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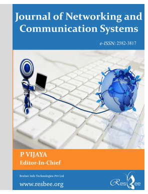

Enhanced Butterfly Optimization Algorithm for Load Balancing Scheme Concerning Latency

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Abstract: It is seen that cloud computing shows high performance in the scenario of storage, calculation as well as networking services from the current research studies however, IoT still suffers from maximum processing latency, position awareness, as well as minimum mobility sustain. In order to address the aforesaid problems, this work combines software-defined networking as well as fog computing. Prominently, the major contribution of fog computing is to extend the computing as well as storing to the edge of the network which would reduce the latency besides the mobility aid. Furthermore, this work aspires to integrate a novel optimization scheme in order to identify the issue in Load balancing regarding the minimization of latency. A novel Enhanced Butterfly optimization algorithm (BOA) is presented in this paper to introduce the optimally chosen load distribution coefficient i.e. time allocation for performing a task. At last, the performance of the developed technique is evaluated with the existing techniques regarding the latency. The experimentation outcomes show that the SDN on the basis of the enhanced BOA approach will effectually reduce the latency as well as enhance QoS in Software-Defined Cloud/Fog architecture.

Keywords: Cloud computing, IoT, Latency, Network, QoS, SDN.

Nomenclature

Abbreviations	Descriptions
SDN	Software-Defined Networking
QoS	Quality of Service
SDWMN	Software-Defined Wireless Mesh Network
IoT	Internet of Things
API	Application Program Interface
SDWSN	Software-Defined Wireless Sensor Network
FNs	Fog Networks
SBI	southbound interface
SDHW-IoT	Software-Defined Hybrid Wireless based IoT
NBI	Northbound Interface
Opt-ACM	Optimized load balancing based Admission Control Mechanism
BDBA	BioInspired Deep Belief Architecture
LB	Load Balancing
SMBCP	Switch Migration Based Controller Placement,
SDON	Software Defined Optical Networks
DRL	Deep Reinforcement Learning

1. Introduction

Generally, the requirements of the network possess quickly altered in rejoinder to the increasing network traffic size as well as the requirements of quality, thus setting high demand on end-to-end objectives [1]. In nature, the existing architectural models of the network are static and therefore, complex to identify the network circumstances. A demanding new network approach called SDN is used to permit the networks to be adaptive requirements. In its fundamental nature, the SDN divides the control plane of the network from the data forwarding plane. For instance, the Open flow switches are used by the data forwarding layer which is programmable through the Open flow controller. A southbound protocol API is used by the switches for instance the Open flow control in order to interfere with the controller. The controller of SDN is act as the data plane devices such as switches as well as a

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router that centrally describes the network policy topology and creates interfaces of multiple southbound protocols [2].

The future generation networking environment is the IoT [10]. It exploits a new protocol stack comprising diverse optimized protocols in order to efficiently handle the flows of the network [11]. Additionally, diverse kinds of technologies are theoretically modeled in a faultless way in its sunshade environment. Wireless Sensor Network is considered as an up-to-date technology particularly well-known for its development of agile network and its several other features like access ease, enhanced effectuality, an architectural model of network flexibility, minimum power utilization, the minimum cost of network devices as well as the model and so on [3]. Every dimension is concentrated on the particular network application as well as corresponding network services. Although various networking advantages, the wireless sensor network features a few severe concerns like the lifespan of constrained networks, security threats, restricted coverage, minimum transition speed, and so on. Numerous restraints cover the development of the network and humiliate the performance of the network while the network scales [4].

Nevertheless, the SDN development in numerous fields possesses a novel bottleneck. To convene high user demands as well as to present the superior QoS, the end-to-end data transmission latency is incessantly compressed. For instance, the latency amid the communication of vehicle systems exploited to assure secure driving should be lesser than milliseconds. Additionally, the medical equipment auxiliary performed with the person or patient with a disability should remain the response time. Thus, exploiting the SDN to attain architectural generalization when meeting the severe requirements of latency has turned out to be a predictable advancement tendency as well as an important research field [5].

The main aim of this paper is to present a novel load balancing approach that aspires to the reduction of latency to enhance the QoS in SDN. A novel enhanced BOA optimization model is integrated with this approach that optimally chooses the coefficient of the load distribution. The performance of the developed optimization model is validated with conventional methods regarding latency.

2. Literature Review

In 2018, Yongli Zhao et al [1], worked on SDON, however, particularly in large-scale networks a single controller can scarcely manage all-optical devices, even as multiple controllers employed in the network can resolve it. In recent times, progressively consideration has been remunerated to the multi-controller model, as well as controllers exploitation was a significant problem in large software stated optical networks. Nevertheless, the conventional model focuses on the controller's static mapping and switches as well as does not regard load balance amongst diverse controllers. It was a significant additional analyzing the association of multiple controllers. The main aim of this work was to develop a multi-controller synchronized exploitation scheme SMBCP based on load balancing.

In 2020, Mosab Hamdan et al [2], developed a thematic classification of LB in SDN, by taking into consideration of numerous metrics from the last technical researchers like the studies of LB. The LB approaches such as the control plane, and data plane as well as some objectives of both the plane LB and the performance measures of the LB approaches were considered. Moreover, many helpful imminent on LB as well as evaluation performance of several capable SDN LB approaches were involved in the study. In 2021, Rohit Kumar et al [3], developed an Opt-ACM for effectual network flow management ensuing in minimized network congestion. Besides, this work mainly spotlights issues of conventional solutions and explains the SDHW-IoT network architecture comprising SDWSN and SDWMN.

In 2021, Vivek Srivastava and Ravi Shankar Pandey [4], developed DRL based approach to attain the route on the basis of an optimized SDN load that was on the basis of the self-learning of human intelligence. Here, for BDBA, the Bio-Inspired RBM was exploited in order to implement the deep learning model to attain an optimized route. Moreover, SDN was exploited to solve numerous issues of network infrastructure to decouple the data plane and the control plane's responsibilities. The control on the network was enhanced by the single controller however; it minimizes the system reliability in the scenario of controller failure. Therefore, the reliability was improved by the distributed controller as well as it minimizes the failure of the system.

In 2021, Binghao Yan et al [5], worked on the architectural model of SDN by means of the objective of minimum latency. Then they analyzed and reviewed appropriate technologies and investigate findings regarding load balancing, traffic management, and flow table management as well as congestion control, in SDN. Additionally, the main objectives of a few of the recent well-known rising network technologies in SDN are minimum latency communication had been described in this paper. At last, the main objectives of this work were to present the fascinated topics with the imminent to endorse their current study in minimum latency communication to attain high accomplishments.

3. System Model of SDN

The architecture model of SDN [8] is categorized into three layers as application layer, the SDN control layer as well as Data/Infrastructure layer. Fig 1 indicates the architectural model of the basic SDN.

In the SDB architectural model top, the application plane presents numerous applications like traffic management, load balancing as well as security. Via the NBI, the application plane transfers their requirement as well as the required behavior network to control the plane. The SDN control plane includes a centralized logical controller that transmits the received requirements of the application layer to SDN data paths and presents the SDN application with the abstract perspective of the network. The separation of the data plane, as well as the control plane, permits the network administrator to simply alter the policies of the network that set up the network administrator to model the flexible, scalable network by handling the requirement of business via the software instead of the hardware. Using the southbound interface the control plane communicates with the data plane frequently named the control-data plane interface which is open flow. Since the SDN controller gathers worldwide data such as processing speed, load as well as communication latency, it would review the best load balancing schemes. Meanwhile, the controllers of SDN allow open plus programming to support routing in the network, resource management, etc using the software programs.

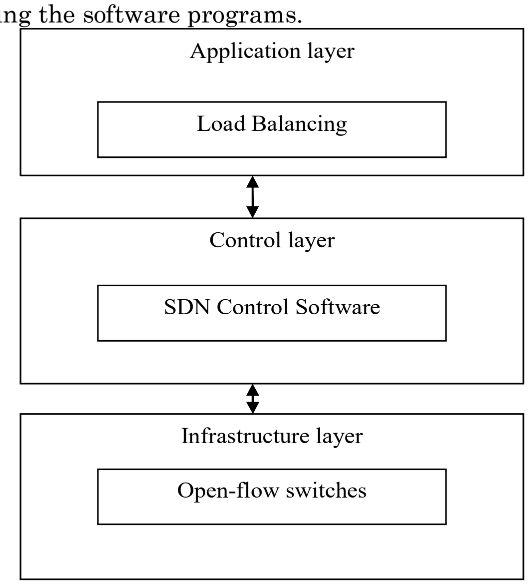

Fig. 1. *Architecture diagram of SDN model*

In SDN, the Data layer is represented as the forwarding plane consisting of numerous network elements i.e., switches. A conventional device depicts the data path as well as forwards the network traffic with the network. On the basis of the rule set by the controller, switches turn out to be an easy forwarding device that forwards the traffic in the SDN. The SBI is described among a data layer as well as an SDN control layer that tries to programmatically control all forwarding. Therefore, the computing task allocation besides the scheme of load balancing of FNs is highly complicated as it should be complex on the basis of the equipment performance as well as the overhead of communication to minimize the latency. This turns out to be the biggest query specifically for the latency-sensitive series [9].

In SDN, the load balancing scheme is concerned with the aware routing protocol that is a requirement entity that helps the availability, as well as the scalability, tends to attain the minimum response time of the application. On the internet, more people are connected with each other which frequently reasons web traffic as well as clearly tends to congestion of the network as well as packet loss. Nevertheless, server load management is not a simple task that frequently reasons redundant service issues. This work develops a novel load balancing approach for SDN which integrates the optimization model as the most important concept to handle the load balancing issue. The SDN case is regarded with the cloud servers, machines and cloud servers, SDN controllers, and FNs. The SDCFN topology is calculated as the weighted undirected graph on the basis of the graph theory wherein $VE = \{ve_1, ve_2, ...ve_k, SD, CS\}$ represents the vertex set.

Node (machine) $ve_i \in VE, SD$ and CSrepresents the SDN controllers, BS, and cloud servers, correspondingly. Using a cloud computing center the performance is improved; this paper contemplates the cloud center as the distributed computing node as well as presumed to possess the computing capability. Likewise, C_{ve_i} denotes the computing capability of ve_i and the weight τ_{ve_i,ve_j} represents communication between nodes latency (machines) ve_i as well as ve_j.

From the end-user to switch the task U is transmitted as well as which should be divided into several sub-tasks that is u_i, and u_i is transmitted to cloud node cd or fog node ve_i for evaluation reason. The node which performs the task distribution, in addition, executes a part of the task. Finally, the outcomes are integrated together and transmitted back to the end-users. Eq. (1) determines the total latency which is exploited in this paper, wherein $m_{ve_i ve_j}$ represents the association of sub-task allocation or not between machines ve_i and ve_j.

$$t(u_i) = \max\left(\frac{u_i}{CO_{ve_i}}\right), \frac{u_i}{CO_{d_i}} + \tau_{ve_{i,c}} m_{ve_{i,c}} \quad i,j = 1,....k \tag{1}$$

4. Load Balancing using an Optimization Model

The main aim of this work is to present a novel load balancing approach that aspires to the minimization of latency through an optimization idea that optimally chooses the coefficient of load distribution time allocation (a) of equivalent tasks, u_i). In this work, a novel enhanced optimization approach (enhanced BOA) is presented for optimal selection. Eq. (2) states the objective function of this paper, wherein $t(u_{CS})$ represents cloud server latency.

$$OB = \min(\max(t(u_1), t(u_2), ...t(u_N), t(u_{CS}))) \tag{2}$$

4.1 Enhanced Butterfly Optimization Algorithm

The proposed Enhanced BOA [7] approach represents that seen the novel candidate associated with the optimal solution in the local search stage using eq. (3).

$$y_i^{g+1} = y_i^g + r^2 \times \left(y_{best}^g - y_i^g\right) \times f_i \tag{3}$$

Where, y_i^{g+1} and y_i^g indicates the ith and jth butterfly solution. The optimal solution plays an important role in the penetrating procedure, as it can direct and illustrate other folks to its own area in an iterative technique. Nevertheless, the optimal individual might be with no trouble trapped into the local optimum for multifaceted multi-peak optimization issues.

In this scenario, the phenomena of premature convergence might happen while supplementary individuals are fascinated with the optimal individuals. In order to identify the problem, the optimal learning approach on the basis of the chaotic series is used to update the optimal solution. It must be seen that chaotic series possess the arbitrariness and ergodicity characteristics that are valuable to furthermore improve the global search capability of conventional BOA, therefore, enhancing the optimal solution quality. Initially,

$$Z_{t+1} = 4Z_t \times (1 - Z_t) \tag{4}$$

Initially, the eq. (4) defines the logistic map is performed to produce chaotic series, subsequently, the optimal solution is updated using eq. (5).

$$y_{best,i}^{g+1} = y_{best,i}^g + rand \times (2 \times Z_i - 1) \tag{5}$$

wherein, *rand* indicates the arbitrary count of the interval [0, 1]; Z_t and Z_{t+1} represents the value of t^{th} and $(t+1)^{th}$ chaotic iteration $y_{best,i}^g$ indicates the updated value of the j^{th} variable in the G^{th} iteration for an optimal solution as well as initial value $Z0$ is arbitrarily produced in the range of [0, 1].

Even though BOA develops sturdy local, as well as global search capability, produces superior optimization solutions to conventional optimization approaches. In the proposed model, it is simple to execute because of its obvious structure, and there are no further parameters. In the proposed algorithm, the chaotic elite learning algorithm is developed to further process the optimal solution quality by producing novel solutions. In this scenario, the adopted model is capable to decrease the prospect of being trapped in the local optimum and improving stay the balance between local as well as global search.

4.2. Adaptive search space reduction method

To enhance the computational effectiveness, the minimization of search space technique was adopted by enthusiastically updating the restrictions of search space using eq. (6).

$$\begin{cases} L_i = \mu_i - w_i \times \sigma_i \\ H_i = \mu_i + -w_i \times \sigma_i \end{cases} (i = 1,2,....,k) \tag{6}$$

In eq. (6), H_i and L_i represents upper as well as lower search space restrictions; σ_i and μ_i represents standard deviation as well as mean value recognized parameters, correspondingly; k indicates the count of unidentified parameters; w_i represents window width and it ascertains the search space decrease rate window width value, consequently, it is fundamental to be suitably devised. By developing a dynamic window width w_i the adaptive search space minimization approach is attained as below:

$$w = \sqrt{\frac{\delta \cdot \psi}{g \times \sigma_i}}; \qquad \psi = \frac{\max\left(\frac{L_i + H_i}{2}, \mu_i\right)}{\min\left(\frac{L_i + H_i}{2}, \mu_i\right)} \tag{7}$$

The newly developed w is ascertained using three variables such as the number of runs, standard deviation value, and the ratio of search range φ.

5. Result and Discussion

The adopted model load balancing scheme was developed the network was implemented with numerous node machines which create the interface with the cloud server as well as every node possesses its individual load. Here, the analysis was performed in 2 schemes and it was varied by the loads such as 0.5GB, 1GB, 1.5GB, 2GB, and 2.5GB, by deviating the network configuration to 10 nodes, 20 nodes, 30 nodes, 40 nodes, 40 nodes, and 50 nodes, correspondingly. The adopted technique performance was evaluated with the existing Threshold Whale Optimization Algorithm (T-WOA) [6] [12] regarding load.

Fig 2 exhibits adopted technique performance in the load of 0.5GB, 1GB, 1.5GB, 2GB, and 2.5GB. Here, it is obvious that in approximately all the connectivity cases, adopted techniques obtain minimum latency. In total, the overall performance exhibits evidence of the dominance of the developed model regarding minimum load.

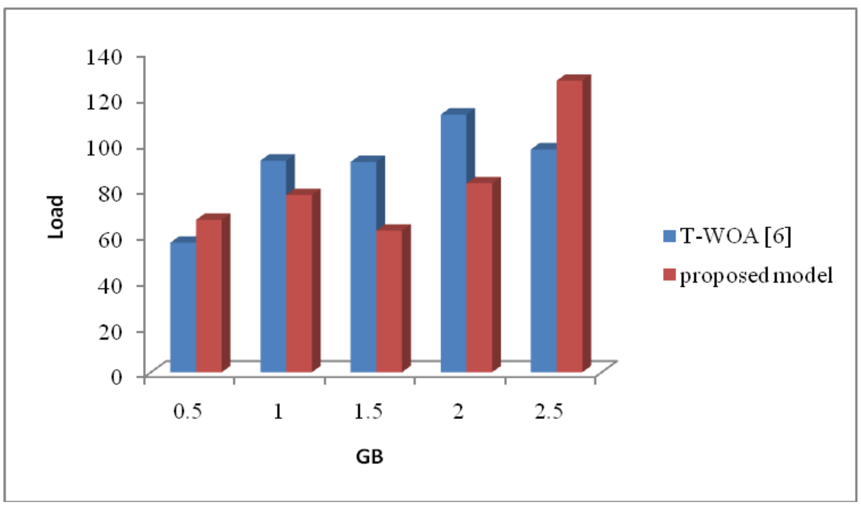

Fig. 2. *Performance analysis of the proposed and conventional models*

6. Conclusion

A tradeoff between the network's power utilization and the delay was investigated and that develops an approximate solution for decomposing the main problem into three respective sub-issues. Therefore, to overcome all the issues, there need some advanced load balancing approaches. This work has developed a novel load balancing scheme with the integration of a novel Enhanced Butterfly Optimization Algorithm, which had identified the issue of Load balancing regarding the minimized latency. A novel optimization approach was presented in order to select the optimal coefficient of load distribution. Finally, the performance analysis of the adopted optimization technique was validated with traditional methods regarding latency. At last, the evaluation analysis stated that while the connectivity was by machines 2, the developed method obtains a minimum load than the conventional models.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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