
A Blockchain based Supply Chain Management (SCM) to Prevent Counterfeit Drugs

Submitted By

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ABSTRACT

The production and distribution of counterfeit drugs is an urgent and increasingly critical issue in Bangladesh. Also it causes a serious threat of pharmaceutical drugs. One of the major reasons of the drugs counterfeiting is the imperfect supply chain. It is difficult to track over the drugs from manufacturing to distribution and the major requirement of the drug supply chain is the assurance of drug quality, together with efficacy and safety. Here we proposed a blockchain based network of drug supply chain management (SCM) from manufacturer to pharmacist where we provide tracking over drugs as well as visibility and the safety of sensitive drug information. The existing drug supply chain of Bangladesh manufacturers don't know what happened with their drugs or which pharmacy is taking their drugs. But our proposed model ensures traceability so that manufacturers will be able to know which pharmacy is taking their drugs through the distributed ledger. Our platform will provide a secure network where all participants can see all the transactions between participants. All sensitive information about drugs will be recorded in the blockchain and other participants will be able to view the information of drugs provided by authentic manufacturer. Also encrypted QR will ensure that illegitimate participants will not be able to make a copy of the information of authentic manufacturer and will not be able to produce fake drugs by providing same information. So it will provide security of information about drugs as well as it will provide an encrypted QR code system so that illegitimate participants cannot know about the information's of drugs.

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LIST OF ABBREVIATIONS

01. SCM = Supply Chain Management
02. QR = Quick Response
03. MR = Medical Representative
04. MPO = Medical Promotional Officer
05. S_k = Secret Key
06. DGDA = Director General of Drug Administration
07. CAB = Consumer Association of Bangladesh
08. Pharmacist = Chemist
09. Pharmacy = Chemist Shop
10. RFID = Radio Frequency Identification
11. DSC = Drug Supply Chain

CHAPTER 1

INTRODUCTION

In this chapter we discussed about the DSC of Bangladesh, the existing system of pharmaceuticals in Bangladesh (we talked with the executives of following pharmaceutical-s), Problems of existing system and related articles to solve these problem using block-chain.

1.1 Existing Drug Supply Chain in Bangladesh

After talking with the executives of pharmaceuticals we get known with the supply chain in Bangladesh. Therefore the following scenario shows how drug transaction happened between participants in the supply chain of Bangladesh:

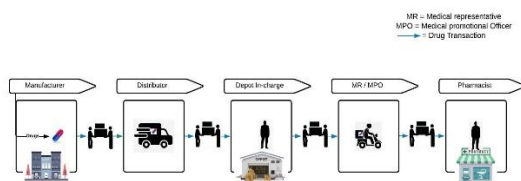


Fig 1.1 : Current DSC in Bangladesh

- **Manufacturer:** The person who produces drugs from raw materials by using various tools, equipment's and processes and then deliver those drugs to depot in-charge by distributor.
- **Distributor:** Who takes drugs from manufacturer and deliver those drugs to depot where a depot in-charge takes the manufactured drugs.
- **Depot In-charge:** The person who takes orders from MP or MPO and place the order to manufacturer

according to the orders of MR's or MPO's.

- **MR or MPO:** The person who visits doctors and takes orders from pharmacy or chemist shop where pharmacist gives order according to the need of drugs.
- **Pharmacist:** The person who places order to MP or MPO by the need of drugs by seeing the prescriptions of doctors.

1.2 Existing System in Bangladesh

Table 3.1 : Existing System Analysis

Features	Company Name			
	SK+F (Eskayef)	ACCAPAC (Web)	Renata	Radiant
Registration and Login	Yes	Yes	Yes	Yes
Security	Yes	Yes	Yes	Yes
View Available Drugs	Yes	Yes	Yes	Yes
Order Drugs	Yes	Yes	Yes	Yes
Blockchain	No	No	No	No
Real Time Order Status Update	No	No	No	No
Real Time Location Update	No	No	No	No
Scope of Delivery	Local	Local	Local	Local

1.3 Problems of Existing System

- **Supply chain management (SCM)** of the pharmaceutical industry doesn't provide visibility. The existing drugs supply chain in Bangladesh is outdated and manufacturers cannot keep track over their drugs.
- It is difficult for any pharmacist to know the origin of drugs.
- Fraudulent activities and unauthorized manipulation become difficult to carry out.

1.4 Literature Review (Blockchain)

The Author in [01], proposed a permissioned blockchain to store transactions and only trusted parties are allowed to join. Also participants have key pairs which are used to assign each participant a specific activity. Similarly, Global Governance of the Blockchain (Gcoin Blockchain) double spending mechanism is proposed to alleviate the counterfeit-drug problem [02]. Also in [03] a RFID is used for each shipment of products and parties can check where or not the products have passed legitimate supply chain. The Author of [04] proposed model assures an electronic pedigree (2D barcode verification) for every produced single unit medicine and helps to trace all distribution chain from the manufacturer to the patient. Also the author of [05], proposed a model where illegitimate participants cannot get access because of public key and an encrypted QR code technique is introduced which will be accessed only by authorized bodies. None of these literature introduce member revocation, but in [06] where the author proposed a member revocation without changing the key pairs of unrevoked members.

CHAPTER 2

PROPOSED MODEL

In this chapter we discussed our proposed model as well as we provide diagrams of our project.

2.1 Proposed Architecture

The following diagram shows the SCM participants and how drugs are going to any pharmacist (chemist shop):

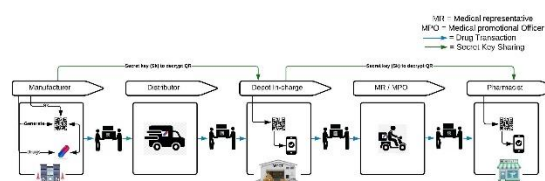


Fig 2.1 : Project Architecture

Manufacturer will generate an encrypted QR code ($S_k(QR)$) before sending drugs through distributor according to the order of depot in-charge. Distributor will give the drugs to depot in-charge and depot in-charge can see the order status update controlled by the manufacturer before he receives the drugs. After getting the drugs in hand, the depot in-charge will ask for the secret key (S_k) from the manufacturer and by decrypting the QR code he can see the information about drugs. When a depot in-charge receives the drug without any payment this is called primary sale according to MSC. Transaction will be recorded in blockchain. After that, the depot in-charge will send those drugs to pharmacy or chemist shop and the same process will be followed like manufacturer and depot in-charge. When a pharmacist or chemist gets ordered drugs and pay money this is called secondary sale.

2.2 Use Case Diagram

This section shows the use case diagram of our proposed system:

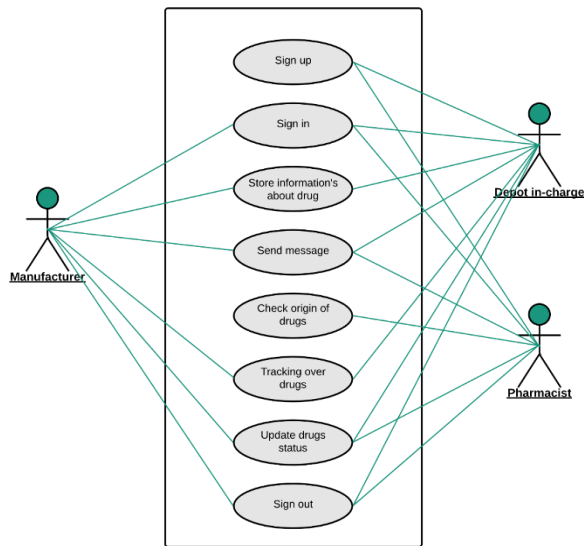


Fig 2.2 : Use Case Diagram

2.3 Activity Diagrams

In this section we showed the activity diagrams for all participants as well as the whole process of our project.

2.3.1 Activity Diagram for Manufacturer

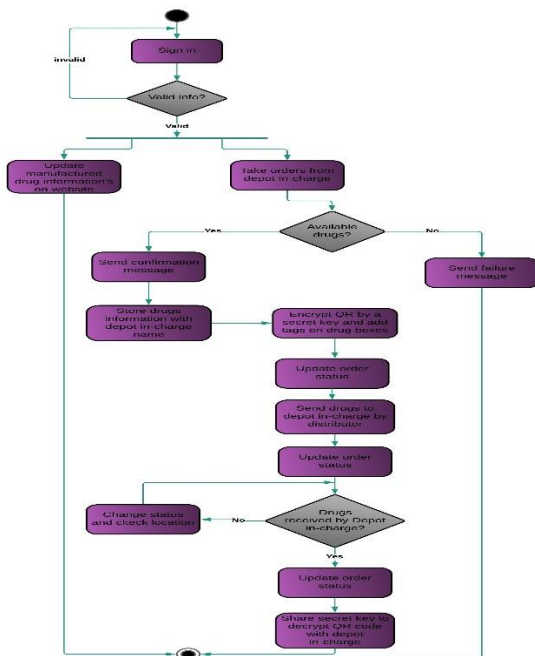


Fig 2.3 : Manufacturer Activity Diagram

2.3.2 Activity Diagram for Depot In-charge

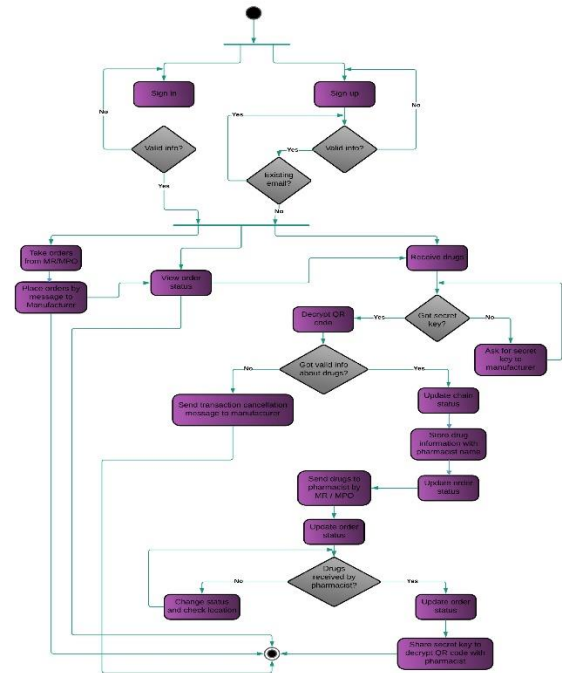


Fig 2.4 : Depot In-charge Activity Diagram

2.3.3 Activity Diagram for Pharmacist

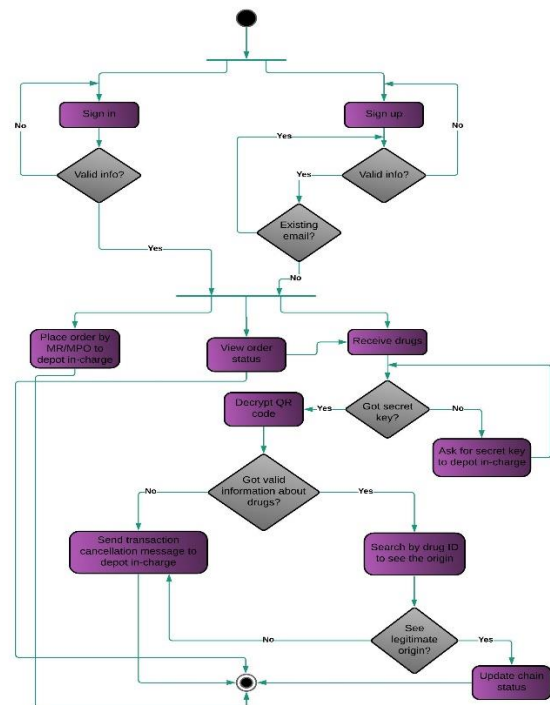


Fig 2.5 : Pharmacist Activity Diagram

2.3.4 Project Activity Diagram

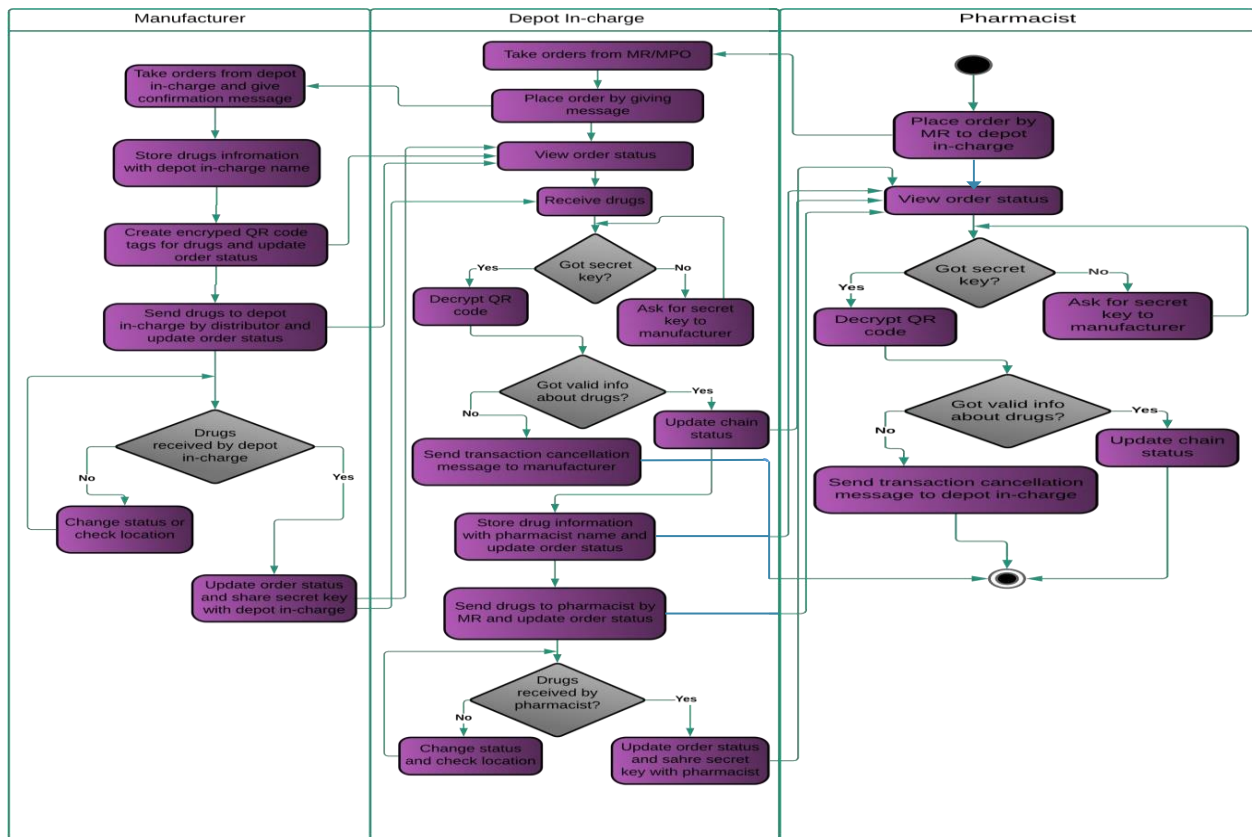


Fig 2.6 : Project Activity Diagram

2.4 Data Flow Diagram

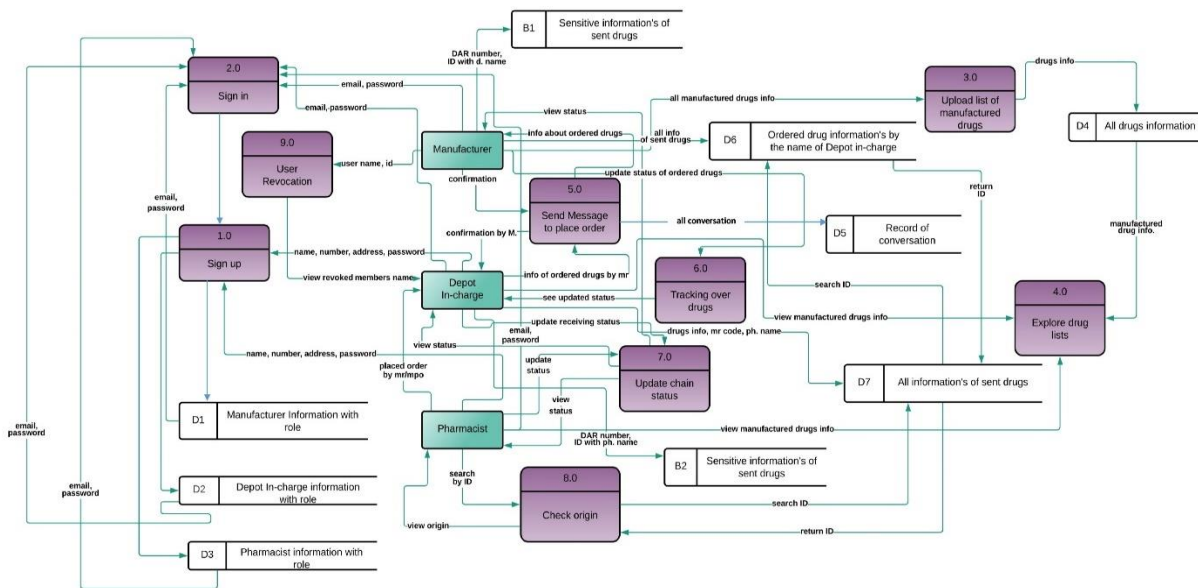


Fig 2.7 : Data Flow Diagram

2.5 Project Specification

This section describes the specifications of our project.

- We have three participants (or we want to add three participants to the network). They are manufacturer, depot in-charge and pharmacist (web app for manufacturer and depot in-charge and mobile app for pharmacist). All participants must be registered without manufacturer.
- Pharmacist can place order to depot in-charge through MR or MPO and depot in-charge can place order to manufacturer for drugs.
- Manufacturer will generate encrypted QR code (using secret key) before sending drugs to depot in-charge and attach the tags on drug boxes and will store drugs information to database.
- When depot in-charge will get the S_k (via email) to decrypt QR code and will confirm that he received drugs from manufacturer transaction will be added in blockchain and drugs location will be viewed by other participants. The same process will be followed when depot in-charge will give drugs to pharmacist.
- Blockchain will provide a transparent network between participants for each transaction records.

CHAPTER 3

COMPETITION AND RISKS

In this chapter we discussed why our project would be a good solution and challenges and risks of proposed system.

3.2 Why Our Proposed Model would be a Good Product

Compared with the other pharmaceutical systems exist in Bangladesh our project will be the good one and also if we compared with the articles we discussed before our product would be better. Reasons are:

- Pharmacist will be able to know that which pharmaceuticals is giving drugs to them.
- Manufacturer can keep track over their drugs.
- All participants can know the location of drugs in supply chain.
- Encrypted QR will ensure the authenticity of drugs. An encrypted QR was introduced before but by their proposed model QR need to be encrypted by the public key of receiver. But if there are multiple receiver it will be a time consuming thing to encrypt QR tag again and again.
- Blockchain (private) will provide a transparent network between participants for the future statistics of transactions.

3.3 Challenges and Risks of Our Proposed Model

This section describes the challenges and risks of our product.

- **Technical Risks:** Block size could be a risk. Blockchain ecosystem have block size limitations (amount of data stored). Ethereum have integrated “side” storage capabilities but we are recommending to minimize the amount of data stored or to store only sensitive data. Risks like “hard forks”, where blockchain changes the rules for the future but allows participants to continue on either the new rules or the old ones. We will work with NIST SP800-171 requirements) so that participants need to agree with rules if any update happens.
- **Business Risks:** All the participants must be trusted. If any participants leak out the sensitive information stored in blocks it will be harmful. For that we are proposing member revocation system which will be controlled by manufacturer to revoke participant who violates rules.

CHAPTER 4

MARKET AND PARTNERS

This chapter describes the potential spending to build this project and describes about the partners those must be present.

4.1 Cost Analysis

In this section we discussed about the cost to build this project. Therefore we attached a chart (draft) of spending analysis:

Table 4.1 : Potential Spending Analysis

Type of Cost	Description	Amount	Percentage
Hardware Cost	1 Router : Tk. 1,800/= 2 Computers Computer 1 : Tk. 70,000/= Computer 2 : Tk. 70,000/=	Tk. 1,41,800/=	36.37%
	Total : Tk. 1,41,800/=		
Software Cost	Domain : Tk. 1500/= (1 year) VPS hosting : Per month : Tk. 1600/= Development period : 3.2 months (14 weeks) Total : Tk. 5,600/=	Tk. 8,100/=	2.08%
	Ethereum : Tk. 1,000/=		
	Total : Tk. 8,100/=		
Developer Cost (Salary)	Junior Developer (2) : Per month : Tk. 30,000/= Development period : 3.2 months (14 weeks) Total : Tk. 2,10,000/=	Tk. 2,10,000/= (salary)	53.86%
Maintenance Cost	Monthly maintenance : Tk. 4,000/=	Tk. 20,000/=	5.13%
	Total : Tk. 16,000/=		
	Monthly internet bill : Tk. 1,000/=		
	Total : Tk. 4,000/=		
	Total : Tk. 20,000/=		
Additional and Marketing Cost	Damage repair : Tk. 8,000/=	Tk. 10,000/=	2.56%
	Marketing : Tk. 2,000/=		
	Total : Tk. 10,000/=		
		Tk. 3,89,900/=	100%

4.2 Market Size

Pharmaceutical market of Bangladesh is expected to surpass \$6 billion by 2025 and Bangladesh exports pharma products worth \$130m a year and it may hit \$450m by 2025 and products are exported to 144 countries [dailystar]. This is a huge market price and an estimated Tk. 600 crore of counterfeit drugs are traded in the Tk. 18,000 crore drugs market in Bangladesh each year [dailystar]. The value of fake and contraband drugs flooding the market is estimated to be between US \$100 million and \$150 million [pharmabiz].

4.3 Partners

All pharmaceuticals (all executives), pharmacists can be the participants. The DG-DA, mobile operators are the most impor-

tant partners. CAB could also be an ideal partner.

CHAPTER 5

VALUATION AND DISTRIBUTION

This chapter shows the social, legal, ethical, environmental issues of our project and distribution channels.

5.1 Social, Legal, Ethical and Environmental Issues

This project is for pharmaceutical (DSC). We are trying to create a SCM so that fake drugs cannot take places and we are solving problems of existing SCM in Bangladesh. So it will have a great impact on our society. In existing system it is easy to produce fake drugs by using the name tag of authentic pharmaceuticals and using any drug without having the required quality can cause side effect as well as death. But our system will solve this problem. As for the environmental perspective our system will play an important role. It is difficult to measure the economic loss due to counterfeit drugs. It will save a huge money if fraudulent activities cannot take place. Also blockchain will ensure the transparency of transactions for future statistics.

5.2 Revenue

As it is a product which will ensure the originality of drugs. So it will increase the sale of pharmaceuticals because they are ensuring the originality of drugs. They can also take commission (10% to 15%) on each transaction for their profit.

5.3 Distribution Channels

This product can be adopted by a smaller trial group. It could be 50 participants including manufacturer, depot in-charge and pharmacist. Another possibility is for the DGDA or CAB to try in a trial group.

CHAPTER 6

CONCLUSION

This sections describes about our future plans.

6.1 Summary

This is a drug supply chain to ensure the drug safety as well as the traceability of drugs. By this system pharmacist will be able to see the origin of drugs and manufacturer will know which pharmacy is using their drugs. This system will provide a transparent drug supply chain.

6.2 Future Plans

This sections describes the features we want to add to our project in next.

- Add DGDA to the network who is the governance body of drug supply chain. DGDA will provide license to pharmaceuticals and pharmacies (chemist shops). Companies have to agree with the profiles where requirements (defined by DGDA of Bangladesh, WHO requirements and NIST SP 800-171 requirements) will exist to get license.
- Auto distance giving and dropping drugs to depot. It will be a fea-

ture by which system will decide which depot in-charge will get drugs first. By this feature remote distance will be served first and nearest distance will be served last.

CHAPTER 7

REFERENCES

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1. Why Encrypted QR Code?

→ Some pharmaceuticals (Doc-tors, Radiant) changes their DAR on each production and it remains secret until drugs arrive at market place. But it is easy to know the number and use it for any illegitimate person. Other Pharmaceuticals (SK+F) changes their packaging style so that any fraud cannot bear the expenses each time. But they have to bear a huge cost.

So we are proposing an encrypted QR code so that frauds cannot know about the information of drugs and cannot produce fake drugs.

1. Why Blockchain, why private blockchain and why ethereum?

→ Blockchain will provide transparency or visibility of transactions. So it will ensure that drugs are coming from legitimate manufacturer. Transaction speed and cost is big issues for public blockchain. But transaction speed is not issue is private blockchain because added blocks do not require computational overhead.

Ethereum provides storage capabilities such as Swarm and IPFS and it is absolutely transparent compared with hyper-ledger.