Prototype of Blockchain in Dental care service application based on Hyperledger Composer in Hyperledger Fabric framework

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Abstract— Most enterprise blockchain applications rely on real world trust relationship such as the business in financial institutions, entertainment industry, supply chain industry, transportation, education, healthcare services, etc. Hyperledger aims to advance blockchain technology that confederate in the cross-industry to open standard platform for distributed ledgers, which can transform the way business transactions are controlled globally. As we know currently the model of blockchain have permissionless blockchain and permissioned blockchain, which the permissionless blockchain such as Bitcoin cryptocurrency that anyone can operate a node and participate through spending CPU cycle and demonstrating a proof of work. On the other hand, permissioned blockchain model control who participates in validation and in the protocol. More over these nodes typically have established identities and form a consortium. Therefore, to make the innovation application that need the authority and permission for submitting the transaction we will select the hyperledger fabric framework to develop our project. Hence this paper will focus to study to develop a prototype of healthcare service application in dental clinic service. In order to keep records transactions that are accessible and controlled the authority by participants which it has a transaction id number that generate by hash number mechanism running by hyperledger composer. This application will create a trust relationship wherein the goal is to set up a set of participants in an ecosystem that it needed in health care service in the field of sharing the medical equipment and transaction that can save a variety of costs and make an interoperability process in the clinics.

Keywords—**Hyperledger Composer, Blockchain, Healthcare services, Blockchain application, Permissioned Blockchain**

I. INTRODUCTION

Currently, a significant opportunity exists for dentistry to shape the standards and technologies that it will use in the future, as well as define how they will be used. "Electronic health Record" as we know in EHR standard one of the terms that has been used to refer to the notion of a completely electronic patient record. These have included terms like Computerized Patient Record, Computer medical Record, Automated Patient Record, and perhaps a dozen more. However, this notion of the Electronic Health Record carries with it no prescriptions regarding technologies or display formats such as the layout chart or screen. As for the terms "Electronic Medical Record" or EMR and "Electronic Dental Record" or EDR, they are bodies of patient data arranged to present information to the provider, other authorized users, and in some cases the patient, and it may include non-EHR data such as reference values for clinical laboratory tests. Another way to think of the EMR or EDR concepts is that they present extracts of the data contained in the EHR with other relevant information. EHR often utilize in many technologies or standards because in healthcare system we need the unique form to be stable for using in the long term it must be available to share data or information to the network organization for sharing the information associated such as pictured or screen capture including the interfaces that need to work together to create, manage, and store in the electronic health record. However, an EDR System for dental care setting could import/export, present, and capture the relevant extract of patient's information in the electronic health records. It is very important that features of such systems make it possible to share health information quickly with authorized provider or the system across more than one organization or maybe across in the multiple health care setting.

Hyperledger Fabric is the solution used in this electronic health record to solve the solution for sharing the information across from the one organization or multi organization by the blockchain as the distributed ledger among the network. Lately we can see many of blockchain platforms that have launched out by various companies such as Ethereum, Corda, Quorum, Ripple, NEM, NEO and others. They also have the ability like Hyperledger fabric, to solve the problem about sharing data across organizations with blockchain technology. However, we are focusing on Hyperledger Fabric because it is using a modular architecture and using smart contract with the permissioned model. It is different from the others because it needs the agreement of node to use the person who can approve with its compatibility with the hospital work process. [1]

Hyperledger Composer is the open source development toolset that allows to make a blockchain applications easier. It can integrate with the existing systems and data with blockchain applications. The component of the model are assets, participants, transactions, model (file .cto), access control (file .acl) etc. which will all build the business network by archive the business network result in file .bna. As this advantage of Hyperledger Composer makes design attributes in the model file and design logic easier with available coding on JavaScript and have client library for node.js. So it can bring more advantages to the health care records which its compatible to the system to design and sharing the information across clinics or hospitals and so on. [2]

II. ARCHITECTURE

A. Business network archive file structure

Figure 1 explains how to use the composer or editor such as visual basic to write the business network definition, comprised of Model file (.cto), Script or Logic file (.js), Access control file (.acl), Query file (.qry) which all these files will pack up to create a business network file (.bna) then this .bna file can be deploy in local computer or cloud to create a web browser application or node.js suitable as user will using.[4]
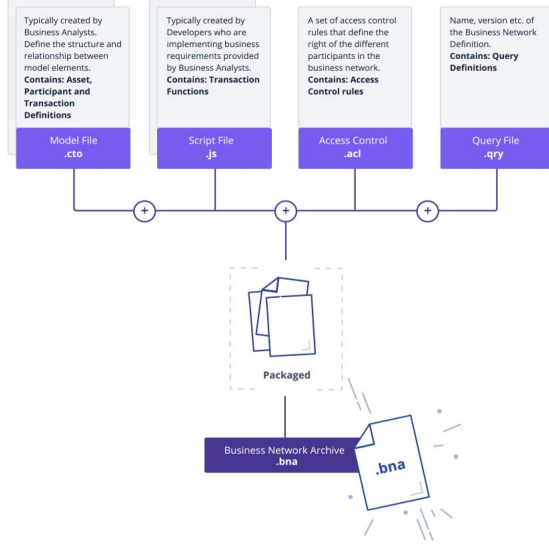

Fig. 1. Business network Archive file structure[4]

B. Full-Stack blockchain solution and integrating the blockchain with existing enterprise systems of record.

In hyperledger composer enable architects and developers to quickly create REST API to expose logic to web or mobile application. Figure 2 shows the architecture that Yeoman (generic scaffolding tool) will generate skeleton Angular app used as a starting point to the blockchain applications then skeleton Angular app will call REST API that generate by Composer Rest Server to use the sources of records to create front-end [3].
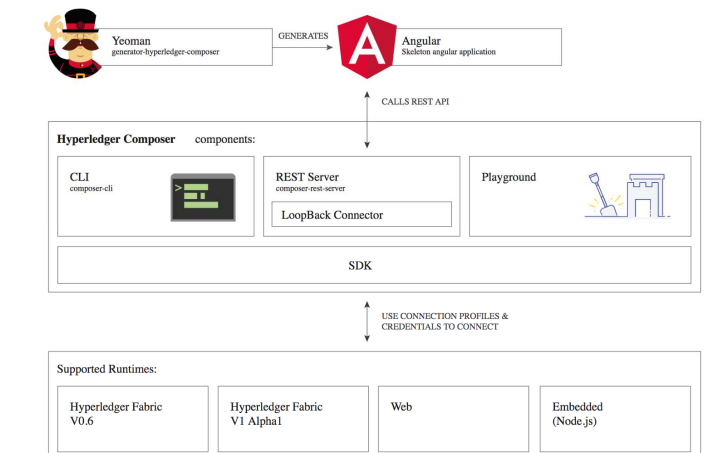

Fig. 2. Full-stack blockchain solution architecture[4]

III. WORKFLOW AND BLOCKCHAIN COMPONENT IN DENTAL CARE SERVICE

A. Workflow scope

As Electronic Dental record claims that Electronic prescribing systems should be easy, convenient to implement, learn, and use effectively by dentist in a variety of practice settings. Integration into the practice management software systems should support and enhance the typical daily workflow of the dental practice [5].

Figure 3 demonstrated the work flow in the application that the situations will happen in the clinic. First, the patient will meet the dentist and then dentist will create and setting the rules of contract with patient including the other transactions which the transaction call "treatment interview" and "treatment plan", asset call "Prescription" and "Contract" by the number of each transaction will related between dentist and patient. Second after patient and dentist was create transactions, clinic will create the transaction call "treatment received" and "treatment fee" then patient will receive the notify message in the third step in order to notice the patient to pay the bill follow in the step fourth. Finally all the transaction will be emit event in to a number of blockchain patient can check all the transaction that has been happen in the system it is mean that patient can get the receive bill wherein this system will keep all transaction that occurred and the transaction has been transfer the ownership and every activities will keep it in the system chain by hash number.
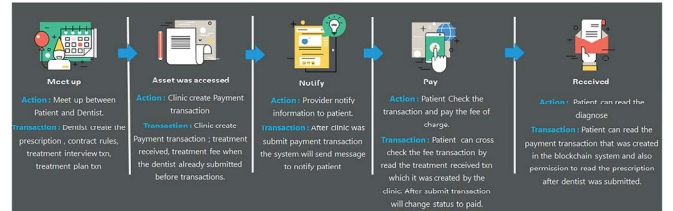

Fig. 3. Workflow scope in dental care service application

B. Participants and Assets

1) *Participants:* The members in the business network

a) *Patient:* Who will receive the treatment from dentist

b) *Dentist:* Who will write the dainose record the historical of patient and plan of treatment in to the system, the treatment will submited by dentist. The transaction such as treatment interview ,treatment plan and assets contract id and prescription id will referenced in the relate transactions.

c) *Clinic:* Who will submit the transaction such as treatment receive to summary all the price to notify payment to patient. Also it can cross check between Patient Clinic and Dentist that the payment is properly.
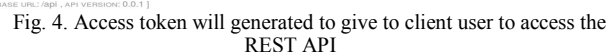
2) *Assets:* Assets are the resource that in the business will be use it can be tangible or intangible it is a key value of the business network.

a) *Prescription:* As the Electronic prescription standard for dentistry will set the guidelines for interoperability, we concider the factors for adoption and use this asset will include diagnoses ,drug name and drug

code, Medicine list which include frequency, duration of its. Furthermore in prescription will include treatment id and medication history.

b) Contract: We include cost of treatment to add in to this asset for make the key value. This asset can transfer the ownership and also share with the other patient dentist and clinic.

C. Functions and Transaction

Transaction will contain the timestamp and transaction id, which are extended to all of other transactions.

1) Treatment Interview: This transaction will keep the history record from patient by dentist. After dentist interview the history of treatment then dentist will write it in this transaction and submit in to the system.

2) Treatment Plan: This transaction will record the dentist's treatment plan such as the plan of orthodontic treatment etc. This transaction can encourage the patient to adherence to the medication and help the patient recognize errors and potential adverse events before the cause harm.

3) Treatment Fee: This transaction will confirm the agreement from patient, after patient submit this transaction. It is mean the query information that have been approve.

4) Treatment Receive: This transaction will involving to the account balance in each participants that the price of each contract, after clinic submit the transaction each participants balance in account will decreased by the price of each transaction.

Blockchain works on a principle of assets (policies, claims), participants (patient, clinic, dentist), and transactions (submit claim, update claim, audit claim). Every time an asset, participant, or transaction is created, updated, or deleted, the blockchain records the event and adds it to the immutable audit trail on the distributed ledger.

IV. REST SERVER AND ANGULAR OUTCOME

A. REST API

The Hyperledger composer have a standalone Node.js that can integrate with exposes business network as a REST API [6]. REST server can be configuring to subscribe to events emitted from a deployed business network and publish those events to client applications. Enabling authentication for the REST server, the clients forced to be authenticated to the REST server before they are permitted to call the REST API see in figure 4.

Fig. 4. Access token will generated to give to client user to access the REST API

Fig. 5. Blockchain in the system

Figure 5 demonstrate the activities of transaction that occur in the system by generate the hash id for each transaction that show the characteristic of blockchain are immutability, tamper proof and traceability.

B. Angular

The Angular will create front-end web application, it will contact the existing REST server, Figure 6 demonstrate the work flow between Hyperledger Fabric reflected to the angular.

Fig. 6. Working flow of application between angular and REST server in Hyperledger Fabric [7]

In figure 7 demonstrate the form of asset prescription which it will submitted by dentist. As this page we can see the attribute create rely on EDR [5] and SNODENT [8] such as the drug code, Therapeutic categories, SNODENT ID etc. as each clinic or hospital will adopt this application they can rely on this attribute or can be change it in the future to be compatible with each organization.

Fig. 7. The asset prescription form in Web app generate by Angular
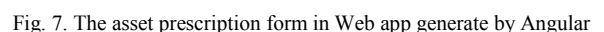
V. SCALABITY PROBLEM

The families of state machine in fabric is Byzantine fault-tolerant (BFT) replication protocols, which promise consensus nodes. The research [9] said that BFT protocol prototypes have been shown to practical minimal latencies allowed by the network and supporting ten thousand of transactions per second. However, BFT and state-machine by the term of number of nodes still discussing and challenging in their scalability among the other blockchain platform. In hyperledger Fabric provides three ordering mechanisms e.g. SOLO, Kafka, and Simplified Byzantine Fault Tolerance (SBFT). [10]

1) SOLO: This protocol is the Hyperledger Fabric ordering mechanism involves a single ordering node , most typically it is used by the developer experimenting networks.

2) Kafka: This protocol is the Hyperledger Fabric ordering mechanism that is recommended for production use. This ordering mechanism utilizes Apache Kafka, an open source stream processing platform that provides a unified, high-throughput, low-latency platform for handling real-time data feeds. In this case, the data consists of endorsed transactions and Read-Write sets. The Kafka mechanism provides a crash fault-torelant solution to ordering. In our project we use this ordering function to run this prototype blockchain of dental service application.

3) SBFT : This protocol is the Hyperledger Fabric ordering mechanism in both crash fault-tolerant and byzantine fault-tolerant, meaning that it can reach agreement even in the presence of malicious or faulty nodes. Hyperledger Fabric community still not finish implement to testing this yet but theirs work still discussing and challenging in their scalability in the term of nodes or replicas as mention above.

VI. FUTURE WORKS

As we study with some medical standard such as the Systematized Nomenclature of Dentistry (SNODENT) [8] to guide the oral health information. SNODENT includes Electronic Dental records (EDR) vendors and other dental clinical technology vendors that may be involved. At this point in our project rely some information from SNODENT to create the prototype in order to develop system record information properly in the dentist field such as electronic prescription, treatment history, treatment plan and also enabling electronic sharing of details transaction information publicly and privately up to the access control has been design. Future work this project can be design and create a larger project that can bring the benefit to the medical field or can use this project adapt to Electronic Health Record (EHR) that can working with the hospital and the other organizations in the business network. Moreover, we can create our own coin can study from Stellar to make the ICO coin that using in the real situation. [12] That it solves the solution of interoperability in electronic health records, which it can adopted to use in the organization relevant the health care in the future.

VII. CONCLUSION

Hyperledger composer is the open development tool set and framework that allow us to develop a blockchain application and integrate with the existing business system easier. By the way in our application enabled dental clinic records benefit individual by enabling interoperability if clinical details a patient characteristic between clinics or hospitals and allowing identification of each patients who need to follow up for specific conditions and improves coordination care. We adapted SNODENT benefit public health by enhancing oral health care efficiency by enabling electronic sharing of detailed clinical information and enabled clinic health records benefit evidence-based oral healthcare by permitting analysis of patient care services and outcomes and improving the cost-effectiveness and quality of care delivered to populations.

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