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OPTIMAL RELAY NODE SELECTION USING MULTI-OBJECTIVE BASED CROW SEARCH OPTIMIZATION ALGORITHM FOR MULTIUSER COOPERATIVE COMMUNICATION NETWORKS

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Abstract

For Wireless sensor network (WSN), mesh network, cellular network and Ad-hoc network, cooperative relaying technique is taken into account as a crucial technique in recent times. To make the data transmission possible, the relay nodes are allocated among source and destination, in the cooperative communication network. Choosing the suitable relay node is still one of the primary issues in enhancing the cooperative communication network's performance. So as to solve this issue, a multi objective based Crow Search Optimization Algorithm (CSA) is proposed for multi user cooperative communication network. Multi objective based channel gain, power consumption and signal to noise ratio are defined in this approach to choose optimal relay node. The presented CSA algorithm functions and chooses an optimal node for relay with the fore mentioned objective functions. The proposed approach is simulated for results and these results show that the proposed approach has performed better than compared approach in terms of Throughput, SNR, lifetime of the network, Energy consumption and Delay.

1. Introduction

In wireless communication, the technique where the data is transmitted to the receiver with the help of intermediate relays is known as cooperative communication. The data with the same band of frequency can never be able to transmit or receive at the same time in a relay in most of the cases. The

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neighboring users act as relay nodes when the received data from the source is sent to the destination. Multiple antennas are not needed for the multiple transmission paths. This network can be defined as the relay networks. As relay selection can get more gain in performance, it has been considered as an important part of cooperative communication. In case of poor quality in source destination, the reliability in overall transmission can be guaranteed by choosing at least one relay. Among various potential relay nodes, choosing a particular node is a crucial task. To choose the relay node optimally, Crow Search optimization algorithm is presented in this work. The performance will be evaluated by using multi objective function as the fitness function and comparing with the existing approach of relay selection. The performance will be evaluated based on Throughput, SNR, Delay, network life time and energy consumption.

An improving relay selection scheme based on the coalitional game is designed by Su et al [7] in the multi-user wireless networks. In the presented approach source node and relay nodes constitute a coalition in order to increase the transmission rate and lower the BER of system. The results show that the presented scheme effectively adapts to wireless networks. A game-theoretical approach for the distributed resource allocation over multiuser cooperative communication network has been presented by Wang et al [8]. It is has been proven that the distributed resource allocation can achieve better results than centralized scheme, without requiring knowledge of CSI. Khan et al. [9] has proposed an auction based scheme for relay selection in cooperative communication. Based on the random waypoint mobility model, a centralized Predicted Mobility Based Profitable Relay Selection Algorithm has been developed. The results of proposed approach have proven to be effective. Rahul Sharma and B. Sainath [10] have proposed a simple, novel and intuitive probabilistic relay selection policy. The proposed relay selection policy and its performance analysis are useful for cooperative D2D wireless DaF relay systems and networks. The proposed approach has performed better than most of the existing algorithms.

The introduction about cooperative communication network, relay network and relay node are provided in section 1 along with the surveys of literatures related to relay selection in cooperative communication system. Section 2 contains the system model and the steps involved in the proposed approach. The simulation results and performance evaluation of the proposed approach is provided in section 3. Finally, in section 4, the presented approach and its effects are concluded.

2. System Model

The system model of the cooperative communication model is depicted in Figure 1. Here, m quantities of users are arbitrarily placed. One user from these users is considered as a source node and the base station is fixed as a destination node. Other than the source node, every other node $(m-1)$ acts as a relay node. Direct communication and cooperative communication, the two types of communications are differentiated in the figure. In the direct communication, the data from the source node is directly transferred to the destination. The power efficiency of the system is directly affected by this communication. Therefore, cooperative communication is selected for enhancing the system's power efficiency.

The cooperation communication network has one of the major issues like maximizing the interest in cooperation process to the system clients. The greater part in cooperation communication is that it encourages the networks to share their resources except the ones provided by the user. In the network of multi user cooperative communication, the relay nodes are selected based on the SNR, channel gain and power consumption. Therefore, multi objective based Crow Search optimization Algorithm is proposed to select optimal relay nodes. The proposed algorithm is based on the crow and its food searching behavior. The objective functions like channel gain, power consumption and SNR are the objective function based on which a relay node are chosen.

Through the relay nodes, the request to send (RTS) frame is forwarded to the destination earlier to choosing the optimal relays. This RTS frame is utilized for channel gain estimation between source and relay at every relay. The clear to send (CTS) frame is replied to the source by destination after getting the RTS frame. The channel gain among the relay and destination at every relay is estimated by using the CTS frame. The data on the relays such as SNR, power consumption and channel gain is gathered because of these initial communications. The best relay among source and destination is chosen depending on this information.

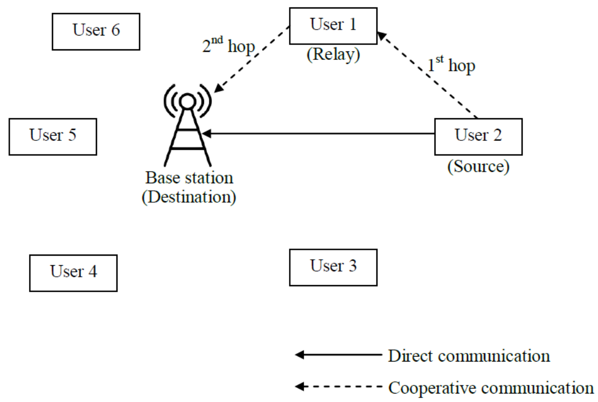

Figure 1. System model.

Signal to Noise Ratio (SNR):

The signal to noise ratio is the ratio of the data signal to the amplitude of the noise. It is used in determining the quality of the transmission channel. From the source to destination, the transmitted signal SNR (β) is determined using the equation (1)

$$\beta_{R-C} = \frac{|\, f_{R-C} \,|^2}{mc} \tag{1}$$

Here, the noise in destination is represented as m_c, the channel coefficient between the source and destination and source is represented by $|\, f_{R-C} \,|$ and the SNR between the destination and source is denoted by β_{R-C}.

The SNR between the h^{th} relay node (QM) and source node at first hop is denoted as β_{R-QM_k}. It is defined using equation (2)

$$\beta_{R-QM_h} = \frac{|\, f_{R-QM_h} \,|^2}{m_{QM_h}}. \tag{2}$$

Here, the channel coefficient between QM_h and the source is represented as $|\, f_{R-QM_h} \,|$. The noise at QM_h is denoted by m_{QM_h}.

The SNR of amplified signal to destination from QM_h in second hop is represented as β_{QM_h-C}. It is defines as in equation (3)

$$\beta_{QM_h-C} = \frac{\eta | f_{R-QM_h} |^2 | f_{QM_h-C} |^2}{m_{QM_h(\eta^2 | f_{R-QM_h} |^2+1)}}. \quad (3)$$

Here, the channel coefficient between the destination and QM_h is represented as $| f_{Qm_h-C} | \cdot \eta$ represents the factor utilized to amplify the received signal at QM_h.

Utilizing the equations (2) and (3), one of the objective functions is defined that an QM_h with lowest SNR of two hops is chosen as an optimal QM_h. This objective function (N_1) is defined using equation (4)

$$N_1 = \beta_h = Min\,(1/\beta_{R-QM_h},\ 1/\beta_{QM_h-C}) \quad (4)$$

Channel Gain. The selection of the optimal QM_h by reducing the channel gain of two hops can be defined using equation (5)

$$N_2 = f_h = Min\,(f_{R-QM_h}, f_{QM_h-C}) \quad (5)$$

Here, N_2 represents the second objective function.

Power consumption: An optimal QM_h is chosen by choosing the QM_h with highest residual power (Q_{Sd}). Using the equation (6), QM_h's residual power is evaluated.

$$Q_{Sd}(QM_h) = Q_{In}(QM_h) - Q_{Con}(QM_h). \quad (6)$$

Here, the starting power of the QM_h is represented as $Q_{In}(QM_h)$. The QM_h's consumed power is represented as $Q_{Con}(QM_h)$.

The third objective function is evaluated using equation (6) and the third objective function is defined using equation (7).

$$N_3 = Q_h = \frac{1}{Max\,(Q_{Sd}\,(QM_h))}. \quad (7)$$

In communication network, the cooperative relay node is chosen based on the three objective functions using the Crow Search Optimization Algorithm.

2.1. Relay node selection using Multi-objective based CSA

algorithm:

The base station chooses the optimal relay node that assists in transmitting the data to the base station or destination from the source which enhances the efficiency of power in wireless communication network. The multi objective based CSA algorithm is proposed to choose the optimal relay node. The functioning of the algorithm is based on the food searching behavior of crows.

Crow Search optimization Algorithm is the novel metaheuristic algorithm that can be utilized to solve optimization problem. In general, CSA has three phases. At first, the creation of position of hiding place of each crow is performed arbitrarily. Considering the initialized position as the best experience, every crow's memory is initialized. Then based on the objective function, the crow values the quality of its position. The crow then arbitrarily chooses one among the flock of crows and tails it for finding the position of the foods hidden by it. The crow updates the position of the food in case the food is good. The crow will not move to the generated position and stays in the current position when the food is not good. The following are the steps of CSA;

Initialization:

In the initialization phase, the initialization of every candidate solution or crow is performed. In this approach, every crow refers to the relay nodes in the network. The population of solutions in *c* search place is represented in equation (8).

$$M_h = [QM_1, QM_2, QM_3, \ldots, QM_m]. \tag{8}$$

Here, the m^{th} relay node or crow in the population from where the solution is arbitrarily chosen and this is represented as QM_m.

Fitness evaluation:

The fitness function of every crow or solution can be evaluated by the estimation of the objective function. In the presented approach, Depending on the multi objectives like power consumption, SNR and channel gain, the evaluation of fitness is performed. The fitness is represented as fit_h.

$$fit_h = \min \begin{Bmatrix} N_1 \\ N_2 \\ N_3 \end{Bmatrix} \tag{9}$$

Updation:

In search space, new positions are created by the crows as follows: From the flock of crows, crow h select only one crow (crow i) in random and for finding the hidden food's position, crow i is followed by crow h. The latest position of crow i is generated as follows

$$M_{h,l+1} = \begin{cases} M_{h,l} + r_h \times em_{h,l}(n_{i,l} - M_{h,l}) & z_i \geq PA_{i,s} \\ \text{a random position} & \text{otherwise} \end{cases} \tag{10}$$

Where, q_i and z_i represent the arbitrary numbers with uniform distribution between 1 and 0. Crow i's awareness probability at l^{th} iteration is represented as PA_{is}. At l^{th} iteration, the length of the flight of the crow h is represented by $em_{h,s}$, $n_{i,l}$ represents the crow i's memory at l^{th} iteration. After the position of the crow is generated, the evaluations of new positions are performed. Each crow updates the memory as in equation (11).

$$n_{h,l+1} = \begin{cases} M_{h,l+1} & f(M_{h,l+1}) \succ f(n_{h,l}) \\ n_{h,l} & \text{otherwise} \end{cases} \tag{11}$$

Where, the objective value is denoted as $f(\ )$ and $\succ$ represents 'better than'. By memorizing the position of hidden locations of food and retrieving it across seasons, the general function of crow is depicted. It is considered that all the crows memorize the hidden place's position and stored in the memory represented as n. At l^{th} iteration, the crow i's position is represented as $n_{i,l}$. The crow i's memory $n_{i,l}$ is initialized in the first step with its initial position $M_{i,l}$. By utilizing the equation (11) on all iterations, this memory is updated to achieve best position food source (best solution). When the new position is better than the old one, the memory is filled with the new position.

Termination:

The algorithm is terminated when the iteration of generation is completed and in terms of value of the objective function, the best position is provided as the best solution for the problem of optimization. The new position is generated when these conditions are not met.

3. Results and Discussion

The presented multi objective based crow search optimization algorithm for the selection of relay node selection is implemented utilizing MATLAB and it is experimented with the assistance of general configured computer. The simulation parameters with their assumed values are shown in Table 1. Mobile nodes of 200 are considered for simulation purpose of the presented approach. Among them 2 nodes are considered as source and destination, then the remaining nodes are taken into account as the relay nodes. The presented approach is utilized to choose the optimal relay node from these relay nodes. 0.1J and 0.5J of energy is uniformly assigned to the relay nodes as initial energy and the source node is assigned with 0.3J of energy as initial energy. 1MHz of Rayleigh fading channel is considered for the presented approach.

Table 1. Simulation parameters.

Parameters	Assumptions
Number of nodes	200
Initial energy of source	0.3J
Initial energy of RNs	[0.1J, 0.5J]
Channel model	Rayleigh fading channel
Bandwidth of channel	1MHz
Relaying protocol	Amplify and Forward (AF)
Receiver noise	Additive White Gaussian Noise
Data rate	100-500kb/s

3.1. Performance analysis:

The performance of the proposed approach is evaluated in this section. The AAA approach utilized for selection of relay nodes is taken for comparison of performances. The performance of the approaches on data rate is evaluated for different distance between source and relay node. The performance is evaluated in terms of throughput, SNR, network lifetime, energy consumption and delay.

3.2. Performance based on varying data rate:

Figure 2 to 5 shows the performance of the proposed approach and existing game approach based relay selection approach for various data rates. They show the performance is evaluated for the approaches in terms of throughput, SNR, network lifetime, energy consumption and delay.

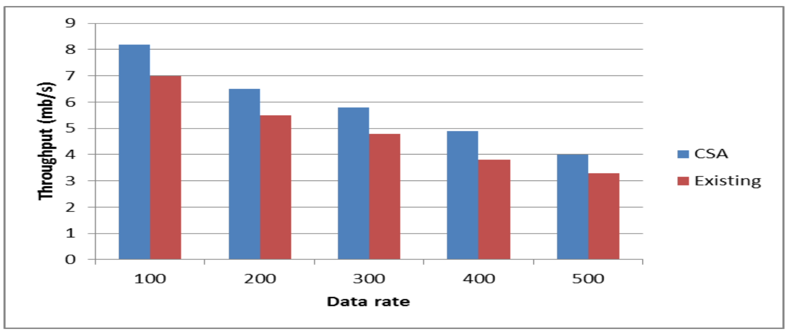

Figure 2. Performance comparison of throughput for various data rate for proposed and existing approaches.

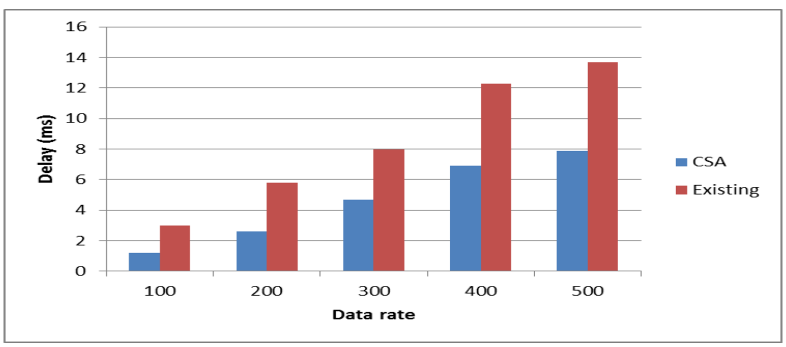

Figure 3. Performance comparison of delay for various data rate for proposed and existing approaches.

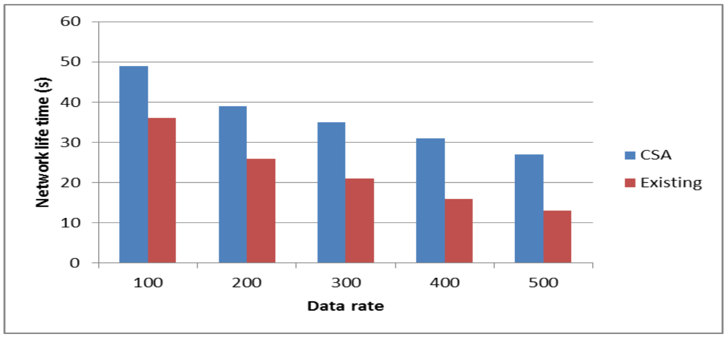

Figure 4. Performance comparison of network life time for various data rate for proposed and existing approaches.

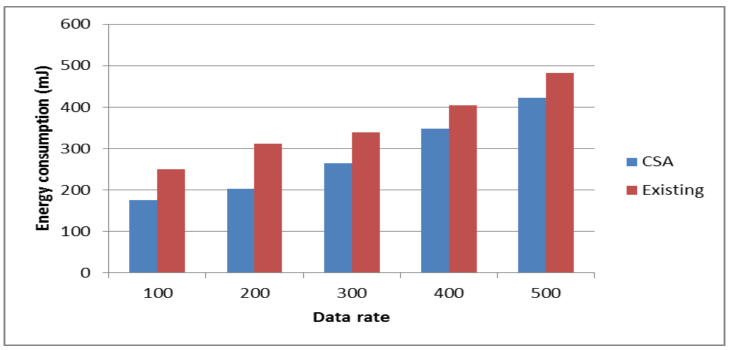

Figure 5. Performance comparison of energy consumption for various data rate for proposed and existing approaches.

Figure 2 shows the performance of the game approach of relay selection and the proposed approach for throughput for various data rates. When the data rate is 100, the proposed approach has a throughput of 8.2mb/s and the existing approach has a throughput of 7mb/s. When the data rate is 500, the proposed approach has a throughput of 4mb/s and the existing approach has a throughput of 3.3mb/s. The order of values has been same for all the data rates. The proposed approach has higher throughput than the existing approach in all the data rates. Therefore it can be assumed clearly known that the proposed approach has better performance in terms of throughput. Performance comparison of delay for proposed approach and game approach based relay selection for various data rate is shown in Figure 3. The delay has to be low for an approach to be effective. The delay for the proposed approach is 2.6 ms and that of the existing approach is 5.8 ms when the data rate is 200. The delay for the proposed approach is 6.9 ms and that of the existing approach is 12.3 ms when the data rate is 400. The order of values has been same for all the data rates. The proposed approach has lower delay than the existing approach. From the figure it has been clear that the proposed approach has performed better than the existing approach in terms of delay.

Figure 4 shows the Performance comparison of network life time of proposed approach and existing game approach for various data rate. The network life time of an approach has to be higher for it to be efficient. When the data rate is 100, the network life time of the proposed approach is 49 s and the network life time of the existing approach is 36 s. When the data rate is 300, the network life time of the proposed approach is 49 s and the network life time of the existing approach is 36 s. The order of values has been same for all the data rates. From the figure it is clear that the proposed approach has higher network life time than the existing approach. Performance comparison of energy consumption for proposed approach and game approach based relay selection for various data rate is shown in Figure 5. The approach which consumes less energy can be considered as the effective approach. When the data rate is 100, the energy consumed by the proposed approach is 175mJ and the energy consumed by the existing approach is 250mJ. When the data rate is 500, the energy consumed by the proposed approach is 422mJ and the energy consumed by the existing approach is 483mJ. The order of values has been same for all the values of data rate. The proposed approach has consumed lesser energy than the existing approach.

From all the results, it can be clearly understood that the proposed approach has performed better than the existing approach. The proposed approach has been effective and outperformed the existing approach in terms of delay, throughput, network life time and energy consumption.

4. Conclusions

By choosing the optimal relay node utilizing multi objective based crow search optimization algorithm, the cooperative communication network's overall efficiency has been enhanced. Using the channel gain, power consumption and SNR as the fitness values, an optimal relay node has been chosen between source and destination. The performance of the proposed approach has been compared with that of the game approach based relay selection approach. Also, the performance of the proposed approach has been evaluated in terms of throughput, SNR, energy consumption, delay and network life time. From the simulation result it can be concluded that the proposed approach has outperformed the existing approach in all its comparison and proved to be effective.

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