Project plan for degree projects   
Version 1.3 – October 12, 2016

DV2572: MASTER THESIS IN COMPUTER SCIENCE

March 19, 2020

|  |  |  |
| --- | --- | --- |
| Thesis | Tentative title | Using blockchain for improved communication efficiency and cooperation: case of port logistics. |
| Classification | ∗ |
| Student 1 | Name | Hangdong Chen |
| e-Mail | [hach17@student.bth.se](mailto:hach17@student.bth.se) |
| Social security nr | 9601121297 |
| Visa expiration date |  |
| Student 2 | Name |  |
| e-Mail |  |
| Social security nr |  |
| Visa expiration date |  |
| Supervisor | Name and title | Lawrence Henesey |
| e-Mail | [larry.henese](mailto:larry.henesey@bth.se)[y@bth.se](mailto:y@bth.se) |
| Department |  |
| External | Name and title | Leave blank if no external\*\* is assigned |
| e-Mail |  |
| Company/HEI |  |

\**2012 ACM Computing Classification System: www.acm.org/about/class/2012*

\*\**Co-advisor from industry or a higher education institution (HEI).*

# Introduction

In this section, I will explain the related concepts involved in this study, including Small Port, Blockchain, Port Community System (PCS), Port Efficiency and Key Performance Indicators (KPI). Then I will explain some of the related work I have done for this research, including the challenge description, blockchain characteristics that may be beneficial to small ports and research status. Also, in this section, through the preliminary literature review, we screened KPIs and determined the system boundaries.

# 1.1 Concept description

# 1.1.1 Small Port

With the development of the global supply chain and the standardized transportation of containers, a port’s position in the logistics chain is becoming more and more important. With more than 85% of all globally traded goods having travelled on a ship at least once during their life-cycle, ports play a key role in the global and local [economy [1].](#_bookmark0) In order to adapt to the fast-growing logistics needs, many large port (such as the Port of Rotterdam, Singapore Port and Hamburg port) improve port business capabilities through the use of new technologies such as artificial intelligence, blockchain, cloud computing and [IoT [2][3].](#_bookmark2) However, in addition to large ports such as Rotterdam port, many small ports also play an important role in regional and national [economies [4].](#_bookmark3) Due to a lack of resources and many other factors, most small ports need to work with multiple third-party companies (such as transportation companies). The mode of cooperation between multiple companies means there are many challenges that information is not shared, and data updates between multiple systems are not timely, etc., which reduces the efficiency of small ports. So small ports have challenges in adopting technologies such as larger ports.[refrence/Tradelens] This research focuses the problem of low communication efficiency caused by multi-company cooperation in small ports. It proposes to use blockchain to improve cooperation efficiency and use simulation method to analyze the feasibility of using blockchain in small ports.

Big port已经在使用区块链技术需要ref。参照teadelens和active 4.1

# 1.1.2 Blockchain

Blockchain (or block chain) was invented by a person (or group of people) using the name Satoshi [Nakamoto[5]](#_bookmark4) in 2008 to serve as the public transaction ledger of the cryptocurrency [bitcoin[6].](#_bookmark5) Blockchain is a growing list of records, called blocks, which are linked using cryptograph[y[5][6].](#_bookmark5) Each block in the Blockchain contains the cryptographic hash of the previous block, the corresponding time stamp, and the data. In general, the blockchain uses a Merkle tree algorithm (such as SHA-256) to calculate the hash value of the previous block. This algorithm can reduce (or increase) arbitrary data to 256-bit binary data, but it is impossible to restore 256-bit binary data to raw [data[8].](#_bookmark6) Such data encryption makes it difficult to tamper with the data on each individual block because modifying the target amount of data requires an extremely large amount of computation.

The main applications of the blockchain are Bitcoin and Ethereum. In the case of Bitcoin, it is a cryptocurrency based on a [blockchain [9]](#_bookmark7) It publicizes the record of transactions through asymmetric cryptography and achieves the role of public oversight. It makes a lot of sense in conducting online, open and verifiable transactions. Ethereum offers Ethernet virtual machines to handle peer-to-peer contracts through its dedicated Ethereum [[10].](#_bookmark8) The emergence of Ethereum marks the era of blockchain technology entering 2.0. The blockchain technology used by Bitcoin, the log records only the transactions that have been made, the applications built with Bitcoin can only be financial scope; and the Ethereum provides a programming platform called Solidity language. This is a Turing-complete language like JavaScript, where users can build Smart contracts and deploy them on the Ethereum chain. The smart contract on the Ethereum chain cannot be tampered with, and it stipulates the responsibilities and obligations of the parties using the contract [[11].](#_bookmark9) The contract will be automatically executed when the conditions stipulated in the treaty are met. Through the technology of smart contracts, more domain applications can be built on blockchain technology, which solves the problem that many parties can’t trust each other.

# 1.1.3 Port Community System (PCS)

Port Community System (PCS) in Europe have a long tradition. The first to be established in ports in Germany, France and UK began to operate in the late 70s or early 80s. Countries such as the Netherlands and Spain started their PCSs in the 1990s or at the turn of the century. According to the definition of the PCS by the International Port Community System Association, the PCS is a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders to improve the competitive position of the sea and air ports’ communities. And PCS optimizes, manages and automates port and logistics processes through a single submission of data and connecting transport and logistics chains [12]. By reducing unnecessary paperwork, the port community system can enhance the efficiency of cooperation between ports, customers, suppliers and other organizations, improving the efficiency and speed regarding port processes, thereby enhancing the core benefits for all parties in the supply chain.

# 1.1.4 Port Efficiency

Research on port efficiency began in the 1980s. In 2013, Wu summarized the factors affecting port efficiency based on existing research. Wu pointed out that port efficiency is closely related to the port’s own operations and the external environment [18].

The external factors are mainly divided into three categories:

- The hinterland economy, the high level of emergency development at the port location, which will promote the rapid development of the port’s resources and capabilities;

- The development of the collection and transportation refers to the degree of access to the port and the hinterland. The degree of development of the surrounding railway, highway, waterway, and pipeline transportation systems affects the ability and scope of the port to undertake and transfer goods;

- Customer satisfaction, customers served by the port include shipping companies, cargo companies, agency companies, etc. Through the satisfaction of port customers to port services, we can understand whether the port has played its due role.

The internal factors of port efficiency mainly include four categories:

- Port infrastructure utilization rate, the more adequate port infrastructure utilization, the higher the port efficiency. This has nothing to do with whether it is a large port or a small port. If the utilization rate of the basic equipment of a large port is low, it will cause waste of resources. If the utilization rate of the basic equipment of a small port is high, the port can also maximize the efficiency of the port and achieve high port efficiency.

- Port loading and unloading efficiency, which is the most important indicator affecting port throughput, directly affecting the processing speed of port cargo;

- Port logistics service capability, directly affects the quality and speed of cargo transportation services;

- The degree of port informatization. The high degree of port informatization can improve the efficiency of port data exchange and further improve port efficiency.

Port efficiency is an important indicator to measure the competitiveness of the port. In this research, we mainly explore the system communication efficiency. The high communication efficiency of the port can improve the efficiency of data exchange between ports and customers, reduce waiting time and improve port efficiency.

# 1.1.5 Key Performance Indicators (KPI)

A performance indicator or key performance indicator (KPI) is a type of performance measurement [13]. According to the definition of Oxford’s Dictionary, KPI is ‘A quantifiable measure used to evaluate the success of an organization, employee, etc. in meeting objectives for performance.’ KPIs evaluate the success of an organization or a particular activity (such as projects, programs, products and other initiatives) in which it engages.

In port system, performance management is a key strategic activity for port communities to evaluate the port performance at both inter-port and intra-port levels [14]. According to the research of Francisconi, the port performance indicators are roughly divided into three categories, Financial, Operational and information[13].

# 1.2 Related Work

# 1.2.1 Challenge Description

With the rapid development of the logistics industry, port logistics plays an increasingly important role in global logistics [1]. With the development of new technologies such as artificial intelligence, blockchain, cloud computing and IoT, many automation technologies and information management technologies have been applied to port logistics and redefine the sea freight logistics [15]. Today, many large ports, such as the Port of Rotterdam and the Port of Hamburg, have begun to use new technologies to implement automated port to keep up with the fast-growing logistics needs. However, for some small ports, most of them need to work with a number of third-party companies (such as transportation companies) due to their lack of resources and many other factors. Different from the large terminals, which have sufficient capacity to uniformly allocate information and resources, in the process of cooperation between small ports and many companies, there is a problem that information is not shared, and data is not updated in time. People don’t trust each other and are not willing to share information that may affect the company’s competitiveness. Lack of trust and scarce information sharing limit the capacity and efficiency of small ports [14]. Although the existence of the port community system has improved the information sharing ability of the port to a certain extent, in cross chain collaborations the information sharing between the supply chain members is a cumbersome process that the PCS in not able to simplify[14]. This situation may cause delays in cargo and trade flows, which lead to a longer lead-time of the process. Therefore, seeking better technology to improve port efficiency has become a new research direction. Blockchain technology has the potential to simplify processes due to its high process visibility and decentralization, so blockchain technology is also considered by many of these breakthrough solutions.

The main purpose of this study is to explore whether the use of blockchain technology in small ports can improve the inefficiency caused by multi-company cooperation in small ports. And use simulation method to analyze the feasibility of using blockchain in small ports

\*explain Why use blockchain

# 1.2.2 Using Blockchain in Small Port

Since the concept of the blockchain was proposed in 2008, this technology is considered a groundbreaking information technology innovation [16], although the technology is still in its early stages, but its potential far exceeds digital currency[14]. In fact, the application of blockchain technology in port logistics has become an important research direction. In March 2017, IBM, IT and Danish shipping giant Maersk (worldmaritimenews.com, 2017) jointly developed a blockchain platform for cargo information storage. It is hoped that the fraud and delays in customs, the time spent in the transportation process, and the cost and waste will be reduced. According to the characteristics of the blockchain, the ability of the blockchain to be applied in port logistics has a strong exploration significance.

Move to intro

According the research of Sultan et al. [17], research of Francisconi [13] and the structural characteristics, the blockchain has the following characteristics:

- Transparency: Blockchain may prevent the creation of organizational silos within existing parties of the supply chain, enabling the different actors involved in the process to access the information. This feature leads to univocal, shared and real-time accessible pieces of information. Instead of having data buried in legacy silos, ERP or TMS, data are accessible in a distributed and decentralized way to supply chain members;

- Traceability: Blockchain is able to keep track of the different processes so that every supply chain member is able to produce or collect information about the product’s lifecycle (supplier information, the manufacturing process information, logistics information and others). This not only provides a guarantee over the product’s origins, but it also offers information about the requirement for the product’s handling, transportation and storage. Finally, this feature enables an easier traceability of the causes and responsibilities for problems occurred in the process;

- Security: The information is stored in a ledger, which is a distributed data structure where transactions are organized in blocks (Kiayias et al., 2016). Each block is secure by encryption based on a hash mechanism so that the ledger becomes a proof-of-work puzzle. The access to information is based on a key system. Therefore, every member of the blockchain, the so-called “node”, is provided with a private key and a public key, which enable him to access the private information and the Blockchain respectively;

- Built-in-trust: The feature of encryption on which Blockchain is based represents the guarantee of trust towards the system. This enables the members of the blockchain to bypass the third parties that serves as a guarantee of financial, physical and information transaction in today’s supply chain. In logistics, this leads to the elimination of documents such as Bill-of-Landings, Letter-of-credits and middlemen such as Freight forwarder and banks.

- Real-time accessibility: Blockchain provides to every user with authorization a real-time access to the information. This faster and broader access to information leads to speed-up the logistic processes and avoid bottle-necks. Benefits are not only related to the information flow, but also to the financial flow.

According to the characteristics of the blockchain and the business case study of the apply the blockchain in the port by Francisconi, I initially speculated that the blockchain technology may simplify the information sharing process between small port and multi-company cooperation and improve the communication efficiency of the port system.

# 1.2.3 Research Status

Francisconi studied the four case studies of blockchain technology application in the port from the perspective of business model and evaluated the potential of applying blockchain in port logistics through literature review and case study. However, it is not clear from the software to verify the feasibility of applying blockchain technology in port logistics. Therefore, this research aims to explore the impact of blockchain technology on port system communication efficiency by simulating the application of blockchain.

# 1.2.4 KPI(s) selection in PCS Efficiency

According to Francisconi’s research, the KPIs for the port are divided into three categories, finance, operations and information, as shown in the table 1[13].

|  |  |
| --- | --- |
| Financial | Freight bill Accuracy |
| Overall Cost for the Information flow of a unit of cargo from the first to  the last nodal point |
| Average cost for detention/demurrage |
| Operational | Ship Turnaround time |
| Road vehicle turnaround time |
| Time spent by cargo awaiting commercial viability |
| Time for goods to be cleared |
| Time spent by cargo awaiting departure of next mode of transport (road  or rail) |
| Overall time of cargo in port |
| Ship’s capacity utilization |
| Hinterland transportation modes’ capacity utilization |
| Information | Security in information sharing |
| Degree of Flexibility in using information technology |
| Access speed to information |
| Accuracy of information regarding status of shipment |
| Provision of on-time updates of cargo information |
| Time required to receive necessary process information |

Table 1. KPIs of port

In this research, we focused on exploring the impact of blockchain on system communication efficiency. Unlike Francisconi’s research, we need more specific measurable indicators as the KPI(s) of this research. So, based on the Francisconi study, we removed the qualitative indicators, and will standardize the deleted indicators as system boundaries (describe in 1.2.5). At the same time, according to Wu’s summary of port efficiency, some measurable indicators that can represent port efficiency have been added. So, in this study, the KPI(s) that will be used and how to be measured is shown in Table 2.

|  |  |  |
| --- | --- | --- |
| KPI | Description | Measurement methods |
| Overall Cost  for the Information flow of a unit of cargo from the first to the last nodal point | It measures the IOIS performance in  terms of information flow total cost. It provides an estimation of the impact of costs relative to the port information flows with respect to supply chain cost. It is calculated by summing the price paid by the different stakeholders in transacting cargo information. | It is calculated by summing  the price paid by the different stakeholders in transacting cargo information. |
| KPI | Description | Measurement methods |
| Average  cost for detention/  demurrage | This represents the detention cost of  the container at the port. This indicator indicates the delay in payment or the timely delivery of documents. | Measured by the total cost  of container detention divided by the total number of containers  From the time the ship starts waiting for the arrival of the port, the time stops until the final ship leaves the port. |
| Ship turnaround time | The total time spent by the vessel in  port, during a given call. It is the sum of waiting time, plus berthing time, plus service time (i.e. ship’s time at berth), plus sailing delay. |
| Road vehicle  turnaround time | The total time required to collect a  container from the terminal or deliver one. For shippers/receivers (and trucking companies), it is the most important measure of a terminal’s efficiency. | Calculate the average time it  takes for a road vehicle to enter the port to leave the port |
| Time spent by  cargo awaiting commercial viability | The time from the communication regarding the cargo unloading at the terminal to the bank, until the proof of commercial viability release. It is a measure of the commercial viability impact on the physical process in terms of process delay. | Calculate the time it takes  from the container to unload at the port to release the commercial feasibility of the bank |
| Time spent by  cargo awaiting departure of next mode of transport (road or rail) | The average time for cargo awaiting at  the terminal after it has received the four green lights. It shows the ease to arrange a transportation mode | Calculate the time from the  container receive 4 green lights to the container is transported by road or rail. |
| Overall time  of cargo in port | The total time of the goods at the port. | The sum of waiting time,  customization and commercial licenses, and process delays. Calculate the total time it takes for the goods to be unloaded from the ship to leave the port |
| Hinterland  transportation modes’ capacity utilization | It measures the percentage of hinterland transportation’s available capacity that is being used. It defines the efficiency in transport’s utilization | Hatch transport vehicle usage  rate within a certain period of time |
| KPI | Description | Measurement methods |
| Access speed  to information | The speed in receiving or accessing the  information needed at the right time in the process. Not only it is a measure  of the information timing but also in-  formation availability. | Calculate the time from the  start of requesting information to the receipt of information |
| Provision of  on-time updates of cargo information | The availability of updated information on the cargo. | It is evaluated by counting  for the average cargo awaiting time for lacking information |
| Port throughput | The port’s ability to handle containers  within a certain period of time | Calculate the number of containers handled by the port within a certain period of time |

Table 2. KPIs selection

# 1.2.5 System Boundaries

Since we use the simulation method for simulation experiments, we will use some hypothetical indicators used in the system and the KPIs deleted in the 1.2.4 as system boundaries to enhance the scientific and rigor of the experiments, boundary indicators and standardized methods in the table. Listed in table 3.

|  |  |
| --- | --- |
| Freight bill  Accuracy | This indicator measures the error probability of the freight order, including  the wrong pricing, the loss of information, etc., but since this is a random possibility and there is no estimable range for the probability of accuracy, in this experiment we I think that the delivery of each shipping order is error-free. |
| Time for  goods to be cleared | Considering that the goods may require customs inspection, this indicator  indicates the average time for the goods to receive customs information. In this study, we do not consider the detention and cost of goods due to customs inspections. |
| Security in information  sharing | This is a qualitative indicator. The risk of security mainly depends on tampering and loss in the process of information transmission. In this study, we assume that there is no information tampering or information loss during information transmission. |

Table 3. System boundaries

# 1.3 Summary

This section describes the meaning of related concepts and related work research. The purpose of this experiment is to explore whether blockchain technology can affect the communication efficiency of small port communication systems and determine the influencing factors. In this study, I will mainly use the simulation method [19] to conduct experiments, which are elaborated in section 4.

# Aim and objectives

Aims:

The aim of this study is to explore whether blockchain technology can influence the communication efficiency of small port communication systems and identify the influencing factors.

Objectives:

-Design model system

-Using simulation methods to test whether blockchain technology can improve system communication efficiency

-Summarize the feasibility of using blockchain technology in small ports

# Research questions

RQ1: Which functions and roles are affected by blockchain based PCS, and how such a setting can be simulated?

RQ2: Which blockchain use-case could benefit small ports and how?

RQ3: What factors in enhance or impede using blockchain in small ports?

# Method

In this research, I mainly use the simulation method [19] to explore the impact of blockchain on the system communication efficiency of multi-company cooperation in small ports. Before conducting the simulation, I will use the literature review method to clarify the model. But in order to more clearly illustrate the content and role of the literature review, I will first describe the flow to use the simulation method in this section. Describe more on Literature Review work

# 4.1 Simulation method

A simulation is an approximate imitation of the operation of a process or system [20]. The aim of the simulation method is to understand the behavior of the system or to evaluate the strategy of system operation. Although the problems in the real world are usually much more complicated than the simulations, we estimate the behavior of the system through simulation, which is acceptable for research [21].

According to Francisconi’s research, he proposed four business cases using blockchain technology. In this study, we will design a model to simulate communication between multi-company collaborations in small port system based on Francisconi’s research and the characteristics of small ports, and explore the impact of blockchain technology on the communication efficiency of PCS in small ports by measuring KPIs. In this research, we will compare the results of KPI measurements between PCS using blockchain and PCS without blockchain (traditional PCS). By comparing the results, we can understand the advantages and disadvantages of applying blockchain in small ports.

This method will focus on RQ 2 & RQ 3.

The following briefly describes the basic steps in the simulation process [18]:

1. Problem Definition

The initial steps include determining the research goals and identifying the issues that need to be addressed. In this study, I will explore the impact of blockchain on the system communication efficiency of multi-company cooperation in small ports

1. Project Planning

Make a project plan for the projects to be completed, including background research, preliminary KPI screening.

1. System Definition

This step is designed to identify the system components that will be modeled and the metrics or performance to be measured and analyzed. A complete system is usually very complicated, because of this study focuses on communication efficiency issues, it will screen some of the functions of communication in the complete port system and design the model based on the blockchain. In this research, we need to compare the results of KPI measurements between PCS using blockchain and PCS without blockchain (traditional PCS), so in this step, we need to determine the functions and user roles involved in the system, and define the content of the two models, one is the traditional PCS (detailed in 4.2.2), and the other is a PCS designed in combination with blockchain technology and small port features (detailed in 4.2.1).

1. Model Formulation

This step will design a model based on the system prototypes and defined problems identified, usually using flowcharts to understand the operation of the model system.

1. Input Data Collection and Analysis

After designing the model, determine the type of data to collect. This step requires collecting new or existing data. The collected data needs to be analyzed for effectiveness, and the content of the data should be ethically distributed. For example, the quality of products produced by the factory should conform to a normal distribution. In this study, I initially thought that it is necessary to collect data on port resources, delay time and other data for multi-company cooperation. The data content that needs to be collected eventually needs to be further confirmed in the prototype analysis and model design section (step 3&4).

Add: data will get from C2SP

1. Model Translation

The model is translated into programming language and generate executable programs. In this research, we will use Python as the main programming language.

1. Verification and Validation

The purpose of this step is to verify the usability of the model and to ensure that the model works as expected through debugging. Verification ensures that there is no significant difference between the model and the actual system, and that the model can represent a real system. Broadly speaking, there are at least three test levels, unit tests, integration tests, and system tests [25, 26,27] for system verification. In this simulation method, since the unit test will test whether each method is successfully executed during the implement process (step 6), we will mainly focus on integration testing and system testing.

In this simulation study, our main requirements for the system are:

A. Every function of the system needs to be consistent with the design

B. The process of the system needs to be consistent with the design.

C. The system model needs to be able to simulate the operation of the real system.

In response to the above requirements, we mainly use the black box test [28] to perform functional and system testing separately, and selected the following methods of testing and verification:

a. Test the different functions of the system, input the test data through the black box test and check if the output is as expected.

b. Perform a system test on the integrated system, including system usage flow, function jumps, etc., to test whether the system can run completely.

c. Fault Injection Test [29], we test the system to run under certain pressure by inputting the error data into the system.

In this study, we will use two systems, so in this step, we will verify the two systems separately

1. Experimentation and Analysis

The simulations were performed using the models we designed. In this study, we will test the results of KPIs to explore the feasibility and influencing factors of using blockchain technology in small ports.

1. Documentation and Implementation

Prepare a research report to discuss the results and implications of the study.

# 4.2 Literature review

# 4.2.1 User roles and system function

In this step, we will provide a literature review of the functions and roles involved in the PCS system. In Section 1.1.3, I briefly introduced the PCS system. Although the PCS system has a long tradition in Europe, due to the decentralized storage characteristics of the blockchain, we are not sure whether the traditional PCS function can be directly applied to the new model. There are also functional differences and data differences between different PCS. Through literature review, we need to further confirm the functions and user roles involved in this model for the model design.

This step will focus on the RQ 2.

# 4.2.2 Traditional PCS

In order to compare the PCS with the blockchain and the traditional PCS system, after confirming the role and basic functions of the PCS, we need to define a traditional representative PCS for comparison test. With the same roles and basic functions, the KPI comparison will be more scientific. In this step, we will review the history of PCS through a literature review and select the PCS system used in the small port as a control.

look international Port Communication System Association page

# 4.3 Summary

In this section I describe the research methods I will use in this study. Through the literature review to determine the role and system approach of PCS, combined with small port features and blockchain technology to design the system model. The model of traditional PCS was determined through literature review, and the differences between the two models were compared by simulation to explore the feasibility and influencing factors of using blockchain technology in small ports.

# Expected outcomes

Through this research we expect to be able to know the feasibility of applying blockchain technology in small ports and to identify factors that enhance or hinder the adoption of blockchain.

For each RQ and the method we design, we expected to be able to get the following outcomes.

- For RQ1 expected outcomes:

We hope to confirm the model’s functional design and workflow through a literature review to confirm the model’s approach and user role.

- For RQ2 expected outcomes:

By analyzing the data obtained from the simulation, we hope to know whether the blockchain improves the problem of inefficient communication in small ports and discuss the possibility and method of applying blockchain technology to small ports.

- For RQ3 expected outcomes:

Through the analysis of the simulation results and the experimental process, we hope to understand the feasibility of using blockchain technology in small ports, and what are the factors that enhance or hinder the application of blockchain.

This study further validates and analyzes the feasibility of applying blockchain technology in small ports through simulation. We hope that this research will expand the application of blockchain technology and explore the capabilities, advantages and disadvantages of applying blockchain technology in small ports.

# Time and activity plan

Based on the important date schedule provided by the BTH Student Portal, I will make the following time and activity plan for my research. Note: The plan will be adjusted as the actual situation.

|  |  |  |  |
| --- | --- | --- | --- |
| No. | Activities | Start date | End date |
| 1 | Submission of project plan | 15week | 2019-09-29 |
| 2 | Literature review for User roles and system function | 2019-10-07 | 2019-10-13 |
| 3 | Literature review for Traditional Port system description | 2019-10-14 | 2019-10-20 |
| 4 | Reserved time | 2019-10-21 | 2019-10-27 |
| 5 | Model design | 2019-10-28 | 2019-11-03 |
| 6 | Collect data and verify data validity | 2019-11-04 | 2019-11-10 |
| 7 | Implement model | 2019-11-11 | 2019-12-01 |
| 8 | Model verification | 2019-12-02 | 2019-12-08 |
| 9 | Experimentation and Analysis | 2019-12-09 | 2019-12-22 |
| 10 | Documentation and Implementation | 2019-12-23 | 2019-12-29 |
| 11 | Reserved time | 2019-12-30 | 2020-01-11 |
| 12 | Submission of draft thesis |  | 2020-01-12 |
| 13 | Write the opposition report | 2020-01-11 | 2020-01-25 |
| No. | Activities | Start date | End date |
| 14 | Submission of opposition report |  | 2020-01-26 |
| 15 | Thesis presentation and defenses | 2020-01-27 | 2020-01-28 |
| 16 | Submission of final thesis for grading |  | 2020-02-09 |

# Risk management

|  |  |  |
| --- | --- | --- |
| No. | Risk | Mitigation strategies |
| 1 | Traditional PCS cannot be determined | If we are unable to determine the traditional PCS model through a literature review, we will contact the small ports on the Baltic coast to understand the PCSthey use as a control. |
| 2 | Can’t collect the data  we need (Part or all) | If the missing data is not critical, I plan to use a random  array to perform multiple tests, or to generate a data set for testing based on a theoretical distribution.修改：数据可以从C2SP中获取 |
| 3 | The implementation of  the model does not meet the design needs or deviate from the design | If it’s for technical reasons, such as computer language limitations, I will try to implement the system using multiple computer languages and then choose the model that is closest to our needs. Before the implementation of the model, I will split the model that needs to be designed, and the requirements are listed as small tasks, which will make the development process clearer and reduce the risk caused by incomplete functions. |
| 4 | The progress is slowed  down and cannot be completed within the planned time | In the project plan, I arranged some reserved time to deal with the unexpected situation. |
| 5 | Since I am developing a blockchain application for the first time, I have no relevant experience before, and problems such as failure may occur during the project development process. |  |

# References formal need change！！！

[1] “Turning Rotterdam into the ‘World’s Smartest Port’ with IBM Cloud & IoT,” THINK Blog, 31-Jan-2018. [Online]. Available: https://www.ibm.com/blogs/think/2018/01/smart-port-rotterdam/. [Accessed: 31-May-2019].

[2] V. Carlan, C. Sys, T. Vanelslander, and A. Roumboutsos, “Digital innovation in the port sector: Barriers and facilitators,” Compet. Regul. Netw. Ind., vol. 18, no. 1–2, pp. 71–93, Mar. 2017.

[3] L. Heilig, S. Schwarze, and S. Voss, “An Analysis of Digital Transformation in the History and Future of Modern Ports,” 2017.

[4] “SMP Dev - Small and medium-sized Baltic Sea ports development challenge.” [Online]. Available: https://www.utu.fi/en/units/cms/projects/finishedprojects/SMP\_Dev/Pages/home.aspx. [Accessed: 04-Jun-2019].

[5] S. Nakamoto, “Bitcoin: A Peer-to-Peer Electronic Cash System,” p. 9.

[6] “The great chain of being sure about things | The Economist.” [Online]. Available: https://web.archive.org/web/20160703000844/http://www.economist.com/news/briefing/21677228-technology-behind-bitcoin-lets-people-who-do-not-know-or-trust-each-other-build-dependable. [Accessed: 04-Jun-2019].

[7] A. Narayanan, J. Bonneau, E. Felten, A. Miller, and S. Goldfeder, Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. Princeton University Press, 2016.

[8] A. V. Mota, S. Azam, B. Shanmugam, K. C. Yeo, and K. Kannoorpatti, “Comparative analysis of different techniques of encryption for secured data transmission,” in 2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI), 2017, pp. 231–237.

[9] “How does Bitcoin work? - Bitcoin.” [Online]. Available: <https://bitcoin.org/en/how-it-works>. [Accessed: 24-Mar-2019].

[10] “Ethereum Project.” [Online]. Available: https://www.ethereum.org/. [Accessed: 24-Mar-2019].

[11] B. K. Mohanta, S. S. Panda, and D. Jena, “An Overview of Smart Contract and Use Cases in Blockchain Technology,” in 2018 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2018, pp. 1–4.

[12] “PCS / Port Community Systems - IPCSA International.” [Online]. Available: https://ipcsa.international/pcs. [Accessed: 24-Mar-2019].

[13] M. Francisconi, “An explorative study on blockchain technology in application to port logistics,” 2017.

[14] K. Sultan, U. Ruhi, and R. Lakhani, “Conceptualizing Blockchains: Characteristics & Applications,” p. 9, 2018.

[15] C. T. Fitz-Gibbon, Performance Indicators. Multilingual Matters, 1990.

[16] P. B. Marlow and A. C. Paixão Casaca, “Measuring lean ports performance,” Int. J. Transp. Manag., vol. 1, no. 4, pp. 189–202, Jan. 2003.

[17] D. Tsamboulas, P. Moraiti, and A. M. Lekka, “Performance Evaluation for Implementation of Port Community System,” Transp. Res. Rec., vol. 2273, no. 1, pp. 29–37, Jan. 2012.

[18] K. W. David, S. Randall P, and Z. Nancy B, Simulation with Arena, Sixth edition. .

[19] J. Banks, Discrete-event System Simulation. Prentice Hall, 2001.

[20] S. Roger D., “Simulation: The Engine Behind The Virtual World.” [Online]. Available: http://www.simulationfirst.com/papers/sim2000/SimulationEngine.PDF. [Accessed: 06-Jun-2019].

[21] “Development of State-of-the-Art on BlockChain technologies in Ports and Terminals v2.4.” .

[22] A. Mahwish, L. Henesey, and E. Casalicchio, “Digitalization in Container Terminal Logistics: A Literature Review,” p. 25, 2019.

[23] . S. A. A., “BLOCKCHAIN READY MANUFACTURING SUPPLY CHAIN USING DISTRIBUTED LEDGER,” Int. J. Res. Eng. Technol., vol. 05, no. 09, pp. 1–10, Sep. 2016.

[24] W. Guoqiang and Yuanye, “Influencing Factors of Port Efficiency and Evaluating Indices System.”

[25] P. Bourque, R. E. Fairley, and IEEE Computer Society, Guide to the software engineering body of knowledge. 2014.

[26] J. Dooley, Software Development and Professional Practice. Apress, 2011.

[27] K. Wiegers, Creating a Software Engineering Culture. Addison-Wesley, 2013.

[28] R. Patton, Software testing. Indianapolis, IN : Sams Pub., 2006.

[29] M. Moradi, B. Van Acker, K. Vanherpen, and J. Denil, “Model-Implemented Hybrid Fault Injection for Simulink (Tool Demonstrations),” in Cyber Physical Systems. Model-Based Design, 2019, pp. 71–90.