Enhancing The Channel Quality in Cognitive Network by Traffic Reduction Method

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Abstract
Cognitive radio (CR) has some specific unique characteristics like flexibility, interoperability and adaptability. Optimal technological candidate is particularly contributed which reduces the challenges towards spectrum scarcenessin multimedia communications. Moreover, this communication over CR networksproduces few severe issues like delay-sensitive, bandwidth-hungry, and loss-tolerant service and particularly ensuring quality of service (QoS). Improved Dynamic Optimization Algorithm (IDOA) is proposed for spectrum sensing in cognitive radio networks (CRN) where for theSecondary User (SU), data traffic is considered. From the comparison of several works in the literature, it is assumed that SU have no packets to transmitalways; but actually data sent per second is considered instead of channel capacity as the possible throughput with which the problem of sensing-throughput tradeoff is reformulated. The parameters such as probability of availability, Signal to Interference Noise Ratio (SINR), Processing time and transmission time are consideredto analyze the efficiency of the IDOA approach proposed which is compared with two state of methods namely Medium Access Control (MAC) and Dijikstra Algorithm (DA).

Keywords-Cognitive radio, Traffic reduction, Optimization, Primary user, Secondary user

Introduction

Cognitive radio (CR), a prominent technique, is employed in exploitingthe spectrum bands which are unused but registered to primary user (PU) [1]. For inactive PU, Secondary user (SU) transmits data over idle channel; or else keeps silent. To protect PU, the channels are sensed by SU [2]. Thus, in CRN spectrum sensing has to be performed. Basically, Sensing-Throughput Tradeoff is an important issue which has to be deeply investigated [3]. From SU point of view, when time taken for sensing is more, low is the false alarmprobability; then chances are more for transmitting data providing high throughput. Moreover, more sensing time reduces the time of data transmission for SUs. Thus, optimal sensing time has to be determined which improves the throughput of SU as well as provides sufficient protection to PU[4].In spite of several related research carried out with remarkable results, till now existing researches make infeasible assumption that SU always has uncountable data packets for transmission. The most challenging issue is the way to maximize the capacity of the idle channel [5].

But this consideration is not the case at all timesas practically data packets are based on the traffic flow [6]. Practically, SU certainly does not always have uncountable data packets for transmission. Thissuggestion simplifies the optimization ofsensing timeproblem, as data traffic have greater impacts on the optimum sensing time[7]. Ultimately, the aim of every study related to spectrum sensing and accessing it for completing data traffic of SUs.In this work, this assumption is ignored. The throughput of SU is defined as the actual data transmitted in the given time, instead of channel capacity and problem of Sensing-Throughput Tradeoff is reformulated according to the data traffic of SU[8]. In this work, a more general model is proposed which proves that forthe sensing time, throughput is a concave function andjust one value alone exists for optimum sensing time obtained using data traffic[9].The objective of this work is to improve channel quality by producing less retransmission to improve the overall energy efficiency and delay.

The remaining part of this paper is arranged as: Related works in the literature are presented in Section 2. In Section 3, the model of the proposed optimization algorithm for traffic reduction is presented. Experimental analysis and the results obtained are discussed in Section 4. To end with, the conclusions are providedin Section 5

Related Works

In [10], an outline about vitality productive subjective system MAC conventions is presented. The efficiencyagainst convention instruments was analyzed by taking various techniques into consideration. In [11], SU were categorized as real time (RT) and non-real time users. Here, game theory was involved to study the cooperation and conflict between both levels. A model based on auction game analyzing the process of decision-making was introduced. Numerous SUs was involved, user blockage probability was reduced, user handoff and channel saturation, and user acceptance probability was increased. In [12], incentives strategy based on reputation was introduced for resolving the hidden terminal problem which was encountered by SUs. The results proved the efficiency of this model. Another strategy employed approachesbased on logical commands/instructions. In [13], a collaborative decision-making process is presented which used fuzzy logicrules based on the Fuzzy Interference System (FIS). where Relative Link Quality (RLQ) and SINR were taken into consideration. In [14], a cross-layer framework was developed for optimizing the video quality of receivers where the performanceof upper layer was considered. In [15],Multi-user transmission was suggested for controlling scalable video content thereby the quality of video was improved. In [16], the apt time slots were determined by optimizingthe sensing period of spectrum sensing. In [17], to minimize the cooperation of users,an adaptation system transmission overintrusive CRN was involved. In [18], distributed multimedia information transmission system was designed using fountain codes and dynamic selection of the number of CR SCs. Here, several SG traffic was considered and solutions were developed for increasing the efficiency of communication infrastructure of CR based on smart grid systems.

Proposed methodology

For reducing the traffic between the primary (broadcasting) and secondary (LTE-A) services and minimizing the spectrum usage by CRN (cognitive radio-based networks), an Improved Dynamic Optimization Algorithm (IDOA)is developed for the Key Performance Indicators (KPIs) for CRN and the procedure for validating the method through experiment. Figure 1 shows the overall system architecture for traffic reduction.

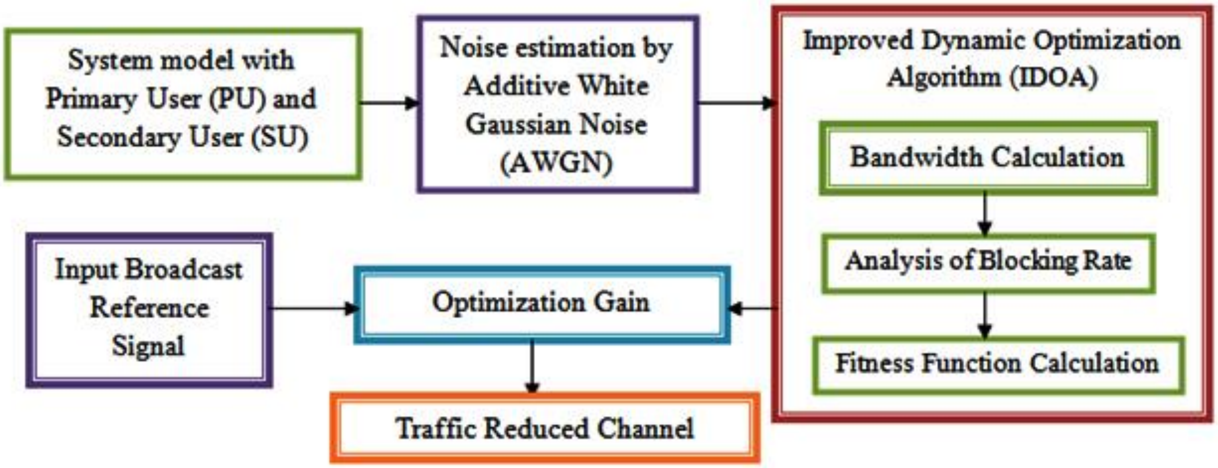

Figure 1-System architecture for traffic reduction

System model

In this system, aCognitive Unit(CU)pair of transceivers in anenvironment with high-traffic having several primary user channels (N) is taken into consideration. Here the idle sensed channelsare accessed by CUswhere interweavingapproach is involved. As channels are from various networks, thefunction of PU on every channel is said to be independent. The process of sensing spectrum depends on the binary hypothesis$H_0$and$H_1$for the signalreceived r(t), wherethe channel'sidleand active states respectively are confirmed.

$$r(t)=\{h.s(t)=w(t)H1\ indicatespresenceofPU \mid w(t)H0\ indicatestheabsenceofPU\} \tag{1}$$

Here, h,s(t) and w(t) indicate channel gain, signal transmitted of PU and Additive White Gaussian Noise (AWGN)correspondingly. But, the sensing results to be reliable, the time for sensing has to be greater than βmin (pre-defined threshold) as indicated below,

$$Bmin = \frac{1}{\gamma^2 fs}\left(Q^{-1}(p_f) - Q^{-1}(p_d)\right)\sqrt{2\partial+1} \tag{2}$$

here Q (.) represents the complementary distribution function,γ indicates the SNR of signal at the CU receiver, andfs is the sampling frequency. In the PU traffic 1 and 0 respectively indicates the active and idle channel states.

Improved Dynamic Optimization Algorithm (IDOA) for traffic reduction

When the coverage areas vary, overlapped network layers differs and bandwidth regions are computed in several ways. Thus, the entire bandwidth of all regions is defined as B^{R_i} within coverage area *Ri* which is as given in equation (3)

$$B^{R_i} = \begin{cases} B^{R_i}_{AP_j} & j \in \{1\}, i \in \{1\} \\ B^{R_i}_{AP_1} + B^{R_i}_{AP_j} & \text{i}, j \in \{2,.....m+1\}, i = j \\ B^{R_i}_{AP_1} + B^{R_i}_{AP_j} + B^{R_i}_{AP_k} & \text{i}, k \in \{m+2,.....m \times n+1\}, j \in \{2,.....m+1\} \end{cases} \tag{3}$$

Queuing model represents the user connection requests,connection number distribution representsqueuing window in the area.Blocking rate of requests made by the user in the network is given as P^{R_i} in equation (4)

$$P^{R_i} = \frac{\left(V^{R_i}\right)^{N_i} / N_i!}{\sum_{j=0}^{N_i} \left(V^{R_i}\right)^j / j!} \tag{4}$$

Here, *Ni* is the number of connections available in the region *Ri*,V^{R_i} is the business reached in coverage area, *Ri*is the arrival rateof service.

The fitness function helps is determining the final connection of u_i to $BS_j$where network KPIs namely interference and spectrum usage are balanced. Thus, fitness function for the network is given by

$$Fit\ (u_i\ ;BS_j) = w1\left(1 - \frac{su}{smax}\right) + w2.\left[1 - \frac{1}{2}\left(\frac{ISLmin}{ISLmax}\right)\right] \tag{5}$$

where ISLmax is the interference created by broadcasting stations which is normalized to maximum interference (ISLmax) and the LTE-A BSs (ISLAmax).

For the extended analysis object, i^th^value is given by

$$S(i) = \sum_{j=1}^{n} aij \sum_{i=1}^{n} \sum_{j=1}^{n} aij \tag{6}$$

Where,

$$\sum_{j=1}^{n} aij = \sum_{j=1}^{n} lij, \sum_{j=1}^{n} mij, \sum_{j=1}^{n} uij \tag{7}$$

Now, assuming that d1=min {V(lij<mij<uij)} the weight vector is w' = (d1,d2,d3….dn)

$$W = w\ (d1,d2,d3,d4....dn)^T \tag{8}$$

$$= \frac{d1}{\sum_{j=1}^{n} lij}, \frac{d2}{\sum_{j=1}^{n} mij} \cdots \frac{dn}{\sum_{j=1}^{n} uij} \tag{9}$$

The spectrum usage indicates the channels required in the uiarea; BSj connection is normalized using maximum channels involved in the Smax band. In the fitness function, every parameter that is normalized reacts to the average performance of the network. Thus, ui connected to BSjandthe best channel in the network supports the goals of KPI optimization instead of maximizing the KPI or QoS. Every SBS is represented by N and total Primary Users K are present which has the ability to send and receive packets through permitted wireless channels. Here, it is assumed that when PU do not transmit then SU uses their channel to transmit information. Let ϕkbe the probability that PU do not transmit, then totally k channels are available. In the stage, SBSs aggregate the information when channels are stationary. Moreover, cognitive pilot channel is involved as a control signal.

Algorithm

```
Input: Bandwidth, blocking rate,users
Output: optimized channel
while Sim <Max_Sim
 for ui< users
 for BSj< BSs
Set_Radiated_Power (ui ,BSj );
for ISLmin : 1 dB : ISLmax);
Evaluate_Interference (ui ,BSj );
Set_Spectrum_Allocation (ui ,BSj );
end for;
if fit (ui ,BSj ) >current_fit
 if Active (BSj )&& Bitrate (BSj )
 connect;
end if;
 end if;
for j=1:k
P_curentCalCurrentBlockingProbability();
admissionConnection();
areaNumberOfUserAdd();
end if
 time 0;
while(time<=adjustmentThreshold)
addAreaBandwith();
getAreaConn();
 P CalCurrentBlockingProbability();
if(P <Ri)
admissionConnection();
areaNumberOfUserAdd();
break;
 end if
```

Experimental analysis

The experimentis carried out and the results are analyzed with the parameters likeprobability of availability, Signal to Interference Noise Ratio (SINR), Processing time and transmission time. These parameters are compared with twostandard methods such as Medium Access Control (MAC) and Dijikstra Algorithm (DA).

- **Probability of availability**

The probability of availabilityis determined by checking the activeness of the frequency channel. For the used frequency band, the deciding threshold is computedusing the average noise floor.

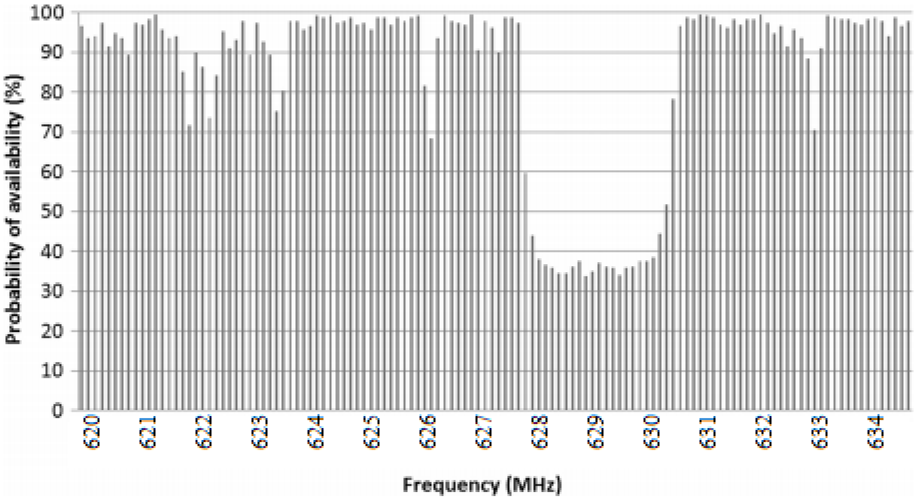

Figure-2 Analysis of probability of availability

Figure 2 illustrates the probability per channel and it is realized that the availability of almost every channel is more than 90%.

- **SINR**

It is difference of platoon member which is estimated by current SINR value using Primary user power level. Receiver part SINR value is represented as

$$\text{SINR} = \frac{Pij}{P\ noise + \sum Pkj} \quad (10)$$

Where,

P_{noise} is Gaussian noise signal strength

Pij is received signal strength frominterfering

Pkj is received signal strength from interfering

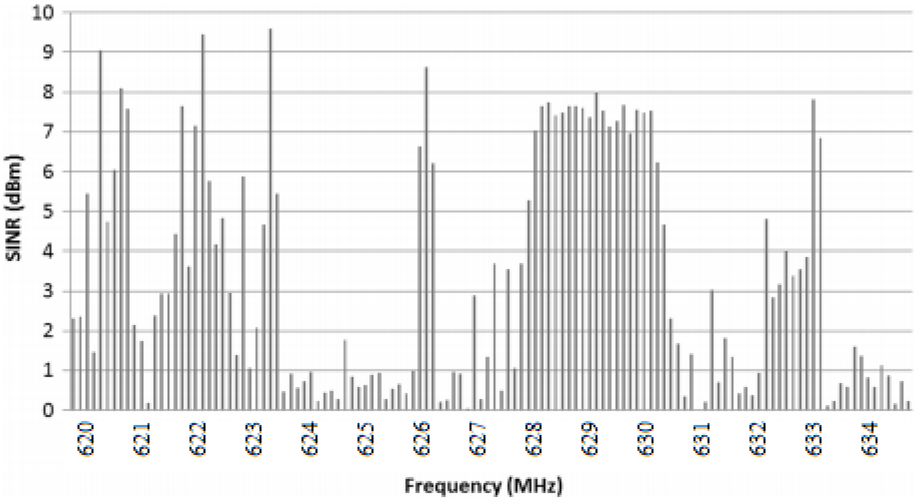

Figure-2 Analysis of SINR

SINR for every channel is illustrated in Figure 8. From the analysis, it is noted that a part of the spectrum offer slow SINR thereby representing spectral opportunities. Moreover, inverse proportion between the estimated availability time and SINR can be estimated for every channel.

Table-1 shows the comparison of processing time for the existingMedium Access Control (MAC), Dijikstra Algorithm (DA) and proposed IDOA approaches.

Table-1 Comparison of Processing time

Analyzed channels	Medium Access Control (MAC)	Dijikstra Algorithm (DA)	IDOA (proposed)
20	1	1	1
30	2.6	1.9	1.6
40	4.2	2.8	2.2
50	5.8	3.7	2.8
60	7.4	4.6	3.4
70	9	5.5	4
80	10.6	6.4	4.6
90	12.2	7.3	5.2
100	13.8	8.2	5.8
110	15.4	9.1	6.4
120	17	10	7.0
130	18.6	10.9	7.6
140	20.2	11.8	8.2
150	21.8	12.7	8.8
160	23.4	13.6	9.4
170	25	14.5	10

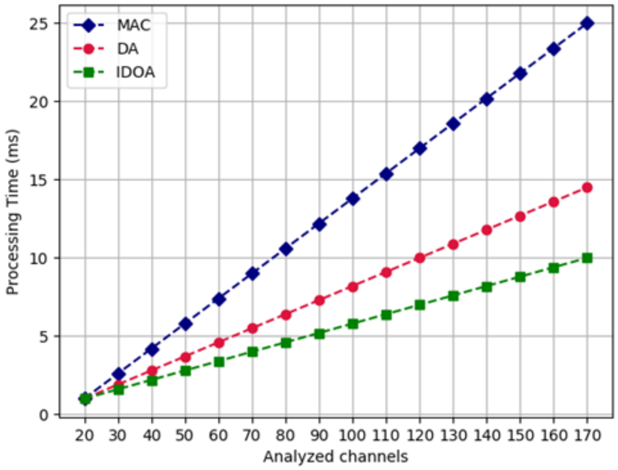

Figure-3 Analysis of processing time

From figure 3, it is observed that the linear rate is achieved for the calculation between analyzed channels and processing time. During this calculation, correlation coefficient is high for the linear approximated data.

Table-2 presents the comparison of transmission time between the existingMedium Access Control (MAC), Dijikstra Algorithm (DA) and proposed IDOA approaches.

Table-2Comparison of Transmission time

Transmission time of the secondary user (s)	Medium Access Control (MAC)	Dijikstra Algorithm (DA)	IDOA (proposed)
20	1	1	1
30	9.3	3.6	2.4
40	17.6	6.2	3.8
50	25.9	8.8	5.2
60	34.2	11.4	6.6
70	42.5	14	8
80	50.8	16.6	9.4
90	59.1	19.2	10.8
100	67.4	21.8	12.2
110	75.7	24.4	13.6
120	84	27	15
130	92.3	29.6	16.4
140	100.6	32.2	17.8
150	108.9	34.8	19.2
160	117.2	37.4	20.6
170	125.5	40	22

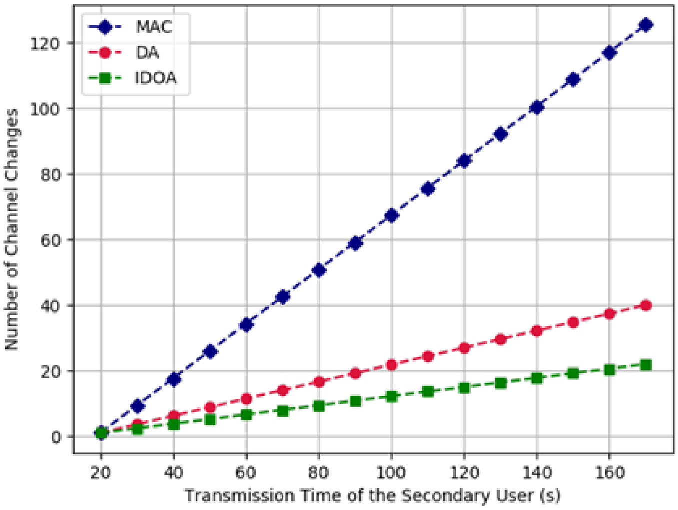

Figure-4 Analysis of transmission time

Figure 4 illustrates that in the proposedIDOAalgorithm, the handoff rate and the transmission time of SU are linearly proportional. Here, handoff is determined using transmission time. Moreover, parameters like delays associated with channel mobility can also be estimated.

Conclusion

This work indicated the sensible realization of the proposed Improved Dynamic Optimization Algorithm (IDOA) for practical spectrum sensing in cognitive radio with the effective selection of backup channel for proactive process. It is concluded from the result section, that the less transmission time improves the spectral handoff rate among radio devices. Moreover, there is improvement in energy efficiency with less processing time. The probability of availability and low SINR rate shows that the proposed method is suitable for less traffic with 40% of bandwidth consumption among spectrum in cognitive radio network. The future work is to include markov decision based artificial intelligence method for reducing traffic and interference.

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