Game Theory and Deep Learning for Predicting Demand for Future Resources within Blockchain-Networks

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***Abstract*— The global Blockchain networks are growing and demand for resources is also growing respectively. The systems are switching from traditional systems to advanced systems where there is a seamless connectivity with 6G communication channels and security of data due to decentralized nature of Blockchain environment. The resources play integral part in Blockchain networks such as computational resources, data storage resources, bandwidth, sensors and energy generation power resources. The forecasting of futuristic demand of resources is important for the smooth functioning of Blockchain networks. The advanced technologies like 6G networks and machine learning techniques, Internet of Things (IoT), Digital Twins, Cyber Physical systems and AI enabled tools are playing an important role in reshaping the Blockchain networks. This research work is utilizing deep learning and game theory to map the resource requirement and to evaluate the Blockchain systems to find the potential demand for resources for smooth functioning of Blockchain enabled systems. The sampling data has been collected from Blockchain nodes and parameter based migration methods are devised to improve the predictions of deep learning models. The resource needs of the software based Blockchain networks can be predicted where the future load can be predicted on Blockchain enabled networks. The trained model based on deep learning neural networks achieves multi-layer conversion combinations through nonlinear modules to make accurate predictions in Blockchain based systems for resource requirement. This article uses the migration theory, combined with the advantages of deep neural networks to produce accurate predictions. The forecasting prediction accuracy of the required futuristic resources on raw variables is attained at 85.87%. The proposed model helps to determine the futuristic need of the resources for smooth functioning of Blockchain systems as many applications nowadays are dependent upon the Blockchain environment due to decentralized and secured nature of Blockchain networks.**

Index Terms— **Resource management; Blockchain, Deep Learning (DL); Game theory; Demand for resources**.

I. INTRODUCTION

The global Blockchain systems are responsible for the smooth execution of many applications across the globe where multiple nations are involved in utilizing the Blockchain networks and computational resources. As the Blockchain based applications are highly relying upon secured and advanced technologies, it is difficult for the nations to continue with the conventional methods of global businesses without switching to newer technologies which promise for safe and secured environment for exchange of data and execution of applications [1]. The focus of applications is shifting to Blockchain enabled environments where third party intervention is not required for any communications and users can enjoy privacy along with secured transactions. The other computational techniques such as soft computing methods, deep learning methods and machine intelligence based smart solutions are embraced by all the global applications to welcome the advanced technologies for flourishing the global businesses worldwide [2]. With the advancements in technologies, Blockchain has captured a remarkable growth in the current era [4]. The adoption of Blockchain technology has given rise to secured data exchange and many applications in the field of global trading, financial transactions, supply chain management, cloud resource management and healthcare data management worldwide. The advancements in technologies such as 6G communications, digital twins and deep learning have created opportunities for prediction of demand for resources in the Blockchain networks, to explore the opportunities and to analyse the futuristic resource needs for Blockchain systems [5]. E-commerce and online trading are going hand in hand for consumers to provide them new experiences for trading and global businesses and Blockchain technology is certainly providing new opportunities to the business players across the globe [6]. In the open era of globalization and integrated openness, the lenient policies of business across the globe are giving rise to software based advanced Blockchain systems and Blockchain systems can work well if the resources are allocated to Blockchain dependent applications on time without putting the applications in a waiting queue for a longer [7]. The advanced technologies ate playing a great role in witnessing the growth of global applications with the aid of Blockchain technology in 21st century beyond the boundaries of imagination. The Blokchain technology allows the nodes from distributed environment to participate in various processes related to diverse applications where decentralized environment is required along with the secured exchange of data [8]. The technologies like 6G communication allow seamless connectivity to the users with the internet and technologies like machine learning, artificial intelligence and evolutionary techniques allow the users to

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utilize the resources optimally for the execution of applications in s secured Blockchain environment [9]. Nowadays, it is indispensable to utilize the advantage of advanced technologies to develop the online Blockchain systems that are utilizing the distributed environment for the exchange of data and to provide a secured access to the consumers to complete various applications such as supply chain management, logistics management, trading management and protection of intellectual property [10]. The advanced methods along with Blockchain have the potential to transform the conventional ways of managing various applications in a more organized and secured manner [11]. The usage of Blockchain based networks is growing by enhancing the privacy of users, and by enhancing the international opportunities for handling supply chain management, resource management, logistic management, healthcare management and finance management [12].

The prediction of the requirements for the resources in Blockchain networks need the usage of advanced technologies such as game theory and deep learning as presented in this article [13]. By analysing the historical data on resource utilization, and network metrics, the resource usage patterns can be determined and futuristic resource demand can be ascertained. The advanced technologies are working cohesively with the Blockchain networks to change the current scenarios of resource management and adapting the accurate forecasting models which can predict the resource requirements in advance since computational and energy consumption resources should be utilized wisely and optimally for the smooth functioning of Blockchain networks [14]. However, Blockchain technology has emerged as a secured technology where the consumers can utilize this technology for any kind of applications where decentralized environment is preferable without the intervention of third party in a secured manner [15]. The predictive models can learn from the historic pattern regarding the futuristic demand for the resources. By integrating predictive models into Blockchain enabled infrastructure, the resource providers can optimally utilize their resources and can also help in preserving the green environment by preserving the energy. The workloads can be predicted in advance and eventually the resources can be predicted in advance. The allocation of computational resources, data storage resources, bandwidth and virtual resources can be made optimally [16]. This can ensure the optimal performance of the Blockchain networks; it can also ensure the optimal utilization of resources and scalability of the Blockchain networks.

This era is witnessing the adoption of advanced technologies like deep learning, 6G networks, mobile computing and Blockchain for handling diverse applications across the globe [17, 18]. The resources are the key instruments for the success of the Blockchain networks and optimal utilization can enhance the user satisfaction by minimizing resource utilization cost, by minimizing the energy consumption and by preserving the green environment [19]. This article is utilizing the distributed environment based on Blockchain nodes, game theory along with deep neural networks for forecasting the future demand for the resources. This can allow the successful execution of applications in a Blockchain environment because resources are needed for all kind of applications whether the applications are compute intensive or data intensive. In our problem statement, MATLAB software has been used to identify and process the training sample according to the depth network algorithm. The mapping relationships are determined between the sample feature dataset and the sample tag dataset matrix with explicitly defined input and output values. The Blockchain environment is affected by risks such as scarcity of resources; shortage of network bandwidth if 6G is not available, Govt policies, cloud operations, basic resources and environmental protection, and these risks can be based on their characteristics and attributes to be corresponding risk indicators, and various resource targets. These demands are the input values to the model, that is, the sample feature dataset X, and the overall resource demand is divided into five indicative levels, corresponding to 5 label categories. The win-win theory based Blockchain system can be defined as a problem with the problem of mapping $X \rightarrow Y$. This requires reasonable attention to the applications which are dependent upon the Blockchain networks to analyse the factors that impact the resource demand and resource supply for successful execution of the applications. The resources are not available in abundance, especially computational resources are expensive to exploit [19, 20]. The optimal usage is only possible when the resource demand is ascertained in advance [21, 22]. That's why it is imperative to predict the resource demand in advance and deep learning models are smart enough to predict the demand in advance accurately but they are computational expensive. This research study is exploiting the strength of deep learning with game theory to prepare the predictive model that exploits the resources optimally by knowing the futuristic demand in advance. Objectives of the research study are mentioned below.

a. To make use of innovative methods to analyse the futuristic demand for the resources such as computational resources, data storage resources, bandwidth and network resources in a Blockchain environment.
b. To determine the characteristics of unseen requirements and evaluation of risks in for matching demand and supply of resources.
c. To determine the factors affecting the demand for resources in a Blockchain environment and role of game theory, deep learning and Blockchain technology for optimal utilization of resources.
d. To design a system in such a way that can forecast the resource requirement if the trading between demand and supply is made through Blockchain devised technology.

The next section elaborates the existing methods for analysing resource requirement in advance and also determines the issues to be addressed for optimal allocation of resources to the applications executed in Blockchain environment across international borders and diverse resources are involved from different geographical locations.

II. LITERATURE SURVEY

The literature survey is a must for analysing the flaws of the existing resource predicting systems and to find the

opportunities in global Blockchain systems by utilizing the advanced technologies like 6G, deep learning, AI, machine intelligence and game theory [2-5]. These technologies cannot be applied without analysing their pros and cons on the basis of existing literature. The solutions projected by the predictive models are reliable if the data and population size is large enough to draw the futuristic predictions. The historical data also plays an important role in designing futuristic models for forecasting the demand for resources. These technologies are also analysed for ascertaining their time and computational complexity [7]. The models presented in [8] based on neural networks can make 94% accurate predictions about the resources global markets, can depict the resource usage trends and in prediction of unseen risks in the global scenarios. The feedforward neural networks as a new branch of artificial neural network (ANN) family are capable enough to deal with the disadvantages of the conventional ANN, where the concealed layers can be increased without minding the threshold limit of hidden layers [8]. The neural networks can work well on the huge data generated by the Blockchain nodes for training and learning and then the learning can be reinforced to predict the outcomes of the unseen data [9]. The research presented in [9] can forecast the need for data storage resources in advance. The research presented in [10] uses the fusion of data collected from different Blockchain nodes based on 5G/6G communications and it represents information in a more cohesive manner for inferring the outcomes of data for better informed decisions [10]. This research is analysing the demand for computational resources. The research is concluded with the remarks that the technical advancements can enhance the optimal allocation of resources by knowing the demand of resources in advance.

The exchange of resources is common in advanced technologies such as Fog computing, cloud computing, Digital twins, and Blockchain environments and prediction of resources is imperative to use the resources in an optimal way to minimise the resource usage cost and to minimise the wastage of computational power and energy [11]. Blockchainis growing rapidly but at the cost of cyber threats and it cannot be denied that with implanting strong security protocols and advanced secured technologies such as Blockchain, the advantage of remote resources can be exploited at the fullest as elaborated by the authors [11]. Nowadays, privacy of users and security of data are mandatory factors for the end consumers and when remote resources are exploited then it is very important to exploit the resources by keeping the user' data safe [12]. The research is going on to integrate multiple technologies for providing secured, fast and reliable solutions to the Blockchain users by allocating the resources on time for execution of their applications and completion of transactions. However many researchers have attempted to address security threats to promote online exchange of resources but Blockchain based decentralised environment is a challenging environment where users join and leave and similarly resources join and leave for their exploitation to share storage and power [13]. In [14], the authors have used machine learning based methods for forecasting the demand for power resources, since many power grids are also exploiting the Blockchain technology and distributed resources for the supply of energy to the end consumers. In [15], the authors have predicted the demand for resources for supply chain systems for the smooth and efficient supply chain management system. In [16], the authors have exploited Blockchain technology for logistic operations and the demand for resources such as computational resources and bandwidth is predicted in advance by using cascaded machine intelligence based algorithms.

There are basically three types of Blockchain technologies used around the world [17]. This allows transactions between two parties except the indulgence of the third party. Blockchain observers are the users who gain only by observing the data of the Blockchain. These observers do not subsidize Blockchain by contributing any data. However, their observations might be logged as transactions in Blockchain technology [17]. Still they are interested in data storage resources for the safer exchange of data between their systems and remote servers. The gap between the demand of resources and availability of resources is determined for optimal allocation of resources. In [18], the authors have made specific analysis on the development of contemporary Blockchain systems, and this is based on the input and output of two aspects, users and providers [19]. The perspective of the acceptance of Blockchain technology for sharing of resources in the international trading system is another advantage of Blockchain and optimal allocation of resources among the international users of Blockchain technology. In order to promote more international competitiveness, the Blockchain technology is growing with innovative concepts by preserving confidentiality, security and user integrity and by exploiting remote resources [20]. The paper presents a prediction model for allocation of resources in Fog environment, particularly for Healthcare applications [23]. Resource allocation involves mapping of resources with the requirement of fog nodes. The article tries to attain management of resources in an effective manner in Fog environment by predicting the resource demand accurately. The algorithm also performs load balancing during allocation of resources. Fog computing utilizes the computational resources for end users and devices [24]. The heterogeneity of devices imposes challenge on allocation of resources in an optimal manner. The article presents a review on resource allocation approaches along with the comparison of the existing techniques with respect to prediction of resource demand and allocation of resources. The article has analysed 108 articles to present a comprehensive review on resource allocation mechanisms based on prediction of required resources by the end users. In [25], the authors have presented an optimal method for resource allocation to avoid deadlock condition in the environment of fog computing. The research outcome focuses on the optimal allocation of resources for avoiding resource starvation among the consumers of Fog resources and preventing the deadlock conditions by predicting the resource demand in advance.

In order to forecast all types of resources such as computational, storage, bandwidth and power resources, we are proposing deep neural networks with the integration of game theory. The existing approaches are focusing on different types of resources but we are considering all resources for predicting their futuristic requirements in the Blockchain environment

accurately for minimizing the resource usage cost, for maximizing the resource utilization. In our proposed approach, we are emphasizing on the usage of game theory and deep neural networks for relying upon the international Blockchain systems. The traditional classic game theory has an important premise assumption that "all players must be a fully rational". We have also integrated deep learning based prediction model to analyse the risks for predicting the demand for resources in advance. The Blockchain nodes are exploited to gather the data for experimental study. The historical data is collected to devise the predictive models based on deep learning and game theory. The next section is highlighting the utilization of game theory in our problem statement.

III. GAME THEORY IN MULTILATERAL SYSTEMS

This paper first of all quantifies the role of computer network technology for Winmetry games, so that the game theory can be applied for predicting the resource demand in a Blockchain environment [18]. Then a network structure selection is performed for designing the multilateral winning Blockchain model based on deep learning technique. Then a mapping of relationship among the participating variables is made for analyzing the demand for resources using Winmetry game theory. A topological structure of deep learning network is devised to make the classification of resources which will be required in suture. Then factors influencing the resource demand are analysed and discussed and their empirical analysis is also presented. Finally the results are evaluated and viability of the proposed work is proved.

a. Set the criteria

Each Blockchain consumer is willing to exile hardware resources, and sometimes the Blockchain users have to exchange information with other computers/users [20]. If they can be exchanged directly, it is known as interconnection communications. When a person or a group of computers need to share information or some computer hardware resources (such as disk, printers, tape drives, communication processors), then some kind of media software are required, which facilitates information and service sharing. In order to discuss and develop computer networks, the Blockchain users are divided into two types of subnets, namely resource subnets, and communication subnets [21]. Communication subnet is responsible for information transmission, communication processor, terminal controller, and switches in the network. It is a category of communication subnets. Resource subnets are responsible for information processing, which is put into networks to use resources for users, such as host systems and terminals. The temporary failure of individual components or computers must maintain the continued operation of the system by replacing resources. However, in a computer network, each resource (especially procedures and data) can be stored in multiple locations, and the user can access a resource in the network through a variety of ways, thereby avoiding the application systems. Single-machine processing power is limited, and due to various reasons (such as difference in time zones), the level of synchronization between the computers is uneven. Theoretically multiple computers can be connected through parallel processing and the entire load can be balanced with the aid of parallel processing scheduling mechanisms. Figure 1 is representing Blockchain enabled architecture where all the resources are also highlighted which participates in Blockchain environment for fulfilling the needs of consumers to execute their respective applications.

b. Mulilateral trading between resource demand and supply using game theory

The hierarchical structure used in multilateral demand and supply of resources comprises two levels. The first level is responsible for maintaining the coordination and cohesiveness between the users and providers who are ready to participate in Blockchain systems; the next level allows the synchronization among the resource consumers and providers in Blockchain enabled networks [21]. This level is responsible for processing of multilateral trading for rational decision makers who are interested in exploitation of resources and sharing the resources.

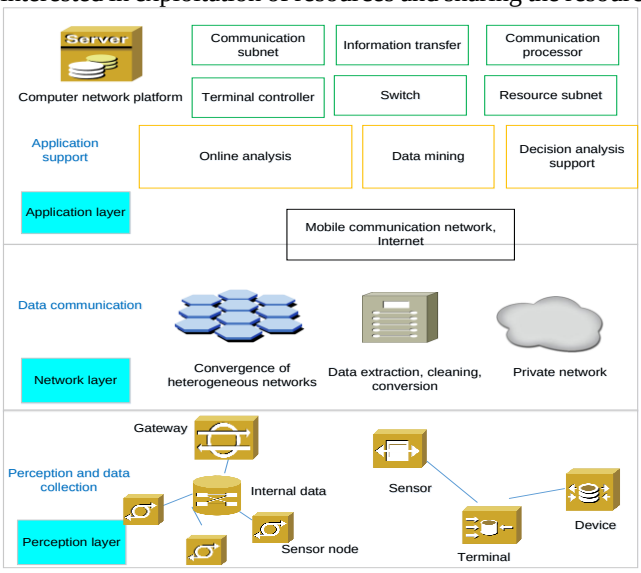

Fig. 1. Layers of resources exploited in Blockchain network

Game theory in this Blockchain based systems unveils a special feature where the bottom level layer is responsible for exchanging the resources between the resource consumers and resource providers of Blockchain based systems for showing advantage over the existing conventional Blockchain system [22]. The consensus mechanisms in Blockchain environment involve participation of decision makers to validate Blockchain transactions. Game theory model analyse the interactions among nodes for assisting to optimize the efficient resource usage and resource allocation [23]. The participants in a Blockchain system make strategic considerations regarding the requirement of the resources. Game theory is applied to synthesize resource allocation strategies for optimal utilization of resources, such as miners can choose which transactions should include a block or miners should pay transaction fees. Understanding these strategic interactions, the game theory can design a model that aids in predicting the patterns in resource demand from users. Game theory model also helps in identifying the threats to resource allocation such as Sybil attacks and/or resource hoarding [24]. Analysing the threats and risk factors behind resource hoarding allows for the development of countermeasures for efficient resource utilization [25, 26].

The game of all levels in the multilateral Blockchain system is divided into many different trivial stages in practice. Subsequently, it is the stage of conducting substantive negotiations between resource users and providers, and each player puts forward the self-interests, demand for disintegration, and the requirements of other parties, thereby outlined some options for resource utilization. Participants in Blockchain environment may form coalitions to optimize the utilization of resource. Participants of Blockchain environment such as miners and users act strategically to match the needs for resource demand and supply. Game theory model can analyse the strategic moves involved in resource demand and resource supply, where consumers are seeking services such as data storage or transaction validation, and resource suppliers try to provide these resources to the consumers. Game theory model analyses the coalition strategies, and helps to understand the strategic participation from alliances to address the resource demands and resource supplies.

IV. RESOURCE PREDICTION USING DEEP LEARNING

A. Network Structure Selection: The various models of deep learning are good at extracting the relationship between global data and domestic data from the available dataset. It can automatically extract features from monitoring data, which has better applicability for various information drivers [27]. The DL based model has unique characteristics, which are showing advantage at discovering multifaceted structures in great dimensional Blockchain data related to mapping of resource demand and resource supply. Convolutional neural networks make use of implicit layers, and neurons are coordinating with the surrounding unit, which again comprises a convolution layer, a cellular layer, a fully connected layer, along with the output layer for providing the output of resource demand. Figure 2 is displaying weights of each layer.

During data processing, the neurons extract the partial characteristics from the previous layer [28]. After getting the input from previous layer, the convolutional layer performs the feature mapping for resource demand with resource supply. The resultant features are then passed to the pooling layer to further streamline the info obtained from the convolutional layer and to remove the redundant features which are not required further. Mainly the parameters are extracted by the convolutional layers and the fully connected layers are integrated with the convolutional layer to produce an output vector which is supplied as input to the output layer and finally outputs a vector including the input category information by outputting the output layer.

Artificial neural network is essentially a mathematical model, which process the complex data and provide the output in the simplest manner. The model is connected to each other by a large number of nodes (or "neuron", or "unit"), with the processing unit and storage of information can be combined with it. In addition to complex logic operations, nonlinear relationships can also be achieved. In depth study inherits the hierarchical structure of artificial neural network on the network structure, and its basic model can be expressed as given in Eqn. (1):

$$y_k = f\left(\sum_{i=0}^{n-1} x_i \bullet w_{ik} + b_k\right) \qquad (1)$$

In Eqn. (1), xi is a neural unit, w_{ik} is the weight, b_k is biased, reflects the intercept of the gradient drop, and f (.) is the activation function. In several common structures of deep learning, DNN has a strong extraction and training capability and fast convergence to produce the desired output. The characteristics and requirements of the multilateral trade system are grasped by the DNN model for predicting the risks in the trading systems and allow the users to make informed decisions. The overall idea is to construct a multilateral trading system based on deep neural network; collect the data from the Blockchain nodes for training, and to determine the learning labels. The usage of MATLAB software is made to iterate and process the training sample according to the depth network algorithm. DNN basic processes and steps can be represented by Figure 2.

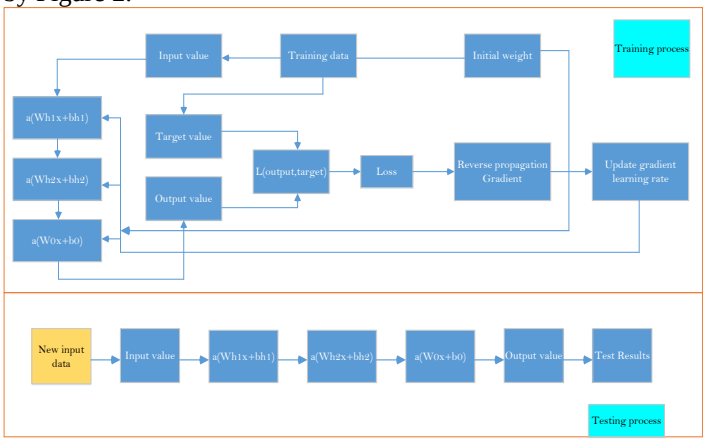

Fig 2. Deep neural network flow chart

As shown in Figure 2, the application of deep learning includes three parts, one is to establish a model and initialize the network; the second is to calculate the network parameters through the training network; the third is to use the well-trained network to test, and test network performance.

B. Mapping of demand and supply of resources

Here, Nash equilibrium has been *utilized* that helps understanding the stable points where the demand for resources and resource supply find a balance or mapping for optimizing the resource allocation. This section mainly defines the input values of the resource demand for Blockchain system with game theory based and DNNs. In DNN, the output value (i.e., the resource demand tag data set) is determined and the mapping of relationship between the input value and the output value is performed.

Sample feature dataset: Sample feature dataset X is the input value of the model. For multilateral trade system a win-win gaming model is useful which mitigate the risk of unavailability of the resources. The win-win model overseas risks of unavailability of resources and these risks can be based on their characteristics and attributes. We expand the sample feature dataset x as the following matrix as shown in Eqn. (2):

D is a number of features of each data, and in the multilateral resource management system to build various risk indicators related to Blockchain based resource requirement.

$$X = \begin{bmatrix} x_1^1 & x_1^2 & \cdots & x_1^D \\ x_2^1 & x_2^2 & \cdots & x_2^D \\ x_L^1 & x_L^2 & \cdots & x_L^D \\ \vdots & \vdots & \cdots & \vdots \\ x_{L+U-2}^1 & x_{L+U-2}^2 & \cdots & x_{L+U-2}^D \\ \vdots & \vdots & \cdots & \vdots \\ x_{L+U}^1 & x_{L+U}^2 & \cdots & x_{L+D}^D \end{bmatrix} \quad (2)$$

For the number of labelling data, the model is impeded to be labelled for international Blockchain system's target resource providers and miners, which are the training samples. U is the number of non-label data, the model is impeded into an unmarked resource management scenario, that is, test samples. Each of the data with D feature can be seen as a vector in the space RD, namely the line in X.

Demand label dataset: The design Y is the output value of the model with the sample demand tag corresponding to the sample resource dataset. It can be expressed as in matrix Eqn. (3):

$$Y = \begin{bmatrix} y_1^1 & y_1^2 & \cdots & y_1^C \\ y_2^1 & y_2^2 & \cdots & y_2^C \\ \vdots & \vdots & \ddots & \vdots \\ y_L^1 & y_L^2 & \cdots & y_L^C \end{bmatrix} \quad (3)$$

Here C represents the tag categories. The mapping of X → Y should be determined with the help of game theory's win-win model. The features are large in dimensions and due to high complexity, it is required that we use deep learning model which is capable enough to simplify the complex problem into the simpler one. The mapping relationship can be very complicated due to high dimensionality of data. Normally, machine intelligence methods can solve the complex problems easily and deep learning methods can solve more complex problems with higher accuracy. The Blockchain nodes generate data in a large volume which cannot be processed by the normal deterministic methods other than deep neural networks. This model can easily predict the resource requirements.

C. Formation of DNN structure

The feature-set generated from Blockchain nodes is fed to the resource demand prediction model that shows the resource demand indicator data with respect to specific regions, the feedforward calculation ascertain the futuristic needs of the resources for the miners in the Blockchain environment. The extraction of features from the input data is performed, so that the representation of the information can become more abstract and further it can be used to forecast the output. The resource demand prediction requires several characteristics to be considered for the forecasting of the factors impact the resource demand for international Blockchain networks across the countries and only DL methods can provide the effective predictions by working on the huge amount of complex data. In this paper, the input is reduced from the multi-dimension data to a 5D data. Deep network provides feedforward propagation of information by the following equations (Eqn. (4) and Eqn. (5))

$$z^{(l)} = a^{(l-1)} \bullet W^{(l)} - b^{(l)} \quad (4)$$

$$a^{(l)} = f_l\left[z^{(l-1)} \right] \quad (5)$$

D. Reverse transmission of errors

The deep learning network itself has the ability to self-learning characteristics, and if the amount of data is large enough, it can even learn from the labelled data. However, due to the limitations of the data volume of the international cultural trade target country, it is not possible to obtain a good effect using the non-labelled data, so this article is trained by cataloguing data. The objective function is expressed in Eqn. (6):

$$J(W,b) = \sum_{i=0}^{N-1} L\left[f\left(x^{(i)} \middle| W,b\right), y^{(i)} \right] + 0.5\lambda \left\| W \right\|_F^2 \quad (6)$$

Where, W and B exhibit the weight matrices and bias forms of each layer are expressed in Eqn. (7):

$$\left\| W \right\|_F^2 = \sum_{l=0}^{L-1} \sum_{j=0}^{n^l} \sum_{j=0}^{n^1} W_{ij}^l \quad (7)$$

The error is determined with the help of reverse propagation method.

E. Neural activation functions

For enhancing the countenance capability of the neural networks, it is mandatory to make use of an activation function which is nonlinear in nature and can also work with the reverse propagation of the neural network. There are many functions which can be used as activation functions in the neural network. In our problem statement, we are using the Sigmoid function as the activation function. As compared to the other activation functions, the Sigmoid function is more acquainted with the features of biotic neurons and it also exhibits scientific properties for activating the neural network. The gradient will attenuate when the number of layers will be deeper in a neural network. Sometimes, the gradient totally disappears and then it is hard to train the deep learning based model. It is important to keep the gradient alive and to avoid the diffusion of gradient. In our problem statement, we have attempted to escape this gradient disappearing problem by introducing Rectified Linear Unit in the Blockchain enabled trading software system as demonstrated in Eqn. (8):

$$f(x) = \max(0, x) = \begin{cases} x & x \geq 0 \\ 0 & x < 0 \end{cases} \quad (8)$$

V. EXPERIMENTAL RESULTS

A. Factor analysis for Blockchain network

Factor analysis has been applied in our problem statement to understand the underlying parameters influencing demand for resources in Blockchain environment. By identifying the influencing factors, this factor analysis technique helps in uncovering the patterns of resource demand and relationships between the resource supply and resource demand. Identifying a set of influencing variables related to the demand for resources in the Blockchain network is imperative for selecting right variables. These variables or factors include block size, resource consumption, storage space, power consumption, bandwidth consumption, network latency, and other relevant metrics. The historical data on these selected factors is obtained for suture analysis. The data should cover the timeframe to

capture the trends in patterns of resource demand. The computational resources measurement indicator is selected for the scale of global resources. The integration of power resources refers to the development of the Blockchain technology with integrated security which requires relevant science and technology solutions to provide energy generation support to microgrids, especially for dealing with the Blockchain enabled power management systems. The development of information technology has enabled global resources to provide a new way of providing the resources to the miners with the ability to obtain information about the availability of the resources in a timely manner. The storage resources are also needed for most of the user applications and it is counted as evaluation parameter for efficiency of Blockchain networks. The Internet usage of any nation is the evaluation index of Blockchain technology applications, and the number of computers owned by urban residents also contributes to the success of Blockchain networks. We have ensured that the data covers a significant timeframe to capture various conditions and trends in ascertaining the resource demand. In order to identify the most important factors or variables for factor analysis to ascertain demand for resources in Blockchain requires access to historical data and analysis on this data. Network latency is the first factor (X1), network throughput is the second factor (X2), computational resources consumed (X3) during the execution of the smart contracts and applications, Blockchain scalability (X4), bandwidth (X5), interoperability (X6), energy consumption (X7), transaction volume (X8), cryptographic complexity factor for security (X9), and cost of resource consumption (X10) are the factors affecting the factor analysis for predicting demand for resources in a Blockchain environment.

B. Testing the feasibility of factor analysis method

Any metering analysis method then requires pre-research methods after determining the effectiveness of the research method. That is, the three original variables selected in this paper for factor analysis are mentioned in the previous paragraph. These factors are chosen for analysis, and the collection of these parameters/factors will certainly affect the trends in prediction of resource demand. There is always a strong correlation among the participating variables that allows the investigation to be executed. We have utilized SPSS 18.0 to regulate the original data which is gathered for the purpose of factor analysis, and an attempt is made to determine correlation coefficient between factors/indicators.

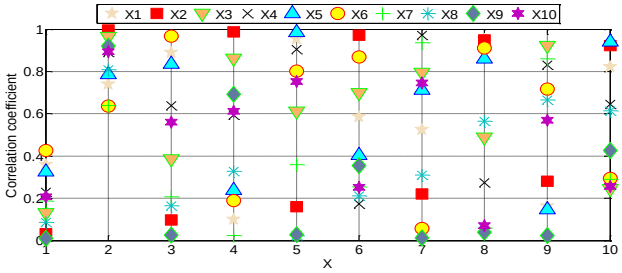

Fig. 3. Correlation coefficient between factors/indicators

Figure 3 is showing correlation coefficient matrix for each factor/ indicator and it can be observed from Figure 3 that the association between the indicators is high if the value of the correlation coefficient reaches to 0.8 or greater than 0.8. This article also calculated a commonality. It is judged that the relationship between the original variable and the common factor needs to be measured by the size of the common degree. The commonality represents the square of the load amount of the load on each of the extracted factors, which reflects how much the each factor is extracted on the information contained in the original variable. Typically, if the correlation value reaches to 0.5 or greater than 0.5, then the extracted information is reliable. The results indicate that the commonality of each participating indicator is greater than 0.5, which proves the utilization of factor analysis in forecasting the demand for resources.

C. Factor Load Matrix (FLM)

The Factor Load Matrix (FLM) for Blockchain-based system involves determining the factors and then assigning loadings to them. In this article, we are considering three parameters such are Network performance (NP), Blockchain resources and complexity (BRC) and Economic viability and cost (EVM) for factor load matrix. The FLM presents the weights assigned to each of these parameters/factors for forecasting the trading decisions. The FLM is shown with values in Table 1.

Table 1. FLM matrix with three indicators

Factors	**NP**	**BRC**	**EVM**
Network latency(X1)	0.8	0.5	0.3
Network throughput (X2)	0.8	0.6	0.4
Compute resources (X3)	0.5	0.7	0.4
Blockchain scalability (X4),	0.6	0.5	0.5
bandwidth (X5),	0.7	0.4	0.5
Interoperability (X6)	0.6	0.5	0.4
Energy consumption (X7)	0.7	0.4	0.7
Transaction volume (X8)	0.2	0.3	0.7
Cryptographic complexity (X9)	0.6	0.7	0.5
Resource cost (X10)	0.4	0.4	0.7

In Table 1., the NP indicator has the highest loading (0.8) for network latency, which reveals that the network latency strongly effect the network performance. For network throughput, the NP indicator has the highest loading of 0.8 which clarifies the correlation of network throughput on the network performance. The computational resources have 0.7 loading for BRC (Blockchain resource and complexity factor) which means that computational resources impact BRC factor at a great extent. The bandwidth parameter also affects the NP factor upto great extent as poor bandwidth can slow down the network performance. Interoperability can impact network performance and also EVM. The energy consumption parameter affects the network performance also impacts the economic viability and cost factor. The transaction volume has direct impact on economic viability and cost factor. More will be the transaction volume in the Blockchain environment; more will be the EVM load. The security issue and cryptographic complexity parameter impacts all by showing load on EVM factor as well as NP factors. Finally the resource cost has direct impact on economic viability and cost on the resource demand prediction model.

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D. MAE scores for the proposed and existing models

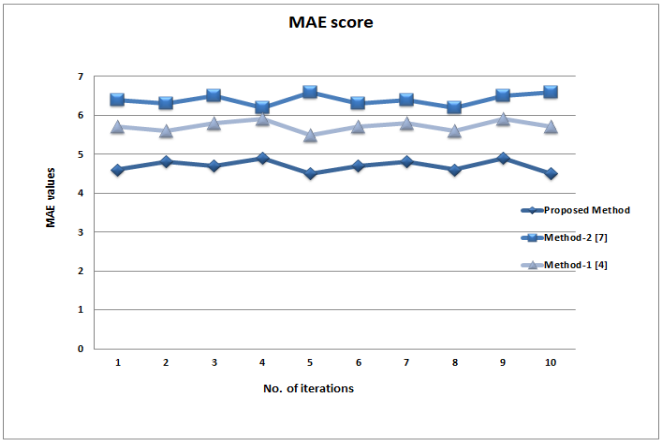

Fig.4. MAE score obtained by the proposed method

In Figure 4, the MAE score of the proposed game theory and DL based method is the highest and hence, the proposed methods can be considered for Blockchain based networks for forecasting the resource requirement where number of factors is to be considered over the benchmarked methods mentioned as Method-1 [4] and Method-2 [7]. Blockchain can be observed a technology which has impacted business, trading, mode of financial transactions, logistics, supply chain management, healthcare systems and transportation. Blockchain technology has changed the conventional way of resource distribution by switching to decentralized treatment of resources. The resource utilization has become easier with the aid of Blockchain technology. The distributed environment provides faster and secured access to the data. The intelligent methods like game theory and deep neural networking techniques make the Blockchain based networks more convenient and more reliable by predicting the demand for resources in advance. This article is making use of deep learning methods for designing a multilateral system where the forecasting can be done regarding the futuristic resources more easily.

E. R-squared values

Table 2. Values for R-Squared

Models	Experiment-1 R^2 Values	Experiment-2 R^2 Values	Experiment -3 R^2 Values
Proposed	0.86	0.87	0.84
Method-1 [4]	0.823	0.80	0.83
Method-2 [7]	0.78	0.78	0.73

The R^2 values provided in Table 2 represent the goodness-of-fit of each model in predicting resource demand across three distinct experiments. R^2 is a crucial metric used to assess the proportion of variance in the dependent variable of resource demand prediction that can be described by the independent variables. The proposed deep learning based model consistently demonstrates strong predictive performance across all three experiments, as indicated by R^2 values ranging from 0.84 to 0.86. Notably, in Experiment-2, the proposed method achieved the highest R^2 value of 0.87, signifying its remarkable ability to explain 87% of the variance in resource demand prediction for that specific experimental setup. Method-1 [4] also stands out with strong and consistent performance, with R^2 values ranging from 0.80 to 0.83 across all three experiments. In Experiment-1, it achieved the highest R^2 value of 0.86, demonstrating its capability to explain 86% of the variance in resource demand prediction.

F. MPE scores for predictive models

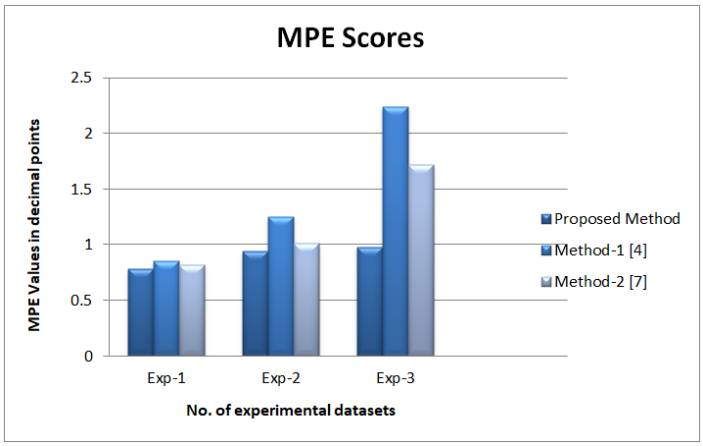

Fig. 5. MPE scores obtained by all algorithms

The MPE values in Figure 5 represent the Mean Percentage Error for each model, which is a measure of the average magnitude of errors between the model's predictions and the actual values, expressed as a percentage. It is commonly used to assess the accuracy of predictions, with lower MPE values indicating better predictive performance. In the context of Experiment-1, the proposed method exhibited an MPE value of 0.78. This means that, on average, the model's predictions deviated from the actual values by 0.78%, indicating a relatively small error in its predictions. Similarly, Method-1 [4] had an MPE value of 0.85, and Method-2 [7] had an MPE value of 0.82 in this experiment. These MPE values obtained by the three methods suggest that all the three research studies are reliable for forecasting resource demand in Blockchain networks but with some degree of error. The proposed design can be utilized to forecast the resource demand of the Blockchain based networks. The miners can make demand for resources and the predictive models can forecast the demand for the resources in advance which can help in optimal utilization of resources with minimization of cost.

G. Resource utilization

The resources can be utilized well if the demand for the resources is predicted well in advance as shown in Figure 6. The utilization of resources obtained by the three algorithms has been compared after the implementation of the predictive models of demand for resources. The Proposed method presents efficiency in resource utilization across integrated nodes, Blockchain nodes, and Cloud nodes. The proposed method of this article demonstrates high resource utilization across all the three types of nodes, with integrated nodes slightly lower than Cloud nodes and Blockchain nodes. In contrast, the resource utilization by Method-1 [4] exhibits the lowest values among these three methods, with integrated, Blockchain and Cloud nodes. Method-2 [7] exhibits slightly higher values for resource utilization over Method-1[4], indicating better efficiency in allocation of resources. The choice of any method can be made based on the specific application requirements but the proposed method shows greater efficacy in allocation of resources and utilization of resources optimally.

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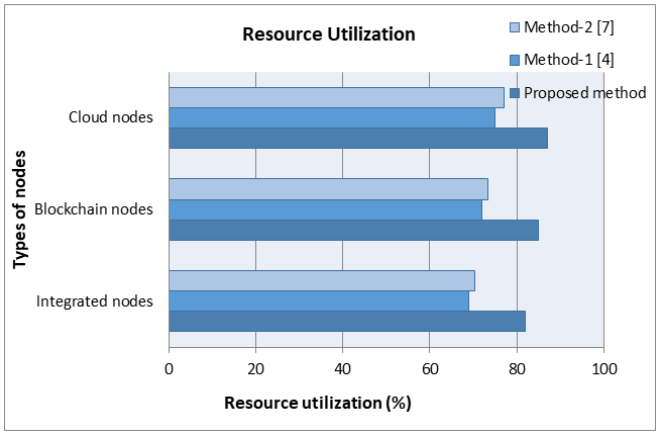

Fig. 6. Resource utilization obtained by all algorithms

VI. DISCUSSIONS

A. Significance of the research study

The purpose of the research is to explore the benefits of integrating two technologies such as deep learning and game theory for forecasting the demand of the resources in Blockchain and Cloud environment. The research study is focusing on enhancing the accuracy of the forecasting model for determining the demand for resources. The research provides insights into the integration of two technologies for better forecasting model. Ultimately, the study contributes to the resource demand prediction methodologies with potential applications in the area of Blockchain and Cloud. The research study is significant since it addresses a critical challenge of managing the resources in Blockchain and Cloud based integrated environment. Effective resource demand prediction is crucial for optimizing the allocation of resources, to ensure wastage of compute and data-resources. The research is offering a novel approach for prediction of resources by utilizing the strengths of both technologies. Neural networks can learn from the complex patterns and game theory helps to establish relationships of data-points for effective decision making. The potential of the research study is in adaptive demand forecasting of resources in a dynamic environment to fulfil the needs of Blockchain users. It can help in saving cost of resource usage, enhance the utilization of resources, and enhances customer services. The research has the potential to significantly provide the solution by using the advanced methodologies such as game theory and deep neural networks for forecasting the demand of resources.

B. Limitations of the research work

The integration of two methods such as game theory and deep learning holds significant promise for predicting the demand for resources. There are potential limitations also which has to be considered while implementing or replicating model in a real time environment. Firstly, the methodology to combine both the methods namely game theory and deep neural networks is a cumbersome process and requires specialized technical expertise for implementation of the model. Secondly, the effective outcome of the approach depends upon the quality of data, as well as service level agreements between the resource providers and the consumers. Additionally, the nature of the Blockchain enabled networks is very dynamic, resources join and leave any time, and the presence of unforeseen risk factors can introduce uncertainties in the forecasting process. Lastly, the scalability of the proposed models requires extensive empirical testing in a real-time environment.

C. Research implications of the proposed research

The accurate prediction of resource demand through the integration of DL and game theory can optimize the resource allocation strategies for Blockchain environment. This can lead to better utilization of computational and data-resources. By anticipating changes in the resource demand patterns, the allocation of resources can be strategized more effectively. Accurate resource demand forecasting also aids in minimizing the costs associated with the resource utilization. Optimized allocation of resources contributes to sustainability goals as it minimizes the waste of resources and also lowers the carbon footprint.

VII. CONCLUSIONS

Blockchain enabled networks have achieved popularity worldwide to promote the diverse applications in a decentralized environment in a secure manner by using smart technologies. However, by determining the demand for resources, the resources can be utilized optimally. This article is designed with game theory and deep neural networks model for predicting the demand for resources for Blockcahin consumers to secure their investments in a Blockchain enabled platforms. The proposed methodology is offering a solution to the consumers by exploiting the advantages of Blockchain, game theory and DL based forecasting model to predict the demand for resources for optimal allocation of computational and data-resources. The results reveal the efficacy of the proposed method is verified by forecasting the demand for resources in Blockchain networks efficiently. The performance of the game theory and DL based prediction model is based on multiple evaluations, and factor load matrix, also the comparison is made with state-of-the-art methods using evaluation metrics such as MPE, MAE, R-squared values, and resource utilization. The proposed dual approach highlights the efficiency in predicting demand for the resources. For future directions, firstly, we will explore the scalability and adaptability of the game theory and DL based proposed predictive model to different Blockchain ecosystems. Additionally, the efforts will be directed towards enhancing the interpretability of the model in Blockchain based dynamic environments.

DATA AVAILABILITY

The data can be shared on a valid request.

CONFLICTS OF INTEREST

There is none to declare as conflict of interests for this article.

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The research has not received any financial assistance.

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