BLOCKCHAIN FOR CONSTRUCTION MANAGEMENT

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Introduction

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Hyperledger project: Blockchain for construction management
Blockchain for construction management

Project Description: Construction Management Blockchain is a project of Hyperledger Summer Intership Program 2019 which provides a way to apply Hyperledger for construction and engineering (C&E), while literature research and practical simulation prove Hyperledger as one of best platform for C&E.

This project was conceived to test the potential of blockchains. To do this, a prototype system is used to model real-world commercial process by defining the properties of participant attributes superimposed with algorithms that describe their trading relationships. These are implemented using so-called smart-contracts that make use of the latest features of Hyperledger Fabric (HLF) and Composer, to model commercial relations between traders in a trust network. Using HLF, a variety of benefits can be obtained. For example, the scheduling, confirmation and commissioning of installed components at a construction site can be recorded and therefore, managed. But management of a HLF network is a demanding job and good design is essential to allow confidential trading to take place. The access control list (ACL), included within Composer, provides the tools to create, read, update, or delete elements within the commercial network’s domain model. The project has advanced this control by making use of application programming interface (API) to connect to Web servers that in turn can provide analysis and management applications. This links to common project management tools, notably Gantt charts and other projects metrics such as individual work rates, cost and budgetary items that can be used in reports and figures.

Tools: Hyperledger Fabric, Hyperledger Composer, Node.js, javascript.
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**Project Objectives:**

- **Obj 1:** Confirm that Hyperledger Fabric (HLF) is a suitable blockchain platform for use on C&E projects and that Hyperledger Composer (“Composer”) is suitable for creating the business model and managing the network.

- **Obj 2:** Design and confirm a system architecture and network configuration for a blockchain solution that is able to support C&E projects.

- **Obj 3:** Establish a set of functions of C&E assembly and administrative processes that are suitable for the application of HLF.

- **Obj 4:** Using an established set of business process modelling tools, define a pilot project that will be used to test the system.

- **Obj 5:** Design and testing programme that can be used to fully evaluate the utility and reliability of a HLF network for the pilot project.
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A project is divided into smaller tasks:

- Task 1
  - Order 1
  - Order 2
  - Order 3

- Task 2
  - Order 4
  - Order 5
  - Order 6

A project is divided into smaller orders for installing each part.
LIFE CYCLE OF AN ORDER

1. Make buying request
2. Make shipping request
3. Deliver order
4. Make installing request
5. Make checking request
6. Installing result
7.1.1 Request change material
7.1.2 Request Shipping back order
7.2.1 Change supplier
7.2.2 Request refund
7.3 Order Completed

An action is made by invoking a corresponding smart-contract.
In a moment, site fore man does an action:
- 7.1
- Or group of action 7.2.1 and 7.2.2
- Or action 7.3
If action 7.3 is done, life cycle of an order is terminated.
SEQUENCE DIAGRAM FOR CONSTRUCTION MANAGEMENT

- Commercial Manager
- Supplier
- Shipper
- Installer
- Clerk of Work
- Site Foreman
- Blockchain

- CreateOrder()
- Buy()
- RequestShipping()
- Delivering()
- RequestPayment()
- Delivered()
- MakePayment()
- DeliveryConfirmation()
- TestResult()
- InstallationConfirmation()
- InstallationAndTestConfirmation()
SEQUENCE DIAGRAM FOR CONSTRUCTION MANAGEMENT

- Commercial Manager
- Supplier
- Shipper
- Installer
- Clerk of Work
- Site Foreman
- Blockchain

Events:
- Change Supplier
- RequestShippingBackOrder
- Delivering
- Delivered
- RequestRefund
- Refund
BUSINESS NETWORK AUTHORIZATION RULES (ACLS)

1a. Restrict ‘CreateOrder’ transaction to Commercial Manager (CM)
1b. Restrict ‘Buy’ transaction to CM
1c. Restrict ‘MakePayment’ transaction to CM
2a. Restrict ‘RequestShipping’ transaction to Supplier (SU)
2b. Restrict ‘RequestPayment’ transaction to SU
2c. Restrict ‘Refund’ transaction to SU
2d. Restrict ‘DeliveryConfirmation’ transaction to SU
3a. Restrict ‘Delivering’ transaction to Shipper
3b. Restrict ‘Deliver’ transaction to Shipper
4a. Restrict ‘DeliveryConfirmation’ transaction to Site Foreman (SF)
4b. Restrict ‘RequestRefund’ transaction to SF
4c. Restrict ‘TestAndInstallationConfirmation’ transaction to SF
4d. Restrict ‘RequestShippingBackOrder’ transaction to SF
5a. Restrict ‘TestFailed’ transaction to Installer (IN)
5b. Restrict ‘TestPassed’ transaction to IN
5a. Restrict ‘Installed’ transaction to Clerk of Works (CoW)
5a. Restrict ‘NotInstalled’ transaction to CoW
7a. Supplier can view history of their own Order only

8a. Shipper history of their own Order only

9a. Each participant can only see their own history transaction only

(All transactions and rules have been implemented in our system)
1. Invoke smart contract
2. Request smart contract
3. Response
4. Update task progress
5. Update Statistics & Charts
6. Response statistics
7. Display progress and Statistic
8. Notify Response
Statistics
Information &
Charts

Controlling progress of project by a Gantt chart

Manipulating budget of project by a Donut chart

Reporting work rate of each participant by a line chart
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Project Deliverables:

- Deliverable 1: a website for user
- Deliverable 2: code is updated to a github
- Deliverable 3: preparing a publication
## List of functions

- Home
- All orders
- All commercial managers
- All suppliers
- All shippers
- All site fore men
- All Installers
- All clerks of work

- List of all create order transactions
- List of all buy transactions
- List of all request shipping transactions
- List of all delivering transactions
- List of all deliver transactions
- List of all deliver confirmation transactions
- List of all make payment transactions
- List of all test passed transactions
- List of all test failed transactions
- List of all installed transactions
- List of all not installed transactions
- List of all test and install confirmation transactions
- List of all request refund transactions
- List of all request shipping back order transactions
- List of all refund transactions
- List of all completed transactions

### Commercial Manager List

#### Commercial Manager 1

<table>
<thead>
<tr>
<th>Class</th>
<th>Commercial Manager Id</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.example.basic.CommercialManager</td>
<td>JohnWick</td>
<td>IBM</td>
</tr>
</tbody>
</table>

#### Commercial Manager 2

<table>
<thead>
<tr>
<th>Class</th>
<th>Commercial Manager Id</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.example.basic.CommercialManager</td>
<td>Khai</td>
<td>IBM</td>
</tr>
</tbody>
</table>

#### Commercial Manager 3

<table>
<thead>
<tr>
<th>Class</th>
<th>Commercial Manager Id</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.example.basic.CommercialManager</td>
<td>LeoTungArh</td>
<td>VNBBlockchain</td>
</tr>
</tbody>
</table>

#### Commercial Manager 4

<table>
<thead>
<tr>
<th>Class</th>
<th>Commercial Manager Id</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.example.basic.CommercialManager</td>
<td>LeonardoOcorpo</td>
<td>Hollywood</td>
</tr>
</tbody>
</table>

#### Commercial Manager 5

<table>
<thead>
<tr>
<th>Class</th>
<th>Commercial Manager Id</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.example.basic.CommercialManager</td>
<td>NguyenTungArh</td>
<td>LinuxFoundation</td>
</tr>
</tbody>
</table>

#### Commercial Manager 6

<table>
<thead>
<tr>
<th>Class</th>
<th>Commercial Manager Id</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>org.example.basic.CommercialManager</td>
<td>TungArh</td>
<td>VietNam</td>
</tr>
</tbody>
</table>
## Buy List

### Buy 1

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1da98ee644295081a867ba07b0f05c00</td>
<td>TungAnh</td>
<td>Long</td>
<td>Order2</td>
<td>2019-09-14T04:57:34.712Z</td>
</tr>
</tbody>
</table>

### Buy 2

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>3122063636287280bc646647612</td>
<td>TungAnh</td>
<td>Jack</td>
<td>Order2</td>
<td>2019-09-16T07:31:45.716Z</td>
</tr>
</tbody>
</table>

### Buy 3

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>b12363b9e000202b1cc1b0016</td>
<td>TungAnh</td>
<td>Long</td>
<td>Order1</td>
<td>2019-09-12T03:46:20.405Z</td>
</tr>
</tbody>
</table>

### Buy 4

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>be35481e50b544e62b08532d4671</td>
<td>TungAnh</td>
<td>Long</td>
<td>Order3</td>
<td>2019-09-19T15:00:23.837Z</td>
</tr>
</tbody>
</table>
# Deliver Shipping List

## Deliver 1

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Shipper</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>0c4e78089d4e3cbe6971e6549c3782b1e265874f7d686047175584e65813db</td>
<td>Thanh</td>
<td>Order1</td>
<td>2019-09-11T04:30:37.760Z</td>
</tr>
</tbody>
</table>

## Deliver 2

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Shipper</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>15b1109a3e3b4c5f7b2d208798627061cc316b10594d7e3b9-8e8c3eac40d</td>
<td>Thanh</td>
<td>Order2</td>
<td>2019-09-16T07:25:37.125Z</td>
</tr>
</tbody>
</table>

## Deliver 3

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Shipper</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>310b65674abf11db4c3d3b0e82a4675aa115d3b2113e0d860b386e10c16a</td>
<td>Thanh</td>
<td>Order1</td>
<td>2019-09-12T04:14:30.050Z</td>
</tr>
</tbody>
</table>

## Deliver 4

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Shipper</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>58b2dd1d4c9bca87fd7b7b66b2244756c28b5a0196e313e41e973ed897ac82</td>
<td>Thanh</td>
<td>Order2</td>
<td>2019-09-16T07:33:41.386Z</td>
</tr>
</tbody>
</table>

## Deliver 5

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Shipper</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>8a17e34b4dc881b577d75a6292022c2e858f1b72ae6b216a64cd8e22d97bb62</td>
<td>Thanh</td>
<td>Order1</td>
<td>2019-09-19T15:40:03.197Z</td>
</tr>
</tbody>
</table>

## Deliver 6

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Shipper</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>3b2799090ca3a317953a2c4a947685719b3869430dd3303c8b1c16511db</td>
<td>Thanh</td>
<td>Order3</td>
<td>2019-09-19T15:46:34.327Z</td>
</tr>
</tbody>
</table>
Refund List

Refund Transaction 1

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Order</th>
<th>Bank Transaction Number</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>20d20c8d7785e8f3c-bb9c377c25e608d148bee98348b7cc025d5b786</td>
<td>Order3</td>
<td>Metinbank#123456780000099</td>
<td>2019-09-20T02:44:01.862</td>
</tr>
</tbody>
</table>

Refund Transaction 2

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Order</th>
<th>Bank Transaction Number</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>f17177b97da5b368b94127b051791275b558a92b8a6356e0358c7b262248f4</td>
<td>Order2</td>
<td>Metinbank#1234567811111</td>
<td>2019-09-14T04:48:53.137Z</td>
</tr>
</tbody>
</table>
## Request Shipping Back Order List

### Test and Install Confirmation Transaction 1

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>544eb9f5415bf6b6b8e22aae5ee9f8771595446a21ee5b044456be6745a9ba46c</td>
<td>Order3</td>
<td>2019-09-20T02:34:08.71Z</td>
</tr>
</tbody>
</table>

### Test and Install Confirmation Transaction 2

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a60ba58eb0cb15a2f2ed213dd500a15c4c9f2c0f8</td>
<td>Order2</td>
<td>2019-09-16T07:20:17.84Z</td>
</tr>
</tbody>
</table>

### Test and Install Confirmation Transaction 3

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>687743d442aad80b050441d9f654d786d88b06701b74dab53b9a14682724c</td>
<td>Order2</td>
<td>2019-09-14T04:48:14.098Z</td>
</tr>
</tbody>
</table>
### Created Order List

#### Created Order 1

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>22c383e2a91c1344e51dc2e54a357fa</td>
<td>TungAnh</td>
<td>Jack</td>
<td>Order1</td>
<td>2019-09-16T07:20:09.06Z</td>
</tr>
</tbody>
</table>

#### Created Order 2

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>810836051122eda4770790930811</td>
<td>TungAnh</td>
<td>Long</td>
<td>Order1</td>
<td>2019-09-11T08:40:16.281Z</td>
</tr>
</tbody>
</table>

#### Created Order 3

<table>
<thead>
<tr>
<th>Transaction Id</th>
<th>Commercial Manager</th>
<th>Supplier</th>
<th>Order</th>
<th>Time stamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>9a6d91019708822c2b0236e2883</td>
<td>TungAnh</td>
<td>Long</td>
<td>Order3</td>
<td>2019-09-19T14:47:41.074Z</td>
</tr>
</tbody>
</table>
Create a Make Payment Transaction

Commercial Manager ID:
John, Leo etc.

Supplier ID:
John, Leo etc.

Order Number:
Order 1, Order 2 etc.

Bank Transaction Information Number:
Bank Name/Transaction no.

Amount of money:
1000, 2000 etc.

Submit
Create a Request Shipping Transaction

Site Fore Man ID:

John, Leo etc.

Shipping Company Name:

John, Leo etc.

Supplier ID:

John, Leo etc.

Order Number:

Order1, Order2 etc.

Submit
Create a Request Shipping Back Transaction

Site Fore Man ID:
John, Leo etc.

Supplier ID:
John, Leo etc.

Order Number:
Order1, Order2 etc.

Submit
Create Shipper

Shipper ID:
John, Leo etc.

Company:
IBM, Microsoft etc.

Submit
Create Site Fore Man

Site Fore Man ID:
John, Leo etc.

Company:
IBM, Microsoft etc.

Submit
List of all create order transactions
List of all buy transactions
List of all request shipping transactions
List of all delivering transactions
List of all deliver transactions
List of all deliver confirmation transactions
List of all make payment transactions
List of all test passed transactions
List of all test failed transactions
List of all installed transactions
List of all not installed transactions
List of all test and install confirmation transactions
List of all request refund transactions
List of all request shipping back order transactions
List of all refund transactions
List of all completed order transactions

Total Budget: 500$
Recommendations for future work:

- Project is only implemented in localhost for testing functions of blockchain system because of limited budget and computer power.

- If project is funded for an free account of cloud and computers, blockchain system can be deployed on cloud by using docker and test in reality conditions.

- With detail documents and source code, it can instruct developer how to convert business needs to algorithms and implement them to chaincode, generate APIs for exchanging data between user and blockchain system, create user interface, make statistics and apply machine learning algorithm for data in transactions. Furthermore, system architecture provides the manner to combine blockchain, statistics and machine learning based on smart contract which would be helpful for Hyperledger to develop extend modules.
Thanks You For Listening!