

Integrating Blockchain in Indian Land Recording and Land Registration System

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Bipasa Sen¹, Dipti Kumari²
¹ Department of Computer Science engineering R.K.D.F University, Ranchi

² Department of Computer Science Engineering, Sarala Birla University, Ranchi

Email Id: bipasa30sep@gmail.com

Abstract: Blockchain has enormous potential and no boundaries. Blockchain technology is an open, immutable, distributed ledger without any central authority and can be a substitute to the traditional transaction system where we keep documents like records, contracts etc. Total number of land digitization completed in India 94.53%. Though Indian land record management system is unable to prevent various types of forgery and land related legal disputes. So, real landowners are suffering from various kinds of land litigation, which raises doubt regarding the existing system's effectiveness, authenticity and reliability. This causes the government's judicial department to be a huge waste of time and money. Underlying technology of cryptocurrency, Blockchain has potential to deal with this kind of problems and assures Record of Rights (ROR) obtaining a smart web-application enabled transparent tamper-proof, collaborative, trustworthy, secure, peer-to-peer, reliable, scalable and automated land recording and land registration system's e-Governance. In this paper we aim to give insight on contemporary systems and how Blockchain-based systemization achieves significant improvement in land registration and land recording systems.

Keywords: blockchain technology, Hyperledger fabric, land records, land registration, smart contracts

1 Introduction

Land is one of the most fundamental capitals of human society all over the world. In the agrarian Indian economy, land is the most valuable asset. Land registration is a government approved transnational process of land to provide certified documents for legal proof of ownership and property title. The government maintains the current status of land records and land registration through the Department of Land and Land Reforms and the Directorate of Registration and Stamp Revenue. Land records and land registration started in India from the British period. Gradually, after the independence of the country, the revision of the land record has been done several times. Apart from this, land records have been amended immediately after land registration. At that time, land records were kept in handwritten books. But as time evolved the Indian government was motivated by the triumph of computer and internet technology to the use of Information and Communications Technology (ICT) for facilitating administration as well as citizens, a friendly e-governance. Land records and land registration systems become an integral part of the e-governance system through web-based portals. The primitive manifesto of these facilities is to reduce time and cost of services and impose accountability with transparency to all information of the government to the denizens, different government agencies and other private sectors. The Indian Government has taken many initiatives for the effectiveness of e-Governance like for optical fiber connectivity, Gram Panchayats Bharat Net scheme; Digital India scheme to make a digital country etc. Among them Digital India Land Records Modernization Programme (DILRMP) scheme initiated for computerized land records systems. Though land records are almost digitized but unfortunately the DILRMP scheme has not yet achieved its full potential for some significant barriers.

By nature, unstructured cadastral land records are complex and sensible. The database which has been used for land record is an unsecured non-relational centralized database and also it holds only the current status of a piece of land. Thus, if anyone wants to know the detailed records of how many times a piece of land has been transferred, it is very tedious, time consuming and may possibly not have exact transactional information due to malfunctioning of data which can be easily achievable and lots of fraudulent activities wrapped around this process. As a consequence, many people are fighting over ownership of the land for different land

rights controversies and most of the time which leads to time and money consuming court cases to settle down. Various government and private agencies, financial institutions who work on land data can be misguided to get flawed records. Therefore, despite modernization there exists a lack of infrastructure to prevent cyber-attacks, data leakage, stop corruption of bureaucrats and third-party interference, narrow traffic and insufficient speed. Considering the present scenario, it has become very urgent to have a fail-safe transparent decentralized single window ecosystem platform for entire land recording and land registration systems which can be rectified by proposed Blockchain technology.

Blockchain technology is the world's first peer-to-peer electronic monetary system. In 2008; Satoshi Nakamoto first implemented this technology on an electronic transmission system and has started a new aeon of cryptocurrency.

Depending upon different variants of Blockchain technology viz permissioned or permissionless and using smart contracts, cryptographic key, digital signature etc. Blockchain technology successfully satisfies the process of verification and authentication which reduces the possibility of user's information being unveiled to cyberpunk. As Blockchain is a network-based database, at any point of time the same copy of ledger cloned on multiple nodes worldwide. So, instead of individuals, a large community managed this distributed database and chances of modification of data are negligible. The uniqueness of Blockchain technology is the use of consensus mechanisms which ensures only valid successful transaction should be enlisted into append only block of Blockchain structure. Whenever any transaction happens, it goes viral all over the network. Then consensus algorithms of all participating computers (validators) verify the legitimacy of the transaction. The majorities (more than 50 percent of participants) of the validators have to validate the transaction and then only the transaction is confirmed. Only after receiving this confirmation from validators, the new transaction is linked with the previous related transaction via hash functions and if any update occurs, it should be reflected in all peer nodes. That's how the immutable Blockchain data structure is established. Thus, if anyone wants to modify past transactional records for which that person has to compromise all the other nodes in the network to reach a cut-off percentage of consensus, that will be an extremely challenging task. Smart contracts are also another exclusive feature of

Blockchain technology. Business principles can easily be wrapped in smart contracts during transactions.

Blockchain data structure and its networking technology is an impeccable one in land recording and land registration systems. We proposed using permissioned, enterprises-grade Hyperledger Fabric, as it is the right type of Blockchain technology-oriented solutions to address the basic functionality and privacy issues regarding land records and land registration systems. Through Membership Service Provider (MSP) it verifies valid members and using channels it provides a way to establish one to one, one-to-many or many to many types of transactional relationships among valid members. Successful implementation of modular architecture based Hyperledger Fabric with smart contracts and appropriate consensus mechanism can restrain land related document falsification.

1.1 Present land recording and land registration systems with its difficulties:

Registration is only recognized as an agreement between two parties for transfer of property in India. The BLRO (Block Land Records Office), SLRO (State Land Records Office) and DLRO (District Land Records Office) are the custodian of the land records in our country. They are the authority to maintain the land record details. Land records are under the jurisdiction of state laws. The office of sub-registrar (SRO) is only undertaking deed registration under the central registration act 1908. In this system SRO does not verify the ownership of the land. So property fraud is uncontrollable in many forms in our country. History shows that by modifying original registered documents, one can sell properties on the basis of modified documents. One can also sell the same property to multiple people by keeping each other under dark.

Details of present land registration and land recording process with all stakeholders:

1. Sellers / Doner
2. Buyers / Done
3. Brokers(optiona
4. Legal professionals(Deed writer, lawyer)
5. Registrar (Government Revenue Officer)
6. BLRO (Block Land And Land Reforms Officer)

1.2 Remonstrated faced

Following chances of disputes involved in the present land registration procedure [9]:

1. Incomplete/missing/erroneous property data
2. Paper based so possibility of human error.
3. Time consuming for processing inefficiencies
4. Irrelevant third parties interference.
5. Double spending problem
6. Government bureaucracy
7. High transaction costs
8. Litigation problem

Hence there is a need for trusted single window platform with more efficiency, prompt service, feasible cost, enhanced security, greater transparency and true traceability for perform and approvals of different activities to avoid the above mentioned problems.

The rest of the paper is arranged as follows. Section II explains related works, section III explains the types of Blockchain network section, IV explains the need of Hyperledger Fabric, V explains block structure of Hyperledger fabric and its integrals, VI explains essential components of Hyperledger Fabric and its logical architecture, , section VII explains proposed Blockchain technology implemented land recording and land registration system's layout and section VIII explains conclusion.

2 Related work:

The centralized traditional way of handling huge sensitive land records of citizen used to be controlled by central authority and was bound to trust the data keepers. Whereas Blockchain technology, which has been introduced as decentralized digital currencies,

but later widely used as network based distributed ledger with smart contract and consensus algorithm to become a substitute for centrally controlled record system.

Based on Ethereum framework, a concept is explored where reliance is based upon proof-of- concept systems (PoC) and decentralized distributed ledger, which can overcome drawbacks of centralized land database systems.

Also, depending upon smart contract and proof-of- delivery consensus mechanism, a public Ethereum platform proposed facilitating more potential, traceable, accountable and trustworthy solution to exchange digital assets in

this paper.

A peer-to-peer (P2P) blockchain network based Inter Planetary File System (IPFS) was proposed for transparent property transactions in real estate which encompasses a complete cost effective, feasible solution connecting all registry offices of the state/country.

But most of these frameworks are either at the conceptual level or at the pilot testing stage trying to pretend implementation possibilities, pros and cons of smart contract regulated land record and land registration systems. In this paper a hybrid type of solution has been proposed where smart contracts and proof-of-concept algorithms combined with Blockchain technology to create a valid land registration system maximize convenience and minimize unwanted interruption.

Various types of scientific experiments are being conducted in this regard so that Eradication of land fraud becomes possible. Simultaneously they shed light on an issue that is of great importance especially for developing countries, where transferring land documents to Blockchain format is most challenging. This paper suggested Hyperledger

Fabric, a permissioned Blockchain network, combined with Interplanetary File System for secure, tamper-proof land record-keeping.

Using the features of Blockchain technology like distributed ledger with smart contract the property rights will be assured. Hyperledger Fabric is a permissioned Blockchain framework, comprises of modular architecture (plug-and-play). For property registration of proposed architecture, the composer layer used for web application and for chaincodes, governed the core part.

Different countries are coming forward to implement Blockchain technology in their land registration and land recording systems. In India Blockchain technology has already been introduced in some states as a pilot project due to its utmost security, supporting the government in revenue collection and other activities, complete automation, better e-governance in a few minutes at a very low cost and also preserving the property rights. The Government of Andhra Pradesh has tied up with a Swedish company for land records and regulations systems so that it can be arranged in the modern Blockchain enable style. As a consequence, people can keep their land records in a shielded form to get rid of unintended altercations.

3 Types Of Blockchain Networks:

Depending on several features of the Blockchain system, it can be categorized into following way:

3.1 Permissioned Blockchain:

People who have been given access permission and different privileges according to their function by the organization's administrator, can only access the distributed ledger of Blockchain. This type of Blockchain is called permissioned Blockchain. Since the access is restricted, the level of security and privacy of this Blockchain is well accepted by different industries.

Table 1

Present Land Registration Procedure	Registration (R)	Payment Procedure (P)
	Step R1 - Online form filling for e-registration Step R2 - Generate Query Number Step R3.0 - Execution of e-deed by deed writer / lawyer Step R3.1 - Donor and Donee submit their signatures presence of deed writer / lawyer Step R4.0 - Submit deed application by executing member (deed writer/ advocate) with court fees to ADSR (Additional District Sub Registrar) Step R4.1 - Seller/ Donor and Buyer / Donee signs all the related documents at presence of 2 witness; Submit fingers impression and snap Step R5 - Presentation of e-deed identified by deed writer/ lawyer Step R6 - ADSR check and allow these deed Step R7 - Government subordinate take a snap of Doner and digital signature Step R8 - Scan and upload the documents by Registration office Step R9 - After successful database updation issue a Mutation Number and a hearing date at BLRO office Step R10 - On that hearing date at the presence of Donor and Donee, mutation is completed	Step P1 - Query for land valuation Step P2 - Query verification by ADSR and approval of ROR Step P3 - Stamp Entry paying stamp duty Step P4 - Government of Registration and Stamp Revenue GRIPS (Government Receipt Portal System) challan Step P5 - Generate Government Reference Number (GRN) and generate e- challan Step P6 - After completion of e-deed execution government subordinate issue a challan of processing fees

3.2 Permissionless Blockchain

A permissionless Blockchain is also known as public Blockchain. Since there are no such restrictions on participation like permissioned Blockchain, anyone can join this completely decentralized network, access the network and validate transactions through consensus installing the proper setup. So this kind of network runs across unknown distrusted members.

Further Blockchain network can be classified as following categories:

4 Why Hyperledger Fabric:

Hyperledger Fabric was initially established at the end of 2015 by the Linux Foundation and supported by 120,000 major corporations with 15,000 engineers. Hyperledger Fabric provides a permissioned, customizable, open source, Business-Blockchain framework for a wide range of industries. Its modular architecture, access control features and unique identity management system and distributed ledger solutions easily manage the intricacy of business, maximizing the confidentiality, transparency, resilience, and scalability of Blockchain solutions.

Land record management system of India is associated with different government departments, financial institutions. Non-profitable organizations and above all huge Indian citizens who work with one another. Based on characteristics of our land records and land registry system, the Hyperledger Fabric platform could be the most acceptable platform to solve land record management system related troubles. If the entire land information management system is regulated under public Blockchain, anyone can be able to connect to the land registry system of Blockchain platform without proper authorization.

Instead of traditional Blockchain system which follows: first order of transactions through consensus mechanism; then execute and lastly update the state of transitions, Hyperledger Fabric follows: first parallelly process endorsement and execution of transaction; then ensure ordering; after that validation of transaction by peers and lastly update state of transaction in Blockchain. So, it has better performance, more flexibility than tradition one and follows determinism approach. Through MSP, Certificate Authority (CA), Channel, modular architecture like different exclusive properties of Hyperledger Fabric ensures customized network, visibility control, offers unique identity verification and its chaincode functionality which enforce the business logic on transactions by fostering faith, openness and keeping data value intact. Also, no mining process and cryptocurrency is needed for transactions in Hyperledger Fabric Blockchain framework.

5 Block structure of Hyperledger Fabric Blockchain and its integrals:

5.1 Block Structure:

Block is the building unit of any kind of Blockchain technology. In Hyperledger Fabric a block consists of three parts.

1. Header: Stores block number starting from '0', hash of current block, hash of previous block etc
2. Data: Stores all information related to each transaction in a sequential order, timestamp, version of the transaction, version of the chain code etc.
3. Metadata: Stores identity of the block creator (signature, public key and received certificate), sign of valid or invalid transaction against every transaction which is given by block committer etc.

5.2 Integrals of Hyperledger Fabric :

5.2.1 Organization:: Organizations play a leading role and form one or multiple consortia in a Hyperledger Fabric Blockchain network. All the participating organizations are "members" of the Hyperledger Fabric network but all of them may not be

members of the consortium. Organizations introduced business protocols governed by the consortium while a new network has been configured. The organizations are further divided into small parts. Those Small parts of the organization that are transactional endpoints are called peer nodes.

For example, the Department of Land and Land Resources and the Department of Revenue can be an Organization in a Fabric network.

5.2.2 Channel:: In a Hyperledger Fabric Blockchain network, channel is a private transactional path among specified organizations to create abstraction for other members of that network and defend data confidentiality with security. Members

need to join any channel for interactions as well as transactions. Each channel has a separate ledger which can only be accessed by that channel members.

5.2.3 Peer:: Every organization participates and contributes to a network by configuring the peer nodes. But each organization may not contribute the same number of peers. Certificate Authority authorized these participating peers of the network by providing signature and special permission. Peers are the base of Hyperledger Fabric. They have the copy of ledgers and chaincodes. Each peer can have any number of chaincode and ledger instances. Also one peer can be owned by a single organization and linked with a single MSP. The APIs of Hyperledger Fabric always interacts with peer nodes for transactional purposes invoking chaincodes to access ledgers. If a peer wants to use a channel of a blockchain network, the policy which has been configured for that channel verifies the peer's identity and determines its legitimacy. The organization owns different

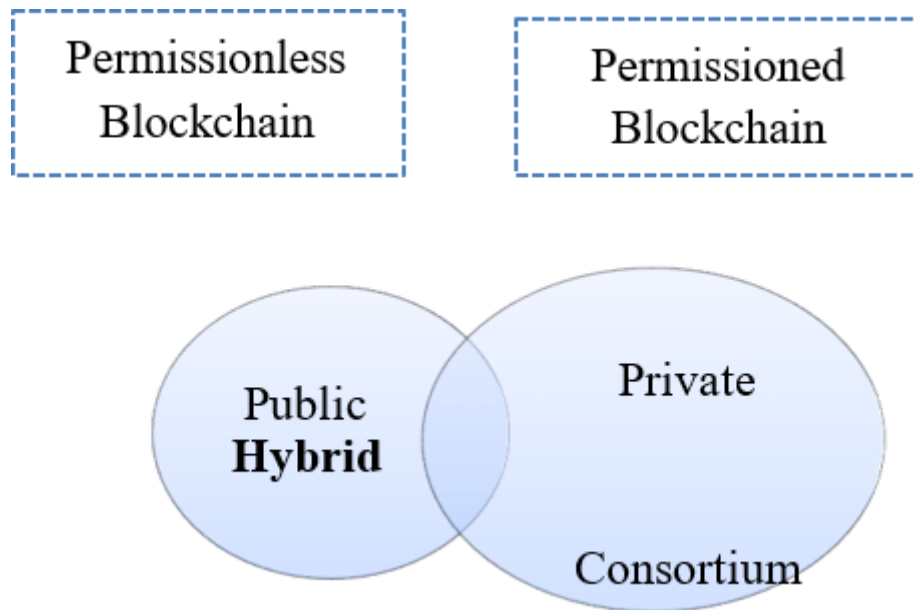


Fig. 1: Classification of Blockchain

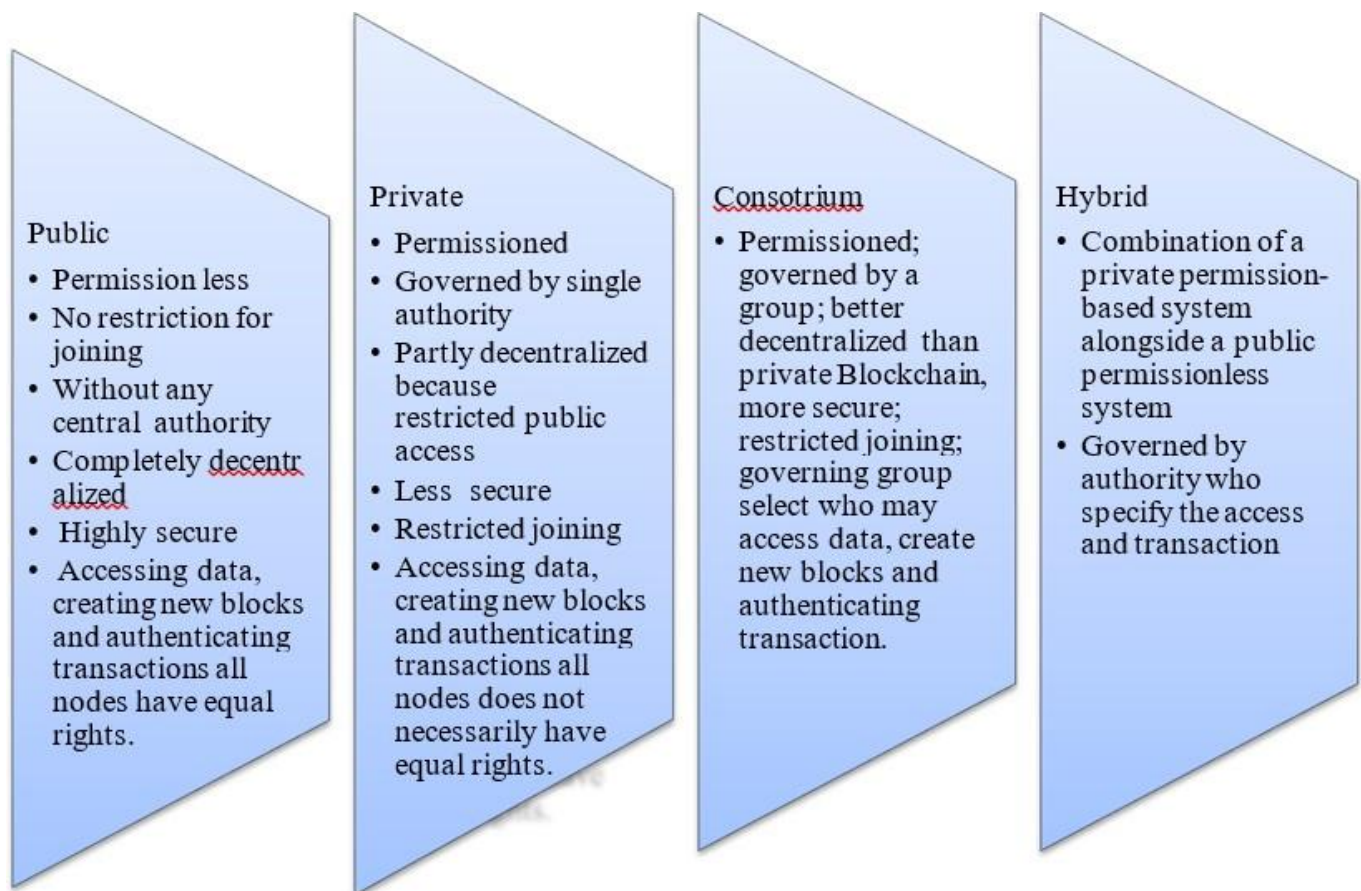


Fig. 2: Explanation of different types

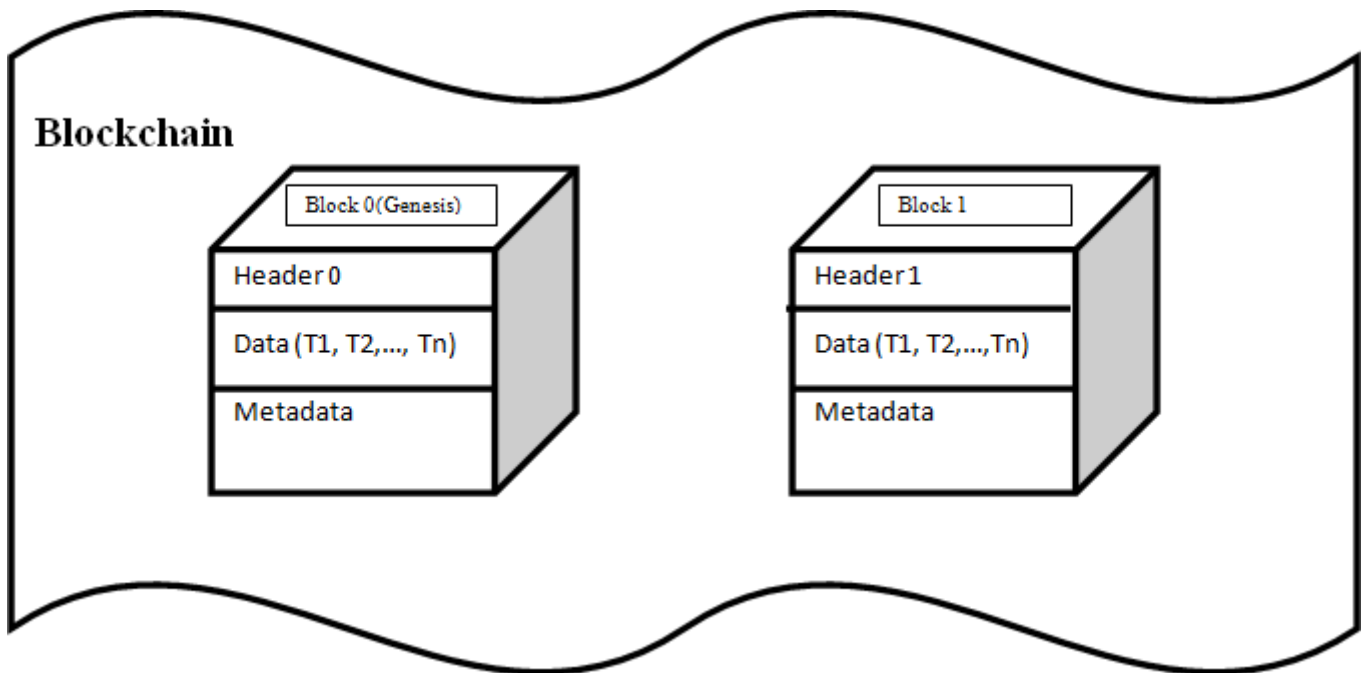


Fig. 3: Block structure

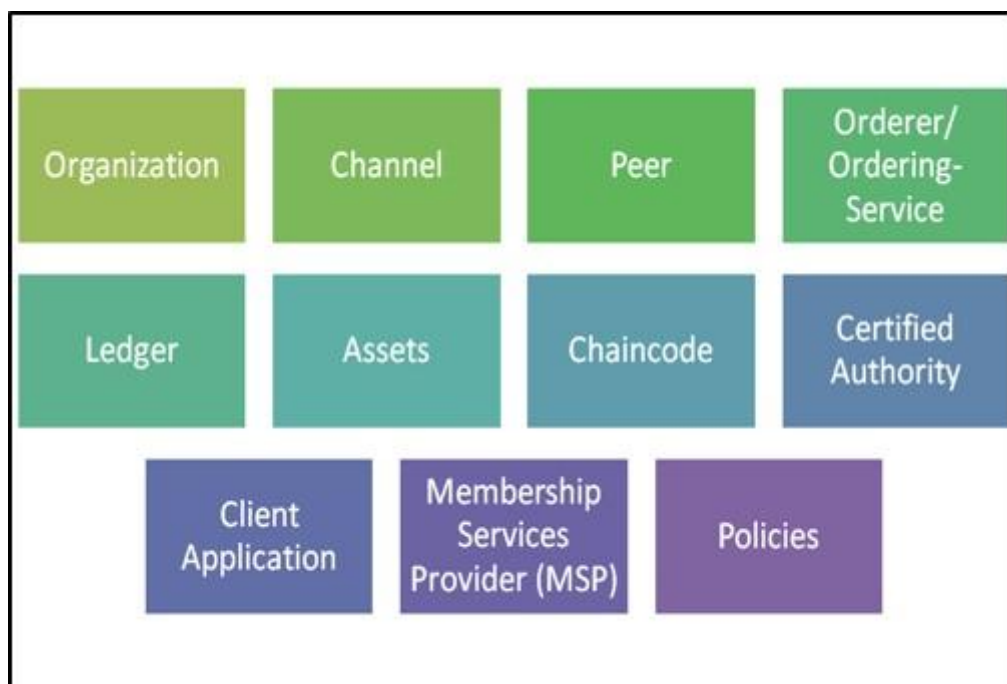


Fig. 4: Components of Hyperledger Fabric

types of peers according to their functions and behavior. Following types of the peers are there:

1. Leader Peers
2. Anchor Peer
3. Committing Peer
4. Ordering Peer

5.2.4 Orderer/ Ordering-service:: Hyperledger Fabric provides a type of independent nodes who order the incoming transactions, called orderer or ordering node and the service served by them all together known as ordering services. The main objective of the order is to keep shared ledgers state consistent and valid of all participating nodes of a network. Though different permission-less

Blockchain networks rely on probabilistic consensus, Hyperledger Fabric relies on deterministic consensus algorithms. Also the modular architecture of Hyperledger Fabric supports the kind of flexibility that organizations can choose their own ordering mechanism (consensus algorithm) which best suits their network among three: SOLO, Kafka, and Simplified Byzantine Fault Tolerance (SBFT). So Hyperledger Fabric guarantees that when any block is validated by the peer it should be legitimate and final. There is no notion of "fork" like other permission-less distributed Blockchain networks. Hence, at any point of time there should always be one Blockchain for a particular network. Besides managing channels, the contribution of ordering- service is remarkable. They possess organization's

access control lists where it mentions who all can read, write and configure data for a particular channel.

5.2.5 Ledger (L) :: A ledger is a prime concept in Hyperledger Fabric. We can visualize a single ledger, but in reality Hyperledger Fabric consists of multiple consistent copies of ledgers. This type of ledger is similar to Distributed Ledger Technology (DLT).

It stores crucial information about business objects, both the current value of these attributes of the object (World state, database of the ledger) and the history of transactions that result in these current values (Blockchain). The

value of the world state changes over time, but once recorded in the Blockchain, it does not. So we can easily derive the value of the world state at any given moment from the Blockchain.

5.2.6 Assets :: In Hyperledger Fabric assets can be anything, for example real estate, land, contract etc. Assets defined by

Hyperledger Fabric as key-value pairs, for example key=LAND and value= Sali/ Suna / Pond

/Bastu/ Apartment etc. Applying chaincode transactions Hyperledger Fabric can modify assets data.

5.2.7 Chaincode :: Smart contract is a piece of code that defines business logic which controls how the life of a business object of a world state evolves. For installation In Hyperledger Fabric, multiple smart contracts are collectively placed in a wrapper, called chaincode. Every chaincode has an endorsement policy associated with it, which is applicable for all smart contracts belonging to that chaincode. If a channel wants to use a chaincode, then maximum members of the organizations using that channel must approve that chaincode definition. Chaincode allows access to the ledger of Hyperledger Fabric through peers.

5.2.8 Certificate Authority (CA) :: The main role of Hyperledger Fabric's certificate authority (CA) is to insure identity by issuing certificates(enrollment), renewal of certificate and revoking certificate if time lapse. Certificate specified attributes are username, password, signature etc. Some information of the certificate is stored inside the ledger, which ensures authenticity of the operator [35].

5.2.9 Client Application :: Client of the Hyperledger Fabric is an application who acts as end-user. CA authority issues the certificate to the client

as evidence of the client's legitimacy for translation over that network. Clients interact with peers and ordering-services for translation through Hyperledger Fabric's Software Development Kit (SDK).

5.2.10 Membership Services Provider (MSP) :: Hyperledger Fabric network works in a trusted environment. Without recognized identities anyone can not transact in this network. The MSP is an authorized body who can provide certificates defining rules to validate member's identity for transaction and scope of their activity across the network. So MSP manages a list of user IDs and has policies which govern how members validate the sign of valid identity at the time of transaction. MSP also specifies the permissions like read-only or full access(read-write) on a channel. A Hyperledger Fabric network can have multiple MSPs and organizations can choose which MSPs to use.

5.2.11 Policies :: When a Hyperledger Fabric's network configuration has been set up some rules and regulations are agreed by the formed consortium of the network. These rules and regulations are called Policies. For example: channel creation Policies, endorsement policies, MSP policies etc. Policies are mostly mentioned in the Channel configuration, but sometimes in chaincode too. Policies are not fixed once it is written down. If all the participating organizations of a consortium want together to make any change over time, they can do that. Policies function is to check whether

all the data that will be authorized to be signed meets all the conditions or not. If not returns an error message informing that the signed data did not qualify some aspect of the policy.

6 Proposed Blockchain technology implemented land recording and land registration system's layout:

6.1 Logical 3-layer architecture:

Programmable modular architecture of Hyperledger Fabric intended to develop flexible solutions where customers have the ability to plug-n-play with its components according to their needs. In 2015 Linux foundation initiated Hyperledger Fabric, a less

expensive cross-industry solution of Blockchain and not dependable on mining as well as crypto currency- based typical Blockchain. Another unique powerful feature is that any mainstream programming languages like java, Node.js, Go etc can be used for smart contracts development hosted by the container technology. Hyperledger Fabric can be logically divided into three parts in terms of application and the services they provide:

1. Registration, Identity verification, audit and enrollment of members through Membership Service.
2. Transactions management, distributed ledger, consensus manager, ledger storage and point-to-point protocol through Blockchain Service.
3. Secure container and secure business condition implementation by Chaincode Services.

6.2 Network setting:

Step 1: Design network with its first member Hyperledger Fabric Blockchain is suitable for this scenario because it promotes trust and transparency between all stakeholders in this cryptographically secure network. Hyperledger Fabric allows set up Blockchain network, create organizations and channels, compose policies and chaincode, and then accept members to join the channels in following steps [36] [37] [38]:

- Step 2: Define and Configure the Interface
- Step 3: Set up a Peer Node
- Step 4: Create Hyperledger Fabric Client
- Step 5: Enlist an Admin
- Step 6: Create Channel
- Step 7: Deploy Business protocols as chain code
- Step 8: Enroll other Members and Create a Multi-Membership Channel

Fabric SDKs enable developers to create applications that interact and manage lifecycle of the network. It also provides a simple API to submit transactions to a ledger or query the contents of a ledger with minimal code. The underlying technology does not exposed to the end user for loose coupling and abstraction of a Hyperledger Fabric network.

Fig.7 shows the layout of a network. So end users can interact through mobile, web, tablet or other types of applications and can do following activities:

1. Register
2. Enroll
3. Create/update/ configure channels
4. Join peers to a channel
5. Deploy chaincode on peers node
6. Instantiate / upgrate chaincode on a channel
7. Call chaincode functions to update the ledger
8. Query the ledger
9. Monitor transactional events

6.3 Working procedures:

1. A client (land seller/ buyer) submits the transaction proposal through the Fabric SDK,
2. The transaction initiates when any member of an organization receives or proposes a transaction request using Hyperledger Fabric's client application (SDK).
3. Hyperledger Fabric's client application then sends a transaction proposal to the all organization's peers for endorsement.

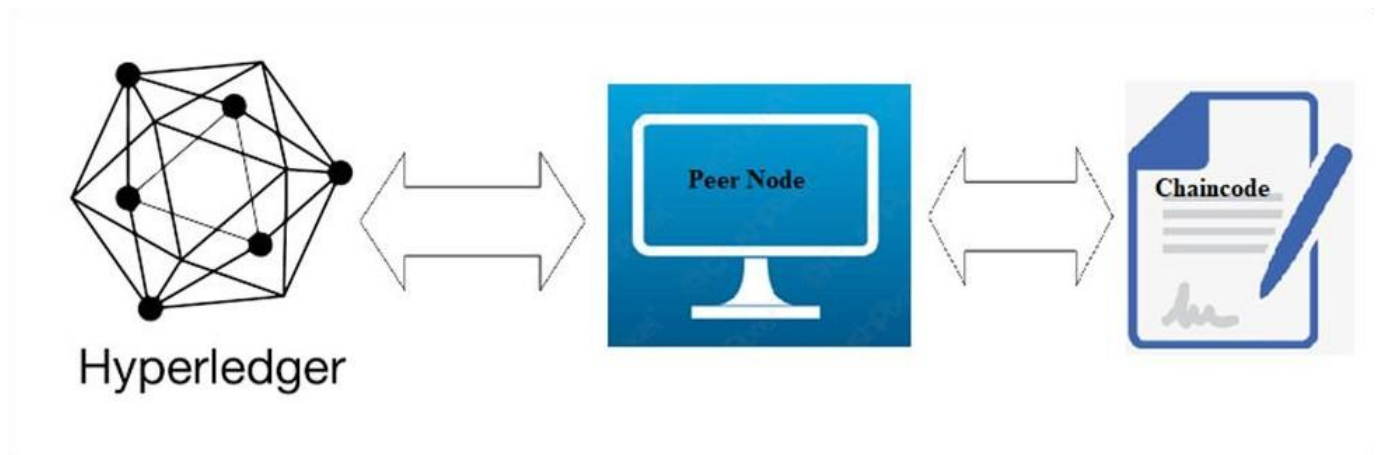


Fig. 5: Chaincode allows access to the ledger of Hyperledger Fabric through peers

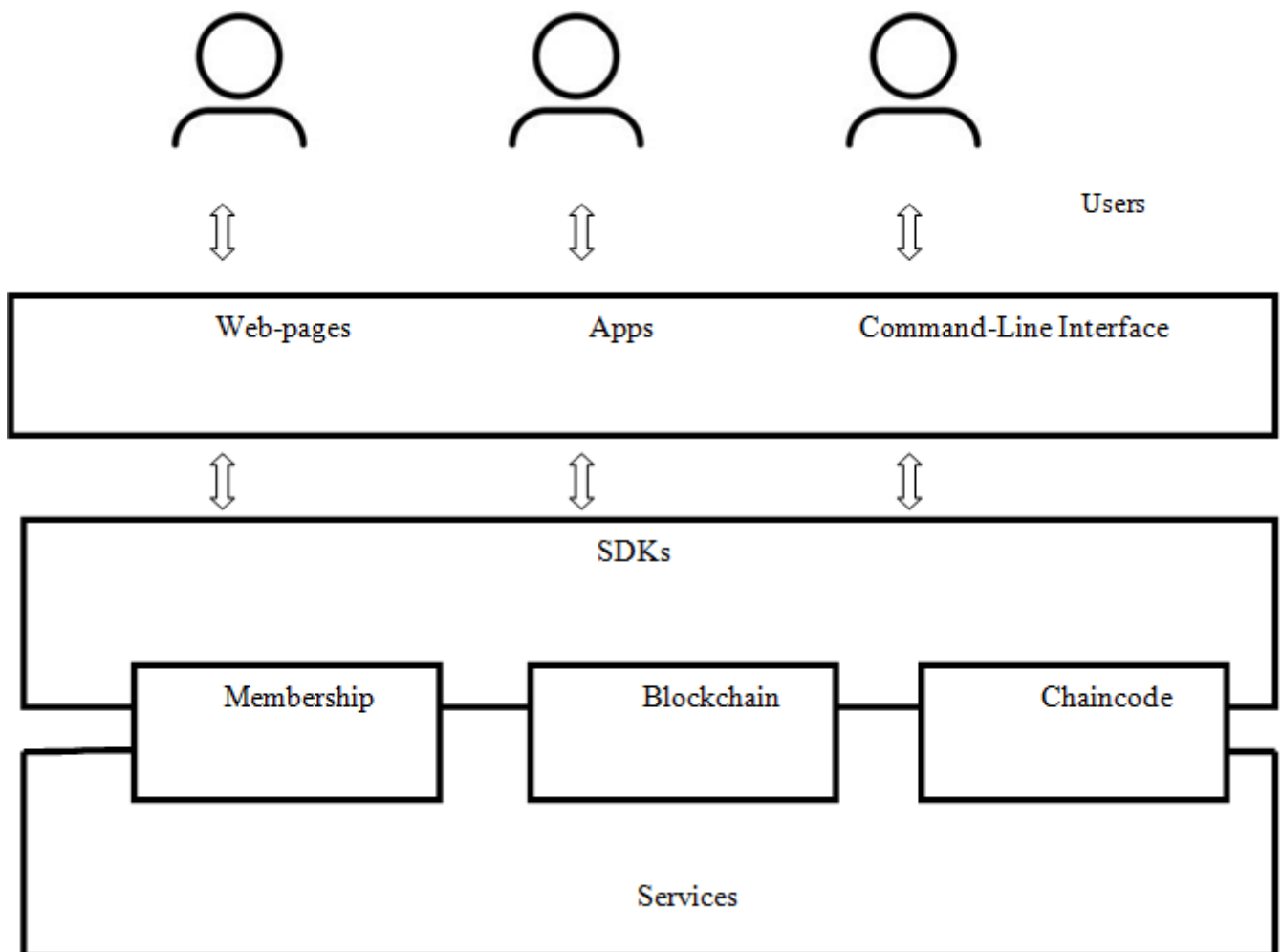


Fig. 6: The logical architecture of the Hyperledger Fabric

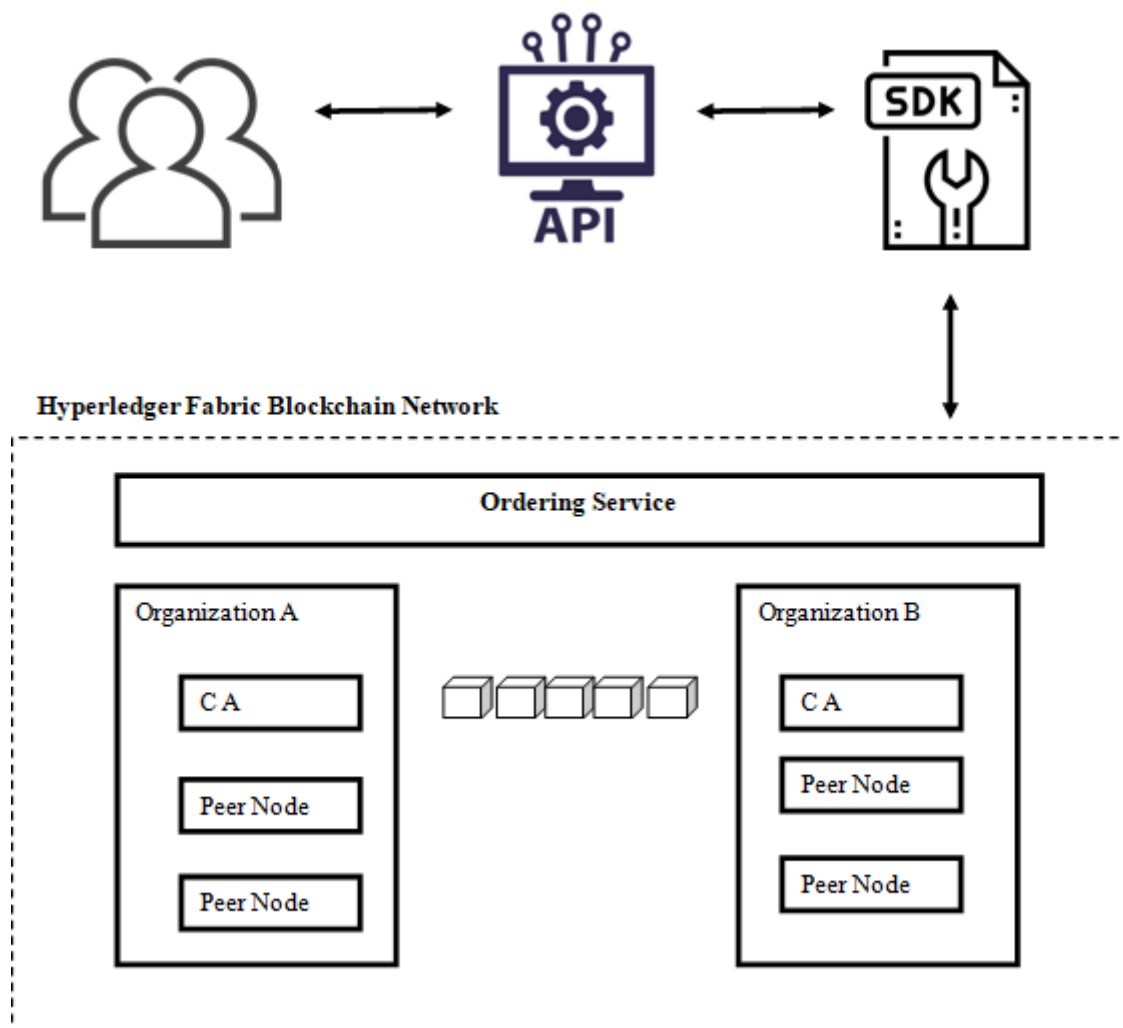


Fig. 7: The layout of a network with two members

4. After receiving transaction requests, peers first verify the client's identity and authorization to execute the chaincode. Then see what the result of the proposed transaction can be. If it matches the expected result, the peers send back client endorsing outcomes indicating acceptance or refusal of transaction with peers signatures.

5. If the client accumulates proper number of endorsement results from peers according to endorsement policy, it sends the endorsed transaction to the ordering service. The ordering service then sorts those received transactions from different channels sequentially. The ordering-service binds transactions per channel into Blocks including their identity and sends those blocks through gossip messaging protocol to all peer nodes of the network.

6. Final verification and validation has done by the peers after receiving new blocks of transactions from the ordering service. Once that over, the new block is added to the ledger. So transactions of that block are committed and finally the ledger state is revised.

6.4 Impact of Blockchain technology adoption:

Blockchain technology in the Land Registry System is a revolutionary step. It could create changes registry system in the following aspects:

1. Globally accepted trustworthy secured and automated platform.
2. Synchronization and discipline will be maintained among all stakeholders
3. Easy backtracking of land
4. Hassle-free transactions
5. Minimize suffering due to land related illegal activities.
6. Government will be able to make easy policy/decisions
7. Reduce judicial complications and increase Revenue collection of our country.

7 Conclusions:

In this paper, we have discussed the present Indian land registration and land recording system with related issues. Also, we have considered permissioned Blockchain technology which could provide a more scalable, paper-free, robust, secure, transparent, less computational required framework for huge records and unalterable land registration and land recording system over traditional one. In the Indian scenario, Blockchain technology has already been initiated in some states for land management systems, but to create a revolution eliminating all grabbing of land through corruption and land dispute, we need infrastructural changes in the whole country and raise awareness of this technology among people.

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8 References

1. Digital India Land Records Modernization Programme (2023) MIS Department of Land Resources Ministry of Rural Development Government of India, <http://dilrmp.gov.in/>, Accessed.
2. Veeramani K., Jaganathan S., (2020) : Land Registration: Use-case of e-Governance using Blockchain Technology", KSI Transactions on Internet and Information Systems (TIIS), 14 (9), 3693-3711, <https://doi.org/10.3837/tiis.2020.09.007>.
3. Satoshi N., (2008): Bitcoin: A Peer-to-Peer Electronic Cash System (PDF).
4. Hakak S., Khan W. Z., Gilkar G. A., Assiri B., Alazab M., Bhattacharya S., Reddy G. T., (2021) : Recent advances in Blockchain Technology: A survey on Applications and Challenges, International Journal of Ad Hoc and Ubiquitous Computing, 38 (1/2/3), 82 – 100, doi: 10.1504/IJAHUC.2021.119089.
5. Pongnumkul S., Khonnasee C., Lertpattanasak S., Polprasert C., (2020): Proof-of-Concept (PoC) of Land Mortgaging Process in Blockchain-based Land Registration System of Thailand, In The 2nd International Conference on

- Blockchain Technology,(100–104),doi:
<https://doi.org/10.1145/3390566.3391669>.
6. Alam K. M., Rahman J. M. A., Tasnim A., Akther A., (2020) : A Blockchain based Land Title Management System for Bangladesh, Journal of King Saud University- Computer and Information Science, doi:<https://doi.org/10.1016/j.jksuci.2020.10.011>.
7. Thamrin R. M., Harahap E. P., Khoirunisa A., Faturahman A., Zelina K., (2021) : Blockchain-based Land Certificate Management in Indonesia, ADI Journal on Recent Innovation (AJRI), 2(2),doi:<https://doi.org/10.34306/ajri.v2i2.339>.
8. Shuaib M., Daud S. M., Khan W. Z., Alam S., (2020) : Blockchain-based framework for secure and reliable land registry system, TELKOMNIKA Telecommunication, Computing, Electronics and Control, 18 (5),2560-2571, doi:10.12928/TELKOMNIKA.v18i5.15787.
9. Ministry of Electronics and Information Technology National Informatics Centre(2023), Centre of Excellence in Blockchain Technology-LandRecord, <https://blockchain.gov.in/landrecords.html>, Accessed May, 2023.
10. The registrationact, 1908, <https://legislative.gov.in/actsofparliamentfromtheyear/registration-act-1908>, Accessed May, 2023.
11. Directorate of Registration and Stamp Revenue,West Bengal(2023), [https://wbregistration.gov.in/\(S\(0bvrvoxhx s3zlngf4fywgay\)\)/index.aspx](https://wbregistration.gov.in/(S(0bvrvoxhx s3zlngf4fywgay))/index.aspx), Accessed May, 2023.
12. Natarajan H., Krause S. K., Gradstein H. L., (2017): Distributed ledger technology (DLT) and blockchain, FinTech note, 1,
13. Khalid M. I., Iqbal J., Alturki A., Hussain S., Alabrah A., Ullah S. S., (2022): Blockchain- Based Land Registration System: A Conceptual Framework, Applied Bionics and Biomechanics, (21), 3859629, doi:<https://doi.org/10.1155/2022/3859629>.
14. Hasan H. R., Salah K.,(2018) Blockchain-based solution for proof of delivery of physical assets, International Conference on Blockchain. Springer, 139–152.
15. Yadav A. S., Kushwaha D. S., (2021): Digitization of land record through blockchain-based consensus algorithm, IETE Technical Review, 1– 18.
16. Metha M., Waghulde D., Deshmukh M., (2021): Secure file storage over interplanetary file system (ipfs), Journal of Advances in Shell Programming, 8(1), 25–32.
17. Bennett R., Miller T., Pickering M., Kara A.K., (2021): Hybrid approaches for smart contracts in land administration: Lessons from three blockchain proofs-of-concept, Land, 10(2), 220.
18. Mukne H., Pai P., Raut S., Ambawade D. , (2019): Land record management using hyperledger fabric and ipfs,” in 2019 10th International Conference on Computing, Communication and Networking Technologies (ICCNT). IEEE, 1–8.
19. Singh P., (2020): Role of Blockchain Technology in Digitization of Land Records in Indian Scenario, IOP Cong. Series: Earth and Environmental Science, 614(1):012055, doi:10.1088/1755-1315/614/1/012055.
20. Ali T., Nadeem A. , Alzahrani A., Jan S., (2020): A Transparent and Trusted Property Registration System on Permissioned Blockchain, 2019 International Conference on Advances in the Emerging Computing Technologies (AECT), Al Madinah Al Munawwarah, Saudi Arabia, 1-6, doi: 10.1109/AECT47998.2020.9194222.
21. Blockchain: The India Strategy Towards enabling Ease of Business, Ease of Living, and Ease of Governance.Part1. (2020), https://niti.gov.in/sites/default/files/2020-01/Blockchain_The_India_Strategy_Part_I.pdf, Accessed May, 2023.
22. NASSCOM Avasant India Blockchain Report (2019), <https://avasant.com/report/blockchain-adoption-indian-states/>,Accessed May, 2023.
23. National Institute for Smart Governance Draft National Strategy on Blockchain, <https://www.nisg.org/blockchain>, Accessed May, 2023.
24. Biswas M., Faysal J. A., Ahmed K. A., (2021) : LandChain: A Blockchain Based Secured Land Registration System, 2021 International Conference on Science & Contemporary Technologies (ICSCT), Dhaka, Bangladesh, 1- 6, doi: 10.1109/ICSCT53883.2021.9642505.
25. Ahila S. S., Ganapathy B., Deepanraj A. M., Jaishaanth S., (2020) : Blockchain Based Land Document Digitization and Secured Storage, International Journal of Future Generation Communication and Networking,13(1),1136-1149.
26. National Strategy on Blockchain. Government of India Ministry of Electronics and Information Technology (MeitY), (2021) <https://negd.gov.in>, Accessed May, 2023.
27. Sarmah S. S., (2018) : Understanding Blockchain Technology, Computer Science and Engineering, 8(2), 23-29, doi:10.5923/j.computer.20180802.02.2018
28. What is Hyperledger Fabric?, <https://www.ibm.com/in-en/topics/hyperledger>, Accessed May, 2023.
29. Property registration system using Hyperledger Fabric,<https://github.com/v4u2chat/property-registration>, Accessed May, 2023.
30. Ali S. , Hassan A.N. A., Ali A., Salman J., (2020) : A Transparent and Trusted Property Registration System on Permissioned Blockchain, Conference: 2019 International Conference on Advances in the Emerging Computing Technologies (AECT)At: Madinah, Saudi Arabia, doi:10.1109/AECT47998.2020.9194222.
31. Behind the Architecture of Hyperledger Fabric,<https://www.ibm.com/blogs/research/2018/02/architecture-hyperledger-fabric/>, Accessed May, 2023.
32. Zhou, E., Sun, H., Pi, B., Sun, J., Yamashita, K., Nomura, Y. (2019). LedgerData Refiner: A Powerful Ledger Data Query Platform for Hyperledger Fabric. 2019 Sixth International Conference on Internet of Things: Systems, Management and Security (IOTSMS). doi:10.1109/iotsms48152.2019.8939212. Corpus ID: 209140648.
33. Ledger,<https://hyperledger-fabric.readthedocs.io/en/release-2.5/ledger/ledger.html>, Accessed May, 2023.
34. Key concepts of Hyperledger Fabric, https://hyperledger-fabric.readthedocs.io/en/latest/key_concepts.html, Accessed May, 2023.
35. Hyperledger Fabric Certificate Authority(CA), <https://www.google.com/amp/s/blog.knoldus.com/hyperledger-fabric-certificate-authority/amp/>, . Accessed May, 2023
36. What Is Amazon Managed Blockchain?, <https://docs.aws.amazon.com/managed-blockchain/latest/hyperledger-fabric-dev/what-is-managed-blockchain.html>, Accessed May, 2023.
37. Get started creating a Hyperledger fabric Blockchain network using Amazon Managed Blockchain, <https://docs.aws.amazon.com/managed-blockchain/latest/hyperledger-fabric-dev/managed-blockchain-get-started-tutorial.html>, Accessed May, 2023.
38. Build and deploy an application for Hyperledger Fabric on Amazon Managed Blockchain, <https://aws.amazon.com/blogs/database/build-and-deploy-an-application-for-hyperledger-fabric-on-amazon-managed-blockchain/>, Accessed May, 2023.
39. What is Hyperledger Fabric, <https://aws.amazon.com/blockchain/what-is-hyperledger-fabric/>, Accessed May, 2023.