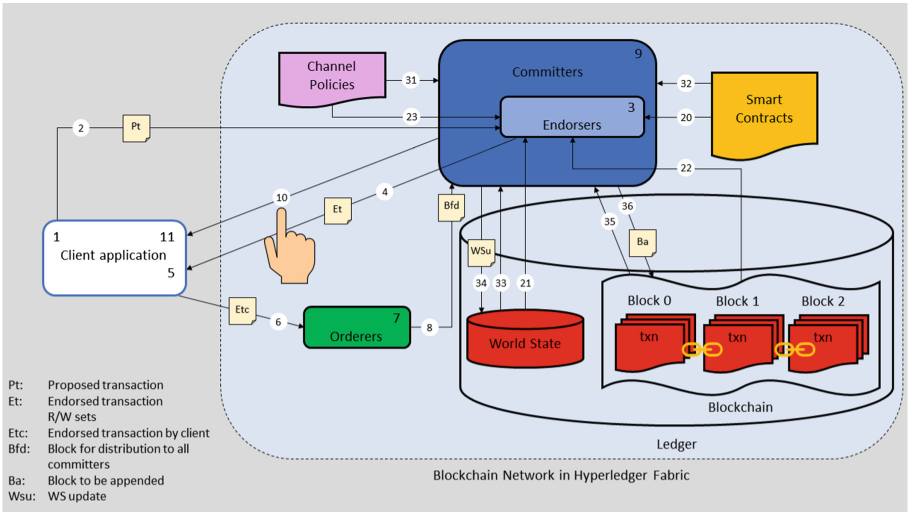


Fig. 5. Conceptual transaction flow architecture

3.1.1 Transaction Is Accepted as Valid and Is Now Part of the Immutable Blockchain, with Effect on the World State

The committers inform each Client application that has submitted a transaction to the Fabric Network that the transaction is now part of the blockchain, that it is a valid transaction and that the World State has been updated accordingly, in case the transaction satisfies all rules.

3.1.2 Transaction Is Not Accepted, Hence Declared Invalid, But Part of the Immutable Blockchain, Without Effect on the World State

The second option is that the committers inform the submitting Client application that the transaction has been declared invalid, nevertheless included with the label invalid in the Block Chain and that this proposed transaction has had no influence on the World State.

The final step in the workflow of a business transaction is the processing by the Client application of the response of the Committers (see Fig. 6).

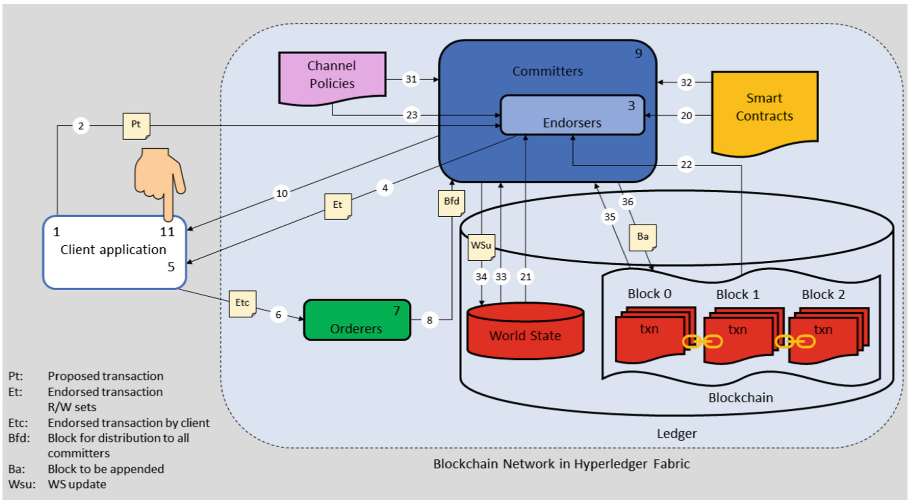
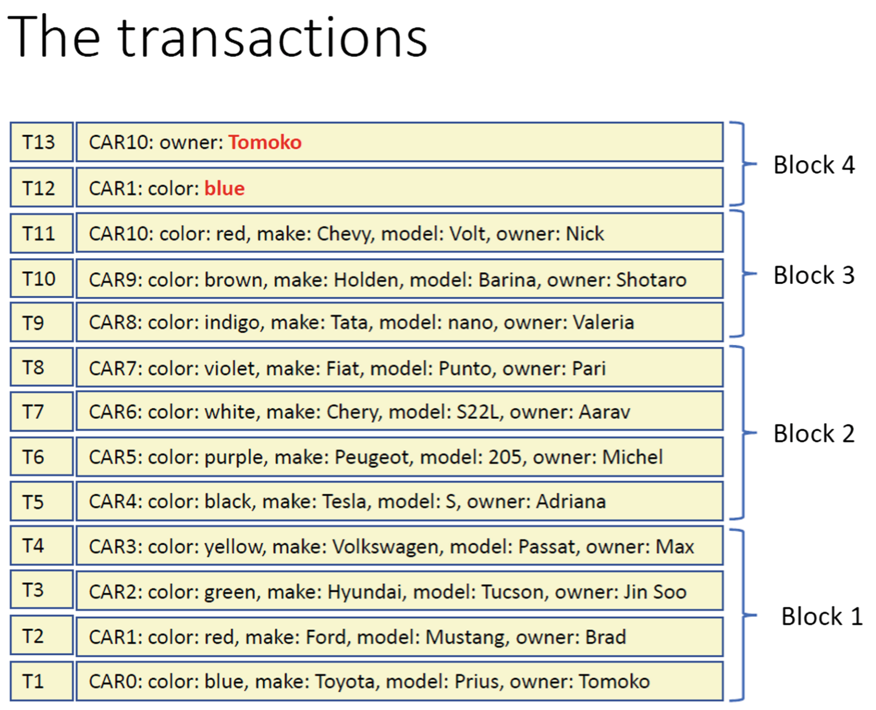


Fig. 6. Conceptual transaction flow architecture

4 Transactions and the Ledger

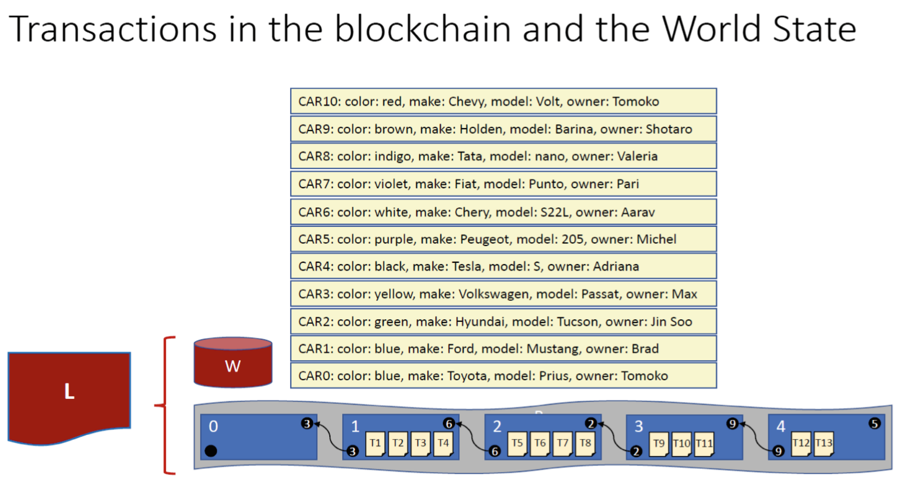
In this paper we have analyzed the ordering and validation-committing stage in the Hyperledger Fabric user transaction cycle using essential parts of FBM, namely consistently using concrete examples expressed as facts. We have illustrated each step in the endorsement phase of the transaction life cycle with a concrete example of a transaction based on the car owner case (called Fabcar with Fabric documentation). In this paper and [1] we have explained the separate stage and sub-stages in the HLF transaction life cycle leading ultimately to an update of the channel block chain and the world state (the last update only when there is at least one valid transaction in the block, see Fig. 7).



The transactions

T13	CAR10: owner: Tomoko	Block 4
T12	CAR1: color: blue	
T11	CAR10: color: red, make: Chevy, model: Volt, owner: Nick	Block 3
T10	CAR9: color: brown, make: Holden, model: Barina, owner: Shotaro	
T9	CAR8: color: indigo, make: Tata, model: nano, owner: Valeria	
T8	CAR7: color: violet, make: Fiat, model: Punto, owner: Pari	Block 2
T7	CAR6: color: white, make: Chery, model: S22L, owner: Aarav	
T6	CAR5: color: purple, make: Peugeot, model: 205, owner: Michel	
T5	CAR4: color: black, make: Tesla, model: S, owner: Adriana	
T4	CAR3: color: yellow, make: Volkswagen, model: Passat, owner: Max	Block 1
T3	CAR2: color: green, make: Hyundai, model: Tucson, owner: Jin Soo	
T2	CAR1: color: red, make: Ford, model: Mustang, owner: Brad	
T1	CAR0: color: blue, make: Toyota, model: Prius, owner: Tomoko	

Fig. 7. Example transactions



Transactions in the blockchain and the World State

CAR10: color: red, make: Chevy, model: Volt, owner: Tomoko
CAR9: color: brown, make: Holden, model: Barina, owner: Shotaro
CAR8: color: indigo, make: Tata, model: nano, owner: Valeria
CAR7: color: violet, make: Fiat, model: Punto, owner: Pari
CAR6: color: white, make: Chery, model: S22L, owner: Aarav
CAR5: color: purple, make: Peugeot, model: 205, owner: Michel
CAR4: color: black, make: Tesla, model: S, owner: Adriana
CAR3: color: yellow, make: Volkswagen, model: Passat, owner: Max
CAR2: color: green, make: Hyundai, model: Tucson, owner: Jin Soo
CAR1: color: blue, make: Ford, model: Mustang, owner: Brad
CAR0: color: blue, make: Toyota, model: Prius, owner: Tomoko

Fig. 8. Ledger = World State + Blockchain

5 Conclusion

By going through all stages of the Fabric user transaction cycle we have developed a deeper understanding of the main elements in HyperLedger Fabric and one of the main take-aways of this article and [1] lies in the observation that we can define a Ledger in this context now as the union of the World State and the immutable block-chain (see Fig. 8).

Appendix A

Example endorsement policies (Source: Fabric Docs 1.2, Architecture Reference, Sub Section Endorsement Policies, Sub Section Example Endorsement Policies) [8].

Suppose the endorsement policy specifies the endorser set E = {Alice, Bob, Charlie, Dave, Eve, Frank, George}. Some example policies:

- A valid signature on the same tran-proposal from all members of E. [Please remember that tran-proposal means endorsement; hence is common language: all endorsers from set E have to endorse.]
- A valid signature from any single member of E[on a tran-proposal].
- Valid signatures on the same tran-proposal from endorsing peers according to the condition (Alice OR Bob) AND (any two of: Charlie, Dave, Eve, Frank, George).
- Valid signatures on the same tran-proposal by any 5 out of the 7 endorsers. (More generally, for chaincode with n > 3f endorsers, id signatures by any 2f + 1 out of the n endorsers, or by any group of *more* than (n + f)/2 endorsers.)
- Suppose there is an assignment of "stake" or "weights" to the endorsers, like
  - like {Alice = 49, Bob = 15, Charlie = 15, Dave = 10, Eve = 7, Frank = 3, George = 1}, where the total stake is 100: The policy requires valid signatures from a set that has a majority of the stake (i.e., a group with combined stake strictly more than 50), such as {Alice, X} with any X different from George, or {everyone together except Alice}. And so on.
  - The assignment of stake in the previous example condition could be static (fixed in the metadata of the chaincode) or dynamic (e.g., dependent on the state of the chaincode and be modified during the execution).
  - Valid signatures from (Alice OR Bob) on tran-proposal1 and valid signatures from (any two of: Charlie, Dave, Eve, Frank, George) on tran-proposal2, where tran-proposal1 and tran-proposal2 differ only in their endorsing peers and state updates.

References

1. Nijssen, S., Bollen, P.: The lifecycle of a user transaction in a Hyperledger Fabric Blockchain Network part 1: Propose and Endorse 2018 (forthcoming)
2. Androulaki, E., et al.: Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains, 30 January 2018

3. The Hyperledger Vision: Hyperledger, Blockchain Technologies for Business (2017)
4. O'Dowd, A., Blockchain Explored A Technical Deep-Dive on Hyperledger Fabric v1, 29 November 2017
5. Vukolic, M.: Hyperledger Fabric an open source distributed operating system for permissioned blockchains. Swiss Blockchain Summer School, Lausanne, Switserland, 22 June 2017
6. Brakeville, S., Parepa, B: Blockchain basics: Introduction to distributed ledgers, 21 August 2017
7. Weed Cocco, S., Singh, G.: Top 6 technical advantages of Hyperledger Fabric for blockchain networks, 21 August 2017
8. Hyperledger-Fabricdocs Documentation, Release master, Key Concepts, sub section Peers, June 2018