

Using Enhanced Stimulated Annealing Algorithm to Performing Investigation in Cognitive Radio Network

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Abstract: This document presents the optimization of quality of service for unlicensed subscribers anticipating the QoS of the primary users as well. The concept of cognitive radio came into existence for the exclusive use of the unused spectrum space by the licensed users. The unlicensed user or the secondary users use the unoccupied spectrum spaces of licensed user's spectrum for the effective usage of the spectrum. The use of live streaming, Voice over Internet protocol (VoIP) and multi media applications which are delay sensitive applications throughout the session. The constraints like delay and throughput and the quality of service are affected due to these applications. To overcome these constraints the tradeoff between these parameters must be employed. In this paper, an extension to the non-work conservation policy is implemented in Cognitive radio network (CRN) by using the optimization algorithm known as Enhanced stimulated annealing (ESA) algorithm to bring forth the tradeoff between delay and throughput.

Keywords: Cognitive Radio, Delay, Enhanced stimulated annealing Algorithm, Optimization, Throughput, Trade-off.

I. Introduction

With the growth in the digital age, nowadays spectrum usage has risen drastically. The use of spectrum has the most prominent position to play in the world of communication. The technology called cognitive radio has developed by the IEEE 802 LAN / MAN Standard Committee (LMSC) and released in 2011. It is an intelligent radio that can change the parameters in accordance to the perceived availability of the spectrum in its operating environment. Cognitive radio supports the cognitive users also known as the secondary users or the unlicensed user and can provide them unused spectrum space to effectively use the underutilized band frequencies. A cognitive radio (CR) has the capacity (cognitive capacity), from the nearby environment to detect and collect data (e.g., transmission rate, bandwidth, energy, modulation, etc.) as well as to adjust operating parameters to ideal results quickly [1]. The cognitive cycle has three phases. They are (i). spectrum sensing, (ii). spectrum management, (iii). spectrum mobility. spectrum sharing. The cognitive cycle is as shown in the following figure 1.

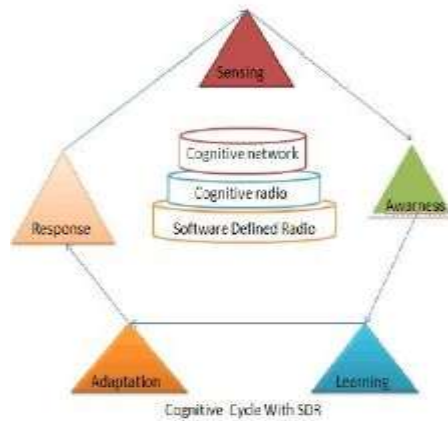


Figure 1: Cognitive cycle

The spectrum sensing is the process to sense the spectrum holes in the frequency range of the system in which the cognitive radio is implemented. Spectrum sensing detects spectral holes and allocates for the opportunistic transmission of CR users. In [3] Multiple sensors for unified spectrum detection, while a multi-energy detector system and various adjustable thresholds for cooperative spectrum measurement were described in [4]. Furthermore, the spectrum management is to choose

the best channels which are available and arrange the connectivity with other users to this channel. The spectrum management is all about avoiding the interference and providing QoS in spectrum environment. Along with provisioning of seamless connectivity nevertheless of the licensed subscribers. The spectrum mobility is regarding the handoff during the licensed user activity on the allotted channel might require users to alter their working channel bands.

A significant condition of mobility management protocols is to provide data on the span of a spectrum handover. Whenever the cognitive user changes its operating frequency these network protocols changes the parameters. This leads to the guaranteed clean and rapid shift with a minimum depletion of the QoS during handovers. The current spectrum sharing research is intended at addressing these problems and can be categorized into four elements: design, conduct of spectrum allocation, method of spectrum communication, and range. The following sketch explains the inter-network and intra network spectrum sharing i.e., figure 2.

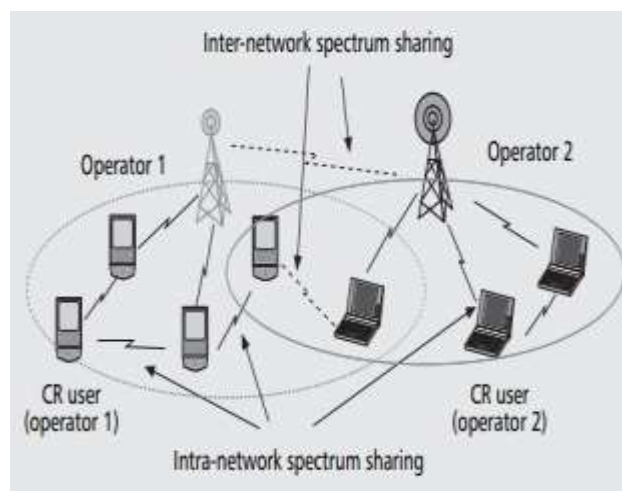


Figure 2: Spectrum sharing

II. Organization Of The Frame Work

In this paper we have considered the cognitive radio network as sketched as below figure 3. The network incorporates of two users i.e., Primary users (PU) and secondary users (SU) and a standard destination. The PU is furnished with a queue, Q_p for the primary user packets and likewise SU is furnished with a queue, Q_s meant for the secondary user packets and the Q_{sp} which is intended for the packets

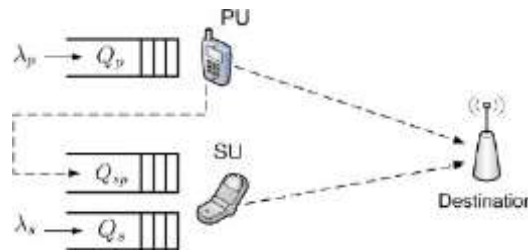


Figure 3: System organization

over headed from the PU packets. The packet arrival rates are defined as λ_p and λ_s using random process of Bernoulli where $0 \leq \lambda_p \leq 1$ and $0 \leq \lambda_s \leq 1$. The evolution of the length of the j th queue is characterized as $Q_{jt+1} = (Q_{jt} - Y_{jt}) + X_{jt}$, for $j \in \{p, sp, s\}$ (1) When a primary user uses the channel to propagate the packets through Q_p towards the destination, the packets are received by the destination a positive acknowledgment (ACK) is sent to PU indicating that the packets are received successfully. In this scenario we assume that the system is interference free channel by using the high detection probability detectors at the MAC layer. The probability of successful packet reception i.e., the probability of no linkage outage, between the primary user (PU) and the destination, the secondary user (SU) and the destination, and the PU and the SU are indexed by h_{pd} , h_{sd} and h_{ps} , respectively. In this layer the PU can be detected for its Idle or the busy states using the detecting sensors at the secondary users.

2.1 When the PU is reserved

Basically, when the PU transmits the packets towards the destination, there exists three probable cases:

- (i). If the destination receives the packets and sends back an acknowledgement to the PU that the packets are decoded perfectly by the destination nevertheless of whether the SU decoded the packets or not.
- (ii). If the packets are decoded by the SU as well as the destination, then the packets are stored in Q_{sp} with probability denoted by 'a'. If accepted by the SU then it acknowledges the source and the packets are released from the Q_p .
- (iii). If neither the SU nor the destination, then the packets are remained in the Q_p for retransmission.

2.2. When PU is not busy

If the channel is occupied by the SU through Q_s with the probability 'b' or from the queue Q_{sp} with probability '1-b'. Otherwise the packets are dropped, and the PU is idle. The condition that the PU is busy, and the slot is under utilized is said to be the WC cooperative policy.

III. Implementation Of Design

The service rates of the PU and SU are formulated as below from the service rate of Q_p is μ_p ,

$$\mu_p = h_{pd} + (1 - h_{pd}) h_{ps} a$$

and similarly, the service rate of Q_s is μ_s ,

whereas the service rate of Q_{sp} is formulated as

The average queue lengths of the Q_S , Q_p and Q_{sp} are indicated by N_p , N_{sp} and N_s individually. These queue lengths are derived from the application of Pollaczek-Khinchine formula [8] with Bernoulli arrival rate which is represented by λ_p using discrete time M/M/1 queue in the MATLAB using communication tools.

The Inequalities of the stability of the queue is formulated such that the network would be operated accordingly. That is

$$\lambda_p < \mu_p, \lambda_s < \mu_s, \lambda_{sp} < \mu_{sp}.$$

Likewise, the average delays of the primary and cognitive user are formulated using little's law such that

$$D_p = (N_p + N_{sp})/\lambda_p, D_s = N_s/\lambda_s$$

For defining the secondary user throughput, the optimization problem is considered as follows. Here we optimized the problem of maximizing the SU throughput with the PU delay constraint. Here is the formula that the problem is framed:

The paper is mainly focused on the concept to improve the QoS even with cognitive user while using the applications like Voice over internet protocol, live streaming and some other media applications like screen sharing etc. Parallely providing the licensed user with the efficient communication channel. The suboptimal policy and the WC policy are principled with the conditions such as arrival rates and the probabilities of the channel as follows: $h_{pd} = 0.3$, $h_{ps} = 0.4$, $h_{sd} = 0.8$. Now coming to the Primary delay constraint, the Threshold limit plays a important role where $\psi = 10$. The problem Q1 is a non-convex function which is converted to quasi convex function to solve in an iterative process with $\psi = 10$ and $\lambda_p = 0.2$ and $\lambda_s = 0.4$.

IV. Stimulated Annealing and Its Advantages

It is a process purely based on the staticalmechanics and Annealing is a process in which the metallic substance is heated up and cooled to make it stronger than before. The stimulated annealing algorithm here used to solve scheduling process in the cognitive radio to avoid delay and to improve the performance of the service. It is very clear that the stimulated annealing process is the best answer for the optimization than the conventional algorithms used. Enhanced stimulated annealing process involves the following steps:

- (i) The tasks on the system are distributed arbitrarily and assess the weight of the scheme (using the OFso) for 'n' number of times.
- (ii) Find the average weight of n-unit weights discovered in portion 1.
- (iii) To conduct multi-thread annealing, select a limit proportion so that any instance with a unit weight higher than 1/5 times of 'n' value (provided) above the median is chosen as a seed.
- (iv) Collect as many seeds as possible.
- (v) Apply for each seed the simulated annealing method.
- (vi) Select the allocation with the minimum weight of the scheme.

Here the temperature is a parameter used to indicate the acceptance ratio in the given system and initial parameter value is fixed such that the proportion of the worst moves of given system is minimum. We suggest a fresh simulated annealing method depending on the concept of estimating each chain's temperature depending on the likelihood of accepting the goal. The evolution of acceptance probability during optimization follows an acceptance schedule: initial value, chain length, final value (or stopping condition) and decrement rule. The system weight enhancement for Enhanced stimulated annealing process is much greater than the simple stimulated annealing procedure as follow in the below equation μ [Enhancement(Enh_SA)] > μ [Enhancement(SA)] . SA is sensitive to the variation of the cooling factor. When the cooling factor increases, the enhancement from the initial system weight and the execution time also increase.

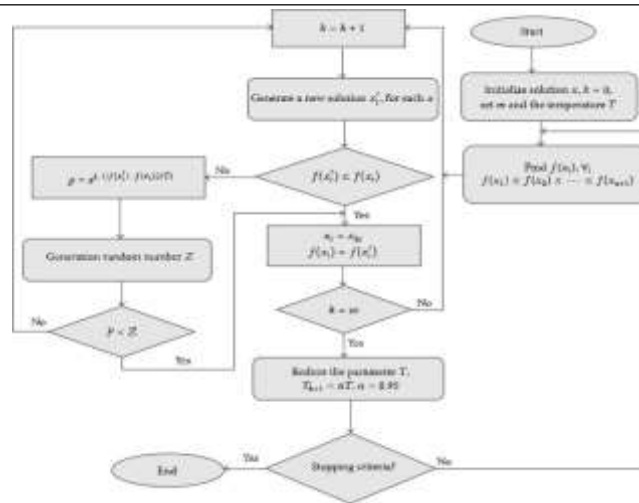


Figure 4: flowchart for Enhanced simulated annealing (ESA)

In addition, the enhancement from the initial system weight and the execution time were found to increase with the increase of the cooling factor for the simulated annealing algorithm.

V. Summary of Results

The following are the graphical representations of the average delay packet versus arrival rate at SU packets, the stable throughput region graphs and the graph that illustrates the average packet delay of the licensed and unlicensed users.

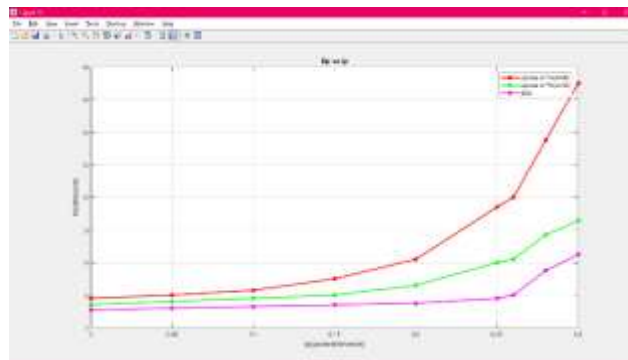


Figure 5: Graph that illustrating the Delay of PU Vs arrival rate on PU with predefined conditions and threshold.

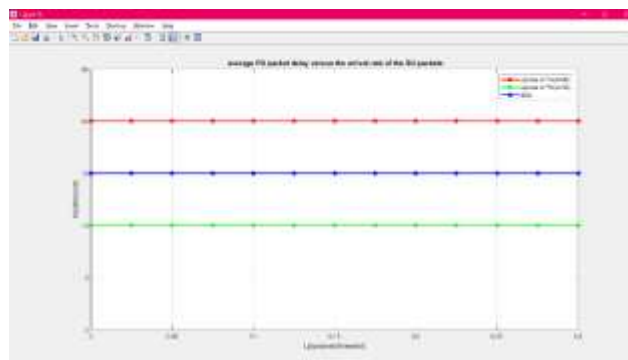


Figure 6: Graph illustrating the average PU packet delay Vs average SU packet delays comparing with the implementation

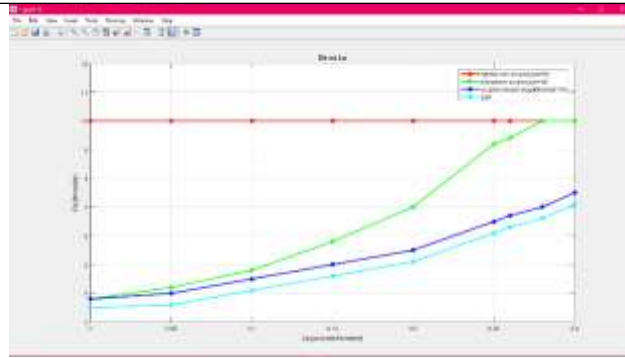


Figure 7: Graph that illustrates the arrival rate and the delay on SU with predefined conditions and threshold.

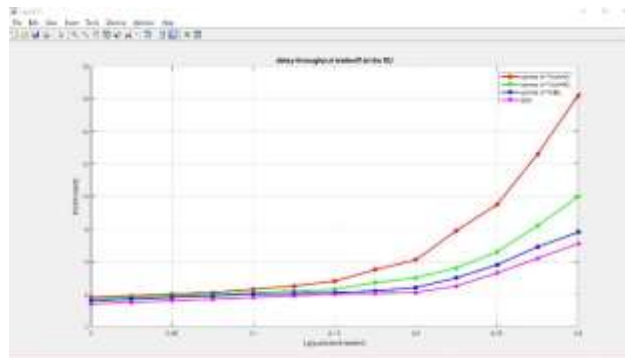


Figure 8: Graph illustrating the Delay and throughput trade off at the SU considering licensed users Delay constraint with a $\psi=10$.

VI. Conclusion

The implementation of the ESA over the conventional work conservative algorithm and the non-work conservative algorithm flowered in best tradeoff between the controversial parameters. The tradeoff or the improvement is about 10%. The result is finalized based on the threshold parameter at different value of average packet delay that the licensed subscribers can withstand. The parameters such as arrival rates and the probabilities of the spectrum used are as follows:

$h_{pd} = 0.3$, $h_{ps} = 0.4$, $h_{sd} = 0.8$

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