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Optimized Resource Allocation in Blockchain Fog-based IOE

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***Abstract* - The vision of the Internet of Everything (IoE) applications is to develop the transaction relationship of real-time response applications. There are various frameworks in the real-world to support the IoE applications, but issues like security, platform independence, multi-application assistance, and resource management are considerable. Fog Computing (FC) has been introduced to scale back the energy consumption and latency for the heterogeneous communication approaches within the Internet of Things (IoT) which is now extended to the Internet of Everything (IoE). While fog computing decreases the computation delay and anticipates traffic data, it also brings the severe challenge on complex resource allocation of the available computation and communication resources under the stringent quality of service (QoS) requirements. The security issue of communication in IoE is enhanced by Blockchain technology. Blockchain is a data structure consisting chain of blocks that grows with each transaction and is linked through cryptography. There's no third party involved in controlling and accessing data. Although the latency and security challenges in IoE would be covered by a Blockchain Fog-based Architecture Network (BFAN) [1] for IoE, optimized resource management is yet considerable. This work is motivated by two different concepts of algorithms and BFAN. The first concept is known as a deterministic algorithm such as Algorithmic Game Theory (AGT) and the second one is heuristic/evolutionary algorithm such as whale optimization algorithm (WOA). The goal of this work is to investigate the optimized resource allocation algorithm in Blockchain Fog-based IoE networks. Game theories are used in an uncertain decision-making situation with certain determinants while evolutionary algorithms are used without predefined factors, therefore the focus is on solving the problem using an evolutionary/heuristic algorithm, WOA in particular. In a heterogeneous Fog-based IoE network with numerous FN, selecting the best node to communicate with is uncertain therefore AGT or WOA can help in finding the nearest node with regards to not increasing the latency and energy.**

Keywords - IoT, Resource allocation, Blockchain, Fog-based network, Optimization algorithms

I. INTRODUCTION

As of late, with the persistent improvement of smart terminals and remote organization innovation, we have entered the new period of the Internet of Everything from the interconnection of individuals and things, and the interconnection of things and things. Increasingly more information is created and disseminated in this colossal and complex organizational climate, welcoming remarkable tension on figuring administrations. The customary distributed computing model can't meet just the heterogeneous, low postponed and thick access organizations yet, also, the utilization of different applications for wise terminal clients. To take care of this issue, another registering worldview was founded in 2011 (i.e., fog computing). These model arrangements with the expansion of a mist layer between the terminal gadget and the customary cloud worker would bear the cost of figuring, stockpiling, and organization administrations.

The principle point is to move some center elements of the cloud to the "close" area of the organization edge, to conquer the deformities of distributed computing concerning area mindfulness, versatility backing, and continuous association. As an amplification of distributed computing, fog processing is similar to distributed computing, since it is additionally an organization-based figuring model that gives information sharing, registering, stockpiling, and different administrations through mist hubs on the Internet. Fog registering is a handling climate with broadly dispersed sending, faced with moderately focused distributed computing. Information stockpiling and preparing are more subject to edge gadgets, so clients of mist figuring normally pay a specific expense to get more viable administrations. The gadget that gives the registering administration can get a specific compensation by giving its repetitive processing assets.

Fog computing model, as an arising processing model, has carried new issues and difficulties to the registering administration field because of its "mist hub as an asset supplier". Taking into account that the mist figuring climate has the highlights of limited assets, wide appropriation, heterogeneous organization, and narrow-minded fog processing hubs, the legitimate administration of these qualities in mist hubs has gotten one of the primary center points in the fog registering research field. From one viewpoint, the pay and cost of the fog hub while contributing assets are frequently not magnificently adjusted. Then again, the cloud agent co-op comes up short on a compelling motivation component to advance the consistent and stable commitment of the mist hub. Given the above issues, numerous researchers have completed examination and conversation, and some advancement has been made. Nonetheless, there are yet numerous issues that confine the broad utilization of mist figuring. As a result, it is important to look for arising advances and strategies to settle the above troubles.

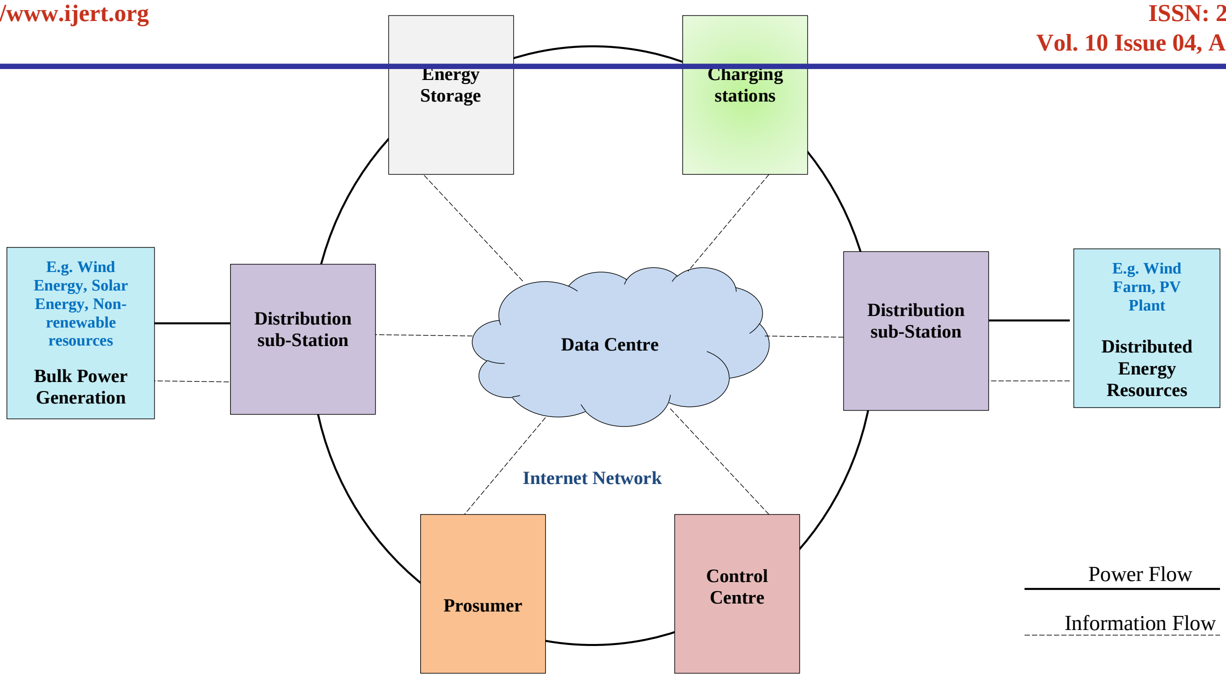

Fig.1 The overall architecture of IoE

Recognizing the achievement and expanding prominence of advanced digital currencies, for example, Bitcoin, blockchain innovation is steadily arising. Its center benefit can utilize information encryption, timestamp, circulated agreement, and financial impetuses in the hub without shared trust in the execution of an appropriate framework dependent on a highlight point decentralized credit exchanging, coordination, and participation. These attributes can address issues identified with the brought together association, the predominance of significant expense, low productivity, and information stockpiling. The blockchain framework for the most part comprises an information layer, an organization layer, an agreement layer, a motivating force layer, an agreement layer, and an application layer. The information layer is utilized to develop information obstructs, scramble and sign information, and add timestamps. The organization layer incorporates conveyed shared organizations for correspondence and information confirmation between hubs. The agreement layer actualizes different agreement calculations like Proof of Work (PoW) and Proof of Stake (PoS) or Delegated Proof of Stake (DPoS). The motivation layer is primarily used to build up the relating motivator instrument, and its given token has inexcusable attributes contrasted and the customary financial award. The agreement layer for the most part utilizes contents or calculations to plan shrewd agreements that all organization hubs should be consistent. At long last, the application layer depends on different application situations of blockchain innovation.

Because of the qualities of blockchain, researchers have done pertinent examinations on the blend of blockchain innovation with distributed computing, fog registering, and edge figuring, remembering research for the mix of blockchain innovation with the Internet of Things (IoT), access control innovation, and other related fields. This paper centers around the asset commitment allotment in the fog computing climate. The basic point is identified with the exploration of legitimate assets the executives with a blend of blockchain innovation and mist registering.

II. RELATED WORKS

As referenced above, asset commitment is a basic specialized issue in asset executives and distribution, particularly in fog computing. Asset commitment alludes to the arrangement of processing, stockpiling, and different assets by gadgets with inactive assets. The BFAN [1] proposed to convey the use of IoE in the keen city, safely and ideally. The BFAN engineering can lessen the FN's normal force utilization and make them versatile, and guarantee that correspondence and calculation are effective. The significant commitments of the BFAN engineering incorporate an energy-effective stage for thing-mindful wired/remote TCP/IP association, intra-essential correspondence in fog computing, and security with Blockchain.

Xi Li el. at [2], Focused on the enhancement of calculation and correspondence asset allotment in fog processing-based remote IoT networks with NOMA. It has been viewed as an overall situation with huge IoT gadgets and displayed the expense and energy utilization for both neighborhoods figuring and offloading processing errands to FN. Additionally [3] proposed an asset assignment technique with an Non Cooperative Game (NCG) hypothesis, which boost and accomplish an ideal Energy Efficiency (EE) for all Device to Device (D2D) pair in the three-level organization. The most extreme conceivable EE of the D2D pair was accomplished through Nash Equilibrium (NE) and Pareto optimality (PO) with the equivalent broadcast power. NE gave even dissemination of EE of D2D pair yet not upgraded. PO furnished an answer with equally appropriated and streamlined EE of D2D pair. At the point when the channel was static, NE gives an ideal arrangement, and if the channel was dynamic, PO gives the ideal arrangement.

An epic calculation dependent on whale streamlining [4] is proposed to decrease the runtime of undertakings and allot ideal assets to errands. The proposed technique recommended a discrete definition for the whale calculation to upgrade the resource allocation (RA) issue in a cloud climate. Each whale is planned as an exhibit. In light of this exhibit, another idea of distance is characterized for the distance function which is extremely valuable for the whale calculation. The spiral function is designed for spiral movement and shrinking and search prey functions are designed for direct movement out.

Huaqing Zhang [5] proposed a joint advancement system in the multi-FN (Fog Node), multi-DSO (data service operators), and multi-DSS (data service subscriber) situation for IoT mist figuring. In the system, the principal Stackelberg games were demonstrated to take care of the estimating issue of the DSOs and the asset-buying issue of the DSSs. At that point, a many-to-many coordinating was proposed between the DSOs and the FNs to manage the DSO-FN matching issue. At long last, another many-to-many coordinating was applied between its combined FNs and serving DSSs to take care of the FN-DSS matching issue.

In the above papers, researchers generally utilize the qualities of aggregate upkeep, recognizability, and high security in blockchain innovation to tackle security issues in the mist registering climate, and asset allotment issues. A few researchers have additionally examined the issue of the blockchain itself so it can more readily serve distributed computing or mist figuring. Further, a few researchers have created blockchain-based frameworks under the climate of distributed computing or mist processing. Although there are still a few issues in the above examinations, for example, low framework throughput, high energy utilization, and too ideal exploratory climate, it very well may be perceived that the utilization of blockchain innovation could tackle numerous issues in fog count, and it is a basic and effective way.

The ascent of blockchain innovation gives the likelihood to tackle the asset, the board issue of fog computing. Simultaneously, it cryptographically ensures the information's irreversible and reprehensible attributes and secures the information security of clients in the fog computing climate. Moreover, cloud agent co-ops, fog agent co-ops, and clients in the fog processing climate likewise compare to the personality attributes of the partnership chain members.

Along these lines, the essential objective of this paper is to propose a fog registering asset commitment model dependent on a coalition chain and advances the blockchain framework into the mist processing network engineering. The prize and discipline component of blockchain is utilized to support mist figuring hubs to contribute assets effectively and to take care of the asset, the board issue of mist processing. The asset commitment conduct of mist hubs and the fulfillment level of errand finish are recorded in the blockchain structure, delivering a wild assessment framework, which can tackle issues like vindictive terrible audit and brushing in useful applications. The essential commitments of this paper can be summed up as follows:

- A blockchain-based fog computing asset commitment model is proposed, which thinks about a fulfillment degree (task consummation degree) as an assessment record for administration given by fog processing agent organizations.
- An investigation of asset distribution between bunches with NBS for a reasonable and proficient arrangement used to talk about the association between the ideal asset commitment methodology of the mist hub and the ideal advantage under the ideal system
- A superior exhibition of the appropriateness of WOA, to examine three asset allotment issues in remote organizations: secure throughput expansion, energy and ghastly proficiency tradeoff, and versatile edge calculation offloading, which are then settled by the WOA calculation. Reenactment results are directed to show that the WOA calculation can unite quickly and accomplish practically a similar execution as in the current calculations.

III. PROPOSED SYSTEM MODEL

Fog registering, as an augmentation of the distributed computing model, is a pitifully concentrated processing worldview contrasted with distributed computing. The alliance chain model in the blockchain is likewise a conventional incorporated public chain. A pitifully concentrated type of disseminated processing permits consolidating the two constructions. This paper proposes an asset commitment model for fog registering dependent on the alliance chain innovation in blockchain, which joins the fog count to utilize the inactive asset participation mode and the attributes of the impetus model in the blockchain innovation to tackle the issue of asset commitment in fog processing. Simultaneously, the wellbeing of the mist registering itself is settled by the high security and non-destructible change of the blockchain innovation.

According to [6] and [7], Fig.2 shows a blockchain-based fog computing graph, which is a normal fog registering a three-layer engineering situation. Full hubs with all square data are set in the cloud server farm. The fog processing gadget has restricted execution and capacity limit and is a powerless hub in certain conditions. The light hubs in the blockchain are conveyed in the fog registering gadget and, as indicated by the distinction in gadget execution, can be utilized to run the number of squares that the gadget can withstand. After the hubs in the blockchain access the framework, a progression of exercises, for example, making a square or casting a ballot should be performed. Every movement needs to record the character of the taking part hubs or confirm it. Along these lines, every hub (i.e., the mist registering gadget in Fig.1) adds a deviated key as the personality. Under this component, each exchange in the framework can be followed, and the mask of illicit hubs is likewise forestalled.

3.1. The Game Theory for Resource Allocation Strategy

As utility processing, distributed computing has many economic highlights, including market highlights of figuring assets, the size of the cloud market economy, and the supplier paid highlights of assets. One of the benefits of utilizing financial aspects guideline to address the cloud asset designation is the market system. The market component is notable as that item costs drifting reflections asset burden, clog, and the unique difference in supply or request condition. Therefore it can

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accomplish the ideal portion of assets with harmony hypothesis. This unique coordination of assets allotment gives a system that is appropriate for the dynamic trait of the distributed computing climate. Every member in the market is in a quest for expanding singular interests. That makes the entire asset portion continuously keep an eye on the ideal condition. It is one of the conventional assets allotment strategies sought after however hard to accomplish.

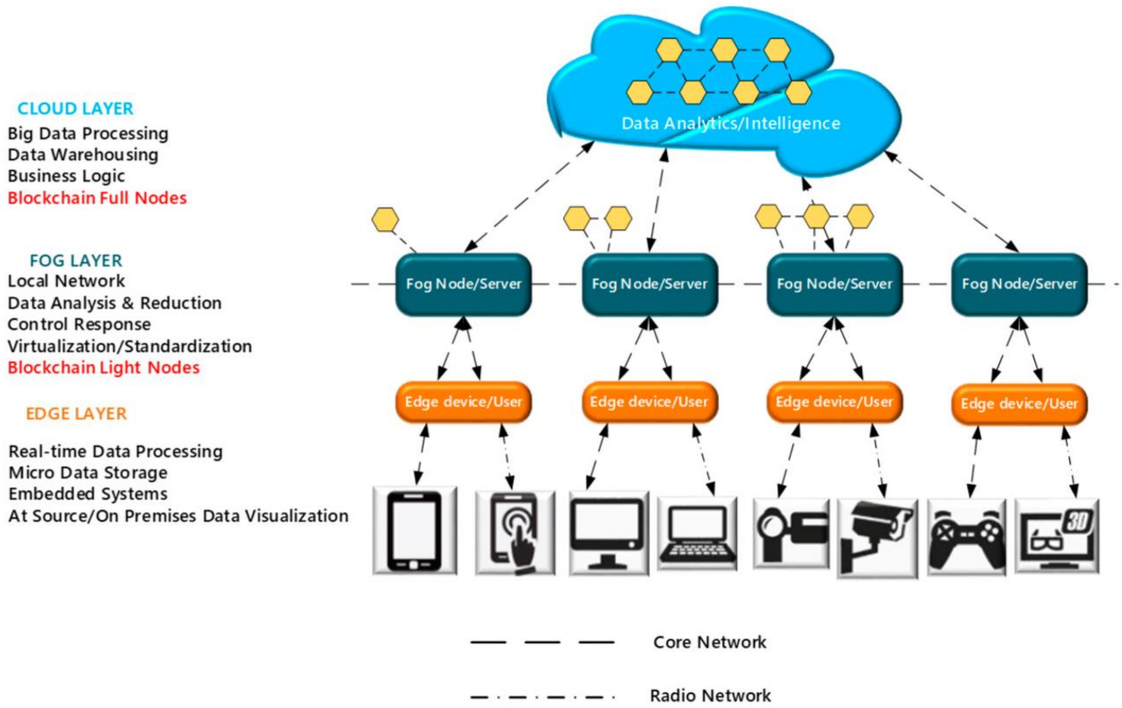

Fig.2 Blockchain-based fog computing architecture [6],[7]

Subsequently, this work investigates the circumstance above and gives the design dependent on financial matters. The cloud design has appeared in Fig.3 which has been proposed in [8]. It has four sections: the clients, asset buyers, asset market, and asset suppliers.

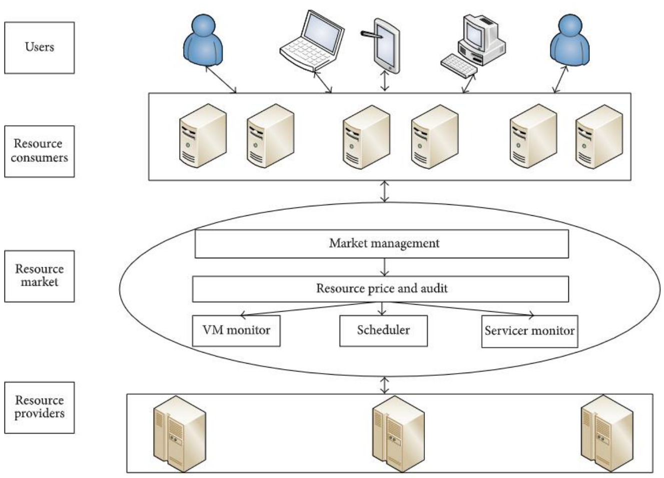

Fig.3 Cloud architecture based on economics [8]

- **Users**- Clients who use distributed computing assets. Cloud clients set forward their prerequisites from their representative to the cloud market, including the necessary QoS depiction. Furthermore, this requires numerous angles to finish the undertaking, for example, CPU type, the quantity of the CPU, memory size, working framework, and its variant number.
- **Resource Consumers**- Private cloud is an asset purchaser, although it gives clients assets. At the point when it can't address clients' issues, it gets assets from the public cloud.
- **Resource Market**- The asset market is the center of this design module. It is the administration for the clients, it figures danger, and it is self-governing. The market is the interface for server farm/cloud agent organizations and the client/agent, utilizing some sort of exchange instrument to arrange the two necessities. It predominantly incorporates the accompanying six sorts of components.
- **Resource Providers**- The public cloud is addressed.

3.1.1 Nash Bargaining Solution Game-Based

On the lookout, the circumstance that various cloud asset suppliers contend with one another might be the Nash Bargaining game model. Nash Bargaining game hypothesis is completely objective with regards to the system with reliance communication hypothesis. The Nash Bargaining game hypothesis focuses on tackling the issue for normal partners from different lines agreeable game assets, common impact, and impact emerging from the examination of the assets. The most magnificent decision is a capacity that any remaining contenders chose. Nash balance systems look into enhancing the adequacy of the time improved design of assets. Here the expression is that asset suppliers give VMs as space methodology. In distributed computing market, the conduct of the relative multitude of assets suppliers can be addressed as Cartesian product S=$S1$ × $S2$ ×⋯×So, where So represents a resource provider o's strategy set.

Utility addresses got fulfillment by offering assistance for an asset lease and every asset supplier's normal income is addressed by the utility capacity, that is, {Uo} = {$U1$, $U2$,...,UO}, o ∈ {1, 2, . . . , O}. s is the decision technique of the asset suppliers in the game. If the game member o is with the technique so, so□ is the portrayal of the determination system by any remaining asset suppliers aside from o and so□ = s−so. At that point, the member utility is communicated as (s). In the distributed computing market, all the asset suppliers need to get the most ideal technique as indicated by value work. Thinking about the instance of a solitary asset supplier, the profits work is as per the following:

$$u\,(s) = (c,h'\,)^{-1}\,(s) - Fc\,(s) \qquad (1.1)$$

The conflict vector in our model is accomplished when haggling between bunches fizzles and it tends to be distinctive as indicated by the non-helpful system. In this paper, we accept that the conflict vector comprises of constants to zero in on the asset distribution when bartering succeeds. NBS is a haggling arrangement for augmenting the result of utility that a helpful game accomplishes comparative with that accomplished in a non-agreeable game with fascinating adages. On the off chance that U is arched, the NBS is interesting, which is gotten by p. At that point, for space n, the ideal force control, and asset distribution joint issue to acquire NBS in our model

$$\rho = \arg\max_{u_i \in U} \prod_{i=1}^{L} (u_i - u_i^c) \qquad (1.2)$$

3.2 WOA: Basic Version

This segment talks about the basics of the WOA calculation including enclosing prey, bubble-net taking care of strategy, and the quest for prey. It presents the twofold form of the WOA calculation and the premium strategy as the requirement dealing with the procedure.

3.2.1 Encircling Prey

Humpback whales can perceive the area of prey (e.g., krill) and cover it. In the flow of WOA calculation the best search agent objects the prey and the other humpback whales update their location towards the best pursuit agent throughout the cycle. The accompanying conditions are utilized to numerically define this conduct

$$\mathrm{D} = |\mathrm{C} \times \mathrm{X}^*(\mathrm{t}) - \mathrm{X}(\mathrm{t})| \qquad (2.1)$$
$$\mathrm{X}(\mathrm{t}+1) = \mathrm{X}^*(\mathrm{t}) - \mathrm{A} \times \mathrm{D} \qquad (2.2)$$

where t represents the current iteration, A and C are coefficient vectors, X^* is the position vector of the best solution acquired as yet, X is the position vector, | | is the absolute value, and the **.** is a Cartesian multiplication. Note that in each iteration, if there find a better solution, and then X^* ought to be updated accordingly.

As it is discovered in [9], Fig. 4(a) illustrates the reasoning behind Eq. (2.1) for a 2D problem. The position *(X, Y)* of a search agent can be refreshed by the location of the current best record *(X^*, Y^*)*. Better places around all the agents can be accomplished concerning the current location by changing the estimation of A_n and C vectors. The conceivable refreshing location of a search agent in 3D space is additionally portrayed in Fig. 4(b). It ought to be noticed that by characterizing the arbitrary vector *(r)* it is feasible to arrive at any location in the pursuit space situated between the central issues appeared in Fig.4. Subsequently Eq. (2.2) permits any pursuit agent to refresh its location in the neighborhood of the current best solution and mimics enclosing the prey.

A similar idea can be stretched out to an inquiry space with n measurements, and the pursuit agents will move in hyper-3D shapes around the best solution acquired as yet. As referenced in the past segment, the humpback whales additionally attack the prey with the air-bubble-net methodology.

3.2.2. Bubble-net attacking method (exploitation phase)

To numerically show the air-bubble-net conduct of humpback whales, two methodologies are planned as follows:

- Shrinking encircling system: This is accomplished by diminishing the estimation of the variance scope of A which is likewise diminishing by a. To simplify the expression it is said that A is an unspecified value in the

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range $[-a, a]$ where a is diminishing from 2 to 0 throughout the span of iterations.

- Spiral updating position: This methodology initially ascertains the distance between the whale situated at (X, Y) and prey situated at (X^*, Y^*).

$$X(t+1) = \begin{cases} X^*(t) - A \times D & \text{if } p < 0.5 \\ D' \times e^{bl} \times \cos(2\pi l) + X^*(t) & \text{if } p \geq 0.5 \end{cases} \quad (2.3)$$

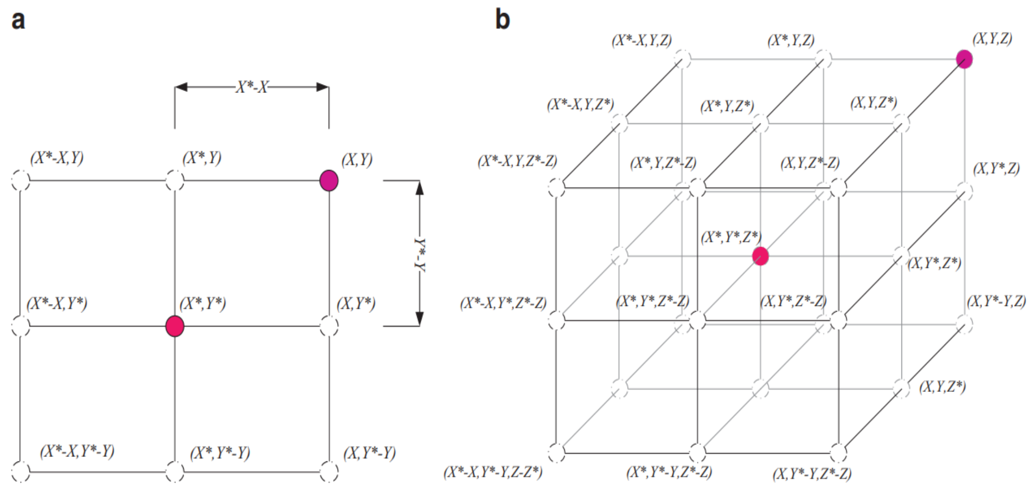

Fig. 4(a) 2D and (b) 3D position vectors and their conceivable next locations (X^* is the best solution as yet) [9]

3.2.3 Search for prey (exploration phase)

A similar methodology dependent on the variety of the A vector can be used to look for prey (exploration). Indeed, humpback whales search haphazardly as per the position of one another. Hence, we utilize A with the random value > 1 or < −1 to imposition the search agent to move far away from a reference whale. Despite of the exploitation stage that we chose the best search agent found so far, in this stage we update the location of a search agent according to a randomly picked search agent. This method along with the criteria $|A| > 1$ empower the exploration phase and make the WOA to carry out a universal search.

$$D = |C \times X_{rand} - X| \quad (2.4)$$
$$X(t+1) = X_{rand} - A \times D \quad (2.5)$$

3.2.4 WOA Optimization Algorithm

The WOA calculation begins with a collection of random solutions. At every cycle, search agents update their location concerning a haphazardly picked search agent or the best solution acquired as yet. The boundary is diminished from 2 to 0 to enable the exploration and exploitation, sequentially. A random search agent is picked when $|A| > 1$, whilst the best solution is chosen when $|A| < 1$ for updating the location of the search agents. Based on the value of p, WOA can shift between the spiral and the circular movement. At last, the WOA calculation is ended by the fulfillment of a termination test.

ALGORITHM.1. Pseudocode of the NSB Game Theory

Initialization*: Sort the ratios L(k) in decreasing order.*
Calculate the values of A_k, B_k, *and* Γ_k, k_{min}, k_{max},
Start
If $k_{min} > k_{max}$ *NBS does not exist. Use competitive solution.*
Else
For $k = k_{min} \rightarrow k_{max} - 1$
if $L(k) \leq \Gamma_k$
Set ks = k and α' s according to the lemmas-NBS found. Stop
End
End
If *no such k exists, set* $k_s = k_{max}$ *and calculate g.*
If $g \geq 0$ *set* $\alpha_{ks} = g$, $\alpha(k) = 1$, *for* $k < k_{max}$. *Stop.*
Else $(g < 0)$
NBS does not exist. Use competitive solution.
End.
End
Stop

K – Frequency of the resource in the channel
A_k – Increasing Sequence
B_k – Decreasing Sequence
S - Nash bargaining solution
α – Player and i is the player vector
g – NBS Solution

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ALGORITHM. 2. Pseudocode of the WOA Algorithm.

Initialize *the whales population Xi (i = 1, 2, ..., n), iteration t = 1, maximum number of iterations* I_{max}*, and set the stopping tolerance*
Calculate the fitness of each search agent
X=the best search agent*
while *(t <* I_{max}*)*
  for each *search agent*
  Update a, A, C, l, and p
    if1 *(p<0.5)*
      if2 *(|A| < 1)*
        Update the position of the present search agent by the Eq. (2.1)
      else if2 *(|A|≥ 1)*
        Select a random search agent ( )
        Update the position of the present search agent by the Eq. (2.5)
      end if2
    else if1 *(p ≥ 0.5)*
      Update the position of the present search by the Eq. (2.3)
    end if1
  end for
  Check if any search agent goes beyond the search space and amend it $(|X^*(t)-X^*(t-1)|\ |X^*(t-1)| <= E)$
  Calculate the fitness of each search agent
  Update X if there is a better solution*
  t=t+1
end while
return X*

From a hypothetical outlook, WOA can be viewed as a worldwide enhancer since it incorporates exploration/exploitation capacity. Moreover, the proposed hyper-3D shape system characterizes a hunting space in the neighborhood of the best solution and permits other search agents to exploit the current best record inside that area. Versatile variety of the search vector *A* permits the WOA calculation to easily shift among exploration and exploitation: by diminishing *A*, some cycle is committed to the exploration ($|A| \geq 1$) and the rest is devoted to exploitation ($|A| < 1$). Notably, WOA incorporates just two major internal variables to be adjusted (*A* and *C*).

Even though alteration and other developmental tasks may have been remembered for the WOA plan to completely duplicate the conduct of humpback whales, we chose to limit the measure of heuristics and the number of internal variables subsequently actualizing a fundamental variant of the WOA calculation.

IV. SIMULATION RESULTS AND DISCUSSIONS

We examine NBS in a three-group model having level blurring and AWGN with zero mean and difference. We consider an organizational situation as demonstrated in the figure. All groups have been coordinated as of now and are fixed in figure 1 out of a region of (300m × 300m). We additionally expect that the sink hub, not showed in the figure for straightforwardness, has all the data of the sensor hubs, and the bunch heads speak with their group individuals utilizing the TDMA technique that was booked as of now. Each group has a bunch head and four bunch individuals from the figure and the numbers composed close to the circles in the figure demonstrate the booking request of group individuals in a group. While the principal issue can be tackled straightforwardly by the NBS, the limitation taking care of method should be utilized in the subsequent model and the third issue is addressed by the WOA with the assistance of both the deterioration and imperative taking care of procedures.

SIMULATION PARAMETERS

PARAMETERS	VALUES
Simulation Tool	MATLAB
No. of Nodes	10-100
Area	300 × 300
Resource Optimization	NBS, WOA
Clusters	4-10
Traffic	CBR
Initial Energy	100J
Transmitter Energy	0.6J
Receiver Energy	0.3J

In this module, a remote sensor network is made. Every hub is arranged and randomly sent in the organization's territory. Since our organization is a remote sensor organization, hubs are allotted with starting energy, communicating energy, and accepting energy. A directing convention is actualized in the organization. Sender and recipient hubs are randomly chosen and the correspondence is started. Introduce the remote organization hubs with a multi-hop network by randomly sending 30 hubs in a territory of 300 × 300.

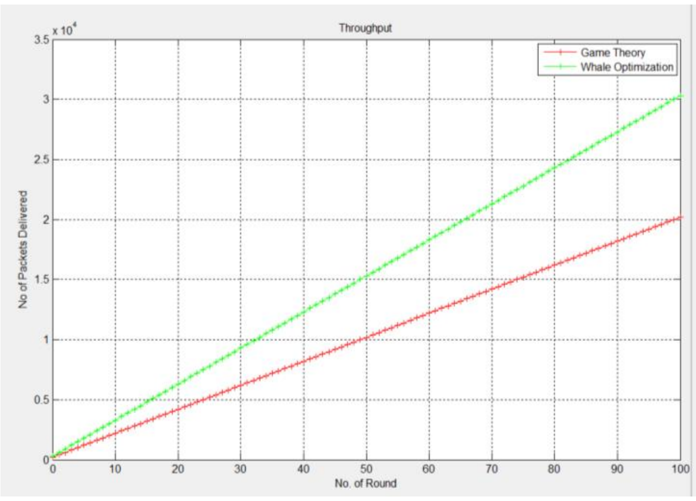

Fig.5 No. of Packets vs. Rounds

The figure shows the reaction time for hub portability occasions and is contrasted the NBS and the WOA organizations. This trial considers the connection success for a solitary information stream and the impact of other

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foundation traffic isn't considered here. The outcome here shows that in WOA the number of packets delivered successfully is higher than in NBS.

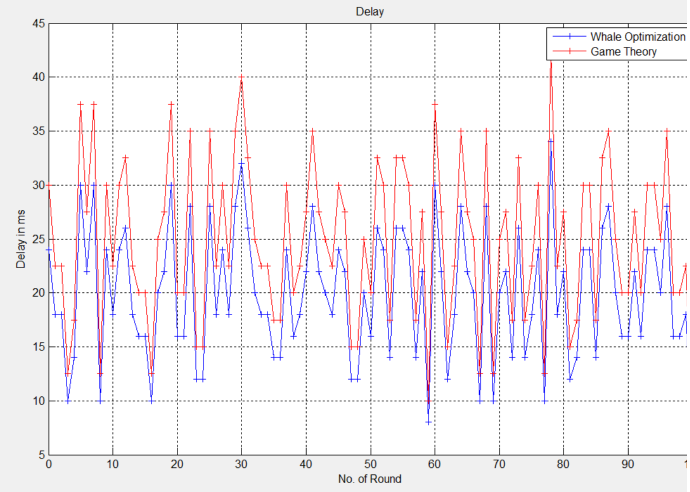

Fig.6 Delay vs. Rounds

The figure is showing the examination chart to address the quantity of bundles delay over the organization in NBS and WOA Approach. Here X-axis addresses the hubs and the Y-axis addresses the quantity of parcels delay in the organization. By increasing the range of iterations as the system input, it is observed that bundle delay of WOA (blue line) remains lower.

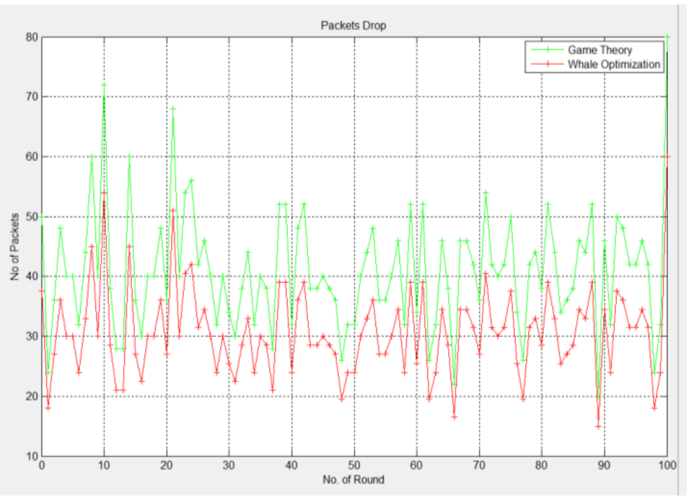

Fig.7 No. of Packets vs. Rounds

The figure shows the reaction time for hub portability occasions and is contrasted and the NBS and WOA organizations. This trial considers the connection failure issue for a solitary information stream and the impact of other foundation traffic isn't considered here. The outcome shows that by increasing the range of iterations as the system input, the number of packets dropped by WOA (red line) remains lower.

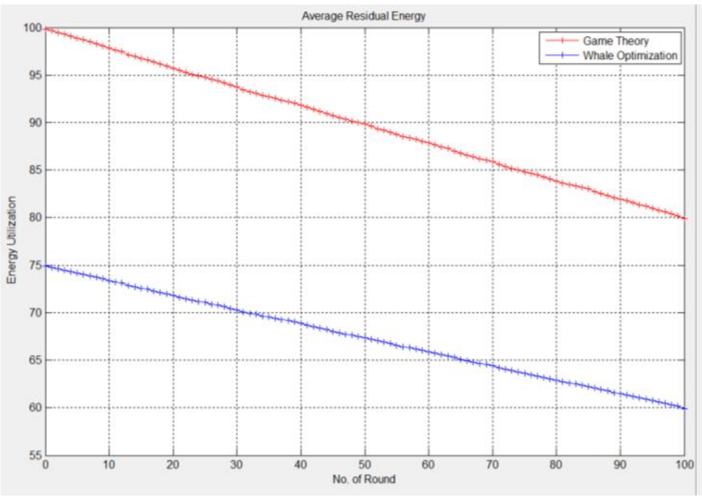

Fig.8 Energy Utilization vs. Rounds

Here X-axis addresses the number of rounds and the Y- axis addresses the energy in the organization. In the event of the proposed network, the prescient guidelines are executed. The outcome shows that the WOA offers lower energy consumption. In other words, by increasing the range of iterations as the system input, it is observed that energy consumption of WOA (blue line) remains lower.

V. CONCLUSION

IoE applications such as smart cities need to be energy-aware, low latency, and scalable. The designed framework Blockchain Fog-based Architecture Network (BFAN) deploys an efficient solution for urban regions to provide Fog-based applications with energy-efficiency, scalability, and security. The contribution of this work is to the optimization of resource allocation in BFAN through an evolutionary/heuristic algorithm called whale optimizing algorithm (WOA) with compare to an Algorithmic Gaming Theory called Nash Bargaining Solution (NBS). The system energy consumption and the latency could be impacted by the different computing modes, and it is expected that the proposed scheme would make an optimal decision for choosing the proper computing model to achieve a good performance. This work analyses the result of the WOA and NBS on the FBNA framework.

V. FUTURE WORK

The fitness function which has been used in the WOA can be replaced by another search algorithm to enhance the runtime of the WOA. This search algorithm can be BAT, DE, etc.

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