Decentralised Artificial Intelligence Enabled Blockchain Network Model

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Abstract : Blockchain and Artificial intelligence are novel technologies which take prominent place across all industries. AI refers to intelligent tasks that are carried out by machines which in-turn are done by humans in olden days. Blockchain a collection of decentralised networks which revolutionizes and upgrades the business operations. Blockchain creates a decentralised environment that shares data which is in encrypted form between ledgers in a confidential way without the involvement of any third party. Blockchain and Artificial Intelligence has been shaping their paths with a slight overlap of their own. Combined decentralised AI networks enables the businesses to take decisions without the need of centralised control activity. Block chain consists of nodes and it follows distributed ledger technology; Proof of Work (PoW) consensus algorithm used in blockchain makes use of lot of computing power and energy for the miners to get reward. To overcome this difficulty, this paper proposes AI enabled Miner Node Selection Algorithm in Block chain Networks based on PoW consensus algorithm. The paper presents a miner node selection with PoW in blockchain which reduce data storage in blockchain by data pruning technique. By executing this algorithm in blockchain network, unbiased blockchain implementation will be easier. The integration of AI with the implementation of blockchain enhances the efficiency of blockchain network by reducing the computational power, energy and time spent in selection of the node which is evident in our experimental results.

Keywords: Artificial Intelligence, Blockchain, Consensus algorithm, Distributed ledger, Miner

1. Introduction

The convergence of blockchain and artificial intelligence increases machine learning intelligence which leads to creating new products. Blockchain provides data security and enables sensitive data sharing cross organisations. The data transactions are between unrelated participants where data are verified securely without seeing the data by others. Blockchain, a distributed ledger has the ability to provide secured storage among trusted participants. It provides exchange of peer to peer transactions in an efficient way without intermediaries.

Data in blockchains are stored in form of blocks. Transactions once committed by peers cannot be edited. All transactions are validated with the consensus of the nodes in the chain. Each block contains information about previous block which forms a chain. Members in networks request new transactions to be executed where new blocks are created and added to the network which results in continuous growth of blockchains. The mining nodes verifies the transactions on the block and digitally signs the block using consensus algorithm. Blocks once created cannot be altered is the main advantage of blockchains. As nodes are added to networks, the process involves massive energy consumption and computational power.

Blockchain integrates several technologies such as cryptographic hash, digital signature and distributed consensus algorithm to work in a decentralized environment. Smart contracts blockchain can keep track of interactions among nodes in the network without the involvement of any intermediary or third parties. All transactions are committed by peer confirmation blocks and no central agent required to check and verify the node blocks.

Automation through cryptocurrency is carried by Bitcoins which is one of the popular applications of blockchain. One of the crucial steps in blockchain network is that, it has to ensure that there is no double spending (i:e) cryptocurrencies cannot be spent in multiple transactions at the same time. The consensus algorithm proof-of-work (PoW) helps to prevent double spending problem in bitcoin blockchain. The PoW is carried out by miners in the blockchain network who secures information about past transaction and also detect and prevent double spending. Due to the several benefits that is achieved through PoW consensus algorithm, this paper attempts to select miner node in blockchain network using the proposed Decentralized AI enabled Block chain Network(DAIBCN) , which makes use of PoW consensus algorithm.

Another technology that has gained popularity in recent days is artificial intelligence (AI) which provides the machine with computing power to perform human activities like reasoning, predicting, learning, inferring, based on the data it collects. The massive amount of data generated by web applications, sensors in internet of technology devices, social media have paved way to the growth of AI [14]. As data generated by these are huge, which we call as "Big Data", there is a need for various machine learning and deep learning techniques Schmidhuber J (2015) which are the subset of AI, to perform variety of analytics for businesses. To date, many organizations like IBM, Google, ebay, Apple, employ machine learning and deep learning algorithms of AI to manage huge volume of data and for decision making. These algorithms depend on a centralized model for training and validating datasets, this centralized nature of AI is prone to hacking and manipulating data Nebula AI (2018), also the authenticity of the sources generating the data are not guaranteed Qi Y (2018). This leads to AI decision outcomes that can be highly erroneous, risky and dangerous.

Decentralized AI

Decentralized AI is basically a integration of AI in blockchain Schmidhuber J (2015). It is one of the promising trends in the AI space. Decentralized AI can be achieved by distributing datasets among many servers/nodes securely using homomorphic encryption thereby ensuring the confidentiality of data. Homomorphic encryption allows the execution of specific types of computations to be done in cipher text and provides results which are also encrypted in the ciphertext. This allows nodes involved in blockchain to execute computations without decrypting them. The decentralized AI enables to process data and perform analytics on the digitally signed and secured data that are stored on the blockchain without intermediaries Nebula AI (2018). DAIBCN proposed in this paper helps to identify miner node among the nodes that are decentralized in a blockchain network. It employs PoW consensus algorithm for node selection.

Proof of Work (PoW) Consensus algorithm

There are several consensus algorithms that work under blockchain. PoW is the first and foremost consensus algorithm in blockchain. This algorithm is used to validate and confirm transactions and add new blocks to the chain. Producing a proof of work is a complex process which requires a complex mathematical puzzle to be solved, for which more computing power is required by the nodes. With PoW, Miners in the network compete against each other to complete transactions and get rewarded.

2. Literature Review

The combination of AI and blockchain impact many fields like IoT, supply chains, financial sectors, civil governance, insurance, medicine, education etc. and bring in many benefits Konstantinos Sgantzos(1). Though blockchain has the potential to disrupt many industries, it is still in its infancy stage Tshilidzi Marwala(2015).

Sgantzos et al has given the usage of blockchains in two ways. Firstly, blockchains are used to store the code. Secondly, by encoding Artificial Intelligence enabled algorithm (AIA), on the blockchain, assists the programmer for Conversion of code from one language to another, searching for algorithms that match patterns etc. Using deep learning techniques and big data mining from existing code repositories, this AIA would present a reliable, secure and disruptive technology [1].

B.Xing et al., proposed the feasibility of AI techniques to verify smart contract[3-4]. Gervais et al[6] introduced a novel framework that shows the implications of various consensus and network parameters of PoW blockchains.

Michael Mylrea has focuses on AI enabled blockchain to a naturally occurring weather event, cyber or cyber-physical hybrid attack. Jianwen Chen(2018) present a new energy-saving consensus protocol PoAI (Proof of Artificial Intelligence) to ensure the decentralization and safety of a block chain system.

Szydlo M, has utilized the Merkle tree [9-11] to store transaction information and generate the digital signature of the transaction set. Guilford J D et al [12] proposed the SHA256 algorithm which is employed in the blockchain to compute the hash value.

Khaled Salah et al [13] proposed implementations in terms of decentralized AI operations and consensus protocols. Fran Casinoa et al propose an application-oriented classification of blockchain. The authors highlighted that the blockchain will become not only more scalable and efficient but more durable as well [5]. In our proposed work, we have achieved scalability, efficiency and durability in the implementation of Distributed Artificial Intelligence enabled blockchain network (DAIBCN).

3. Proposed Methodology

This paper proposes Decentralized AI enabled Block chain Network (DAIBCN) model. A blockchain is a distributed, decentralized, immutable ledger used to store encrypted data and Artificial Intelligence enables analytics and decision making from the data collected. Integration of AI into blockchain enhances blockchain's underlying architecture, minimize energy consumption by miners, build robust and secured blockchain network. Block 0 is the first block of a blockchain and is called genesis block. Genesis block does not have reference to a previous block.

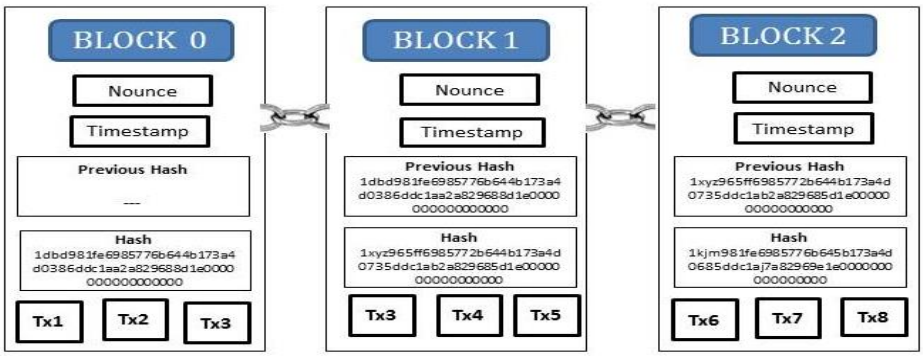

Fig. 1: Structure of a Blockchain

Components in DAIBCN

Table 1 depicts the Components of the Distributed Blockchain enabled blockchain network

Table1: Components of the Distributed Blockchain enabled blockchain network

Node	A computer or a small server system within the blockchain which maintains copy of the distributed ledger
Transaction	Single unit of a record or data that is to be executed
Block	A block is an append only data structure that consists of lists of transactions, on which action to be performed
Block Header	A block header is the unique identity of a particular block on a blockchain
Nounce	Random string of number that is used only once to a hashed block
Chain	A method used to store data in discrete blocks linked together
Miner	Special nodes which validates and executes block of transactions before adding to the chain
Consensus PoWalgorithm	A set of rules on which a nodes in the blockchain network operates
Hash	The output of a cryptographic function that maps inputs to specific, but seemingly arbitrary outputs
Merkletree	A cryptographic hash value for the branch. Here tree's leaves are transactions and the branches are blocks.
Wallet	A Digital wallet that allows users to manage bitcoins
Transaction Fee	The fee charged to users when performing crypto transactions on the network
Rewards	New bitcoins that are awarded by the blockchain network to eligible miners for each block they mine successfully.

Decentralized AI based Blockchain Architecture

The set of processes involved under DAIBCN are illustrated through the following steps and the architecture diagram is shown in figure 2.

1. Decentralised AI blockchain network is designed based on certain network rules
2. Client Nodes are authenticated and added to the blockchain network
3. Newly generated transactions within the blockchain are broadcasted to all nodes
4. Nodes within network validate the authenticity of sender, receiver and the transaction based on validity rules.
5. Miner nodes collect a set of new transactions to form a block
6. DAIMNS algorithm selects the best miner node based on decision trees.
7. Best Miner nodes execute all transactions within a block.
8. Miner node then broadcast the block to all other nodes to update the blckchain
9. Blockchain is pruned using AI to minimize the data storage

The proposed architecture AI enabled to select miner node, thereby cost involved in competing during the mining process in reduced.

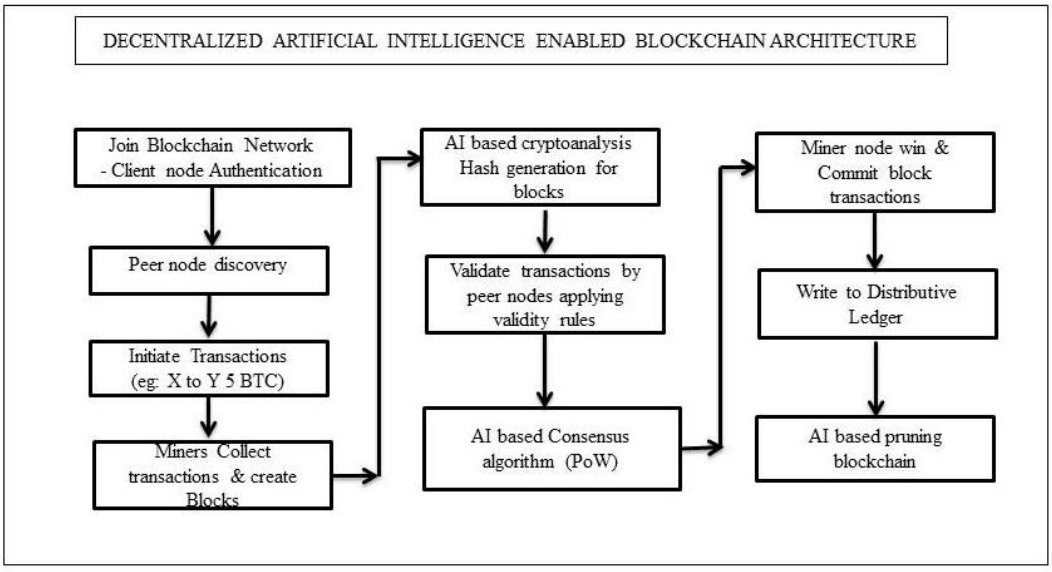

Fig. 2. Decentralized Artificial Intelligence enabled Blockchain architecture

Phases in DAIBCN

The Decentralized AI based Blockchain is categorized into four phases. The phases are:

I. Blockchain Initialization Phase

The blockchain network is designed using valid network rules. The rules regarding valid node, transaction fees, reward points, miner node selection rules, ledger creation process etc are followed. Node creation into a blockchain network involves agreement to the initial level of the network system. The first block which is pre-configured block is an genesis block. After genesis block, every other node in blockchain are added based on protocol designed.

II. Client Node Authentication Phase

The nodes that join the blockchain network are selected by an authentication process. The clients generate a private key and a public key by using RSA algorithm.The private key is the confidential and public key is used as the client identity. The Hex representation of public key is used in virtual currency transactions.

CreateClient(newnode)

1. Create a newnode instance in blockchain
2. Privatekey←RSA.generate(crypt.random.new) // generates a private key for newnode
3. Publickey←private_key.publickey()
4. Signature← PKCS1_v1_5(privatekey) // digital signature protocol
5. Identity←binascii.hexlify (publickey) // Hex representation of newnode

After the Client nodes are formed in blockchain, transactions are initiated in the network. For example if X wants to transfer a BTC of 50 to Y then the following sequence of steps are generated:

Transaction(sourcenode, destnode, value)

1. Initiatetransaction(sourcenode, destnode, value, timestamp)
2. Dicbject← Create dictionary transaction object
3. Sign_transaction←privatekey(Dicobject)
4. Broadcast_transaction(sign_transaction)

The Transaction() function initiates transaction of transferring 50 BTC from X to Y where X is sourcenode and Y is destnode. The transaction is signed using SHA algorithm. The signed transaction is sent to all nodes in the network to check the validity of source node, destination node and transaction. The verified transaction has previous block hash and nounce. The nodes willing to mine collect the transactions into a block and create hash for entire block. The competing miners are selected based on decentralized artificial intelligence blockchain miner node selection algorithm.

III. AI based Miner node Selection Phase

Miner node selection is one of the key aspect of blockchain. This is solved through implementing one of many possible consensus models. Miners win cryptocurrency and/or transaction fees for being carrying out the transactions. All nodes generate transactions. The miner nodes collect N transactions and form a block. Miners collect any transactions as per their choice based on the reward value. New block is formed from previous block hash value. Miners instead of solving a complex puzzle, the proposed AI enabled algorithm choose a miner node based on decision trees.

Table 2: Decentralised AI based Miner node selection criteria

H/W Type	OS Version	Storage Space	R/W Speed	CPU	RAM	Band width	Up speed	Down Speed	Up time	Fastness	Wallet Balance	BackUp	Reward Point	Failed Tr	Trust level
DK	Win	VH	VF	VH	H	H	H	H	FULL	Y	75BTC	GOOD	100BTC	0	5
DK	Unix	VH	F	H	H	VH	VH	H	FULL	Y	25BTC	GOOD	55BTC	1	5
LP	Mac OS	H	M	M	L	L	L	L	HALF	N	5BTC	BETTER	30 BTC	1	5
LP	Win	M	L	L	L	VL	VL	L	HALF	N	2BTC	BETTER	2BTC	2	4
DK	Linux	L	VL	VL	VH	H	L	M	Q	Y	7BTC	POOR	-	-	3

The AI chooses the miner node based on parameters such as H/W type, storage space, R/W speed, CPU speed, RAM size, Bandwidth, dwnspeed, up speed, Up time, fastness, wallet balance, backup strength, reward points, failed

transactions rate, trust level etc. The values of attributes are Very High (VH), High(H), Medium(M), Low(L), Very Low(VL). Up-time isthe amount of time the miner node will be active during a day whether full day, half day etc.

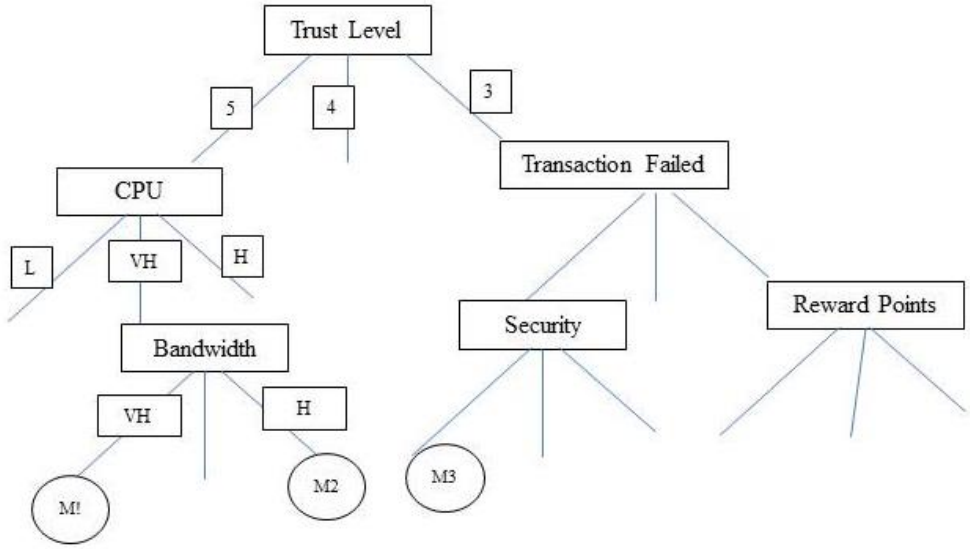

Fig. 3: Partial Decision tree for Miner Node selection

The Fastness specifies how fast the transactions are completed by the miner. Reward point specifies the amount of points won by the miner's nodes each time a block gets executed. Failed transaction denotes how many times the transaction is failed by the miner node. Trust level is the trust value of the miner node. Based on the above parameters the DAIBC algorithm decides which node to be selected as miner node based on decision tree Fig3. Based on the above parameters, the DAIBC algorithm decides on which node is to be selected as miner node using the decision tree in figure3. The decision rules are applied for each competing miner node and competency score is calculated for all miners who wish to mine a specific block using decision tree rules Miner_node_selection() algorithm. A miner with high competency score will win mining process. If competency levels of any two miner nodes are same then a random miner node will be selected for mining. The chosen miner node executes all transactions and new block is added to the network. The idea of proposing decision tree algorithm is to select a minor node automatically without allowing the nodes to compete in the networ

Algorithm: **Miner_node_selection(Blocknumber, T[], M1)decision rules:**

```
If (Trust level=5 and Reward point>100BTC and Failed transaction<2 and
CPU speed=Very High and bandwidth=High …) then
        Competency_score= 5.0
Else if (Trust level=5 and Reward point>100BTC and Failed transaction>2
and CPU speed= Very High and bandwidth=High … )then
        Competency_score= 4.9
Else if (Trust level=5 and Reward point>100BTC and Failed transaction>2
and CPU speed= High and bandwidth=High …) then
        Competency_score= 4.8
Else if ……

return (Competancy_score)
```

IV Pruning Phase

As more and more blocks are added to the chain, it becomes too long to keep all blocks in memory. Hash functions are applied to combine two or more hash blocks called Hash Root. Once Hash Root is created then old transactions are removed from the local storage.After certain threshold limit say 1024 blocks, all data to historical transactions are deleted. A pruned block usually takes 90GB instead of 1.4TB of actual archival node. The transactions are selected based on their significance. Transactions which will not affect future transactions are removed from network and archived.

PruneBlocks(B1)

1. T[]←Select the set of insignificant transactions from blockchain to be removed
2. H←Hash(f(T1),f(T2),f(T3)……)
3. P←Prune(H[])
4. Send pruned blockchain P to network to update by all nodes

4. Experimental Analysis

The DAIBC blockchain network is implemented in Python.The DAIBC blockchain network is implemented in Python.The genesis block is created using Client class, Transaction Class and Block Class. For cryptoanalysis, SHA algorithm in python libraries is used. The proposed DAIBC algorithm not only helps in energy saving, it automatically selects the miner node and also tries to reduce the load of the blockchain network by pruning some of the unwanted data in blockchain network. Figure 4 shows the genesis block generation.

```
Number of blocks in the chain: 1
block # 0
sender: Genesis
-----
recipient:
30819f300d06092a864886f70d010101050003818d0030818902818100f4642d39
1c14e937c5cc0dadbb578233a17b70ac177f5b99eaa86545ca0d4ff43a237675ce
3bac36f816aadce280870a172f3bc74b9efc6c38a788c5a3e49cbf48438500412d
50aa58ae29196f4da2e62975cbeec1516a84ca86d79f35cc375153803599a71836
bc61fab25e7fea700bcd3bf5ab3af4315479e5fec7515803af0203010001
-----
value: 500.0
-----
time: 2020-04-20 08:38:52.199854
-----
```

Fig. 4. Creation of Genesis block

The efficiency of proposed model using artificial intelligence is represented in terms of energy consumption, time taken to execute transactions, memory consumption and time taken to mine blocks etc.

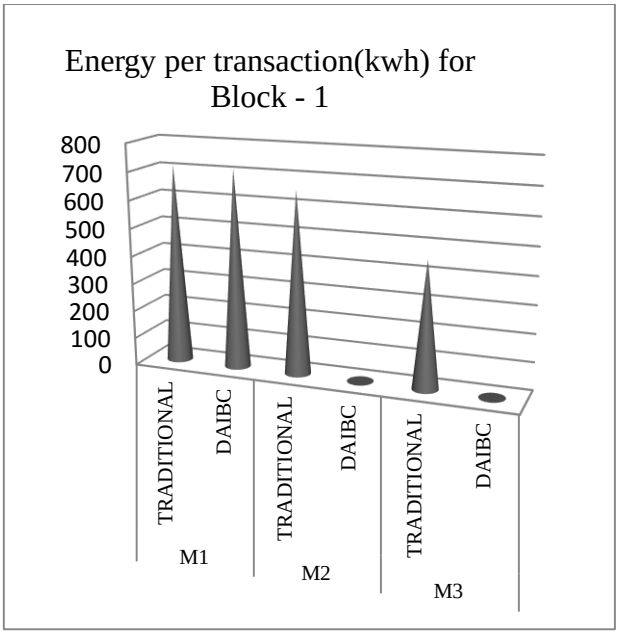

Fig. 5: Energy Consumption

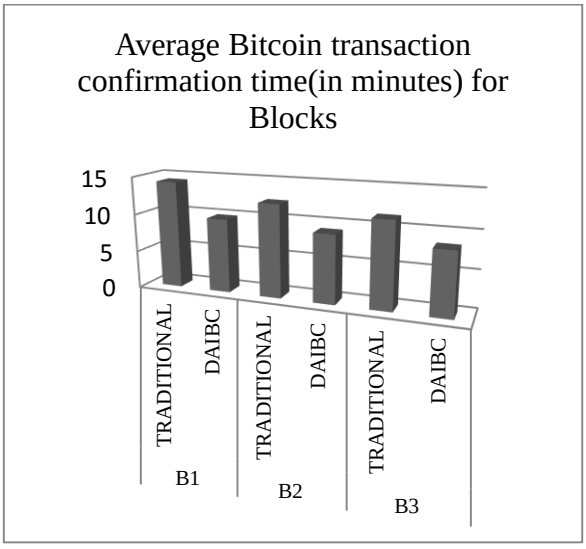

Fig. 6: Commit time for transaction

The energy consumed by a transaction for a block is shown in figure 5. Using the traditional methods M1, M2, M3 miners compete and try to solve the mathematical puzzle which consumes a lot of energy. DAIBC selects the miner node as M1 based on AI. Selected node M1 will execute the set of transactions while M2 and M3 will not participate in the mining process. Hence a lot of energy is saved. As miners execute the transactions based on AI selection, network traffic reduces and average timetakenfor transaction confirmation is decreased sufficiently. In traditional methods blocks B1, B2 and B3 are mined by all miners M1,M2, and M3. But in DAIBC method B1 is mined by M1, B2 is mined by M2 and B3 is mined by B3. Hence lot of network traffic is reduced and transactions are executed in 7-8 minutes.

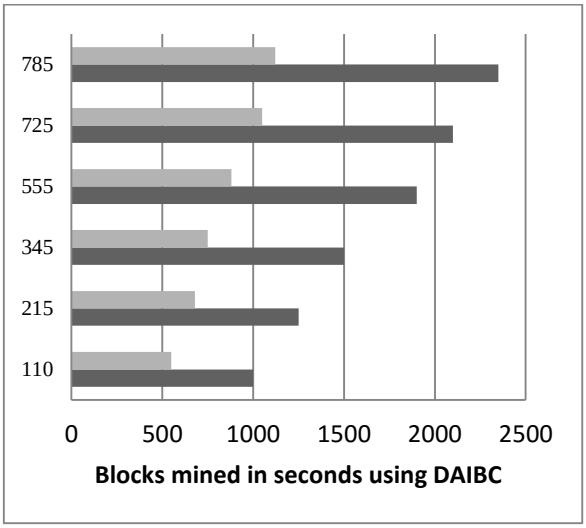

Fig. 7: Blocks mined in seconds

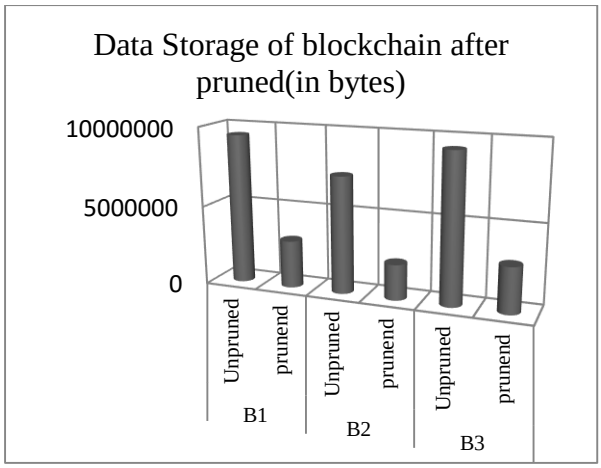

Fig. 8: Data storage in DAIBCN

From figure 7 it is evident that blocks are mined very fast because the set of transactions collected by miners are confirmed by the proposed DAIBC algorithm within seconds and transactions are executed in seconds.

```
Number of blocks in the chain: 1
block # 0
sender: Genesis
-----
recipient:
30819f300d06092a864886f70d010101050003818d0030818902818100f4642d391c14e937c5cc0dadbb5
78233a17b70ac177f5b99eaa86545ca0d4ff43a237675ce3bac36f816aadce280870a172f3bc74b9efc6c
38a788c5a3e49cbf48438500412d50aa58ae29196f4da2e62975cbeec1516a84ca86d79f35cc375153803
599a71836bc61fab25e7fea700bcd3bf5ab3af4315479e5fec7515803af0203010001
-----
value: 500.0
-----
time: 2020-04-20 08:38:52.199854
-----
--------------
====================================
Number of blocks in the chain: 4
block # 0
sender: Genesis
-----
recipient:
30819f300d06092a864886f70d010101050003818d0030818902818100f4642d391c14e937c5cc0dadbb5
78233a17b70ac177f5b99eaa86545ca0d4ff43a237675ce3bac36f816aadce280870a172f3bc74b9efc6c
38a788c5a3e49cbf48438500412d50aa58ae29196f4da2e62975cbeec1516a84ca86d79f35cc375153803
599a71836bc61fab25e7fea700bcd3bf5ab3af4315479e5fec7515803af0203010001
-----
value: 500.0
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time: 2020-04-20 08:38:52.199854
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--------------
====================================
block # 1
sender:
30819f300d06092a864886f70d010101050003818d0030818902818100bc280d4a724ccf5b365840915d5
d0dc03edc99239071eaa7fafde11bdd66384e0fe3687aaceb33c686a1e89efe552fd25cb323d7eed60544
3a8843557623a50df138e940fbea53a0c9d5b38abc66fb3681b6f5147b04c1915b8597a1066611173b139
```

Fig. 9: AI enabled blockchain with 4 blocks

The memory required to store blockchain network is pruned as shown in figure 8. The hashes of blocks are hashed to store limited header data instead of entire block chain network. The AI enabled blockchain network is shown in figure 9.

Advantages of the Proposed System

- Security:By employing homomorphic encryption in decentralized AI, Security is enhanced
- Scalability:Provides scalability by employing ML algorithms, AI helps in increasing data to a greater extent

- Optimization: Optimized Energy Consumption
- Automatic Governance: No intermediaries or third parties
- Efficiency:Efficiency is achieved by predicting the utility of a node before mining

5. Conclusion

In this paper, the intersection of two trending technologies AI and Blockchain is employed for the implementation of Decentralized Artificial Intelligence enabled Blockchain network (DAIBCN). The proposed DAIBC algorithm automatically selects miner nodes by means of adopting decision tree model. The need for calculating complicated hash function by the miner nodes in order to qualify themselves to get reward is reduced. The experimental results shows that there is considerable amount of saving in energy and also the commit time for the transaction is also reduced as the selection of the node is done automatically by means of the proposed AI enabled algorithm. In order to facilitate better storage in blockchain network and to reduce the chain length, data pruning is done in the blocks. As a result of this pruning process, the number of blocks mined in seconds increases and also data storage in blocks is also enhanced. This study clearly shows that Artificial Intelligence enabled blockchain network bring in several benefits like reducing the energy consumption by the node, reduced time and saving in storage, thus making the blockchain network a more efficient one.

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