CoviChain: A Blockchain based Distributed Framework for Healthcare Cyber-Physical Systems

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***Abstract*—This is a demo abstract based on our previously published article [1]. Some of the significant challenges of central cloud systems and the blockchain include lack of scalability, security risks and higher energy consumption. As a solution, an application with an off-chain Interplanetary File System (IPFS) distributed storage system is presented as CoviChain. The IPFS is used for storing and hashing different data formats of various sizes into immutable links. The links are passed through smart contracts of the Ethereum blockchain to provide a double hash guarantee, along with user access permissions.**

I. Introduction

For collecting data and performing analytics, different application fields are using a variety of technological tools. For example, data is collected from patients through sensors and delivered to the doctors remotely for treatment and diagnosis in the H-CPS [2], [3]. The data gathered are stored in central and cloud systems, but that makes them exposed to various attacks [1]. As the traffic increases, the downtimes and upload times become higher, causing latency. The cloud and central systems belong to public service domains, so they are more vulnerable to attacks and provide less control over resources.

Fig. 1 shows various problems that reside in central, cloud storage, and blockchain systems. In emergency situations, data transmissions should take place at faster speeds without any modifications or privacy breaches. One solution to reduce changes is to transfer data through a blockchain, but they suffer from high fee implementations, consume a lot of energy, and are harder to scale [4]. This paper presents an off-chain solution in a distributed way for higher security with lower cost and energy requirements. Table I compares healthcare statistics storage and security levels for central, cloud, and blockchain to the current proposed CoviChain.

II. CoviChain: IPFS Based Decentralized Storage and Security

CoviChain embeds two technologies, distributed IPFS and decentralized blockchain (see Fig 2). An off-chain IPFS is used for storing large-size data to make it available with or without an Internet connection. The substantial data collected from various devices reside on the edge end-systems. As the source of data can be gathered from any location, IPFS can be used as a tool for retrieving web pages from wherever required with fast speeds and without data getting edited or censored.

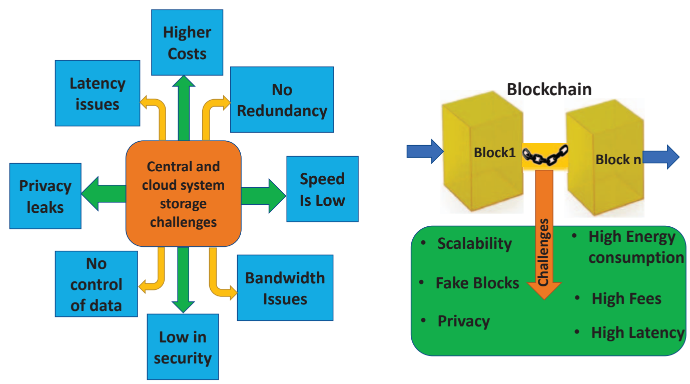

Fig. 1: Challenges in Central Cloud based Blockchain.

TABLE I: Data Storage in Healthcare Cyber-Physical System (H-CPS) [1].

Application	Protocol	Edge	Data Storage	Security	Computation
Aarogyasetu	iBeacon	No	C	High PB	High at CS
Trace Together	BlueTrace	No	PC	Possible PB	High at CS
MedRec	SC	No	Off-chain C	Single Hashing	High at CS
CoviChain [CurrentPaper]	IPFS	Yes	off-chain D	Dual Hashing	Less at CS

C - Centralized PC - Partially Centralized PB - Privacy Breach
CS - Client Side D - Decentralized

The IPFS system generates a hash of the data and converts them into immutable links [1]. The hashes generated for each data file act as unique keys.

The smart contracts feature in Ethereum allows creating access permission rules and the logic for sharing and retrieving data. The contract reads and performs a cryptographic function on the links for storing and transmitting among participants having access. Only those having the authorization to view the data can retrieve the data [5].

III. Implementation of the Proposed CoviChain

We deploy CoviChain near the IoT-edge after data is gathered. The Infura gateway provides a development platform

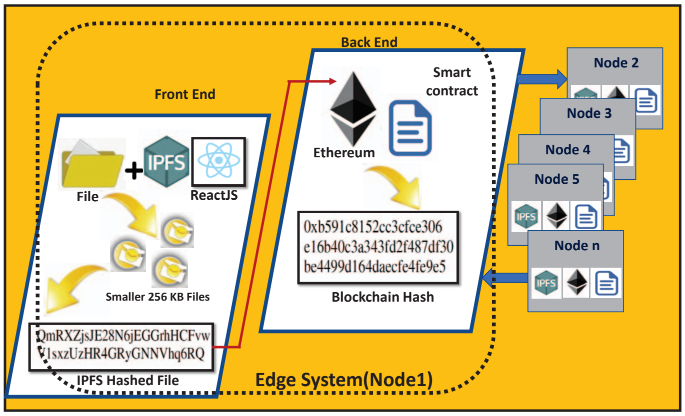

Fig. 2: Proposed CoviChain system with IPFS and Blockchain.

and program interfaces for designing applications of IPFS with blockchain. The IPFS functionality was implemented using React JavaScript programming in the front end [1]. In the first phase, the data was divided into smaller segments of the 256 KB buffer file and converted into a hash link. The system can take in any format and size of data to give a buffer file as output. The hash link coming from the IPFS was sent to the Ethereum wallet to calculate the transaction fees and time. The backend was designed using the solidity programming language for reading and writing the values of the transaction. The blockchain functionality resides at the rear end, which embeds timestamps on the IPFS link transactions.

The verification of the proposed system was performed using the Ropsten blockchain test network. The connection to the testnet was made using the truffle and web3 API's provided by the Infura gateway. The gateway creates a unique key for accessing blockchain explorer to migrate the transactions from the Ethereum wallet. Once the hashed link moves to Ropsten explorer, we have tracked and recorded all transaction details with timestamp and hash. Fig. 3 shows the transaction in blockchain explorer Ropsten [6].

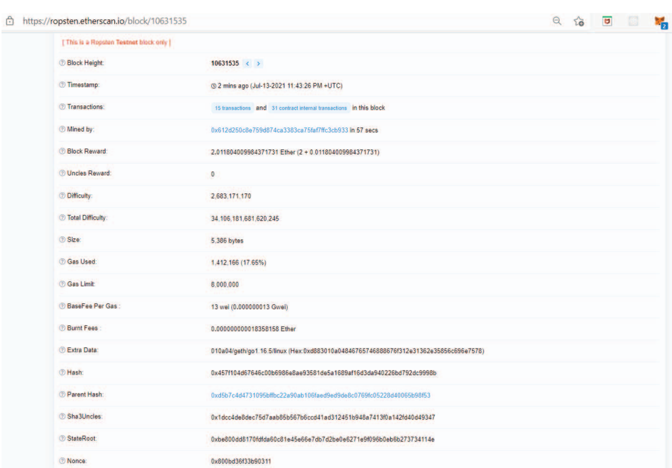

Fig. 3: Validation of CoviChain in Ropsten Explorer.

The hash results obtained from both IPFS and Ethereum blockchain are presented in Table II. The transaction times and cost are noted down for different formats (.csv, .zip, .txt, .jpeg, .png and .gis) and sizes of data. The overall latency is reduced compared to central and cloud storage systems. Security concerns are evaded using a blockchain. In the current paper, the transaction cost, energy consumption, and data validity time issues present in the blockchain are hindered using the IPFS. Table III illustrates the results for reduced mining times and cost inside the blockchain.

TABLE II: Double hash refuge for data file [1].

File	File-Size	IPFS-Hash	BC Hash
.txt	97 KB	QmRTyUIHJthg fhsdjh8gfs6fstR RFdcdfjc8RYT Dh7safgj9hsd	0xb591c8152 cc3cfce306e16b4 0c3a343fd2f487 df30be4499d16 4daecfe4fe9e5
.csv	4.41 MB	QmYUDWJCT UAqJL97kfJ7JZ J9Mjm8FTHLvw NwJJmPS8bKev	0x6aefa11dd5 2d5782ea0c64 8ad66b590efb42 f402451c7b9307 947a4ac308992

TABLE III: Reduced Cost and Time [1].

File	File-Size	Time (ms)	Gas Fees	Cost($)
.txt	97 KB	39	0.00460792eth	8.34
.csv	4.41 MB	77	0.00489103eth	8.85

IV. Conclusions

This paper presents a blockchain with IPFS distributed storage for substantial data. The data is successfully hashed twice for storing and transmitting between authorized users. The proposed system is cost-effective and valuable for sensitive data transmissions. The validity time in the blockchain is decreased, and latency issues of central and cloud systems are evaded through the proposed CoviChain.

References

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