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Insights on Blockchain Frameworks For Decentralized Application Deployment

Sanjay H A
Department of Information and Engineering
Nitte Meenakshi Institute of Technology
Bengaluru, India
Sanjay.ha@nmit.ac.in

Tulasi Srinivas
Department of Information and Engineering
Nitte Meenakshi Institute of Technology
Bengaluru, India
Tulasi.s@nmit.ac.in

Madhu N
Teligenz Tech. Solutions
Bangalore, India
madhun.mailbox@gmail.com

Sarang Parikh
Round Finance
Varanasi, India
sarangparikh22@gmail.com

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***Abstract* — Blockchain, the digital ownership revolution technology brings together cryptography, peer-to-peer networks, and digital time stamp. It is referred to as blocks that contain digital information stored in a public database. The database is a shared and irreversible archive with no central authority. Hence it can be termed as a transparent technology that distributes the system among all its participants equally and every participant of the system is accountable for its happenings. With limited Blockchain knowledge, end users find it difficult in choosing an appropriate Blockchain framework for deploying their applications. In this paper, we discuss in detail the different frameworks available for the adoption of Blockchain. This work will provide complete insight into various blockchain frameworks based on important parameters like Deployment, Smart Contract, Type of Consensus Algorithm, Privacy, Crypto coin, Anonymity, etc.**

Keywords — Blockchain, Consensus, Hyperledger, Smart Contract, Solidity

I. INTRODUCTION

Blockchain technology was introduced with the invention of bitcoin, which enabled bilateral financial transactions. This technology helps to track the ongoing records and to plan the future business model by stalking past actions and performance of the business. With this ability, the technology which was used only for virtual currency has now spread to different domains like Healthcare, Intelligent transportation systems, business operations, smart property, Government, Science, and Education, etc. [1]

Since the 1980's the use of e-cash or digital currency has been an area of focus for several researchers and business organizations. The invention of Bitcoin in the year 2009, engraved a new milestone in this journey of cryptocurrency which triggered the concept of blockchain technology. Blockchain is a decentralized shared ledger that serves as a monolithic fact/truth for the consortium participants from the organizations. The key features like Decentralized Technology, Immutability, cryptographically secure, Peer-Peer Distributed Ledger, Consensus, and Faster Settlement made Blockchain Technology powerful and popular.

The following are the building blocks of the blockchain that ensures systematic operation and usage.

- Node — Participant
- Transaction — An atomic event that forms the smallest building block of a blockchain system. In other words, blockchain is a database and transaction is a record in the database.
- Block — Data structure used for storing a single or set of transactions that are distributed to all nodes in the network. To simplify it's like a page in a distributed ledger.
- Chain — A sequence of blocks in an orderly
- Miners — Specified users who extract transaction data for verification and validation of blocks
- Consensus— Protocol to carry out operations in blockchain manner similar to linked lists.

The blockchain revolution is broken down into four categories:

- Blockchain 1.0: Generation of cryptocurrency deployment and digital payment systems
- Blockchain 2.0: Generation of Smart contracts, Smart property, Mortgages
- Blockchain 3.0: Generation of Applications in the area of government, health, science, literacy,etc.

Blockchain X: This is a future interpretation of the public blockchain service made available to be used in a similar context as that of the best search engine used in the present day.

This Paper gives a complete insight into various Blockchain Platforms, Deployment Models, Smart Contract, Consensus Algorithms, and Comparison of various Blockchain Platforms. Also, this paper will provide information about various Tools/SDKs for the development of Decentralized Applications on the Blockchain Platform.

II. EASE OF USE

A. Deployment Models

A deployment model provides platform, configuration, and services for applications to build and run seamlessly in a distributed architecture.

All blockchain structures fall into three categories and these are used based on the requirement and use cases of the organization(s):

1. Public Blockchain / Permission-less Ledgers- In this model, data and access to the system are available to anyone willing to participate in the decision-making process. All the users maintain a copy of the ledger on the local nodes and use the consensus mechanism to decide the subsequent state of the ledger. e.g. Bitcoin, Ethereum, Litecoin, etc. [3].

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2. Private Blockchain / Permissioned Ledgers - In this model, operations are controlled by a group of individuals from a specific organization or authorized users who have permission to operate and share the ledger among themselves. Eg: Hyperledger, Ripple, etc.
3. Consortium blockchain- This model is also referred to as semi-private blockchain, controlled by a group of individuals belonging to multiple like-minded organizations. It is more efficient than public blockchain with the privacy and security measures equivalent to a private blockchain. Eg: R3 and Consensus

TABLE I. COMPARISON BETWEEN BLOCKCHAIN TYPES [5]

	Public Blockchain	**Private Blockchain**	**Consortium blockchain**
Permission	Permissionless	Permission	Permission
Read Access	Any participant	Invited participants	Any / Invited participants
Write Access	Any participant	Authenticated participants	Authenticated participants
Ownership	None	Single Organization	Multiple Organizations
Anonymity	Preserved	Not preserved	Not preserved
Decentralization	Complete	Partial	Partial
Transaction speed	Slow	Fast	Fast
Consensus determination	All Miners	Authorized miner of the organization	Consortium Miners of the organizations

B. *Smart Contracts*

A smart contract is a tenacious, self-verifying, and tamper-proof software program representing an agreement that is self-executable when precise conditions are satisfied. It is written in a language that a computer or target machine can understand. A smart contract is not a part of Blockchain, it works as an add-on making it a very desirable and powerful feature. It is embedded as business logic that binds agreements between parties.

All enforced rules and conditions in the smart contract are executed as specified and anticipated, in the immediacy of governing bodies like banks, government, etc. In case of the permissionless ledger, smart contracts are open i.e. it is accessible to any participants for both read and write. Contemplating the current legal situations, smart contracts can be acceptable if the code is written is understandable by humans as well as machines.

The primary goals of the smart contract are:

- Satisfy the rules and conditions of the contract
- Reduce malicious and accidental exceptions
- Reduce the use of trusted third party
- Simplifies the decision-making process

To satisfy the mentioned goals, smart contract possesses the following four properties:

- Self-Executable
- Enforceable
- Semantically sound
- Tamper proof and tenacious

From the above properties, it is observed that the first and second properties are mandatory and need to be implemented. Whereas the third and fourth properties are optional or can be implemented based on some scenarios.

1) *Oracles:*

In general, although smart contracts can be applied for any business logic, it has a downside when we consider access to external data. Consider an example of accessing data from an IoT device or financial organization required by the contract, oracles act as an interface between smart contracts and the external data. Oracles can fetch or deliver different types of data based on the requirement for the smart contract agreed by the parties.

Oracles are of two categories (i) Centralized Oracle (ii) Decentralized Oracle.

Some types of oracle that are commonly used are:

- Software oracles
- Hardware oracles
- Inbound oracles
- Outbound oracles
- Consensus-based oracles

2) *Smart Contract Languages*

Blockchain operations are parallelizable, it becomes important that the programming language for coding the smart contract should be versatile. Here is the brief difference between various languages used in coding smart contracts.

TABLE II. SMART CONTRACT LANGUAGES

Languages	**Platform**
Solidity	***Ethereum, Monax, Hyperledger-Burrow***
Solidity is an object-oriented programming language developed to implement smart contracts to work on various platforms, most notably Ethereum. It's a computationally universal programming language. The code gets compiled to bytecode.	
Plutus	***Cardano***
Plutus is a Haskell-like, strictly typed purely functional programming language used for defining smart contracts in Cardano.	
Golang	***Hyperledger***
Golang is a robust language, used for programming blockchain applications, across large-scale network servers and big distributed systems.	
JAVAScript	***Hyperledger, Ethereum***
JavaScript is a lightweight, dynamic, and object-oriented programming language. It is perfectly suitable for blockchain operations to handle asynchronous actions.	
Type	***Etherium***
Vyper is a successor of Serpent (which is obsolete). Vyper is logically equivalent to Solidity but syntactically equivalent to Python.	
LLL (Low-level Lisp-like Language)	***Etherium***
LLL is a low-level language analogous to assembly language. It's just a tiny wrapper over coding in Ethereum Virtual Machine(EVM).	
Simplicity	***Etherium***
Simplicity is functional language based on combinatory logic designed for cryptocurrency used in various blockchain applications	

Bitcoin Script	***Bitcoin***
Transaction processing needs scripts to run and complete / commit the transaction. A stack-based scripting language called Bitcoin script is used in the Bitcoin protocol. Scripts are resource-efficient as it requires less processing power. The Script programming language does not possess programming constructs such as loops and it is not a computationally universal programming language.	
Michelson	***Tezos***
Michelson has been introduced by including several characteristics from many language families. It is a stack-based language having a strict static type, high-level data types, and primitives which is domain -specific. Smart contracts in Tezos blockchain uses Michelson	
Sophia	***Æternity***
Sophia is a language containing constructs like structures explicitly built to cater to the needs of the smart contract used in Æternity and it is based on OCaml. Æternity emphasizes real-world connections in the Internet of Things which works based on a combination of proof-of-work with proof-of-stake.	
Rust	***Libra, Bitfury Exonum, NEAR***
Rust is a robust, lightweight language that can be executed on embedded devices that require performance-critical services. Rust is flexible and can be integrated with other languages.	

C. Consensus

On a Blockchain network, all peers confine to a single version of truth provided by a distributed computing concept known as the Consensus [3]. The consensus mechanism is broadly classified as

1. Proof-based (leader-based, Nakamoto consensus) - In which a final value is proposed by an elected leader.
2. Byzantine fault tolerance-based - a traditional approach based on a series of voting systems. [2]

TABLE III. TYPES OF CONSENSUS PROTOCOL

Consensus Protocols	**Description**	**Used in**	**Type of Consensus Mechanism**
Proof of Work	Acceptance by the network is done by providing a recommendation value based on the proof which verifies the adequate number of computational resources available.	Bitcoin	Proof-based
Proof of Stake	Users are provided with sufficient impartial opportunity to mine the transaction blocks based on the stake they hold which results in minimizing the attempts for malicious attacks and improves the performance.	Ethereum	Proof-based
Delegated Proof of Stake	Using the method of voting each node delegates the approval of the transaction to other nodes holding the stake in the system.	Bitshares	Proof-based
Proof of Elapsed Time	It chooses a guaranteed wait time to elect a leader by adopting a trusted, secure and random execution environment.	Hyperledger Sawtooth Lake	Proof-based
Deposit-based	Every node that participates has to provide a security deposit to propose a block before the start of a transaction in the network.	Casper (Ethereum)	Proof-based
Proof of importance	A level of trust and importance will be established by the user by keeping track of the course and usage of the tokens. Users are given an opportunity based on the current stake held by them.	Nemcoin	Proof-based
Federated / federated Byzantine	Transactions thatare approved by the majority of trusted peer nodes that are part of the same cluster are propagated in the network.	Stellar consensus protocol	Byzantine based
Reputation -based	Over a period, every node Builds a reputation in the network and a leader is chosen based on its reputation.	GoChain	Leader based
Practical Byzantine Fault Tolerant algorithm	It implements the concept to protect against Byzantine faults that are adopted by modern blockchain platforms.	HyperLedger Fabric	Byzantine based

D. Blockchain Frameworks

The development, deployment, and support of all the complex products are being simplified by a software bundle by frameworks. Framework usually includes only the keycomponents; all the meticulous components must be implemented by the developer based on them. In this section, we discuss the various popular frameworks in practice.

1) Bitcoin

An electronic payment system was developed by Satoshi Nakamoto in 2008. It was purely based on mathematical proof. Traditionally, if X wants to transfer money to Y, X will raise a transfer request to the bank. The bank verifies and authenticates X and it also checks the balance in the account. If the transferable amount is less than the bank balance amount, it transfers the amount to Y. Similarly, in the bitcoin scenario if X wants to transfer money to Y:

1. The transfer request (intention) is published to the nodes in the network.
2. The nodes scan the entire network to validate that A is an authenticated user, A has the bitcoin coin to be sent and A hasn't sent that to someone else.

3. Creates a block with details like blockid, Previous blockid, Transaction hash, Number of transactions, etc.
4. A newly created block is added to the nodes Blockchain.

A Bitcoin wallet doesn't have any bitcoin. Instead, it holds X's bitcoin address, which keeps a record of all the previous transactions. This is the public key of X, it's a string of 34 alphanumeric characters. Every public is paired with a private key of 64 alphanumeric characters. Though the two keys are related, it is impossible to decipher private keys from the public key.

2) Ethereum

Vitalik Buterin, a programmer from Toronto dreamed of a new platform Ehereum based on the principle of blockchain technology. Ethereum is an open-source platform used to create a decentralized application (dAPP) using smart contracts. The platform not only supports digital transactions but also property details, sharing details, or anything else that has value in it that can be sent or received. Its native cryptocurrency is known as Ether Token. Though the structure of the ethereum blockchain is analogous to bitcoin its functionality slightly differs.

In ethereum, the node stores two kinds of information 1) All the ether transactions, 2) the current state of each smart contract. Its network keeps track of the current information of all the connected dAPPs, which includes the balance of each user, all the smart contract codes, and where it is stored. Unlike bitcoin, Ethereum provides user accounts that display the Ether tokens that appear in X's wallet.

3) Hyperledger

The Hyperledger Project was announced in December 2015 by the Linux Foundation as an open-source framework for examining, building, experimenting, and collaborating on the development of distributed ledger systems. The overall project is primarily 2 sections: 1) Modular Frameworks - consist of the major building blocks and platforms for building a variety of distributed ledgers and their components. 2) Modular Tools - a diverse set of tools that can manage metrics and work in conjunction with the larger frameworks.

4) Litecoin

Litecoin is publicly released computerized money which permits about zero-cost installments everywhere throughout the world. It was made by a Google worker, Charlie Lee. It’s completely decentralized and guarantees that all exchanges are not limited to a solitary server and are accessible to everybody.

It works by shared associations. It exiles the need for a mediator and wipes out the value-based expenses. Contrasted with Bitcoin, its exchanges take less time, and are more secure.

5) Stellar

Jed McCaleb and Joyce Kim started the Stellar project. It is a non-proprietary, decentralized payment protocol that allows transborder transactions between any pair of digital currencies. Its native currency is called lumen (XLM). It is mainly used for tracking ownership.

6) Ripple

This crypto business was started by Jed McCaleb. Ripple is both a stage and money. The Ripple stage is an open-source agreement that is deliberated to authorize rapid and tolerable exchanges. Its native currency is XRP.

Anyone can utilize the stage to make their blockchain applications utilizing RippleNet. RippleNet is a system of institutional installment suppliers. For example, financial organizations can utilize Ripple to give a frictionless encounter to send cash universally. If A needs to send cash to B say $1,000. Rather than sending the cash around, A will purchase a measure of XRP that is worth $1,000 and send this to B's institutional Ripple wallet. B will change over this to the cash they work in and the exchange is settled within minutes.

7) Quorum

Quorum is an Ethereum based Distributed Ledger Technology (DLT). The goal behind this is to give a permissioned execution of Ethereum which underpins the exchanges and the contract protection. The difference between the two is that quorum has these additional properties:

1. Network and companion authorizations the board - it is a permissioned framework that implies that the Quorum is not available to all. Hence the trade happens between members who are pre-endorsed by an assigned expert.
2. Enhanced exchange and contract security - Quorum presents the idea of open and private exchanges. The open exchanges are like Ethereum however with regards to the private exchange the information isn't presented to general society.
3. Voting-based accord components - It depends on casting a ballot agreement system also called as QuorumChain. It delegates casting ballot rights to other people using a shrewd contract. It also tracks the status of casting a ballot hub.
4. Better execution - According to the advancement group, the framework can without much of a stretch to get the job done more than 100 exchanges for every second which are higher than Bitcoin and Ethereum.

8) Verge

Verge is a decentralized digital asset that aims at providing completely anonymous and instant transactions by preserving the privacy of the user. It is built over the services like Tor - Enables anonymous communication and Invisible Internet Project (I2P) - making it difficult to access the geolocation of the user. This makes the verge transactions virtually untraceable.s

This user-controlled and third-party independent platform is being enhanced further using RootStock (RSK) - to include 2-pay ped design and Turing complete technology and the Ring Confidential transactions. It's the only cryptocurrency on the market combining all the above-mentioned features.

9) Zcash

Zcash is digital money that offers exchange protection. Here the security is guaranteed as close to home and exchange information is kept private through zero-learning

proofs. This enables exchanges to be confirmed with no data about the sender, collector, and the sum executed. The exchanges on Zcash are auditable and guideline consistent. The private location that includes protected exchanges is known as the z- address. The different location that permits straightforward exchanges is known as the t- address. There are 4 essential kinds of exchange on Zcash. 1) from a z-address to a z-address (private exchange). 2 from a z-address (de-shielding) implies the sender's data is kept private while the recipient's data is open on the blockchain. 3) from a t-address to a z-address, the sender's data is open, yet the beneficiary's data is private. 4) open exchange where both the sender and beneficiary are t- addresses.

10) Dash

Evan Duffield ran over Bitcoin in 2010 and was inspired by its innovation. He used Bitcoin's code and fabricated his own digital money, Dash. It is a Self-Governing and Self-Funding Protocol. But due to lack of security, it is now obsolete.

11) Monero

Monero is a vague, non-proprietary digital asset that focuses mainly on the user's privacy and anonymity. In Monero, mining is unbiased and is done on individual moneros or by joining mining pools where the participants get a bonus for their activities. As the mining is not application-specific it can be performed on a standard device using Windows, macOS, Linux, Android, and FreeBSD OS. Monero provides security to the exchanges by using ring signatures just like verge and one-time-use address called stealth address for each transaction. Monero is somewhat similar to the barter system as it provides a fungibility feature. which means that two units of a currency can be mutually substituted and there is no difference between the two.

TABLE IV. COMPARISON OF BLOCKCHAIN FRAMEWORKS

Frameworks	Deployment	Smart Contract	Consensus Algorithm	Centralized	Privacy (private transactions)	Crypto coin	Anonymity
Bitcoin	Public	Yes	PoW	No	Yes	BTC	Theoretically Yes
Ethereum	Public	Yes	PoW	No	Yes	ETHER	Theoretically Yes
Hyperledger Fabric	Private / consortium	Yes	Configurable	No	Yes	No Native Crypto-currency	Yes
Hyperledger Sawtooth	Private	Yes	PoET / PBFT / RAFT	No	Yes	No Native Crypto-currency	Permissioned
Corda	Private	Yes	PoS	No	Yes	No Native Crypto-currency	Permissioned
Litecoin	Public	No	PoW	No	Yes	LTC	Theoretically Yes
Ripple	Public	No	Probabilistic Voting	No	Yes	XRP	Theoretically Yes
Stellar	Public	Yes	Federated Byzantine agreement system	No	In Transit	XLM	Theoretically Yes
Quorum	Private	Yes	Consensys is not achieved (PBFT)	No	Yes	JPM	Yes
Verge	Private / Public	Yes	PoW	Partial	Yes	XVG	Yes
Zcash	private	Yes(Solidity)	PoW	Partial	Yes	ZEC	Yes
Dash	private	In Transit	PoW	No	Yes	DASH	Yes
Monero	private	Yes(Solidity)	PoW using Crypto Night	No	Yes	XMR	Yes

III. APPLICATIONS OF BLOCKCHAIN

Decentralized Applications (DApps) since the advent of Blockchain technology has been applied in the area of finance. In recent years blockchain-based applications are increasing linearly. Blockchain is applied in various areas such as Education, Finance, Governance, Healthcare, Industry, the Internet of Things(IoT), Supply chain management, e-voting, Privacy, and Security.

Christopher Ehmke et.al. [9], A Lightweight and Scalable Blockchain Protocol explained how one can use Ethereum to keep the state of the system clear in the present block and further include the ongoing system state in new transactions enabling all participants to validate incoming transactions. It further explains how the transactions can be validated without having access to the whole system state, thus enabling users to participate in the network without having to download the blockchain beforehand. Subramanian, H et.al [10], Decentralized blockchain-based electronic marketplaces, In his work proposes a decentralized marketplace, buyers and sellers transact directly, without manipulation by intermediary platforms using blockchain. SyncFab has developed a Smart Manufacturing Blockchain that provides an advanced effort to decentralize manufacturing via a public, peer-to-peer ecosystem, powered by the MFG Utility Token [11]. Schulz, T., Schafer, B et.al [12], Legal challenges for the use of blockchain-based E-voting systems in Germany, demonstrates the e-voting system. This work provided an insight into how blockchain technology can be applied in one of the processes of the governance of a country. This work also posed a practical issue in terms to comply with the German law for deployment as a substitution to the standard procedure.

IV. CONCLUSION

This paper has discussed the fundamental building blocks of blockchain and various popular platforms for building DApps. It also provides the comparison between each framework based on the essential properties which need to

be analyzed for adopting appropriate blockchain platforms for the implementation of DApps. It has been observed from our survey that there is an inclination towards the development of applications in private and consortium platforms which enabled new smart contract languages to emerge. This survey provides an essential insight into the Blockchain arena which could help the developers to opt for an effective development tool to solve many real-world problems. It is understandable that even though blockchain appears to be in its prime time, it has a lot of potential lefts

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