

Optimal Algorithms for Load Balancing in Optical Burst Switching Networks

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Abstract: Data packet drop can happen in Optical Burst-Switched (OBS) when two data bursts are competing on the same wavelength. Recently, many techniques have been developed to solve this problem but they do not consider the congestion. Also, it is necessary to balance the load system in the OBS network. The Ant Colony Optimization (ACO) technique can be applied to determine the straight and the safest route. However, the ACO technique raises both power utilization as well as the execution time. In this study, Cuckoo Search (CS) and ACO methods based approach is proposed to avoid the congestion and load balancing in the OBS network. This strategy evaluates the intensity of hotspot data and then launches the congestion rate optimization process that depends on their load situations. The congestion rate optimization represents the available bandwidth, data distribution rate, queue size, and access rate, and also these factors are optimized through the CS technique. The fitness utility in the CS technique adjusts the distribution rate in the OBS network, and the proposed ACO technique solves the energy utilization problem. The simulation results proved that the presented strategy evades both the end-to-end delay as well as the possibility of packet drop.

Keywords: Ant colony optimization; cuckoo search; optical burst-switched; load balancing; congestion control

1 Introduction

OBS [1] is a significant switching technology in future networks. However, the major concern in OBS is the routing pathway choice that can manipulate the burst loss possibility robustly. Therefore, almost all literature presumed that the shortest pathway routing in these analyses are not optimized. Several studies [2] use load balance strategy in circuit-switching systems with distance routing algorithms. However, this strategy is inappropriate for OBS networks due to the high speed requirement for burst communication. Though, deviation routing [3] can be a substitute in OBS, it has several drawbacks such as additional offset-time and probable harmful effects [4]. However, it is efficient for conceiving the present link congestion rather than the network's entire status. One possible strategy is to choose a set of optimized routing algorithms based on the entropy of useful topography and traffic load dispersion [5].



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The quality of service in OBS networks is mostly based on several key restraints, explicitly, route restraints, link restraints, and tree restraints. The foremost fundamental restraint is the bandwidth; likewise, the delay as well as delay-jitter [6]. Fuzzy and CS techniques are employed to discover the table route at the sender and also at the receiver node. In this approach, the route detection part is restricted cleverly by applying the fuzzy logic which restricts the router request messages. Thus, the compulsory additional overhead can be resourcefully embarrassed [7]. This intellectual hybrid strategy is the major efficient meta-algorithms that chooses the steadiest and the optimal path between the recognized routes via computing fitness function.

An ACO based load balancing algorithm is discussed in [8]. In order to balance the sensor node's energy consumption, pheromone trail update method is employed and also it uses the pseudo-random route discovery technique. A heuristic update algorithm is utilized to optimize the path formation. To reduce the energy utilization, energy based broadcast method is utilized.

Multi-objective Optimization using the ACO algorithm (MOACO) is discussed [9] for grid over OBS networks. It optimizes three parameters; load balancing, payment and completion time using ACO algorithm by considering the resources from computational and network simultaneously. However, MOACO method is unable to balance the network load efficiently and also increases the packet drop rate.

In this study, fusion of CS and ACO technique is proposed for adaptive load balancing in the OBS network. In this strategy, the ACO technique is employed for establishing a route from the source to the destination. The CS technique is employed for congestion evading if the congestion is present by adjusting the distribution rate. The congestion control is essentially focused to avoid the packet drop and to remove the congestion as well.

2 Related Works

Congestion occurs when the necessary resources are extra than its obtainable capability. It leads to data packet loss, throughput destruction, and energy wastefulness. To avoid congestion control in the Medium Access Control (MAC) layer, a hop-by-hop cross-layer control approach is constructed in [10]. It adjusts the data transmission rate and channel access priority dynamically based on the MAC's information such as buffer occupancy ratio to avoid the congestion.

A sink switching technique is discussed in [11] to avoid congestion control. At first, the congestion is detected using two mechanisms; buffer occupancy and channel utilization strategy. Based on the node rank, it sends a feedback to the congested node. An efficient cross-layer congestion handling strategy is discussed in [12] to detect and avoid congestion. The buffer occupancy is utilized to discover the congestion, and also a hop by hop back pressure method is employed to response quickly when congestion occurs. The source transmitting rate is reorganized through the adaptive rate control technique.

Fuzzy logic based congestion control algorithm is described in [13] based on the local information such as node rate and buffer capacity. This system has the ability to discover the vital signals and also gives priorities based on their importance. It offers an improved service quality to transmit important signs. A new rate control method based on an energy-efficient and emergency-awake MAC is discussed in [14] for avoiding congestion. It is a context-aware scheme that reacts immediately to any emergency events and maintains the usual traffic rate.

A congestion-aware network which improves the transmission performance is discussed in [15]. It consists of two mechanisms to control the congestion; dynamic input arbitration and the selection of router path adaptively. In different traffic scenarios, it improves the throughput. An adaptive routing mechanism based on limited traffic load entropy is utilized to attain better operation in [16]. Router

circuits are designed in such a way that they tolerate the delay variations. It uses mousetrap like protocol with bundled data method to design the router circuits.

A low-latency pipelined switch designs are discussed in [17]. In order to attain high throughput, the router traversal and arbitrations are mixed. This system also provides ultra low latencies. The throughput is enhanced with a data-aided valuation method in [18]. Channel estimation techniques are employed for resource allocation and high throughput is achieved based on the selection and assignment of relays and also channel assignment. Frequency band suppression and throughput enhancement approach discussed in [19] helps to minimize idleness as well as increases the bandwidth capability.

3 Optimal Algorithms for Balancing the Load in OBS Networks

In this study, the fusion of CS and ACO technique is employed to balance the load for reducing the congestion in OBS networks. The distribution rate optimization is adapted through the CS method that permits the forwarder's distribution rate within the recipient node access rate and diminishes the overcrowding. During data transmission, if the forwarder node has greater queue size, then this strategy balances the congestion. The fitness utility is computed to establish the queue size, available bandwidth, distribution rate, access rate, and congestion rate.

This fitness utility estimates the forwarder node distribution rate by using the recipient node access rate. The fitness utility selects the current distribution rate which is lower than the highest distribution rate. Fig. 1 illustrates the working function of the CS method. The fitness utility is computed by Eq. (1) is given below.

$$f = f_{AB} + f_{DR} + f_C + f_{QS} \tag{1}$$

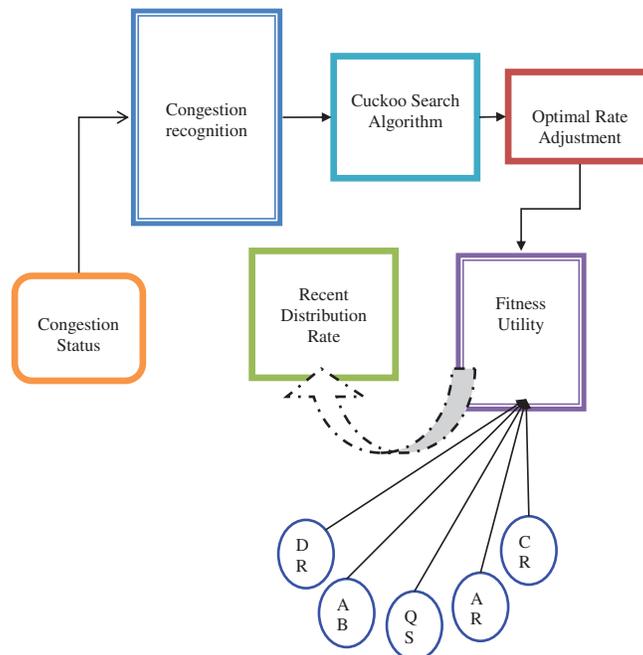


Figure 1: Working function of CS technique

3.1 Distribution Rate

The distribution rate shows that how much the forwarder's recent distribution rate is lesser than the earlier distribution rate of the forwarder. The congestion is avoided if the distribution rate is lesser than the access rate. The distribution rate is obtained by subtracting the ratio between the difference of earlier and recent distribution rate and the earlier distribution rate by one. It is denoted as f_{DR_s} and defined in Eq. (2).

$$f_{DR_s} = 1 - \frac{DR_e^m - DR_r^m}{DR_e^m} \quad (2)$$

where DR_e^m is the earlier distribution rate as well as DR_r^m is the recent distribution rate.

Available Bandwidth rate (AB):

When the distribution rate reduction manages the congestion, the node bandwidth establishes the value of the recent distribution rate. It should be reduced for optimal fitness. The AB factor requires distinctions between the AB of the node and the recent distribution rate. The subsequent part in the fitness utility is measured on the AB of the forwarder node, as well as it is computed by using the Eq. (3),

$$f_B = AB - DR_r^m \quad (3)$$

where AB is the available bandwidth.

Access rate (AR):

The AR of the recipient node should be high for a reliable data communication in the wired network. The purpose is to enhance the access rate task. The AR is obtained by subtracting the ratio between the difference of earlier and recent distribution rate and the recipient node access rate by one. Therefore the AR for the maximal work is achieved. The AR is computed by using the Eq. (4).

$$f_{AR} = 1 - \frac{(DR_e^m - DR_r^m)}{A_e^m} \quad (4)$$

where A_e^m is the recipient node access rate

Congestion Rate (CR):

The CR must be the small when the fitness utility is maximum. The congestion should be minimized to the effective function. The lesser rate of congestion offers superior performances. The congestion rate is measured by the congestion condition. The total congestion rate is diminished by subtracting the rate over the range value of one Eq. (1) which is a significant parameter. The congestion is computed by using the Eq. (5),

$$f_{AB} = 1 - \frac{(1 - TC_m)}{DR_r^m} \quad (5)$$

where TC_m is the total congestion condition

Queue Size (QS):

The last factor conceived measurement is the QS . This parameter in the communication must be lesser for the enhanced function. The QS is computed by using the Eq. (6),

$$f_{QS} = \frac{(Q_m - DR_e^m)}{VQ_m} - \frac{(Q_m - DR_r^m)}{VQ_m} \quad (6)$$

where Q_m is the queue size and VQ_m is the virtual queue size. From the highest fitness utility, the recent distribution rate for the congestion method is selected and utilized by the optimization technique.

3.2 Cuckoo Search Algorithm

It is established on the incubate mutuality character of the cuckoo species. In this approach, the CS technique is applied to optimise the router path. The CS helps to solve the optimization problem by the incubate mutuality character of the levy flight. The adaptative alteration deals with the problem locally and globally with additional search designs. The procedures required in the CS technique are given below:

Stage 1: Initially, the people of the host nest are selected. Presume which the host nest primary people is the recent distribution rate to be selected DR_r^m the rate of the value calculates on $N \times P_j$. Here, N represents the total nodes as well as P_j denotes the recipient. The highest amount of iterations is determined through the optimal result choice. Allow the preliminary people of n host nest represent,

$$X^f = (x_1, x_2, \dots, x_g) \tag{7}$$

Stage 2: Create cuckoo through levy flight via Adaptative Procedure Size (APS). The optimal position for the cuckoo from the host nest is selected from an arbitrarily created host nest. The recognition of the optimal feasible nest via cuckoo establishes on the levy flight. The subsequent formula denotes it,

$$X_d^{(t+1)} = X_d^t + \beta \oplus Levy(\gamma) \tag{8}$$

Here $Levy(\gamma) = t^{-\gamma}$ and X_d represents the recent solution

Then finished an one iteration, following solutions are created arbitrarily through the levy flights. The fresh arbitrary solution creation applying the levy flights holds on becoming the optimization technique to determine the optimal solution. By creating the resolution-making in an adaptative manner, the optimization procedure can be enhanced.

In this ACS technique, the arbitrary creation after the iteration is assisted through an adaptive size of steps. Cuckoo thoroughly explores the recent surroundings for the brooding via missing the recent nest; here, the best solution is not well-matched. But, the ACS method conducts the quick convergence of the best solutions.

The original resolution is substituted with the APS,

$$X_d^{(t+1)} = X_d^t + \beta_A \oplus Levy(\gamma) \tag{9}$$

here β_A denotes the step size and the value of β_A is established by,

$$\beta_A = \frac{y_{best}}{D_i \times 10} \tag{10}$$

here D_i represents the preliminary distribution rate, also y_{best} is the greatest feasible resolution in the earlier iterations. In the CS, the value of β is mainly accepted to be union. Though the value of the β is selected should minimize the local optimum problem, therefore we enhance the efficiency of CS technique. Levy flight is an arbitrary pass at that the recent resolutions are conceived for the optimization. Levy flight selects flight route from a greatly chased feasibility compactness function. The ACS established new solutions created over the meta-heuristic technique. Next, the fitness value for X_d is computed i.e.,) $f(X_d)$

Stage 3: Select the Arbitrary Nest

A solution explicitly distribution rate is preferred at the host nest If the preferred distribution rate's fitness utility is smaller than the ACS distribution rate, the distribution rate of the cuckoo substitutes the preferred solution in the nest.

Since the nest X_j , an arbitrary nest is selected declare X_j .

Compute the fitness utility of the X_j .

If $f(X_d) > f(X_j)$

Restore j through the solution created via the levy flight that is cuckoo.

Stage 4: Worst nest elimination

Even if the solution of the nest is from the cuckoo depends on the detection rate, the resolution with the smallest value is ignored. In this stage, the distribution rate that is larger than the earlier distribution rate is neglected, utilizing the worst-case situation.

Based on the detection rate range P_a between 0 and 1, the worst nests are discarded.

Sage 5: category

The optimal feasible solution in the sequential iteration is categorized based on the fitness utility. Keep the optimal solution and categorized the optimal solution.

Step 6: Iteration

Iterate till acceptance is attained.

Depend on the category value, the optimal feasible resolution is preferred: the rate adapted distribution rate offering the best proficient congestion supervision management.

Through the nonstop iteration of the ACS optimization technique, the greatest best distribution rate is the recent distribution rate for the congestion-free data the communication is received. The recent distribution rate rendered through the CS technique is set as the distribution rate of the forwarder via the recipient concerning the distribution rate of the recipient node. The recent distribution rate received is established to be beneath the distribution rate at the congestion period. As a result, it evades the congestion in the strategy.

3.3 ACO Algorithm

The source desires to transmit the data to the destination via multiple hops; the ACO algorithm is used for transmitting the data. ACO is prompted by the behaviour of an ant as well as it finds better probable routes. To discover the better route, ants are noting their trails together with pheromone while they shift within a network. If the source has no path during data transmission, a route detection procedure is launched other than; a route with a great pheromone value node is chosen. Then, the source chooses the in-between hop attains by pheromone value. This Pheromone Value (PV) computation among nodes i and j is given below.

$$PV_{i,j} = (1 + PV_{ij})RP(k) \quad (11)$$

This route preference capacity is calculated by the count of the hop, delay, and energy values. This computation is expressed below.

$$RP(i) = \frac{d_i h_i E_i}{\sum_{j \in R_i} d_i h_i E_i} \quad (12)$$

where R_i is the set of routes that are searched through the route detection and $RP(k)$ denotes the route preference capacity of the h path. This PV is updated periodically and stored in a table. The highest PV node is picked out as a forwarder node. During data communication, the packet loss rate is lesser than the threshold, and then the source transmits the data. Otherwise, the source checks if the forwarder node's congestion status is established on node queue size. In position evaluation, if the feasibility for the congestion next distribution rate optimization is executed, the ACS is applied to change the distribution rate of the in-between nodes. The recent distribution rate is selected through the fitness utility by using

the introduced ACS; the optimal distribution rate is attained. Therefore, the congestion is evaded also further managed through the optimized rate readjustment. Fig. 2 explains the flowchart of the CALB in the OBS network.

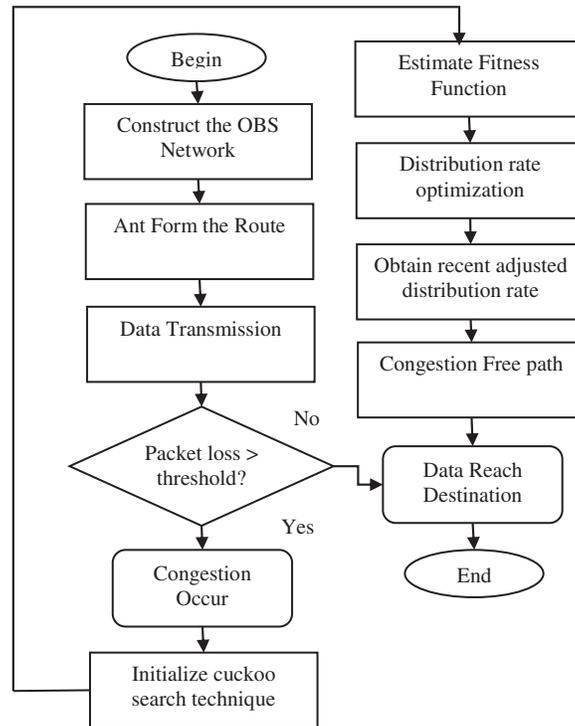


Figure 2: Flowchart of CAALB

4 Performance Evaluations

The performance of the CAALB is analyzed by using the Network Simulator (NS2). The routers are distributed in the simulation environment. The CAALB scheme simulation has 16 nodes deployed in the simulation area 500×500 , and every node transaction range is 250 meters. The WRED/RIO priority queuing is utilized in this study. To measure the performance of the proposed CS based routing strategy, a network simulation model is developed. Burst traffic in the OBS network is assumed to be Poisson. The size of the packet is 1250 bytes. The crucial routes are worked out by applying the ACO routing, while the alternate paths are obtained from the ACS algorithm for all node pairs. The performance of the CAALB is evaluated by packet loss ratio, delay, throughput, and residual energy based on different traffic loads and simulation times.

4.1 Throughput Analysis Based on Simulation Time

Throughput is a vital parameter for measuring the operations of the OBS network. In this protocol, the throughput is specified as the amount of data packets effectively obtained at the receiver. Fig. 3 shows the obtained throughput with respect to simulation times.

It can be seen from Fig. 3 that the CAALB method has higher throughput than MOACO. The higher throughput implies that the CAAB method distributes the load and improves the OBS network efficiency whereas the MOACO method focuses on balancing the network load.

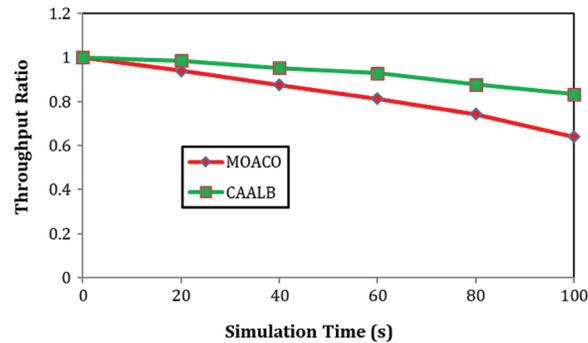


Figure 3: Throughput of MOACO as well as CAALB

4.2 Residual Energy Analysis Based on Simulation Time

Residual energy is defined as the whole energy exhausted by every node divided by the amount of data packets perfectly distributed to the receiver. This metric evaluates the energy efficiency of the OBS network. Fig. 4 shows the analysis of residual energy with respect to simulation times.

It can be seen from Fig. 4 that the CAALB method has higher residual energy than MOACO method. In CAALB, the data forwarder is chosen by the pheromone value and energy is the main factor in computing the pheromone value. Thus it increases the energy efficiency in CAALB method. But, the MOACO method does not use the energy factor and thus it has poor energy efficiency.

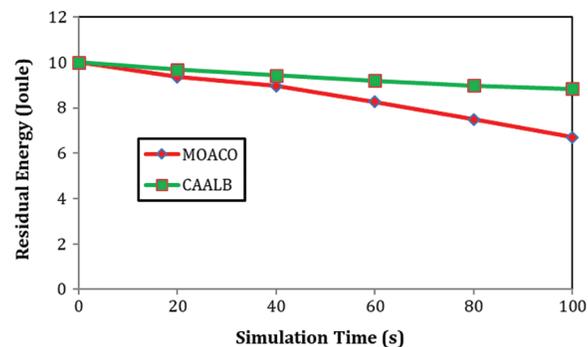


Figure 4: Average energy of MOACO as well as CAALB

4.3 Throughput Analysis Based on Traffic Load

Fig. 5 shows the obtained throughput with respect to different traffic loads.

It can be seen from Fig. 5 that the throughput of CAALB method increases to 36.76% compared to the MOACO method. Generally, the throughput represents the range of productive information release via a transaction channel. It is typically evaluated in bps. In this scheme, the throughput is specified by the fraction of data obtained at the destination to the entirety rendered data.

4.4 Packet Loss Analysis Based on Traffic Load

The packet loss represents the drops of one or more communicated packets to get to their destinations. Fig. 6 shows the packet loss of CAALB and MOACO methods with respect to various traffic loads.

It can be seen from Fig. 6 that the CAALB methods has minimum packet loss compared to MOACO method. The packet loss happens when the when the traffic increases. This is due to that the increase in

traffic load leads to increase in router power. Thus, the packet loss ratio increases linearly while increasing the traffic load.

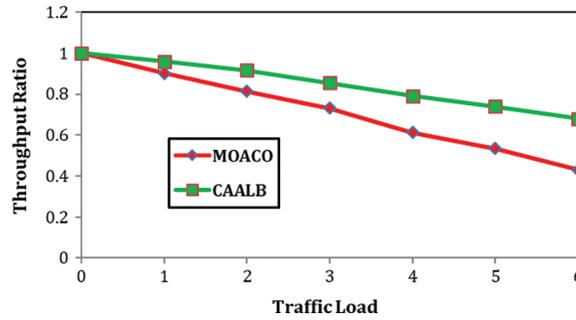


Figure 5: Throughput of CAALB and MOACO

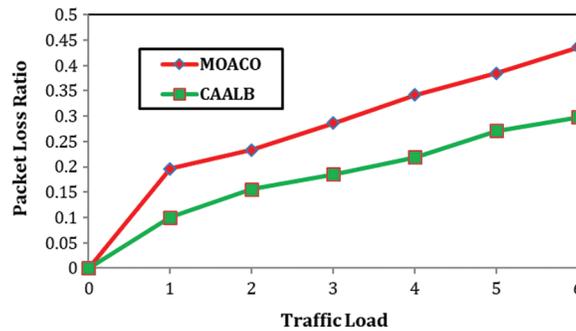


Figure 6: Packet loss ratio of CAALB and MOACO

4.5 Delay Analysis Based on Traffic Load

Fig. 7 shows the analysis of delay in milliseconds with respect to different traffic loads.

It can be seen from Fig. 7 that the data communication latency increases in CAALB when the traffic load increases. But, in MOACO method, the latency is increased to 40.31% though it does not allocate the route properly. Thus the network congestion is avoided in CAALB method that uses the cuckoo search algorithm.

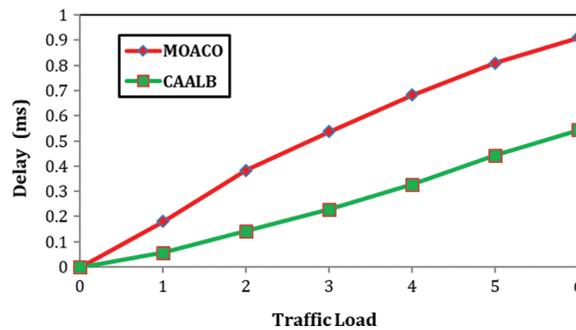


Figure 7: Delay of CAALB and MOACO

4.6 Residual Energy Analysis Based on Traffic Load

Fig. 8 shows the analysis of residual energy with respect to different traffic loads.

It can be seen from Fig. 8 that the energy of CAALB is higher than MOACO method. To exploit the lifespan, the residual energy is a significant operation parameter. Thus, the CAALB efficiently chooses the next router connection based on the residual energy information. As a result, a longer life span is assured by managing the residual energy.

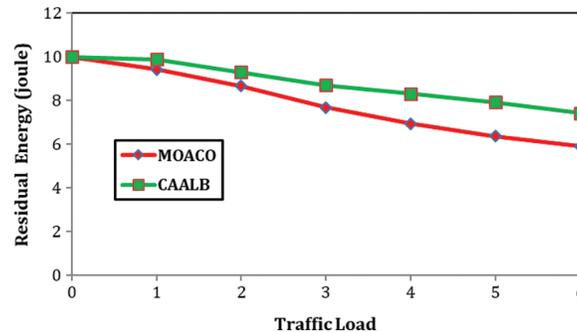


Figure 8: Residual energy of CAALB and MOACO

5 Conclusions

In this paper, an efficient ACO and CS routing technique for optical burst switching is presented. These techniques significantly reduce the packet loss in the network compared to networks without any contention avoidance techniques. The ACO technique establishes the route from the source to the destination. The pheromone value picks out the data from the forwarder node. The load balance is achieved by using the CS based distribution rate re-adjustment technique that adjusts the distribution rate of the transmitter. The node fitness utility is calculated via the available bandwidth, access rate, congestion rate, distribution rate, and queue size. The recent fitness utility for the current distribution rate enhances the system function. The simulation results illustrate that the introduced strategy evades both the end-to-end delay and packet drop possibility.

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