Probability Detection of Spectrum using Differential Evolution and Symbiotic Organisms Search in Cognitive Sensor Network

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***Abstract*-The spectrum congestion due to the static spectrum allocation scheme in wireless communication had been an issue. In this paper, cognitive sensor network had been proposed to handle the loophole in the spectrum intelligently. In order to achieve a reliable spectrum sensing, an optimization scheme with fast convergence speed has been employed to optimize the sensing performance. The parameters of differential evolution and Symbiotic Organisms Search have been set for solving the optimization problem in probability detection of spectrum for cognitive sensor network. The probability detection of spectrum formulation in cognitive sensor network has been modeled in MATLAB and the optimization has been simulated using the differential evolution and symbiotic organisms search algorithm.**

Key words: Cognitive Sensor Network (CSN), Differential Evolution (DE), Symbiotic Organisms Search, Internet of Things (IoT), Probability Detection, Energy Management

I. INTRODUCTION

According to many researches it has been found that the allocated spectrum (licensed spectrum) is not utilized properly because of static allocation of spectrum. It has become most difficult to find vacant bands either to set up a new service or to enhance the existing one. In order to overcome these problems, we are going for "Dynamic Spectrum Management" which improves the utilization of spectrum. Cognitive Sensor Network (CSN) is a form of dynamic spectrum management. With CSN being used in a number of applications, the area of spectrum sensing has become increasingly important. As Cognitive Sensor Network technology is being used to provide a method of using the spectrum more efficiently, the probability detection of spectrum is key to this application. The ability of CSN to access spare sections of the radio spectrum, and to keep monitoring the spectrum to ensure that the CSN does not cause any undue interference relies totally on the probability detection of spectrum elements of the system.

For the overall system to operate effectively and to provide the required improvement in spectrum efficiency, the CSN must be able to effectively detect any other transmissions, identify what they are and inform the central processing unit within the sensor network so that the required action can be taken. CSN has four major functions. They are Probability detection of spectrum, Spectrum management, Spectrum Sharing and Spectrum Mobility. Depending on transmission and reception parameters, there are two main types of cognitive sensor network:

1.Full Cognitive sensor network, in which every possible parameter observable by a wireless node (or network) is considered.

2.Spectrum-Sensing Cognitive sensor network, in which only the radio-frequency spectrum is considered. Towards this end,

Cognitive Sensor Network (CSN) is a recently emerging paradigm that aims to utilize the unique features provided by CR concept to incorporate additional capabilities to Wireless Sensor Network (WSN). The spectrum scarcity problem is envisaged to be addressed by Dynamic Spectrum Access (DSA) schemes. Cognitive Sensor Network (CSN) is the key enabling technology to provide dynamic, i.e. opportunistic, spectrum access.

II. PROBABILITY DETECTION OF SPECTRUM FORMULATION

Probability detection of spectrum is one of the major elements in the Cognitive Sensor Network. By definition, probability detection of spectrum means to sense and study the condition of the spectrum to see whether the spectrum is in use or is being vacant. The CSN sensing Design can be divided into two layer which is MAC sensing layer and PHY sensing layer. MAC sensing layer is responsible for access strategy while PHY sensing provide the spectrum sensor. What we are interested here is the role of energy detector in the PHY sensing layer.

The energy detector will measure the energy received on a primary band during an observation interval and declares a spectrum hole or white space if the measured energy is less than a properly set threshold.
The probability of detection is formulated as,

$$P_d=(Q^{-1}(P_f)\sqrt{(w^T\Sigma_{H0}w-w^T\Theta)})/\sqrt{(w^T\Sigma_{H1}w)} \quad (1)$$

III. DIFFERENTIAL EVOLUTION (DE) ALGORITHM

DE is a population based optimization tools that attacks the given problem by sampling the objective function at multiple and random chosen points. DE optimizes a problem by maintaining a population of candidate solutions and creating new candidate solutions by combining existing ones according to its simple formulae, and then keeping whichever candidate solution has the best score or fitness on the optimization problem at hand. Differential Evolution algorithms can be divided into four steps, namely Initialization, Mutation, Crossover, and Selection. DE is used to solve the optimization problem in probability detection of spectrum in CSN.

DE generates new parameter vectors by adding the weighted difference between two population vectors to a third vector. Let this operation be called mutation. The mutated vector's parameters are then mixed with the parameters of another predetermined vector, the target vector, to yield the so-called trial vector. Parameter mixing is often referred to as "crossover".

If the trial vector yields a lower cost function value than the target vector, the trial vector replaces the target vector in the following generation. This last operation is called selection. Each population vector has to serve once as the target vector so that NP competitions take place in one generation.

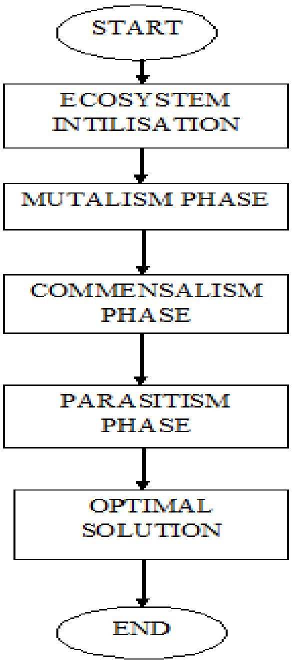

Fig. 1. Flowchart for DE

IV. SYMBIOTIC ORGANISMS SEARCH ALGORITHM

A new robust and powerful metaheuristic algorithm called Symbiotic Organisms Search (SOS) to numerical optimization and engineering design problems. Symbiosis can vary between mutualism, commensalism, and parasitism, though these grade into each other, and it is often difficult to tell which is involved in a given relationship. In mutualism, both organisms benefit. In commensalism, one benefits and the other is unaffected. In parasitism, one benefits and the other is harmed. SOS is used to solve the optimization problem in probability detection of spectrum in CSN.

Similar to other population-based algorithms, the proposed SOS iteratively uses a population of candidate solutions to promising areas in the search space in the process of seeking the optimal global solution. SOS begins with an initial population called the ecosystem. In the initial ecosystem, a group of organisms is generated randomly to the search space. Each organism represents one candidate solution to the corresponding problem. Each organism in the ecosystem is associated with a certain fitness value, which reflects degree of adaptation to the desired objective.

The character of the interaction defines the main principle of each phase. Interactions benefit both sides in the mutualism phase; benefit one side and do not impact the other in the commensalism phase; benefit one side and actively harm the other in the parasitism phase. Each organism interacts with the other organism randomly through all phases. The process is repeated until termination criteria are met.

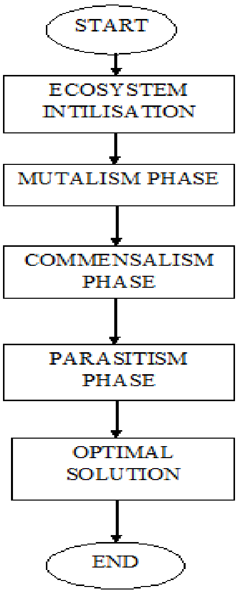

Fig.2.Flowchart for SOS

V. COMPARISON RESULT & DISCUSSIONS

Symbiotic Organisms Search does not use tuning parameters but Differential Evolution uses tuning parameters. In MATLAB, the parameter setting for SOS is N=50 (N=population size) whereas the parameter settings for DE are N=50,c=0.9(c=crossover rate),f=0.5(f=scaling factor). The Global minimum value for SOS is 22 but the Global minimum value for DE is 17. The probability detection of spectrum for SOS is 0.9922134 whereas the probability detection of spectrum for DE is 0.90512. The output for SOS is very linear when compared with DE

SOS	DE
1.Parameter settings N=50	1.Parameter settings N=50,c=0.9,f=0.5
2.Global minimum value is 22	2.Global minimum value is 17
3.Probability detection of spectrum is 0.992134	3.Probability detection of spectrum is 0.90512
4.The output is linear	4.The output is linear

Table 1. Comparison of SOS with DE

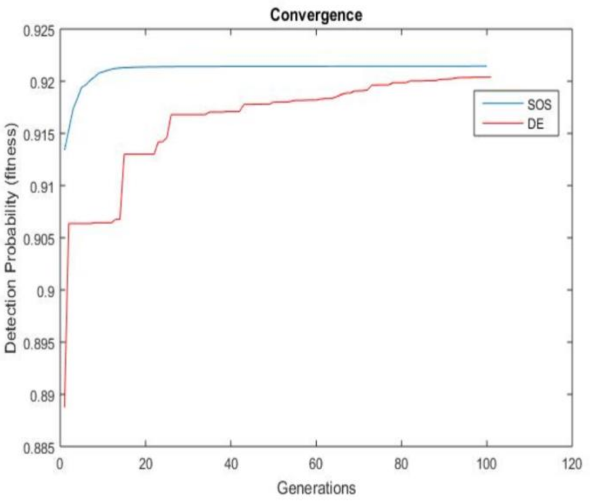

Fig.3.Comparison Result

VI. CONCLUSION

Cognitive Sensor Network is used to increase the probability detection of spectrum. The issue of interferences is reduced by using the optimization tools like Symbiotic Organisms Search and Differential Evolution. Hence, we can conclude that the Symbiotic Organisms Search is a better optimization tool for the probability detection of spectrum in CSN.

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