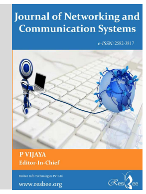
Vol.3 No.3 July 2020

Journal of Networking and Communication Systems

Received 11 June, Revised 30 June, Accepted 7 July



Hybrid Crow Search and Grey Wolf Optimization Algorithm for Congestion Control in WSN

Daniya T
Sathyabama Institute of Science and Technology
Chennai, Tamilnadu, India.
daniya.t1988@gmail.com

Abstract: In this paper, a novel congestion control method is developed for WSN. Here, a congestion control technique based on the multi-objective optimization algorithm called Hybrid Crow Search (CS) and Grey Wolf Optimization (GWO) named (CSGWO) algorithm for rate optimization and regulating data arrival rate to parent node from each child node is proposed. The multi-objective optimization model considers node energy in its fitness model. The priority-based transmission is set up as an optimization algorithm that controls the arrival rate based on priority: child node energy and output available bandwidth. To alleviate the congestion, rate modification to optimum value is exploited. The novel method is evaluated with conventional methods. Finally, the experimentation outcomes show that the developed model has superior outcomes comparing with the conventional algorithms.

Keywords: WSN; Node Energy; Parent Node; Child Node; Qos Parameters

Nomenclature

Abbreviations	Descriptions
BS	Base-Station
REFIACC	Reliable, Efficient, Fair and Interference-Aware Congestion Control
WSN	Wireless Sensor Networks
QoS	Quality of Service
ACSRO	Adaptive Cuckoo Search Based Optimal Rate Adjustment
GWO	Grey Wolf Optimization
CS	Cuckoo Search
SNs	Sensor Nodes
IACC	Interference-Aware Congestion Control

1. Introduction

In a WSN, sensors assemble information regarding the environment and inform the BS. Applications might need the announcement to be incessant, periodic, else on event incidence. In a few event-based applications, nodes can convey important data volumes towards the sink ahead of event incidence, for instance, surveillance applications and video tracking. As sensors contribute to the similar wireless channel, disputation on the obtainable bandwidth is predictable. The packet collision happens via loss of packets else links interference or because of congestion on intra-path and inter-paths nodes radically affects application throughput and reasons the maximum energy utilization in a real environment [1]. Congestion control comprises 2 types such as detection of interference and congestion, and a rate control method enterprise that regulates the reporting rate.

Congestion is a predictable occurrence for wireless and wired networks. No network can be announced as congestion-free to control the network congestion, and it is considered as a serious chore [4]. Congestion control turns out to be even trickier for WSNs because of its restricted resources associated with the information processing, transmission capability storage, and most outstandingly power supply.

Generally, congestion happens while resource demands go beyond the obtainable ability which brings in performance, energy and dependability degradation, consequently it turns out to be a requirement to compact with this difficulty in the best manner to extend the lifetime of the network. Conventional congestion control methods have a few challenges, like an optimal evaluation of traffic load at congested

https://doi.org/10.46253/jnacs.v3i3.a4

paths else link, and beside the exchange paths for traffic recreation [3]. The distribution of traffic beside the swap paths is not based on traffic estimation.

The main concern of the method is based on the hop count before definite delay a packet experiences from source to destination. The aforesaid deprecates fame as a practical technique. Hence, new sufficient methods are necessary to make sure congestion control helped through a complicated routing [6].

The most important objective of this work is to propose a hybrid multi-optimization method that permits data arrival rate from child nodes to within service else transmission rate of parent node; thus aiding in congestion control. While parent node traffic limits queue size, the proposed method took over its part counterbalances the congestion. The developed method resolves these challenges by controlling the data arrival rate to the parent node from each child node exploiting a multi-objective optimization model considering the node energy in its fitness model.

2. Literature Review

In 2020, Divya Pandey and Vandana Kushwaha [1] presented a challenge was performed to in attendance a methodical evaluation of new efforts helped at decontamination congestion control technologies in WSNs. Taking into consideration of traditional methods and soft computing based techniques. It was a feasible initiative to get a holistic examination and revise both techniques together. At last, this part examines develop complexity, several optimization techniques.

In 2016, Tao Dong et al [2], worked on a congestion control method in underwater WSN using time delay was represented. Also, bounded-ness of positive equilibrium, whereas example density was positive for every node and diverse event flows exists at the same time, was examined that entails which the samples sensor node density cannot go beyond the Environmental carrying capability. Subsequently, the time delay was considered as a bifurcating parameter, dynamical behaviors that comprise Hopf bifurcation, and local stability, were examined.

In 2016, Mohamed Amine Kafi et al [3], proposed a competent congestion control-based schedule method, named REFIACC protocol. The proposed method checks the interferences and assures maximum bandwidth fairness consumption between SNs using the scheduling communications. The congestion and the interference in intra and inter paths hot spots were alleviated during tackles considered with the difference among links' capacity during scheduling procedure.

In 2016, Vaibhav Narawade and Uttam D. Kolekar [4], developed an ACSRO for congestion control and avoidance. The rate modification regulates the share node rate to alleviate congestion. The developed rate optimization approach performance was validated exploiting the estimated measures like delay, throughput, congestion level normalized loss of packet, and queue size.

In 2015, Mohamed Amine Kafi et al [5], developed an approach named IACC. It permits increasing link capability consumption for every node by controlling interference and congestion. This is attained via fair utmost rate control of interfering nodes in intra and inters paths of hot spots. The developed protocol was estimated using the experimentation, whereas outcomes adversary efficiency of proposed method regards the throughput and energy saving.

In 2016, Syed Afsar Shah et al [6], worked on the model to control the congestion in the WSNs and proposed a comparative analysis. The congestion control models were classified as centralized through partial congestion control and dispersed by means of dedicated congestion control.

3. Congestion Model in WSN

Fig 1 exhibits the schematic diagram of the proposed model. The congestion occurs when the arrival rate augments significantly higher than the transmission rate. By exploiting the total queue size, if congestion leads to occur subsequently congestion level has occurred. The congestion level stands for phase at that inward packets initiate to congest. In a threshold value congestion level is set. The congestion leads to occur as a result the rate optimization process is entitled as congestion level maximizes further than a threshold value. In the sensor networks, the congestion is controlled by offering the rate optimization to congested levels. The minimization of the rate of arrival data from child nodes is stated as rate optimization. The optimization method produces the rate of the new arrival for child nodes that are lesser than that of the arrival rate of the final period.

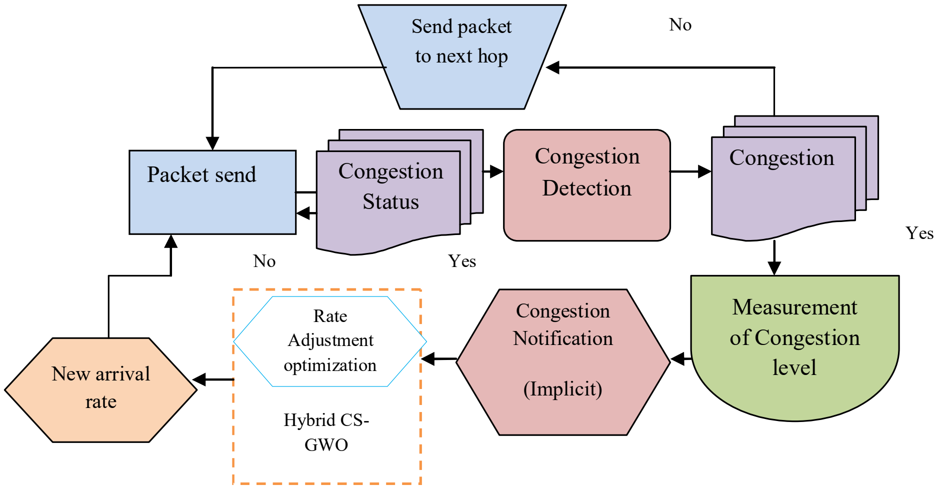


Fig. 1. *Schematic diagram of the proposed model*

As same as data arrival rate from child node congestion control is based upon the parameters, AVAILABLE BANDWIDTH of the node and the transmission rate of the parent node. From the child node, the rate of arrival data is minimized, so that the parameters are optimized.

Here, the optimization is performed by exploiting the hybrid algorithm, which is an integrated form of the CSA and GWO method to combine the power of both methods.

The fitness model offered using the optimization method presents gone the part of the child node to send node data. Using developed method, the new arrival rate altered controls congestion that is rate-adjusted explicitly rate of arrival data is minimized than that of the preceding rate of arrival nodes and transportation of data occurs by means of altered arrival rate.

The congestion model notification is subjected to the packets' header part. Hence, extra control messages which are transmitted for congestion control are evaded that maximize energy effectiveness, and therefore congestion in nodes, is regulated. In WSN, the rate optimization process continues incessantly helping in congestion-free convey of data packets.

3.1 Fitness Model to Select an Optimal Solution

In the developed fitness model, multiple parameters of QoS are contemplated for the increase of the fitness model. The parameters of QoS treated as the available bandwidth, data arrival rate, congestion, rate of transmission and energy in the developed fitness model. Considering these 6 constraints, the main aim is to maximize the optimal reach capability that is attained in the developed fitness model. It is recognized as the majority significant to control network congestion. Besides, altering the arrival rate might affect QoS. In the fitness model, consider, the utmost number of parameters, QoS can be hold on to optimal arrival rate. Here, 6 parameters are included to find the fitness model. The fitness model has to be high for the new arrival rate estimate. Considering diverse QoS parameters the fitness model is stated in the eq. (1):

$$f \rightarrow \max\left(f^{bandwidth} + f^{arrivalrate} + f^{trxrate} + f^{queuelength} + f^{congestion} + f^{energy}\right) \tag{1}$$

3.1.1 Arrival Rate

In the fitness model, the first parameter is the arrival rate, which is calculated in the number of packets per second. Here, the fitness model is represented by means of arrival rate is to locate a new rate of arrival data from a child node, which is lesser than the preceding rate of arrival child nodes during congestion time.

In network, to remove congestion arrival rate value is lesser than the transmission rate value. In rate limits, while difference; new arrival rate value is least. Through subtracting value attained from the general difference among new and old arrival rates by means of old arrival rate in the denominator by 1, the value of new arrival rate which is lesser than the preceding value of arrival rate is obtained. In the fitness model, the primary maximal factor concerning the child node arrival rate is stated and computed by the eq. (2), $Arrival_r^l$ indicates old arrival is a rate and is $Arrival_n^l$ indicates a new arrival rate.

$$f^{arrivalrate} \rightarrow \max\left(1 - \frac{Arrival_r^l - Arrival_n^l}{Arrival_r^l}\right) \tag{2}$$

3.1.2 Available Bandwidth

The second parameter considered is Available Bandwidth calculated in byte per second. The node bandwidth, at that arrival rate minimization, is detained to regulate congestion, which is based upon the new arrival rate value to be minimized for optimal fitness reach capability. The bandwidth factor needs to be the difference among Available Bandwidth of node and new arrival rate value. In the fitness model, the second factor is based on Available Bandwidth of the child node, and it is computed exploiting eq. (3), ABW indicates available bandwidth of node.

$$f^{bandwidth} \rightarrow \max\left(ABW - Arrival_{ll}\right) \tag{3}$$

3.1.3 Transmission Rate

The third parameter is the transmission rate, which is calculated in the number of packets per second. For the parent node, the rate of the transmission ought to be high for the augmented transmission of data performance in WSN. The purpose is to exploit the rate of the transmission function. It is attained by subtracting difference value in new and old arrival rate by means of parent node transmission rate in the denominator by "1". The transmission rate range for maximal function is obtained. Eq. (4) denotes the transmission rate estimate in the objective model, Trx_r indicates the parent node transmission rate.

$$f^{trx\ rate} \rightarrow \max\left(1 - \frac{\left(Arrival_l - Arrival_{ll}\right)}{Trx_r}\right) \tag{4}$$

3.1.4 Congestion

The fourth parameter is congestion is calculated in the number of packets per second. In the maximum fitness model, the congestion factor should be the least. The congestion ought to be minimized for competent sensor networks' performance. Minimal congestion value offers an enhanced objective model. The congestion is based upon the position of congestion level pays congestion control. By ratio among factor utilizing dissimilarity from general congestion level by means of 1 and the rate of arrival, congestion function is done minimum in developed fitness model.

The value of the complete congestion level is decreased by the value of subtracting over range value 1 that is the most significant factor in congestion minimal. The congestion function is computed exploiting eq. (5), nCL_l is the overall congestion level.

$$f^{congestion} \rightarrow \min\left(\frac{1 - nCL_l}{Arrival_{ll}}\right) \tag{5}$$

3.1.5 Queue Length

The fifth parameter is the length of the queue measured in the number of packets loss per second. In transmission network length of the queue must be least for enhanced performance. It is based upon a difference among 2 factors measured using the physical queue length of the parent node. The function concerning queue length is computed exploiting eq. (6), PQ_l indicates the physical queue size, VQ_l indicates the virtual queue length.

$$f^{queue\ length} \rightarrow \min\left(\frac{\left(PQ_l - Arrival_l\right)}{VQ_l} - \frac{\left(PQ_l - Arrival_{ll}\right)}{VQ_l}\right) \tag{6}$$

3.1.6 Energy

The sixth parameter is the summation of energies of links in the path. In transmission path network energy ought to be high for enhanced performance. It is based upon the energy required to transmit and receive data among 2 nodes via a path and the number of packets transmit. Presume the total number of nodes is there. Let k clusters, subsequently, on average there will be n/k total nodes per cluster, whereas every cluster possesses 1 parent node and (n/k) - 1 Child nodes. The energy utilization for a single child node W_{child} is merely for transmission of m bits to the Parent node. Therefore, energy exploited in every child node is stated in eq. (7) and (8):

$$W_{child} = W_{Trx}(m, d) = W_{Trx-elec}(m) + W_{Trx-amp}(m, d) \tag{7}$$

$$W_{child} = m \cdot W_{ele} + m \cdot \varepsilon_{amp} d^{n}_{to\ parent} \tag{8}$$

Every parent disperses energy W_{parent}, in the response of signals from all child nodes of which cluster, signals aggregation, and aggregate signal transmission to BS. Therefore, the energy dissipated [7] is stated in eq. (9-11) in the parent node.

$$W_{parent}=\left(\frac{n}{k}-1\right)\cdot m\cdot W_{ele}+\frac{n}{k}\cdot m\cdot E_{DA}+E_{Trx}(m,d) \quad (9)$$

$$W_{parent}=\left(\frac{n}{k}-1\right)\cdot m\cdot W_{ele}+\frac{n}{k}\cdot m\cdot E_{DA}+E_{Trx-ele}(m,d)+E_{Trx-amp}(m,d) \quad (10)$$

$$W_{parent}=\left(\frac{n}{k}-1\right)\cdot m\cdot W_{ele}+\frac{n}{k}\cdot m\cdot E_{DA}+m\cdot E_{ele}+m\cdot \varepsilon_{amp} d^{n}_{to\ basestation} \quad (11)$$

In eq. (9), E_{DA} indicates energy exploited by Parent for aggregation of data. At present, energy utilization in a cluster stated in [7] is computed by eq. (12).

$$f_{energy}\rightarrow \min\left(W_{parent}+\left(\frac{n}{k}-1\right)W_{child}\approx W_{parent}+\frac{n}{k}\cdot W_{child}\right) \quad (12)$$

Based on the maximum fitness model, for the congestion control model, a new arrival rate is selected. The new arrival rate offered by the fitness model is chosen exploiting optimization method.

4. Hybrid CS-GWO Algorithm for Congestion Control

In conventional GWO [9], the primary subject of apprehension is that each and every search agent (wolves) are updated on basis of α indicates optimal search agent, β indicates second optimal search agent and δ indicates third optimal search agent in entire optimization procedure as stated in Eq. (13). Fundamentally, this location updating model guides to premature.

$$\vec{Y}(t+1)=\frac{\left(\vec{Y}_1+\vec{Y}_2+\vec{Y}_3\right)}{3} \quad (13)$$

In addition, a similar optimization procedure as stated in Eq. (13) happen restricted exploitation ability in the final phases of optimization.

Hence, to surmount the aforesaid challenges of the exiting GWO, it is hybridized with CS [10] to attain an appropriate balance among exploration and exploitation.

$$y^{i+1,t+1}=y^{i,t}+r_i\times f_l^{i,t}\times\left(m^{j,t}-y^{i,t}\right) \quad (14)$$

In particular, the CS algorithm integrates a control parameter f_l in its location updating formulation as stated in eq. (14) that permits the search agents to choose the magnitude of step movement to the additional search agent. This parameter plays an important job in obtaining global optima as a higher value of f_l guide to global exploration when a little value of f_l outcomes to local exploitation. As aforesaid, GWO has superior exploitation capability other than deprived exploration ability, hence in developed method; a higher value of f_l is used to use CSA's outstanding exploration quality as stated in Eq. (15). It represents, the developed approach can efficiently exploit the 2 methods benefits and consequently, it can attain sturdy universal applicability. In the proposed method, rather than the updating from α, β and δ a search agent is permitted to update its location merely exploiting α, and β as stated in eq. (15).

$$\vec{Y}(t+1)=\vec{Y}+f_l\times rn\times\left(\vec{Y}_1-\vec{Y}\right) \quad (15)$$

One more significance accumulation, to sustain population diversity, not all individuals in a population is updated by α, and β updating direction, however using α merely in the developed method. This represents a shrinking approach that sets up a developed technique to get away from the local optimum.

Even though the developed method has the outstanding abilities of exploitation and exploration of CS and GWO algorithm, on the other hand, an appropriate balance of these 2 stages must be attained to attain better performance. It represents, to obtain the necessary exploitation and exploration ratio, a fixed balance probability among eq. (15) and (16) is not approving. Hence, an adaptive balance probability is developed that permits developed algorithms to reach the acceleration all during previous steps of optimization procedure wherein current phases of optimization assure solutions will encompass the utmost probability to be used. The adaptive balance probability (ρ) is computed as below:

$$\rho=1-\left(1.01\times t^3/\max\_itr^3\right) \quad (16)$$

In eq. (16), t indicates current iteration and $\max\_itr$ denotes the maximum number of iterations.

The B parameter plays an important role in complementary exploitation and the exploration of a search agent. In particular, the parameter B is seriously based upon $\vec{b}$ that eventually controls the search procedure direction. A higher value of $\vec{b}$ make an easy exploration stage but a lesser value eases exploitation. It represents an appropriate chosen of $\vec{b}$ can present a standing balance of exploitation and exploration that can cause better performance. In conventional GWO, the value of $\vec{b}$ is linearly minimized from 2 to 0 exploiting eq. (17).

$$\vec{B} = 2\vec{b}.\vec{r}_1 - \vec{b} \quad (17)$$

Previously, numerous methods of updating control parameters $\vec{b}$ encompass been developed, like [10]. Hence, it is seen that better performance is attained if control parameter values $\vec{b}$ are chosen exploiting a nonlinearly minimizing algorithm, rather than a linearly minimizing method. As aforesaid, an enhanced model, as exhibited in Eq. (18), is exploited to produce control parameter values $\vec{b}$ in the optimization procedure. This scheme permits the developed method to efficiently explore search space in the evaluation of the conventional GWO.

$$b = 2 - \left(\cos(rn(\ )) \times 1/_{Max\_itr}\right) \quad (18)$$

Algorithm: Pseudo code of the proposed algorithm

```
Initialize grey wolves population Y_i (i = 1,2,...,n)
Initialize parameters b , B and C
Calculate each Search agent fitness
Y_α indicates optimal search agent
Y_β indicates second optimal search agent
while ( t <max_itr)
        For each search agent
            if ρ >rand
                By Eq.(13), update current search agent location
                else
                By eq.(14), update current search agent location
            End if
        end for
Update value of ρ  b by eq. (16) and eq. (18)
Update parameters B , C
Compute all search agents fitness
Update Y_α , Y_β
t=t+1
end while
return Y_α
```

5. Result and Discussion

5.1 Experimental Model

In this section, experimentation setup and simulation outcomes were explained. Here, the sensor network with 1000m X 1000m square sensor field and the network was experimented by means of 100 SNs distributed arbitrarily in the sensor field was obtained.

5.2 Performance Evaluation

Table 1 summarizes the performance analysis of the developed method. Here, the parameters attained after 10s of simulation time. Here, it obviously is shown that the developed method attained the performance enhancement in all the measures like normalized packet loss, throughput, delay, energy, normalized queue size, and sending rate. Here, the throughput of the developed model is high however the conventional method is low. Likewise, the delay is low for the developed model while comparing with the existing techniques. The main motivation for the enhancement of the developed model is the modification of the sending rate at each iteration.

Table 1. *Performance analysis of the proposed method*

Time =10s	GWO	CS	Proposed
Delay	0.14	0.08	0.0466
Throughput	0.42	0.44	0.62
Sending rate	0.0961	0.0992	0.0998
Normalized packet loss	0.6999	0.6699	0.4999
Congestion	0.2	0.2	0.1
Normalized queue size	0.14	0.08	0.0416
Energy	0.2182	0.202	0.0999

6. Conclusion

A novel congestion control method for WSN on basis of a hybrid CSGWO algorithm was proposed. This idea was exploited to minimize congestion issues in the congested network as the optimization method evades congestion to decrease average data arrival rate to parent node from child nodes, by considering node energy in its fitness model. The priority-based transmission was set up as an optimization algorithm that controls the arrival rate from each child node based on its priority, output Available Bandwidth and child node energy. Modification of rate to optimum value was exploited to alleviate the congestion. The proposed method produces the new arrival rate from the child node that was lesser than that of the arrival rate of the final period. The proposed method presents a fitness model based on the parameters of network congestion founded on that control was offered. The new arrival rate chosen for child node was situating utilizing chosen value of fitness function.

References

[1] Givya Pandey, Vandana Kushwaha,"An exploratory study of congestion control techniques in Wireless Sensor Networks", Computer Communications,Volume 1571, May 2020,Pages 257-283.

[2] Tao Dong, Wenjie Hu, Xiaofeng Liao,"Dynamics of the congestion control model in underwater wireless sensor networks with time delay Chaos", Solitons & Fractals,Volume 92,November 2016,Pages 130-136.

[3] Mohamed Amine Kafi, Jalel Ben-Othman, Abdelraouf Ouadjaout, Miloud Bagaa, Nadjib Badache,"REFIACC: Reliable, efficient, fair and interference-aware congestion control protocol for wireless sensor networks", Computer Communications,Volume 10115, March 2017,Pages 1-11.

[4] Vaibhav Narawade, Uttam D. Kolekar,"ACSRO: Adaptive cuckoo search based rate adjustment for optimized congestion avoidance and control in wireless sensor networks", Alexandria Engineering Journal,Volume 57, Issue 1,March 2018,Pages 131-145.

[5] Mohamed Amine Kafi, Djamel Djenouri, Jalel Ben Othman, Abdelraouf Ouadjaout, Nadjib Badache,"Interference-aware Congestion Control Protocol for Wireless Sensor Networks", Procedia Computer Science,Volume 37,2014,Pages 181-188.

[6] Syed Afsar Shah, Babar Nazir, Imran Ali Khan,"Congestion control algorithms in wireless sensor networks: Trends and opportunities", Journal of King Saud University - Computer and Information Sciences,Volume 29, Issue 3,July 2017,Pages 236-245.

[7] Narawade, V., &Kolekar, U. D," ACSRO: Adaptive cuckoo search based rate adjustment for optimized congestion avoidance and control in wireless sensor networks", Alexandria Engineering Journal, 2016.

[8] S. Mirjalili, S. M. Mirjalili, and A. Lewis, "Grey wolf optimizer," Advances in Engineering Software, volume. 69, page no. 46–61, 2014.

[9] A. Askarzadeh, "A novel metaheuristic method for solving constrained engineering optimization problems: crow search algorithm," Computers & Structures, volume. 169, page no. 1–12, 2016.

[10] N. Mittal, U. Singh, and B. S. Sohi, "Modified grey wolf optimizer for

[11] global engineering optimization," Applied Computational Intelligence and Soft Computing, page no. 8, 2016.

[12] W.Brajula and Praveena S, "Energy Efficient Genetic Algorithm Based Clustering Technique for Prolonging the Life Time of Wireless Sensor Network", Journal of Networking and Communication Systems (JNACS),Volume 1, Issue 1, October 2018.

[13] Amit Kelotra and Prateek Pandey,"Energy-aware Cluster Head Selection in WSN using HPSOCS Algorithm",Journal of Networking and Communication Systems (JNACS),Volume 2, Issue 1, January 2019.