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Original Article

Burst Formation and Burst Assignment to Ingress Nodes in Optical Burst Switching Network Using ABC

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Abstract - *The burst formation & the burst assignment to ingress nodes for the routing purpose are the two concerns in the Optical Burst Switching (OBS) network covered in this study. The proposed research optimized the existing communication state using Artificial Bee Colony (ABC) by ranking the ingress nodes. To do so, ABC is supplied with a modified set of fitness functions that repeats itself to validate the list of ingress nodes. The proposed work results in optimal Quality of Service (QoS) parameters, resulting in increased throughput, PDR and reduced delay in the overall network. The suggested work is evaluated against current state-of-the-art methodologies and with other Swarm-based algorithms.*

Keywords - *Burst formation, Assignment, ABC, QoS, Network.*

1. Introduction

Due to the substantial increase in data transmission across cloud infrastructure, organizations are pressured to choose a dependable route, particularly copper cable transmission. Several technologies were developed, such as optical transmission, 4G wireless transmission, and communication using the 5G network [1].

Out of these methods, information via an optical network is best due to its benefits, including quick transmission, minimal signal attenuation, excellent safety, & wider bandwidth [2].

Three widely used optical switching paradigms have been established for viable optical transmission. These are Optical Channel Switching (OCS), Optical Packet Switching (OPS), and Optical Burst Switching (OBS) networks [3]. One of the hottest study areas is OBS. OBS can be thought of as an optical circuit switching version. Information is transmitted in OBS as a collection of packets.

Table 1 demonstrates the distinct differences between these three switching paradigms. An end-to-end link is formed in the OCS network among the source and destination nodes to prevent conversion at the intermediate nodes.

The switching of packets along the way with various buffering and processing operations has been done in OPS using the optical domain. The OBS network overcomes the limitations of both techniques mentioned above and supports the switching functions over the internet [4].

Table 1. Differences between OCS, OPS, and OBS network

Features	Optical Channel Switching (OCS)	Optical Packet Switching (OPS)	Optical Burst Switching (OBS)
Uses and bandwidth	Low link usage for dedicated path establishment	Allow traffic by sharing the same bandwidth	Statistical multiplexing allows the multiple nodes to share the bandwidth
Setup latency	Very high setup latency	Very low setup latency	Very low setup latency
Switching speed	Switching speed is faster	Very high switching speed is required	Medium switching speed is required
Processing complexity	Lower	Higher	Between OCS and OPS

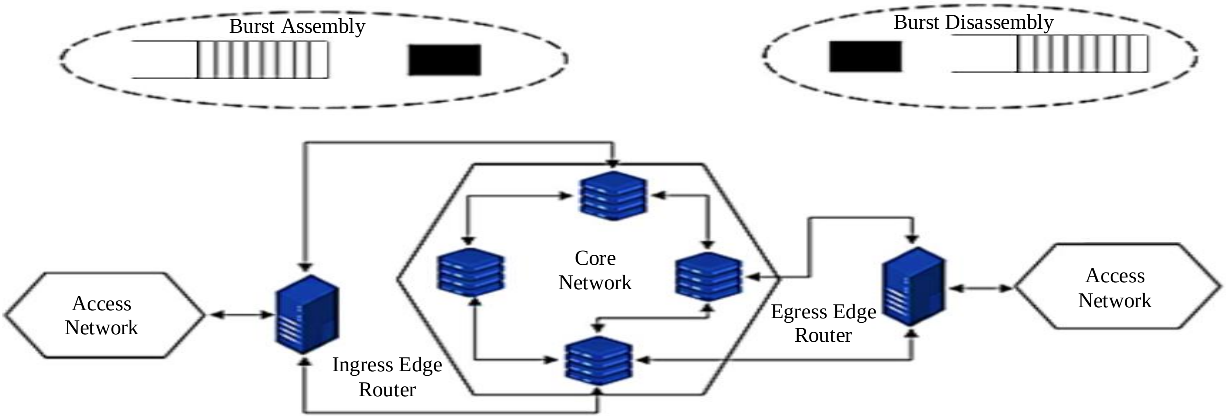

Fig. 1 Architecture of OBS network [1, 2, 15]

An OBS network generally comprises three parts: an ingress node, an egress node, and a network of additional nodes [6]. User data from the access network is combined at the ingress (source) node into a burst for optical domain transmission. The data accumulated in a burst assembly queue and the packets being broadcast to the egress node both required the same level of service.

A control packet called a Burst Control Packet (BCP) can be issued beforehand at the core node to avoid buffering. This packet contains details on the length of the data burst and its arrival time [7]. The burst may be of any size, which is not fixed, but designing a system with significant variations is difficult. Data processing using the BCP for fixed-length bursts is shown in Figure 2. After some time, the separate wavelengths are employed to convey the data bursts. The BCPs have a specific control wavelength. The time between the data burst and BCP sending is offset, sufficient for BCP processing and configuration at intermediate nodes. To reserve the resources before the arrival of the subsequent burst, the offset time is determined.

The data burst is broken up into packets once it has reached the egress node, and then it is transferred to the user through the access network [8]. It is dropped when a data burst hits the intermediate node and finds out the wavelength is in use at that particular time. The packet loss is termed contention loss, which may occur during the simultaneous arrival of data bursts that may exceed the available bandwidth at that specific time.

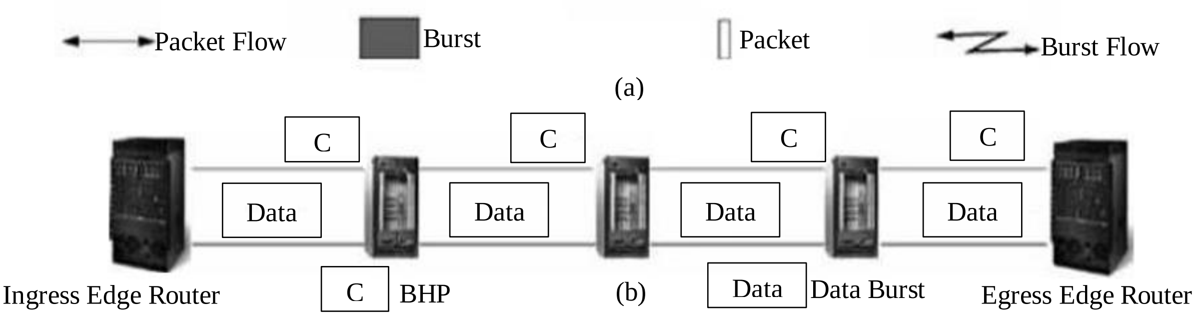

Fig. 2 Architecture of OBS network [1, 2, 15]

The packet loss performance is better, although the packet length is fixed, and the buffer is efficiently designed in the OPS network. To account for the QoS disparity at ingress nodes based on offset time, approaches based on offset time, and approaches based on burst duration. Various methods were developed for the OBS network. Burst assembly strategies were given for application in the real world because the burst size is not known [10, 11]. In Time-Based burst techniques (TB), the transmission of the burst takes place irrespective of size and padding is used for the minimum size of the burst, which restricts the delay. However, Length-Based burst techniques (LB) include bursts that are not transmitted until the burst of decided size is not developed.

However, delays occur in this technique, and traffic self-similarity may incur the problem, which may gain the packet size [12-16]. This paper investigates burst generation in OBS networks, considering length- and time-based approaches. The primary contributions of this study are the following:

- The creation of burst assembly considering the length & bursts' time before they arrive at the egress node.
- An extended Swarm framework is developed to enhance the system's performance in forming bursts with minimum information loss between the ingress node and egress node.

- The developed framework improves the burst assembly process and proposed work compared with existing studies to validate the outcomes.

The structure of the paper is organized according to this section, followed by a presentation of state-of-the-art studies in section 2. The research gap and novelty of this study are discussed in section 3. The proposed work, including the burst formation techniques, is presented in section 4. The statistical results and evaluation of different parameters are illustrated in section 5. Calculating the network's throughput is also given in section 6. The paper is finally concluded in the last part of this article.

2. Related Works

BS is a promising technology with a switching solution for optical transport networks. Due to the wide variety of communication services, Quality of Service (QoS) is crucial in setting the networking system apart. The traditional networking systems are based on coding techniques, switching policies & intelligent control systems in wireless or wired systems [13-16]. The literature has investigated time-based and length-based burst assembling techniques in OBS networks.

Shukla et al. (2018) solved the problem of contending bursts by estimating the burst length. The burst length is developed and fixed so that the average waiting time is kept to a minimum while the burst loss probability is kept to a minimum. The estimation of burst will help the authors to decide the size and avoid contention loss. The analytical results in terms of burst release and burst length are estimated. The packet arrival time was calculated, and optimal values were selected to minimize the average waiting time. The minimum error was 0.87 for a burst of 20 packets around 3.8 units in length. The study provided better results but was limited to the desired results for different burst lengths [10].

Shamandeep et al. (2022) proposed a deflection routing approach using machine learning. The authors demonstrate the improvisation in QoS parameters using machine learning. The authors divided the aggregated dataset into groups to arrange them as good, moderate and bad clusters. The created clusters help avoid data communication, while deflection routing is based on the created clusters and their ranks.

Rajab et al. (2018) evaluate predictive Machine Learning (ML) to reduce the probability that BCP flooding risks may materialize in OBS networks and recommend a decision tree-based architecture as a feasible countermeasure. This uses a learning method that builds rules from tree models using information from numerous simulation runs. The findings demonstrate that 93% of BCP flooding attacks will be correctly sorted into either Behaving (B) or Misbehaving (M) classes when using the concepts obtained from our learning system. The proposed system provides an accuracy of about 87% and is limited to building the network using enough nodes [17]. Barpanda et al. (2018) presented a QoS-aware burse switching technique by allocating the wavelength in the OBS network. The study is based on identifying a bi-objective problem minimized using the objective functions for the transmission requests. The authors used the Differential Evolution technique for the dynamic selection of route and framework development to reduce the burst loss. The authors computed the network congestion and proposed the burst loss model. The analytical results are improved, but the study was limited to determining the delay and wavelength resources for specific applications [18].

Gupta and Asthana's (2018) study discussed a technique that allows for the storage of bursts by demonstrating an estimate of burst length for a specific load and assembly time. However, each burst may contain different numbers of packets. As a result, the first control packet in OBS is delivered to a reserved advance path, and then an explosion is transmitted along the same way. Since the burst length is unknown, contesting bursts cannot be stored; deflection routing is employed instead. Finally, simulation data are Offered for mathematical analysis, with results displayed using graphs [19].

Chakraborty et al. (2020) used the predictor models to determine the performance of bursts in the OBS network. The traffic in the OBS network was predicted using the Linear SVM, Linear Regression, and Random Forest techniques. The probability of determining the blocking of bursts was determined using the principal component analysis technique, and a further Wilcoxon rank test was used that provided an accuracy of about 80%. The study is limited to providing the validation and constraint to use the limited number of nodes [20].

Vo et al. (2020) presented a QoS differentiation-based technique to avoid data loss. The burst's duration and offset time are taken into account by the authors. The parameters are adjusted adaptively as per feedback void size. The proposed mechanism successfully improves the scheduling rate and reduces the burst delay. However, the proposed mechanism failed to avoid the head overlaps and also needed to determine the time offset for complete isolation of scheduling [11].

Cui and Srivastava, in 2021, developed the multi-objective genetic algorithm-based routing optimization method, and it transforms the multi-constrained network QoS issue into a constrained multi-objective routing optimization issue. The best route for OBS network service is found while working under several constraints to optimize OBS network QoS routing. The results show that an optical OBS can send out video, text, and photos with an average latency of less than 400ms when utilizing the suggested method. The proposed algorithm can increase the packet delivery rate of information transfer while reducing transmission time, blockage probability, and OBS network costs [21].

Duong et al. (2022) focused on developing a controlled retransmission system in the OBS network. The mathematical analysis and state transition diagram were implemented in addition. The suggested retransmission system is additionally validated using a retrial queue-based analytical model. The design and analysis findings demonstrate that, regarding byte loss probability, successful retransmission rate, and network performance, the regulated retransmission strategy is more effective than the earlier suggested schemes [22].

Ujalambkar and Chowdhary, in 2022, put a PROMETHEE-II-based multi-criteria channel selection technique to improve network performance and decrease bandwidth utilization and latency. OBS networks are in charge of sending heterogeneous network traffic as rapidly as possible to the desired nodes.

A significant difficulty for OBS networks is channel allocation for network traffic because of the massive amount of data through optical media. The OBS central controller operates the principal optical switches and directs network traffic across the proper channels in the client-server architecture the authors created. Although the data transmission rate has increased, optimal bandwidth utilization is challenging [23].

Oh. Se-yoon and Hyun, in 2002, to improve network performance, the study discussed references that emphasized the shortcomings of existing approaches. The study showed that upgrading the network to IPV6 without hardware and increasing the network packet flow lifetime was possible. The strategy outlined addresses the difficulties in wired-wireless integration and seeks to lessen problems with handoff [26]

J. Spath et al. (2002) discussed increasing network speeds; this study used a tried-and-true protocol and applied it to hybrid architecture. By increasing the signal strength of the MPLS devices and allocating distinctive autonomous numbers to identify them within the network domain, the authors in reference [27] increased the network's effectiveness [28]. This resulted in a reduction of processing, forwarding, and routing overheads.

The authors of [29] implemented a proposed scenario and compared it to various algorithms to determine its efficacy. According to their findings, the current algorithm delivered more accurate results than the old methodology. There are now several issues, such as bandwidth limitations, connection problems, and unresponsive next-hop stops. The current strategy has shown to be very successful in resolving these problems.

3. Research Gap and Novelty of the Work

It is challenging to handle the contention loss for a bufferless optical burst switching network in a burst switching network.

1. Contention, which reserves the data burst wavelength, is one of OBS's research gaps. Optical burst switching networks use data contention methods like wavelength conversion, burst splitting, and fibre delay lines.
2. By effectively utilizing bandwidth and reducing contention losses, optical burst switching networks are more advantageous than optical channel and packet switching. The performance is superior regarding packet loss even if the packet length is set and the buffer can be readily designed in an optical packet switching network.
3. Various methods were developed for optical burst switching networks to account for the QoS disparity at ingress nodes based on offset time and approaches based on burst duration. Burst assembly strategies were given for application in the real world because the burst size is not known [10, 11].
4. In Time-Based burst techniques (TB), bursts are transmitted regardless of size, and padding is employed to set a minimum burst size that limits the delay. However, using the based burst technique, the bursts are delayed from transmission until they reach the predetermined length. However, this method causes latency and traffic self-similarity, which may cause an issue that increases packet size.

After discussing the research gap, this paper investigates burst generation in OBS networks, considering length- and time-based approaches.

- The assembly of bursts considers the length and timing of bursts before they reach the egress node.
- The system's performance will be improved in the production of bursts with the least amount of information loss between the ingress node and egress node, thanks to the development of an enhanced swarm framework.
- The created framework enhances the burst assembly process compared to previous research to validate the results.

4. Proposed Model

The suggested work is centred on developing bursts in the OBS network utilizing the ML framework. The QoS differential based on offset time and burst length is considered when forming the burst assembly. The High-Priority Burst's (BHP) offset time is longer than the Low-Priority Burst's (BLP) offset time, which is one of the Offset Times (T_{off}) based approaches.

$$B_{HP} > B_{LP} \tag{1}$$

The burst with the most extensive Offset Time is scheduled in assembly when contention arises, whereas the shortest (T_{off}) is dropped. The burst Length can be Short (L_S) or Long (L_L), depending upon the burst priority. In the case of LB differentiation, B_{HP} is set to L_S while B_{LP} is set to L_L.

The main reason for setting is that a burst having L_S has more probability of scheduling with the filling of voids and is more successful than a burst having L_L. Further, the formation of burst assembly is divided into two QoS-based requirements: Fixed time-based and fixed length-based, which are explained in the following sections.

4.1. Fixed Time-Based Burst Assembly

The fixed assembly time algorithm uses the algorithm with a specified time mechanism as the primary criterion. Considering the Time (T) set for the formation of bursts, each burst must be larger than the minimum length. Consider a time for burst formation is fixed with a Time window (T) with a minimum (L_{burst}) of n number of packets. Generally

$$n < \lambda T \tag{2}$$

Where L_{burst} is the Burst Length, and λ is the Average Arrival Rate of the traffic. Initially, t=0 as defining the parameters $((t))$ for the arrival of data at time t=0, $((t)) = 0$. The different step considered is given as follow:

Algorithm 1: Time-Based Formation of Burst Assembly

1. Consider the queue of burst assembly is empty, and the time counter is set to 0 with the incremental counter.
2. When $t = T$, if $(k_i(t)) \geq n$ then send every gathered data packet for burst (j)
3. Else
4. Using padding, raise the size of the data until it reaches a size of n and then send it as a Burst j at a rapid pace.
5. End if
6. Increase the index of burst and repeat from step 1.

4.2. Fixed Length-Based Burst Formation

Fixed length-based BA algorithm considers the maximum assembly time as the primary criterion depending on the burst size. The burst has been sent as soon as the L_{burst} exceeds the given burst length to reduce delay. The algorithm for fixed-length BA is given as follows: -

Algorithm 2: Length-Based Formation of Burst Assembly

1. Set the different parameters such as maximum L_{burst} of N and minimum l_{burst} of n with a complete assembly window of Time (T). Normally,

$$n < \lambda T < N \tag{3}$$

2. With a maximum assembly Time window of (T) as ((t)), the data accumulated in the i^{th} burst at time t. In this case, k_i (0) $\neq 0$ because, if the size is more significant than n packets, it is feasible that some data from the previous burst (i=1) still exists in packets.
3. If the buffer assembly is not empty or new data arrived then initiate the timer, t = 0 and it is incremented with time;
4. If $(k_i(t) \geq n)$ then
5. Go to step 2;
6. End if
7. If (t) ≥ T then
8. If (k_i(t) < n then
9. Rise the size of the data in the burst assembly to n using padding & send the data out as burst (i) immediately;
10. End if
11. Increment I;
12. End if
13. While $T_{data\ size} > N$ do
14. Subtract the L_{burst} of N from the buffer and, send the burst (i) immediately and increment (i)
15. End while
16. Go to step 1.

The given algorithm forms the burst of maximum burst size ‘N’ by ensuring that maximum BA time ‘T’ must be small relative to N’s largest burst size. In such a scenario, this length-based BA method is equivalent to the time-based BA method. In other words, the time-based algorithm is identical to the length-based method only if λT" N. However, N may be relatively small to T so both ways will be treated differently for the formation of Burst Assembly. Figure 3 shows the burst-switching process in OBSN during the burst formation.

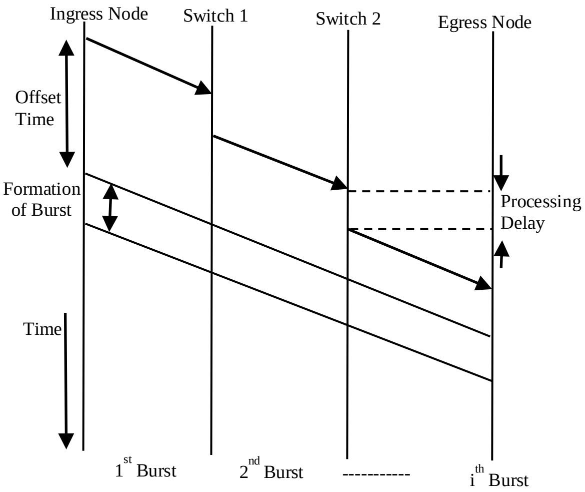

Fig. 3 Burst switching in OBS network [5, 6]

The method of time-based switching implies that the burst may be created according to time or length. The proposed preliminary approach utilizes a hybrid approach scheduling in which either a fixed time interval is over or a fixed length of packets has been attained is simulated. The suggested work analyses the Quality of Service (QoS) factors based on the simulation to assess the system’s performance. Based on the QoS, the proposed work creates a rank of ingress nodes utilizing Artificial Bee Colony (ABC) based on Swarm Intelligence (SI) algorithm architecture. Figure 4 depicts the total system architecture as follows.

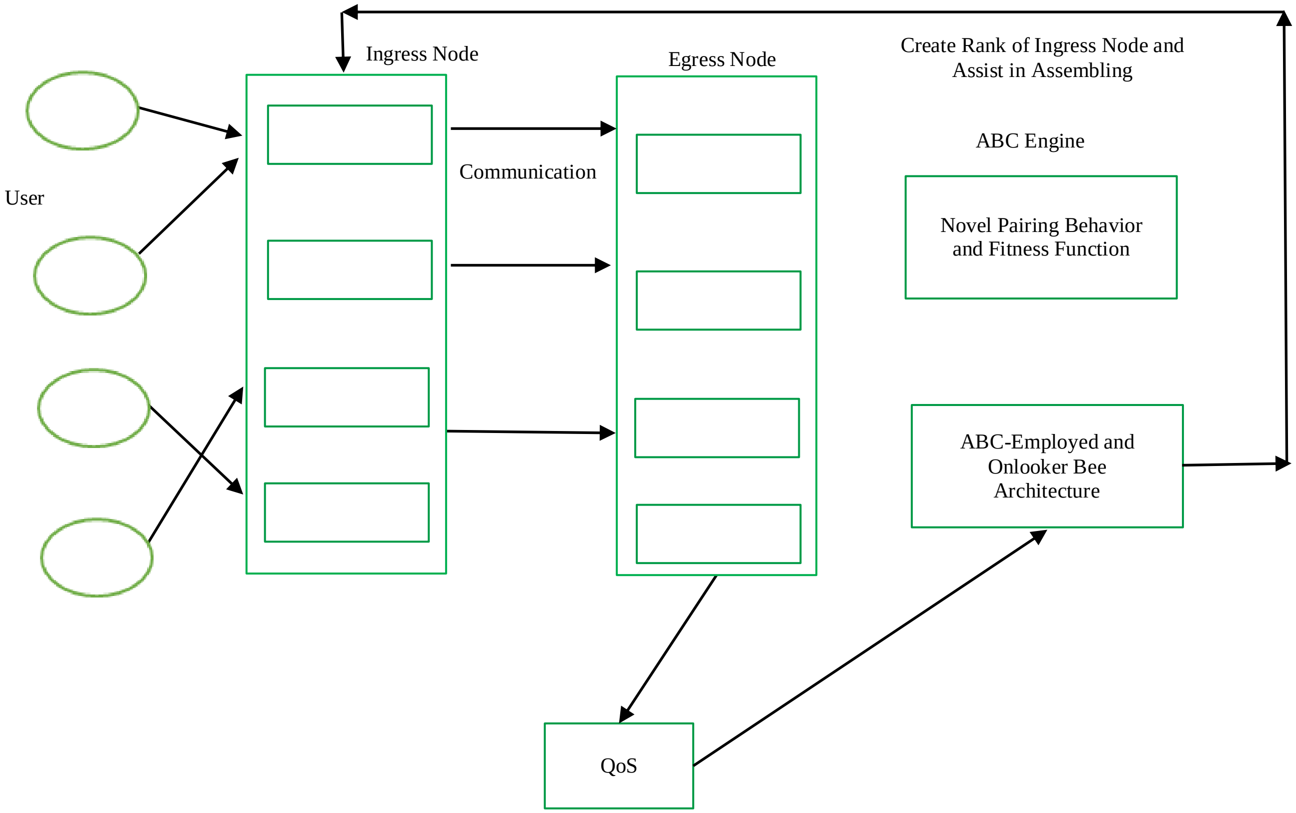

Fig. 4 System model of proposed work

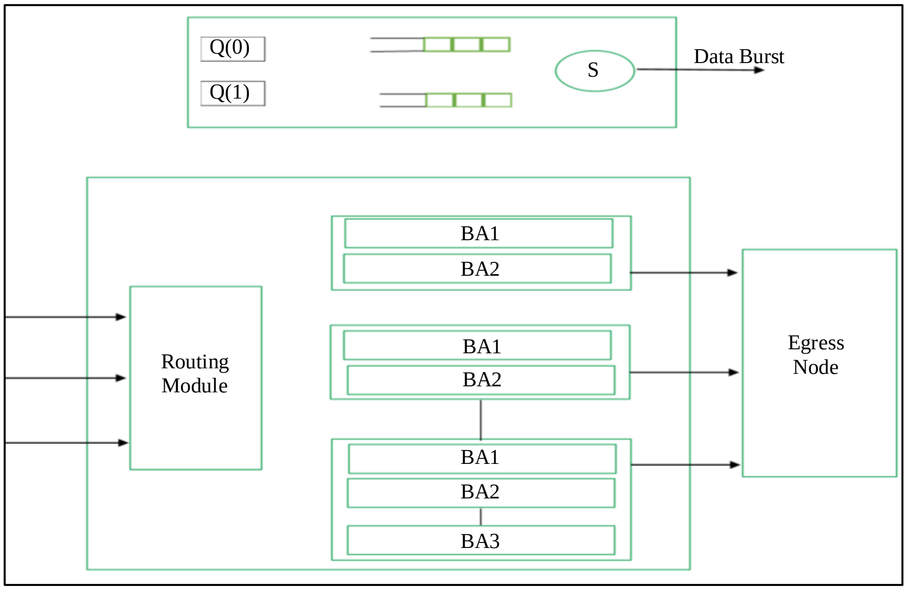

Fig. 5 The routing schemes

To list down the ingress nodes, the scheduler at the ingress node broadcasts the requirements to other ingress nodes. Based on the buffer delay, the overall computation delay is computed using equation (4) as follows.

$$D_b = \frac{Br}{At} \tag{4}$$

Where B_r is the total remaining burst in the buffer of the ingress node before putting the request burst in the queue, AE is the average execution efficiency of the ingress node. The ingress node with the minimum Db is selected for sharing the load as per the deflection routing concepts shown in Figure 5. The ABC algorithm architecture uses the ingress node information with QoS parameters presented in Table 2.

As shown in Table 2, at the source end, there may be 1 or more than one ingress node. One ingress node may act in multiple formations with other ingress nodes.

This is done to share the network's load and increase the network's efficacy. For example, the route highlighted in red consists of the same ingress node, 73. In the proposed case scenario, ABC uses this information to rank the routes via the involved ingress nodes for the burst assembly and assists the network when the burst assembly is needed. The overall work can be illustrated using the following flow diagram shown in Figure 6.

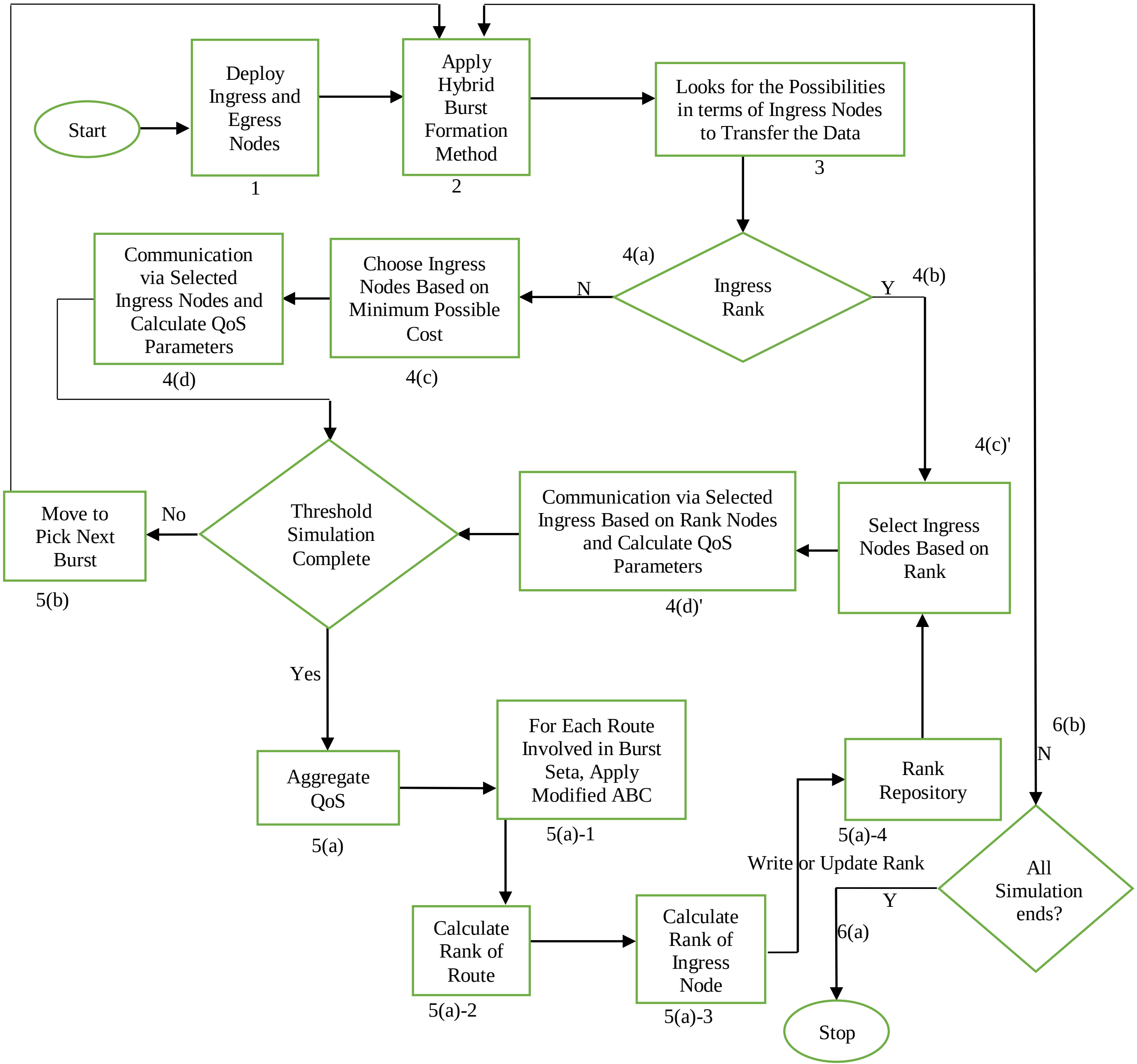

Fig. 6 Proposed work flow

In this context, the ordinal measure of the ABC algorithm is provided as follows.

4.3. Artificial Bee Colony (ABC) Optimization Technique

Karaboga [24] developed the ABC optimization techniques by analyzing the social behaviour of the swarm bees. In the ABC algorithm, each bee is considered as a data packet. A colony of bees forms a coherent behaviour, and integrated behaviour discovers more food from the flowers in the form of nectar. Each bee colony consists of three distinct groups: scout, employed, and observer bees, each performing a specific function. Scout bees pick one of them and randomly search the surrounding area for a new source. Scout bees locate a new food source and save the position in their memory.

Additionally, after returning to their hives, the bees have done a waggle dance to communicate information about the meal. Afterwards, some scout bees search for food, and employed bees utilize the previous food source. However, onlooker bees wait for the exchange of information through dance by scout bees, and then these bees are selected as a source for exploring the best food as the bee's fitness function or response of the bees towards the food source. Various engineering and industrial applications will solve their complex problems using these optimization algorithms.

The main steps of the algorithm are: -

i. Initialization of bees
ii. Repetition of bees until they locate the food source.
iii. Sending employed bees for supervision
iv. Information exchange by the scout bees
v. Sending onlooker bees for the best optimal food
vi. Sending scout bees to get information about more new food source
vii. Repeat until desired results are obtained.

The proposed optimization technique is applied to form bursts in different steps considering the QoS differentiation as per length-based and offset time-based burst formation.

Table 2. Routing results post burst formation

Total Number of Bursts	Ingress Nodes Involved	Egress Node	Average Burst Utilization	Throughput	PDR	Delay
10331	77, 40	14, 8	0.31517984	6151.79843	0.37821581	8.74906968
10220	43, 42, 94	25, 24, 55	0.15134629	4513.46293	0.18161555	9.43408233
10942	100, 72	73, 52	0.46890467	7689.04667	0.5626856	7.13341023
10681	63, 83	21, 28	0.29320635	5932.06347	0.35184762	8.05367432
10990	12, 74, 73, 27	1, 7, 7, 2	0.42944178	7294.41779	0.51533013	7.0574326
10197	87	12	0.25189816	5518.98163	0.3022778	9.28795518
10017	37, 78, 97	10, 22, 27	0.12302727	4230.2727	0.14763272	9.68826011
10790	88	42	0.13902759	4390.27593	0.16683311	9.64591407
10331	73, 89, 56	30, 37, 23	0.0995531	3995.53101	0.11946372	10.8005078
10621	16	12	0.25885383	5588.53829	0.31062459	8.30188842

Step 1: The bee population consists of employed and unemployed bees. There is only one group per type of food. Around the food supply, there are numerous bees in use for distinction. Therefore, the number of bees engaged is directly correlated to the food supply, and these food sources identify the initial solutions, with each solution then being developed in connection to the problem. Each set of ingress nodes at the source end will function as an employed bee in the case of the proposed task. The group of bees is represented by B.

Step 2: Using the relationship mentioned above in step 1, a new answer is created for each particular problem [24]:

$$x_i^{t+1} = x_i^t + \beta_0 e^{-yr^2 ij}\left(x_j^t + x_i^t\right) + \propto \qquad (5)$$

$$Th_{solution} = Rpop\ (B_{\mathrm{QoS}} > \sigma)$$

Where σ is the average of the sample population considered, where x_i^{t+1} is the next stage of one bee, x_i^t is the current state of the bee, $\propto$ is the randomization parameter {0-1} r_ij is the distance of the distribution =x_i – x_j, where i and j are the bees, β is the food attraction index, and γ is change in attraction. To form the ABC architecture, the following algorithmic approach is adopted.

```
1. While gen.  // where gen in the maximum number of generations to populate a new solution
2. For $i = 1 : B$
   a. for $j = i + 1 : B$
   b. $x_i^t = x_i^t$. QoS // Extract attained QoS
      $x_j^t = x_j^t$. QoS // Extract attained Qos
   c. Calculate the next state by applying equation (5)
   d. If $x^{t+!} > Th_{solution}$
   e. $Th_{solution} = x^{t^{+!}}$ // Update the threshold solution
            i. $(i, j) += + x_i^{t^{+!}}$
            ii. End If
3. End For j
4. End For i
```

After producing a new solution, if its value exceeds that of the existing solution, it is replaced; otherwise, it is not used.

Step 3: This step involves computing the probability of bees from each site using Equation 6 [25].

$$\text{Probability} = \text{Sort}\,(\text{Mean}(\text{R})) \quad (6)$$

// The probability is the sorted order of the rank

Where, $Probability$ is the probability of selection by the onlooker bees. As per fitness value, several bees are allocated to various numbers of packets in the burst. Considering the fitness value, all the bees in the population are earmarked for the food site. After computing each source's worth, a new solution is produced using the Equations (4-6). This solution replaces the former if the value is better; if not, it is omitted. The exact process is carried out for forming the bursts.

Step 4: After the computation of the finite solution, repetition will be finished once the condition for the given algorithm is met; otherwise, it will return to step 2.

The scheduling of packets in the burst assembler forms the basis of the routing architecture, which supports burst generation while considering QoS differences. The routing node chooses the output port for each data packet before sending it to the burst assembler module.

Packets are gathered depending on priorities, which might be high or low, for associated egress nodes. Priority class Q has two queues: Q(0) for high priority and Q(1) for low priority [11]. When the offset time is reached, as a burst is created, the scheduler sends it to the output port, as shown in Figure 6. The suggested algorithm's efficiency is evaluated based on two factors. The first aspect compares how well ABC performs when it helps the framework and how well it performs when it allows the OBS network.

The proposed work in the second scenario has been contrasted with comparable state-of-the-art pieces, and the following example is provided in the next section.

5. Results and Discussion

The evaluation of the results has been made on the base of QoS parameters based on Average burst utilization, PDR and delay based on the scenario that if the ingress node increases, what effect does it make on the overall received QoS parameters. To do so, the following simulation setup has been completed.

Table 3. Simulation ordinal measures

No. of Ingress Nodes	Min: 50, Max: 150
Simulation Tool	MATLAB
Toolboxes	Data Acquisition Toolbox
Supported OS	Windows 8 and above/ Macintosh 13.01 and above

For comparing the proposed work, A minimum of 50 ingress nodes and a maximum of 150 ingress nodes have been deployed for the simulation. A comparison has been made to validate the suggested outcome with two other state-of-the-art methods in the same simulation environment. When ingress nodes increase to 20% of the current number, there is a 1000-burst increase in load on the network. Initially 10,000 bursts have been initiated. Proposed works have been verified using the QoS parameters, as shown in Table 4.

As shown before, the suggested work has been validated for a minimum of 50 ingress nodes and a maximum of 150 ingress nodes. The proposed method performs more effectively overall than the other state-of-the-art methods, Rajab et al. [17] and Shamandeep et al. [15]. The proposed work chooses the ingress nodes with higher rank due to the ingress nodes' rank-based mechanism. After a set number of 1000 simulations, the rank is also modified.

Hence, the nodes never become overburdened or under-loaded. With an increase in the number of ingress nodes, the overall throughput in bursts per second rises. This results from the ingress nodes' ability to share their burden; hence, more ingress nodes allow more bursts to transfer.

For the maximum number of ingress nodes, viz. 150, the proposed work demonstrates a throughput of 9243 bursts per second, whereas the total number of bursts that could be transferred via Shamandeep et al. [15] is noted to be 8296 burst per second. For a similar scenario, 7966 bursts per second have been observed by Rajab et al. [17]. The proposed work has also been evaluated for delay and PDR. In both scenarios, the proposed work shows improvement compared to the other two states of art techniques. The improvements compared to state-of-the-art techniques can be represented using Figure 8.

Table 4. QoS comparison

No. of Ingress Nodes	Throughput Proposed	PDR Proposed	Delay Proposed (sec)	Throughput Shamandeep et al. [15]	PDR Shamandeep et al. [15]	Delay Shamandeep et al. [15] sec	Throughput Rajab et al. [17]	PDR Rajab et al. [17]	Delay Rajab et al. [17]
50	8608.39	0.905	3.906	8359.24	0.834	4.200	8516.921	0.809	4.285
60	8883.14	0.923	3.254	7580.98	0.900	3.722	7635.509	0.848	3.670
70	8612.56	0.898	4.049	7735.45	0.833	4.501	7037.737	0.817	4.052
80	8510.10	0.892	4.245	7745.71	0.795	4.613	7195.066	0.767	4.889
90	8730.16	0.919	4.719	7987.19	0.915	5.053	7301.056	0.791	4.719
100	8959.17	0.944	5.875	8927.61	0.863	6.343	7781.836	0.855	5.926
110	8438.70	0.903	6.479	7864.29	0.778	6.596	7526.745	0.884	7.284
120	9183.22	0.916	7.091	8263.30	0.790	7.640	8047.130	0.871	7.643
130	8644.87	0.981	7.894	7680.60	0.919	9.366	7528.052	0.886	8.987
140	9238.61	0.970	7.993	7936.00	0.941	8.999	9114.969	0.952	9.001
150	9243.93	0.989	8.947	8296.23	0.960	10.136	7966.619	0.933	9.593

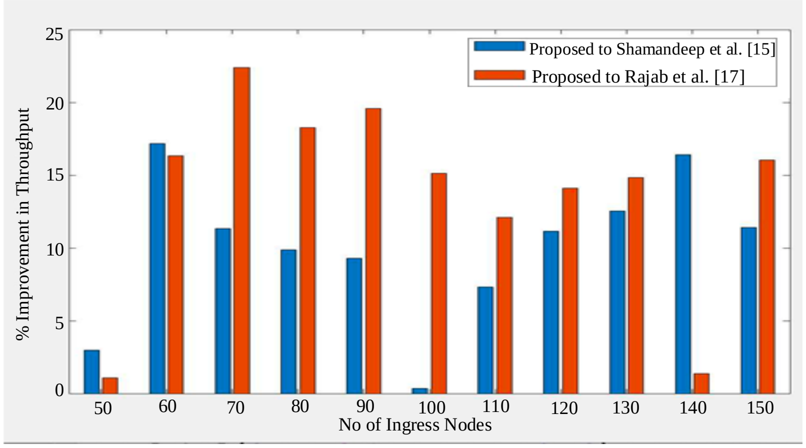

Fig. 7(a) Improvement analysis on throughput

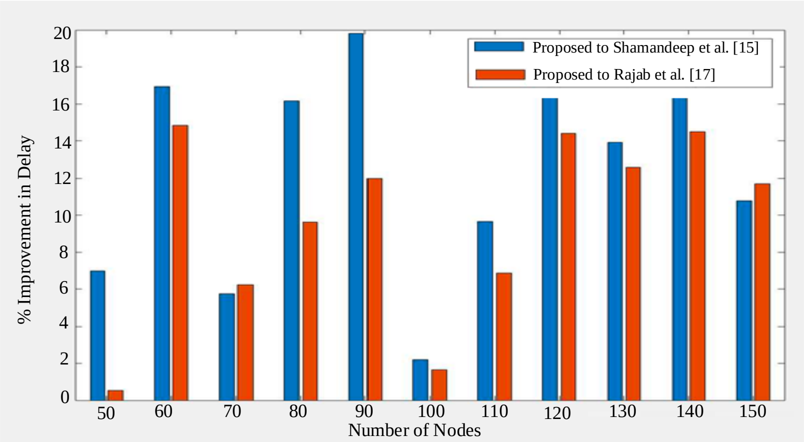

Fig. 7(b) Improvement analysis on delay

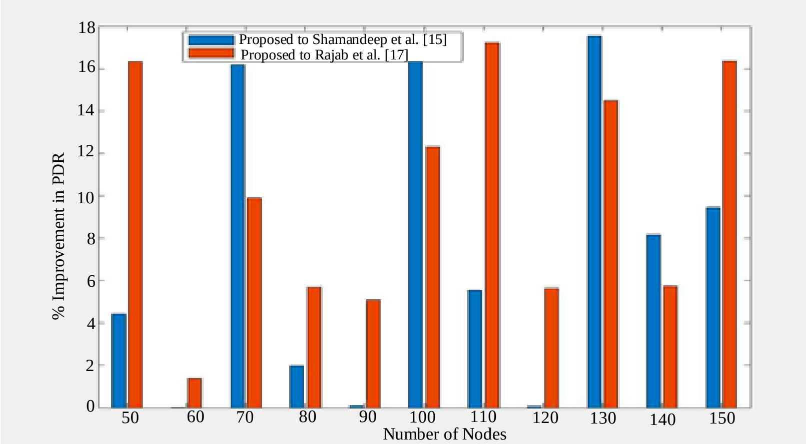

Fig. 7(c) Improvement analysis on PDR

In terms of throughput, the proposed work is 9.9862 % improved overall compared to Shamandeep et al. [15] and 13.74% compared to Rajab et al. [17]. Regarding PDR and delay, 7.8011%, 9.0528% and 9.0108%, 7.5107 % improved compared to defined state-of-the-art techniques. The improvement is due to the better ranking policy of the proposed work that minimizes the delay by considering a more efficient ingress node for load transfer and sharing.

To be more specific on the ranking mechanism, the suggested ABC algorithm is compared with state of the art optimization algorithm and the results are listed in Table 5.

Table 5. QoS comparison of optimization algorithms

No. of Ingress Nodes	Throughput Proposed ABC Bursts per Second	PDR Proposed ABC	Delay Proposed ABC (Sec)	Throughput PSO	PDR PSO	Delay PSO (Sec)	Throughput Firefly Bursts per Second	PDR Firefly	Delay Firefly
50	8722.806	0.920	3.578	8538.943	0.788	4.092	7384.987	0.836	4.103
60	8567.357	0.917	3.818	8269.727	0.813	4.422	7198.328	0.903	4.270
70	8479.224	0.903	4.280	7226.611	0.902	4.731	7811.350	0.834	4.384
80	8948.031	0.925	4.404	8415.531	0.886	4.452	7617.373	0.915	5.146
90	8430.910	0.920	4.505	8019.693	0.815	5.371	7706.652	0.872	5.005
100	8476.741	0.890	5.264	7708.013	0.802	5.887	7475.528	0.879	5.845
110	8424.904	0.934	5.620	7745.738	0.800	5.776	7215.482	0.833	6.648
120	8424.322	0.891	6.056	8157.364	0.875	6.486	8101.981	0.844	6.315
130	8457.136	0.986	6.978	7463.351	0.948	8.583	7027.002	0.947	7.063
140	8469.295	0.887	7.476	7756.153	0.754	7.803	7662.024	0.767	7.811
150	8456.437	0.963	7.823	8419.009	0.846	8.240	7266.349	0.950	9.173

Table 4 shows that the work suggested is superior to all other comparative optimization algorithm architectures because of its distinctive method for sampling the rank covered in the proposed work section. To be precise on the improvement, the % improvement in each aspect is shown in Figure 8 (a,b,c). The proposed work demonstrates improvement in a range of 7-10% in every aspect of the usage of the SI algorithm.

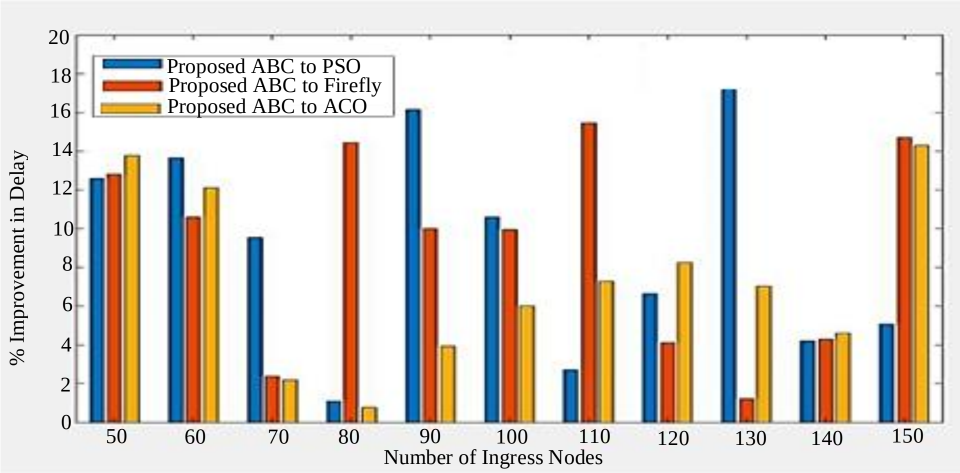

Fig. 8(a) Improvement analysis of the proposed ABC with other SI algorithm on delay

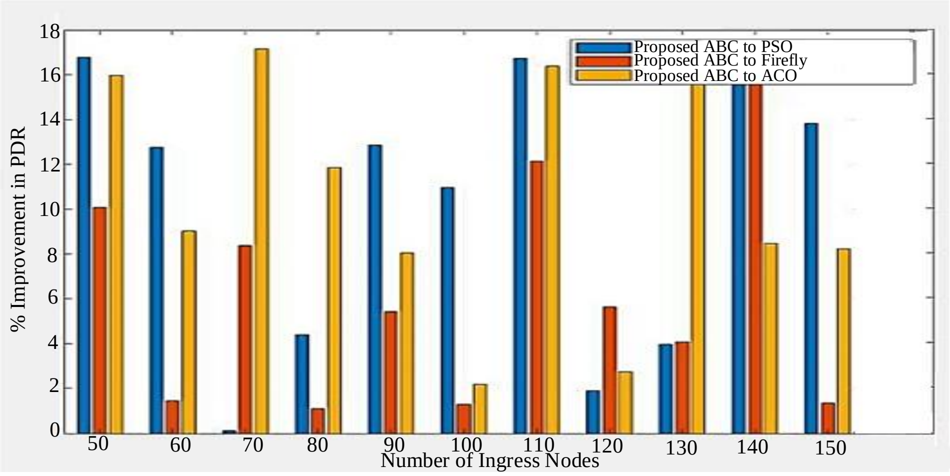

Fig. 8(b) Improvement analysis of the proposed ABC with other SI algorithm on PDR

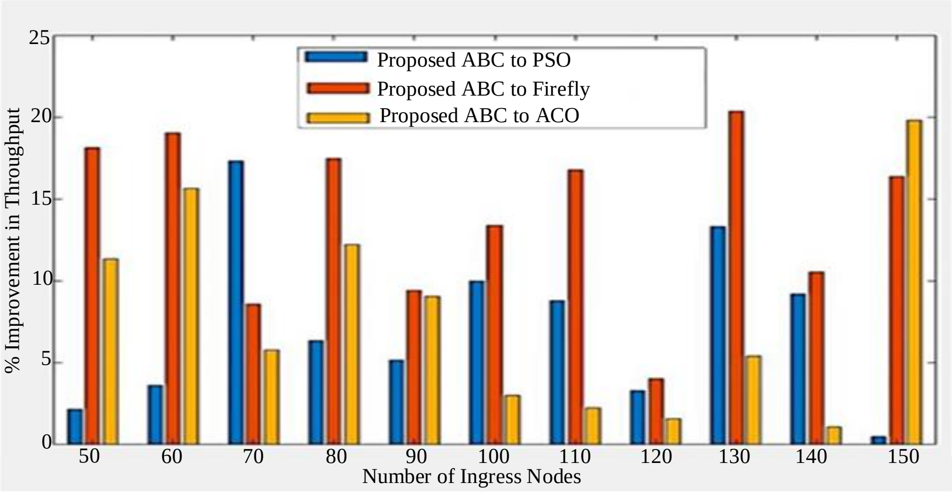

Fig. 8(c) Improvement analysis of proposed ABC with other SI algorithms on throughput

6. Calculating the Network's Throughput

Throughput is a crucial parameter that indicates the current speed of a network. It serves as a primary indicator of network speed for an organization. In the event of reduced network speed, congestion may be the cause.

In such cases, alternative measures can be taken to enhance network quality. The current network possesses a minimum bandwidth of 5.07 packets per second, while the suggested system is expected to operate at 2.5 packets per second. The outcome mentioned above was obtained via the employment of the OPNET simulator [21, 22]. The MPLS network [23, 24] utilizing packet switching technology establishes a virtual circuit from end to end and designates a random port for transmitting data between disparate networks. The proposed framework is designed to be resilient across a range of network devices with varying processing speeds while ensuring that end devices receive a high quality of service. The throughput output shown in Figure 9 is prepared using the OPNET simulator in which the time in seconds is represented in the y-axis. Firstly, the packets start rising from 0 to 7 packets and then begin forming a sine wave graph as soon as the time of transmission increases.

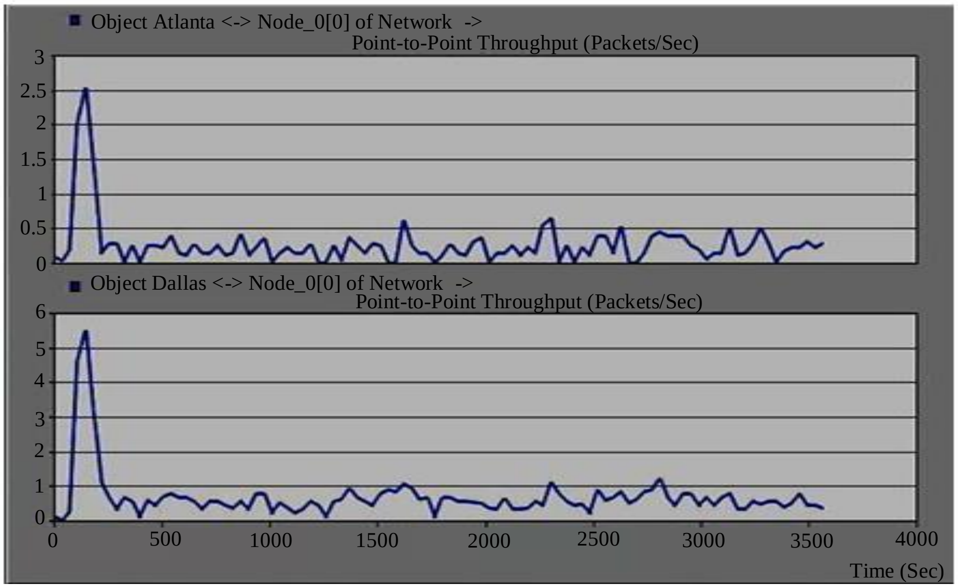

Fig. 9 Network simulation using the MLPS

7. Conclusion

This paper discusses a swarm-based optimization algorithm to rank the ingress nodes based on their performance during burst allocation. The burst is formed using a hybrid method of burst formation that includes a combination of time- and length-based burst formation. The proposed work forms a ranking mechanism based on the QoS parameters attained up to a specific simulation to transfer the burst from one end to another from the ingress nodes to the egress nodes. Once the threshold simulation is complete, the data in terms of QoS and list of ingress nodes involved in the communication is aggregated. Each set of ingress nodes is considered as one bee in the proposed work, and the rank of the bee is further divided into individual ranks by sharing the rank in equal proportions.

The proposed ranking method is evaluated for QoS parameters by comparing it with two other state-of-the-art techniques presented earlier. To be precise on calculations, the proposed work is 9.98% and 13.74% more efficient in terms of throughput as compared to [17] and [15], whereas 7.8011%, 9.0528%, and 9.0108 %, 7.5107 % more efficient in terms of PDR and delay as compared to [15] and [17]. The proposed work can be modified further by introducing a training mechanism that may reduce the overall computation complexity of the burst communication.

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