Optimization the Cognitive Radio Decision Based on Improved Nature Inspired Approach

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Abstract

Cognitive radio networks (CRNs) are group of nodes prepared through cognitive radios which can improve the performance automatically via changing its behavior to adapt to the environment. Although various routing protocols that reflect the CRNs decisions are proposed to incorporate the varying degrees of adaptation, these protocols are to provide QoS guarantees to the CRNs.

In order to effectively transmit data packets and to develop cognitive routing protocols and to enforce challenges as a result of the changing nature of the obtainable spectrum, this research proposes an optimization path routing algorithm depend on the basis of the one of inspired approaches (Specifically improved cat swarm algorithm) to speed up the exploration for the optimal routes. This algorithm is a new met heuristic algorithm. It is being used for solving optimization problem.

This paper presents an advanced routing algorithm specified for this networks, this algorithm is based on the cat swarm algorithm, makes the transmission process effectual, adaptive in addition to scalable with an cumulative number of nodes. The new guideline proposed better satisfies the demands of QoS and show that the algorithm is valid and effective in controlling the packet loss ratio, time delay and the residual bandwidth while satisfying service requirements, emphasizing of some important characteristics of cat swarm search algorithm. Finally simulation results illustration that the proposed work offer efficient bandwidth exploitation.

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1. Introduction

One of the modern and effective process of computing is nature inspired algorithms which are imitative from the learning of natural scheme. However, candidate solutions from the optimization strategy depend on the policy of individuals in a population, and then determines the superiority of the solutions through using the fitness function [1] . The frequently used nature inspired procedures are Genetic algorithm, Particle and cat swarm and many more. Among those CSO are well-known for their wide applications as efficient evolutionary optimization algorithms. However, as depicted in this paper at length, intelligence of swarm cooperation and social interaction mode [2] .

In cognitive radio networks , the components of this network sense, learn, in addition to react to changes in network condition. It can learn from the adaptation and make advance decisions, taking into consideration of end-to-end objectives [3] . It can perceive the external environment, and then intelligently and automatically changes its behavior to adapt to the environment. And it is more suitable to offer quality of service . In order to make CN provision QoS better, QoS routing is a very important mechanism, especially multiple-path routing is widely concerned [4] .which develop to improve the spectrum utilization through comprehending simultaneous transmissions of secondary users (SUs) with primary users (PUs) as long as adequate process of PUs is protected [5] .

In this paper a new routing optimization technique based on improvement cat swarm optimization will be proposed. CSO it is a Meta heuristics-based procedure which makes few or rather no traditions around the problem being explained then it explorations over a huge space of candidate solutions. In this paper, it will be concentrated on the problem of determine efficient route selection algorithms to meet the delay-constraint necessities. This problem will be addressed as a unicast model. The algorithms proposed in this paper will discuss and compare with existing delay constrained unicast routing algorithm as abbreviation as (DCUR).

The proposed procedure has the following properties that make it the best to apply in computer network: It must be able to exploit the complete performance of the network deprived of cutting the requests of some specific call, It must be intended to allow reservation process of resource to be constructed into the routing. Finally it must be able to optimize on several constraints which is vital in the circumstance of quality of service routing.

2.Related Work

There have been many works done in the area of routing algorithm in cognitive radio network by using different methods.

Junaid Qadir [6] provide a various techniques used for developing cognitive routing protocols. The researcher discusses several decisions making methods in addition to learning techniques from AI in order to make a suitable decision in the environment of CRN.

Dandan LI [7] proposes a multiple-path routing algorithm on the basis of the referenced multiple-path routing algorithm. The new guide line proposed better satisfies the demands of QoS. Simulated contrast by means of OPNET show that the algorithm is valid and effective in controlling the packet loss ratio, time delay and the residual bandwidth.

Daniel Simion [8] proposes a multi objective routing algorithm using PSO. A imitation prototypical was form where the inspired algorithm is dispersed applied then the finest path is designed on every node until specific destination is reached.

HE ZhiQiang [9] presents a complete study of bio-inspired methods for cognitive radio networks. Explicitly, ant colony and particle optimization are additional explored with instances besides numerical simulation.

Israa Hadi, Mustafa Sabah[10] recommend a innovative block matching procedure which use the global search capability of Cat swarm optimization has been suggested to decrease a number of exploration positions in the motion estimation procedure besides aids as guide for resolving several optimization problems.

3.Cognitive Radio Network

Cognitive radio is distinct as a radio that can alteration its transmitter parameters based on collaboration with its situation. After this explanation, some features of cognitive radio can be distinct: Cognitive ability over real-time collaboration with the radio situation, the portions of the spectrum that are unused at a exact time or position can be recognized. As explained in Figure 1, this network permits the practice of temporally unused spectrum, mentioned to as spectrum hole or else white space. Thus, the finest spectrum may be designated, shared with additional users, then subjugated without interference with the specific licensed user [11][12] .

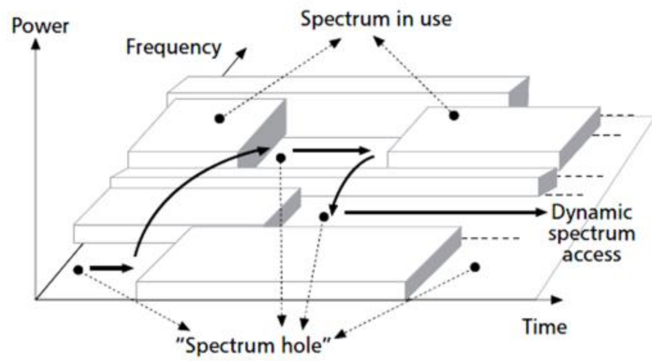

Figure 1: The spectrum hole concept.

4. Cognitive Radio Network Techniques

The key tasks of cognitive radios can be summarized in four tasks as shown in Figure 2 below. These abilities can be recognized over the roles of spectrum management that discourse the following chief challenges related with spectrum such as sensing, decision, sharing, in addition to mobility. In this paper explains the concept of spectrum decision, which deals with routing strategies that represent the main problem in this paper [13] .

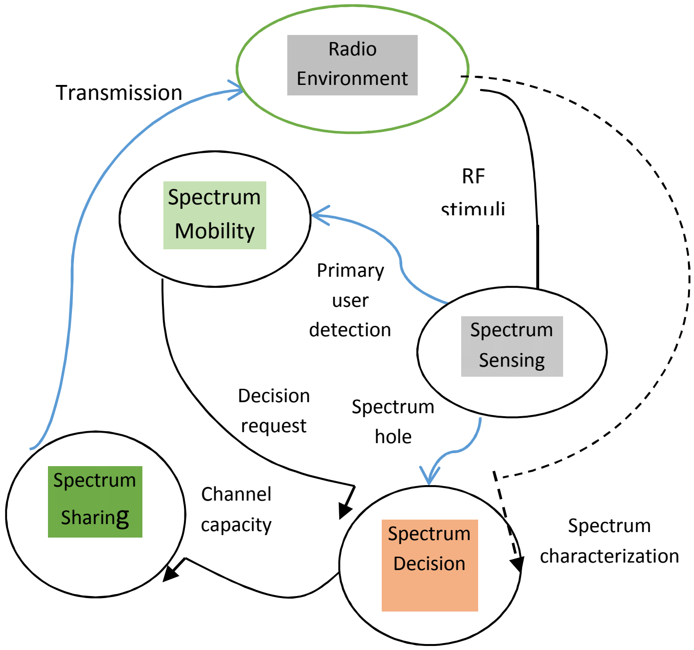

Figure 2: Radio Environments.

5. Spectrum decision

Cognitive radio networks involve the ability to choose which is the finest spectrum band between the obtainable bands conferring to the quality of services necessities of the specifics applications. This concept is termed spectrum decision which is related to the channel features and processes of primary users [14] . Moreover, this stage is affected through the actions of other users in this network. This stage typically involves of two steps: first, every spectrum band is categorized, based on not only local explanations of users but furthermore statistical information of primary networks. At that time, based on this description, the greatest suitable spectrum band can be selected [7][15][16] .

6. Optimization

Optimization is a familiar term in all walks of life. Optimization leads to effective resource management through efficient and effective solutions to the problems. The complexities of the optimization problems encountered in the field of engineering mainly due to complex objective function and non-linear constraints, has diverted the attention of engineers to seek the help of more efficient and versatile meta-heuristic algorithms. One of the promising fields in meta-heuristic optimization algorithms is the swarm intelligence. The methods incorporated in Swarm Intelligence consist of a collection of stochastic, population based meta-heuristics inspired by various natural phenomena, which naturally strive to optimize their work, and swarm based optimization algorithms work on the cooperative behavior of these simple agents, leading to learning during iterations. Thus the optimization procedures adopted in swarm intelligence based algorithms, decentralizes and distributes the optimization task, thereby reducing labor to arrive at a global optima [16] .
The local search technique employed by these simple agents or swarms coupled with randomization increases the variety of solutions on the global level, thereby balancing the amalgamation of intensive exploitation and global exploration. The parallel nature of working among these simple agents reduces the computing time especially in case of large optimization problems [17] .

7. Meta Heuristics Algorithms

The approaches depend on meta heuristics are able of accepted decision in addition to near to optimal solutions to specific problem of rational size, that smaller the time of computation. The original expression “heuristic” derives from the Greek verb heuriskein, which denotes ‘‘to find’’. a another term ‘‘meta’’ denotes ‘‘beyond, in an upper level’’. Consequently, these algorithms that join heuristics “that are usually very problem specific” in a additional common framework. Dissimilar people distinct this behavior in different ways, but Blum in addition to Roli observed these definitions as well as concluded basic characteristics which distinguish these algorithms [18] .

It represents strategies that "guide" the search procedure, so the objective is to competently discover the space of a search so as to discover near- optimal solutions. However the strategies which represent these algorithms variety from straightforward local search actions to complex learning actions. Remembering that these algorithms are approximating as well as non-deterministic. As a result met heuristics are not problem specific. Today's additional superior met heuristics use search knowledge to guide the search process. A broad classification of nature inspired meta heuristics algorithms classified into five categories as shown in figure 3 below: [17] [18]

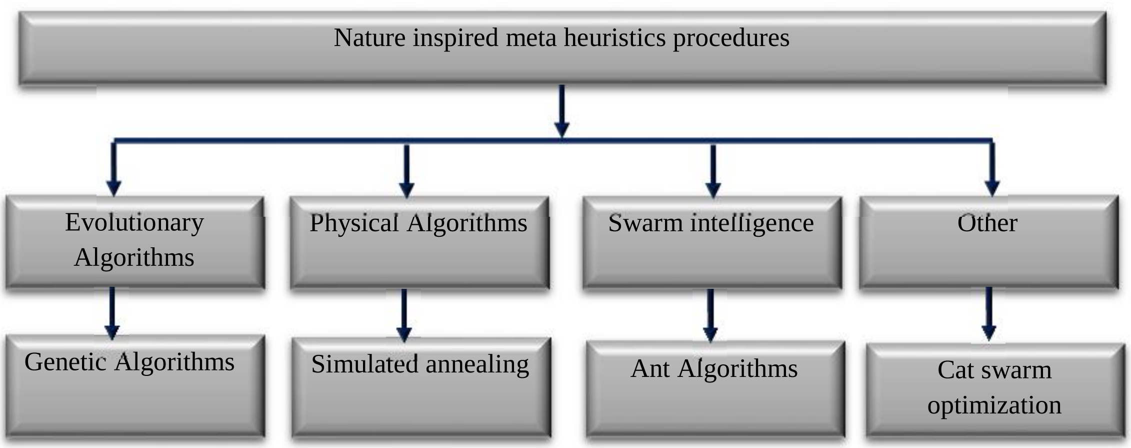

Figure 3: Categories of Meta Heuristics Algorithms

8. Cat Swarm Optimization (CSO)

A further current optimization procedure depend on SI is an algorithm that called Cat Swarm Optimization. This optimization procedure is improved depend on the ordinary activities of this animal. It had been discovered

that cats expend the majority of their time sleeping as well as watch something attentively their situation rather that running following effects as these activities leads to extreme utilize a resources . However, in order to imitate these two significant activities properties of the cats, the CSO indicates to these activities properties as seeking as well as tracing modes, which symbolize two diverse actions inside this algorithm . The first mode that called (tracing) models an activity of the individuals(represented cat in this type) when running following a goal whereas the second mode that called (seeking) models an activity of the cats while resting as well as monitoring their environment [19] .
Moreover, in contrast with other optimization algorithm, earlier researches have exposed that this algorithm has an improved performance in order to minimize a cost function of specific problems [20] .

9. Proposed Algorithm:

A spectrum opportunity consider the most significant feature, wherever channel obtainability has to be exceedingly taking into account in several routing train in cognitive radio network. a choice of a whole path, starting from source to specific destination, is likely to be completed one time if we have stationary topology in case of a primary user is inattentive for the whole message time.

However, network situation may variation so fast that the routing in CRN train would choice the succeeding hop route on a spread foundation(under unstable radio environment scenario). For instance, every node should examine for the finest succeeding hop, besides the packet would go through until it touches the specific destination. In this state, routing procedure would track in each node that represent as secondary user, therefore there is specific determination will be done through the node of this network for every incoming packet for choosing the succeeding hop.

Some methods can be applied to evade high delays in data delivery of node to- node, For instance, the optimization is initiated when a variation in the primary user performs is distinguished. However the operation of select the succeeding hop should be depending on QoS constraint of a secondary user; in this paper, define a mathematical model for the single objective and multi objective problems.

First metrics which used in proposed algorithm is a hop count, so in order to optimize this metrics, we state $x_{a,b}$ the probable track between nodes *a* and *b*. therefore, the optimization in expressions of whole hop counts for a specific movement *m* from node to node will be describe in equation (1):

$$\min \sum m \sum x_{a,b}. \quad \ldots\ldots\ldots\ldots \quad (1)$$

second metrics is delay, so the expression of optimization for reducing the delay $d_{a,b}$ for every link *(a, b)* on the path is (2):

$$\min \sum m \sum d_{a,b} \cdot x_{a,b}. \quad \ldots\ldots\ldots\ldots \quad (2)$$

in this paper we declared a next hop metrics as single objective and declare the delay with inertia weight in addition to hop account as multi objective function as we describe in equation(3):

$$\min \sum m \sum w_k \cdot fit_{a,b}. \quad \ldots\ldots\ldots\ldots \quad (3)$$

Under the constraint that $\sum w_k = 1$.

9.1 Spectrum Decision using Cat Swarm Optimization

In CSO, a set of arbitrary solutions is created. This random initial individuals is dispersed in the population size in the direction of the optimal solution over a number of repetitions (moves) depend on huge amount of information near the design space that is shared through completely members of the individuals.

When applying this procedure to solve a specific optimization problems, the first stage is to make a choice on the number of individuals that represent the (cats) to practice. Every individuals in the population has the many features such as (position, velocities for every dimension in the location, also a fitness value of each individuals depend on the fitness function in addition to a flag to show whether the individual is in seeking or tracing mode).

This algorithm preserves the finest solution after every cycle and when the condition of termination is fulfilled, the last solution is the finest location of one of the individuals in the population. This algorithm has two general modes, namely seeking and tracing mode and the mixture ratio abbreviation as(MR) dictates the construction of theses modes.

The processing of spectrum decision is seeking for the finest location within the area of search, in which a point of the minimum error requirements to be found that represent as comparable criteria in this procedure. So as to accomplishment a improved percentage of accuracy, the more positions inside the located exploration will be matched; yet, the additional computation times should be consumed on searching. In this section, the objective of applied the ICSO algorithm to spectrum decision approach is to accelerate the exploration of matching, achieve higher precision, faster computation speed in addition to reach a superior route.

A superior procedure must expend less calculation time on searching approach as well as accomplish the better solution. So, in this part, the ICSO procedure will be described in order to accomplish certain objectives such as accelerate matching search strategy, get higher precision, faster calculation speed and reach a final objective target. Concurrently, it adds the concept of information exchanging so that the proposed procedure can switch information haphazardly, that imitates the assistance property among separated classes (each contain number of nodes). The share of close best solution among different separated groups of cats will be the objective of information exchanging process. Furthermore this procedure was design to develop the performance measures as well as achieve better convergence inside less iteration. However, all objectives can be accomplished through apply the information exchanging concept in addition to add a new parameter (that will be selected haphazardly) to the position equation as inertia weight, followed by setting a new appearance for the equation of velocity in order to improve the capability of searching in the region of the finest individuals. Consequently , the algorithm provides a global search if the selected value of inertia weight was taken as a large whereas the algorithm provides a local search if the selected value of inertia weight was taken as a small.

9.2 The proposed algorithm: Optimal Path based on ICSO: (OPICSO)

The optimal path depend on ICSO will described as follows.

Step1: A population of M individuals is created with haphazard locations inside the area of searching (which is typically a region centered on the present node location) that constructed from nodes in CRN; and then haphazard velocities are allocated to every cat.

Step 2: Choice number of individuals then set them into tracing mode based on flag indicators, then the others individuals set into another mode (seek).

Step 3: Estimation the fitness value of every individual swarm according to the objective function. In the spectrum decision operation, a hop count and delay with inertia weight as the (similar criterion) will be selected.

Step 4: Calculate a fitness value of every individual swarm through applying the locations of this individuals swarm(cats) into the fitness role (hop count and delay), which denotes the conditions of our objective, and preserve the finest cat into memory.

Step 5: Pick up a collection of individuals swarm successively then sort these individuals in this collection based on values of fitness.

Step 6: : Transfer the individuals based on their flags, if *catk* is in first mode(seeking), set the individual to this mode procedure, else sent it to second mode(tracing) procedure.

Step 7: Every time, select the (W) parameter which represent the inertia weight haphazardly in variety between 0.4 and 0.9 so as to regulatory extreme wandering of individual outside the area of examining .

Step 8: Choice the close finest solution from the neighbor collection and substitute the individual, which has the poorest fitness value in this collection. Nevertheless the close finest solution and the individual must not come from the similar collection.

Step 9: Replication the above steps for every collections.

Step 10: Every time in the modified tracing mode procedure, the equation of second parameter(velocity) can be update as declare in equation (4):

$$V_{k,d}= V_{k,d} +r_1c_1(X_{lbest,d} - X_{k,d}), \quad \dots\dots\dots \; \dots\dots\dots(4)$$

Where:

d=1,2,…….,M

$X_{lbest,d}$ indicates the coordinates of the close finest solution in single group.

Step 11: Custom a new formula of the second parameter which is a (position) through combining two relations:

first the average information of present in addition to previous location and second, the average of present besides preceding velocity will be used.

Step 12: Termination conditions. This state happened If a number of repetition matches to the maximum or error criteria of the procedure less than a specified small number ε.

10. Simulation Results

To validate the performance of proposed procedure, an example of network that has 5 nodes spread on 50mx50m range besides there are four channels each user can utilize. Certain channels are employed via primary units (haphazardly selected); then a residual channels can be used via secondary users. These channels are imaginary of equivalent BW and different delay and cost. The expected situation could be seen in figure 4. As an example, node1 has certain stream of traffic flow that wants to send it to node 3. Consequently, we have to inspect the multi routes. In this situation the objectives fitness function are least delay and acceptable cost.

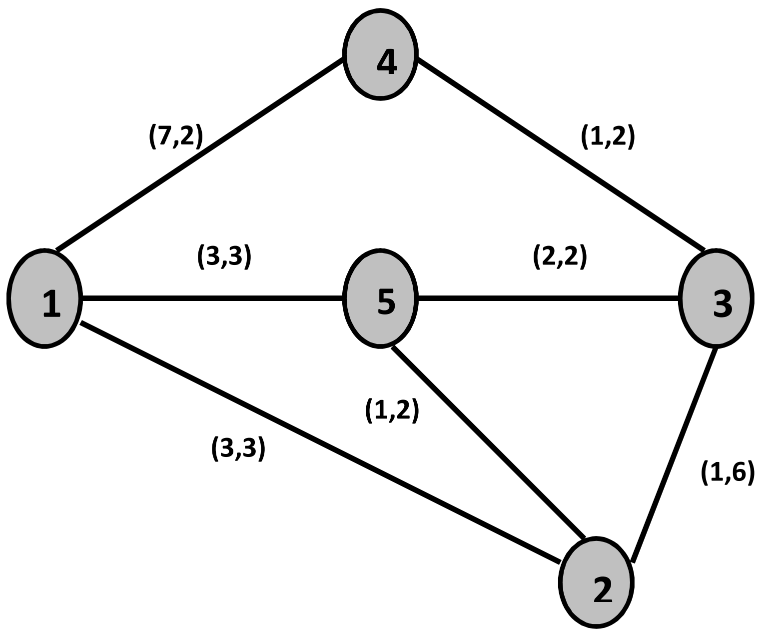

Figure 4: Network used in simulated results.

While executing the proposed algorithm in domain of spectrum decision , the location of x_i , would denote a candidate path from specific source to the destination. The probable routes are firstly intended through every routing procedure. The optimization is obvious founded on the wanted objective function which in the circumstance of CRN could be least delay otherwise maximum performance. As we monitored above, the original generation of the individuals has to be inside a possible set of solutions. This solution such as routes from node1 to node3 such as: {node1-node2-node3}, {node1-node5-node2- node3} in addition {node1-node5-node 3}.

Alternatively, the path {node1-node5-node4} is not possible, generally because node3 is out of variety of the spread decision of node1. Moreover, an alteration on a v_i^{t+1} which represent the update of velocity , should be prepared, in order that the new solution, x_i^{t+1} , is an real path between node1 and node 3.

Finally we compare the proposed algorithm with DCUR procedure under diverse situations and diverse weights, in order to demonstration the efficiency of proposed algorithm in the process of optimization. Table 2 illustrations that the proposed algorithm has further flexibility to choice the best path based on the weight strategy (w_1 besides w_2) in order to minimize the objective criteria's (hop count in addition to delay).

10.1 Demonstrated Example:

As a demonstrated example a collection of five call-requests in a simulated network constructed from 5-node are executed through the (DCUR) procedure. Then a similar requests are executed through the proposed algorithm. This network is shown in figure 4. All edge is categorized with an well-ordered pair representing the (cost, delay) values of the link. All edge is supposed to have a total BW equal to 30 units. Some examples of call-requests prearranged in Table 1 are supposed to happen one subsequently another in the exact order. Moreover, Table 2 specifies the least-cost as well as least-delay routes among each pair of vertices in the simulation cognitive radio network.

Table 1: Set of Call-requests

Id	Source	Destination	Bandwidth	Delay Constraints
1	1	3	10	6
2	2	4	10	7
3	2	4	10	6
4	2	4	10	6
5	2	4	10	7

Table 2: Results of the Executing of DCUR and ICSO

Call Number	DCUR	W1	W2	ICSO
1	Accepted ; Cost=8 Path: 1— 4 — 3	0.9	0.1	Accepted ; Cost=8 Path: 1— 5 — 3
2	Accepted ; Cost=10 Path: 2— 1 — 4	0.6	0.4	Accepted ; Cost=4 Path: 2— 5 — 3— 4
3	Accepted ; Cost=10 Path: 2— 1 — 4	0.4	0.6	Accepted ; Cost=10 Path: 2— 1 — 4
4	Rejected	0.1	0.9	Accepted ; Cost=10 Path: 2— 1 — 4
5	Rejected	0.1	0.9	Accepted ; Cost=4 Path: 2— 5 — 3— 4

10.2 Performance metrics:

In this part, the performance metrics of the suggested procedures besides the comparative between traditional algorithm with proposed algorithm will be described. For an accepted call-request "R" let us describe the functions:

- ***Accepted(R)*** denoted as 1.
- ***Cost(R)*** is represent as a cost of the route selected for call request.
- ***Dist(R)*** is a distance of the route (in expressions of hop-count) selected for call request.

All functions return zero if a call request is rejected.

We can addressed the total number of call-requests produced as a "N" The succeeding metrics were used to investigate the performance criteria of the routing procedures.

- **Average Call Acceptance Rate** represent the average likelihood of accepting a real-time channel establishing demand.

$$ACAR=\frac{\sum_{i=1}^{N} accepted(R)}{N} \ldots\ldots(5)$$

- **Average Cost** represent the average cost of the recognized channels.

$$AC=\frac{\sum_{i=1}^{N} \cos t(R)}{\sum_{i=1}^{N} accepted(R)} \ldots\ldots(6)$$

- **Average Routing Distance** represent the average hop-count of a recognized channels.

$$ARD=\frac{\sum_{i=1}^{N} dist(R)}{\sum_{i=1}^{N} accepted(R)} \ldots\ldots(7)$$

Consequentially, for measuring the throughput of network the first metrics will be used While the second metric are significant in the setting of real-time multimedia applications that need a call to be set rapidly. Finally the third metric is significant in the case that a shorter route consumes less network resources in addition to contribute to improving network throughput besides lowering cost.

Table 3 summarizes the three performance metrics of algorithms in the above example. It obviously shows that the proposed method heuristic scores over the traditional algorithm.

Table 3: Summary of the performance Metrics of DCUR and ICSO

performance Metrics	DCUR Performance	ICSO Performance
Average Call Acceptance Rate	**0.6**	**1**
Average Cost	**9.33**	**6. 7**
Average Routing Distance	**2**	**2.4**

11. Conclusion

In this paper, we have explored the critical challenges in designing and optimizing CRN and proposed the nature inspired approach exploiting evolutionary and collective intelligence. Also we analyze the current multiple-path routing which based on the features of CN. And find that they cannot be applied in CN directly, because it cannot satisfy the problem of QoS constraint. Thus a new adaptive decision sensing procedure process depend on enhancement Cat Swarm Optimization is suggested to decrease the number of search positions in the routing procedure.

higher accuracy and faster computation speed in optimal path can obtained from proposed algorithm. A high probability for discovering the true minimum (accurate next node) is expected regardless of the movement complexity contained in the sequence, yet the CSO approach is capable of achieving high accuracy in CRN environment. Because the proposed algorithm does not consider any fixed search pattern or any other movement assumption . The proposed algorithm outperforms well known algorithm like DCUR at time delay of data packets, packet loss rate of network and rest bandwidth. But it should be improved at the stability of controlling time delay.

Yet, with the purpose of develop the traditional cat optimization from views of speed besides prediction accuracy, proposed algorithm engrosses the benefit of parallel computing to improve the first mode (tracing mode) such that a modified tracing mode is implemented. So that the proposed process creates a plurality of traditional algorithm to exploration the finest parameters in the estimate the succeeding node autonomously in addition simultaneously over isolating the “cat swarm” into certain collections. Therefore , it adds information exchanging approach so that the traditional algorithm can exchange information irregularly, which imitates the collaboration among collections. However, in case of variety bound of velocity, an adaptive inertia weight to velocity calculation will be added.

Experimental consequences validate the high performance of the suggested process in expressions of complexity in view of computational, discovering the global route finest result, faster convergence besides estimation precision. We find that the result of proposed algorithm better in competitive performance compared to the traditional algorithm..

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اتخاذ القرار الامثل للشبكة الادراكية المعرفية بالاعتماد على الطرق المستوحاة من الطبيعة المطورة

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المستخلص

لشبكات المعرفية هي مجموعة من العقد يتم اعدادها من خلال موجة معرفية والتي بدورها تستطيع تحسين اداءها بصورة اوتوماتيكية بواسطة تغيير سلوكياتها لتتكيف مع البيئة ، بالرغم من ان العديد من البروتوكولات التي تعكس هذه الشبكات قد تم اقتراحها فعلا لتشمل عدة مستويات من التكيف والتي توفر بدورها نوعية جيد من الاداء.
لارسال بيانات بصورة صحيحة وتطوير بروتوكول ادراكي ولفرض التحديات كنتيجة لطبيعة المتغيرة للطيف الممكن الحصول عليه.
هذا البحث يقترح خوارمية تحسين لمسار تستند على اسس واحد من الطرق المستوحاة وبالتحديد خوارزمي القطة المحسنة لزيادة سرعة استكشاف المسارات المثالية و هي خوارمية دلالية ارشادية جديدة.
هذا البحث يقدم خوارزمية ايجاد مسار متقدمة متخصصة لهذا النوع من الشبكات والتي تجعل عملية الارسال فعالة و متكيفة و قابلة للتوسيع بعدد متراكم من العقد. الطريقة المقترحة تحقق بصورة افضل متطلبات تحسين الخدمة و تبين ان الخوارزمية صالحة و فعالة للسيطرة على نسبة خسارة الحزم ووقت التاخير والسعة المتبقية للحزمة بينما ترضي متطلبات الخدمة وذلك بالاستناد على بعض الخصائص المهمة لخوارزمية القطة. اخيراً توضح نتائج المحاكات ان البحث المقترح يوفر استكشاف كفوء لسعة الحزمة.

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