Spectrum Utilization in Cognitive Radio Environment

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Abstract

In this work, a cognitive user locates within licensed network with several wireless nodes, which communicate with each other by using N licensed channels. We proposed and compared three spectrum utilization algorithms namely; RSHS (Random Spectrum Hole Selection), RSHS_TT (RSHS using Threshold Transition) and RSHS using Minimum Rate (RSHS-MR) . The numerical results confirm that the RSHS-MR technique has benefit of less average packet collision during specific period of the simulation time.

Introduction

Cognitive Radio (CR) technology is a promising solution of spectrum scarcity in emerging wireless communication networks. The idea of CR is based on *overlay spectrum sharing*, in this approach, secondary users are allowed access to licensed channels whenever primary users are off and must leave the channel before the licensed signal appearance. In this work, sensing modules equipped on CRs and able to monitor licensed channels states in terms of their occupancy and vacancy in cooperative manner. To this end sensing, recognising and predicting licensed channel states are crucial challenges in cognitive radio context. In this work the aim is to reuse unused spectrum bands in an efficient method, without harming license transmission (Figure 1).

Motivation

In cognitive networks a competitive scenario requires to explore and exploit appropriate licensed spectrum holes in network coverage area. Beside in this case primary channel usage obeys random distribution , therefore, an appropriate channel access mechanism could significantly improves the QoS of the both primary users and cognitive users. Here our aim is to evaluate and compare three spectrum hole selection approaches namely; RSHS, RSHS-TT and SHS-MR. In addition, average channel collision and channel utilization are considered to be performance evaluation metrics.

System Model

The assumed network topology is shown in Figure 1 where utilisation of the licensed band by the PU is modelled as a Poisson process with arrival rate parameter λ . The licensed channels' states are estimated by an ON/OFF binary signal, in which interval OFF/ ON times follow exponential distribution. Moreover the interval times are assumed to be identical independent random variables which have λoff/ λon arrival rates respectively . In sum, The probability that state OFF is in use at time t, on channel i , is given by;

$$P_{00}^{i}(t) = \frac{\lambda_{on}^{i}}{(\lambda_{off}^{i} + \lambda_{on}^{i})} + \frac{\lambda_{off}^{i}}{(\lambda_{off}^{i} + \lambda_{on}^{i})} e^{-(\lambda_{off}^{i} + \lambda_{on}^{i})t} \quad (1)$$

Here the binary channel state signal can be expressed by,

$$\mathcal{F}(t) = \begin{Bmatrix} 0 \; channel\; i\; occupied \\ 1 \; channel\; i\; vacant \end{Bmatrix} \quad 1 \le i \le N \quad (2)$$

And

$$\mathbb{C}(t) = \{ i \,|\, P_{00}^{i}(t) > \eta^{i} \} \quad 0 \le i \le N$$

Here $\mathbb{C}(t)$ indicates set of the proper unoccupied channels at time t. The proposed techniques explore appropriate spectrum hole with respect to the collected channels' characteristics. Also part of the proposed algorithms are illustrated in Figure.2. Finally the performance of the spectrum hole accessing techniques evaluated by AVerage channel Collision (AVC) and Average Channel Utilization (ACU) during specific simulation time (3000ms) , which are defined by,

$$AVC\% = \frac{Number\ of\ packet\ collision}{Number\ of\ transmission\ packets} \times 100\ /sec \quad (3)$$

$$ACU\% = \frac{T\left(1 - F_{off}(T)\right) + \int_0^T x f_{off}(x)dx}{E(T_{off}) + E(T_{on})} \times 100 \quad (4)$$

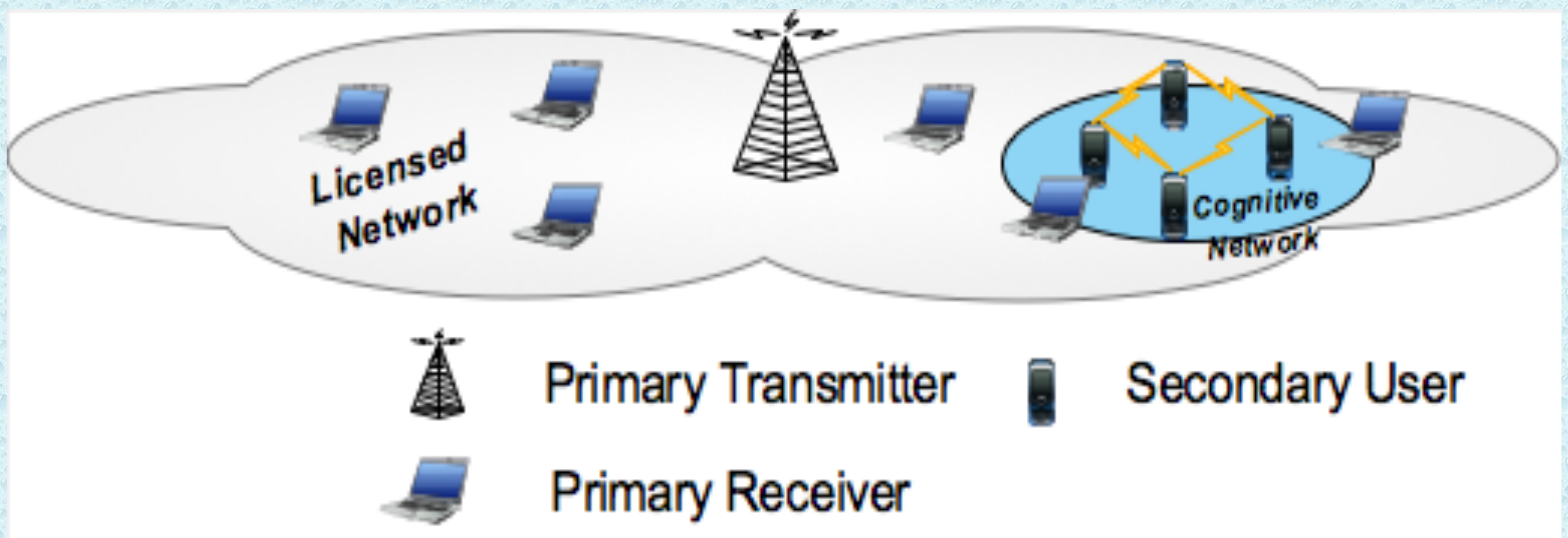

Figure1 Network topology, cognitive radio network reuses unoccupied licensed channels

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1.  Input  Initial values Ti s, η, λi off , λi on, N
2.  While(j≤N); licensed channels observation
3.  If channel j is occupied
4.  uj(t)=0
5.  Else
6.  uj(t)=1
7.  end
8.  Update Channel State Database(CSD)
9.  j=j+1
10. end
11. X= rand(F(t)); random channel selection
12. If (x≠0); x is a sequence number of channels
13. Adapt radio parameters
14. Run transmission task
15. Else
16. Cease transmission
17. end
18. End
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a)

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8.  for i=1:N; proper channels estimation
9.  While (P00i(t)≥η) then
10. SHD (i)←i ; update SHR (Spectrum Hole Database)
11. end
12. y=rand(C(t));  appropriate channel chosen
13. If (y≠0)
14. Adapt radio radio parameters
15. Run transmission task
16. Acknowledge Flag (AF); collision flag
17. ( AF=1); collision occurs
18. Stop transmission
19. Go to 2
8.  else
9.  Go to 12
10. End
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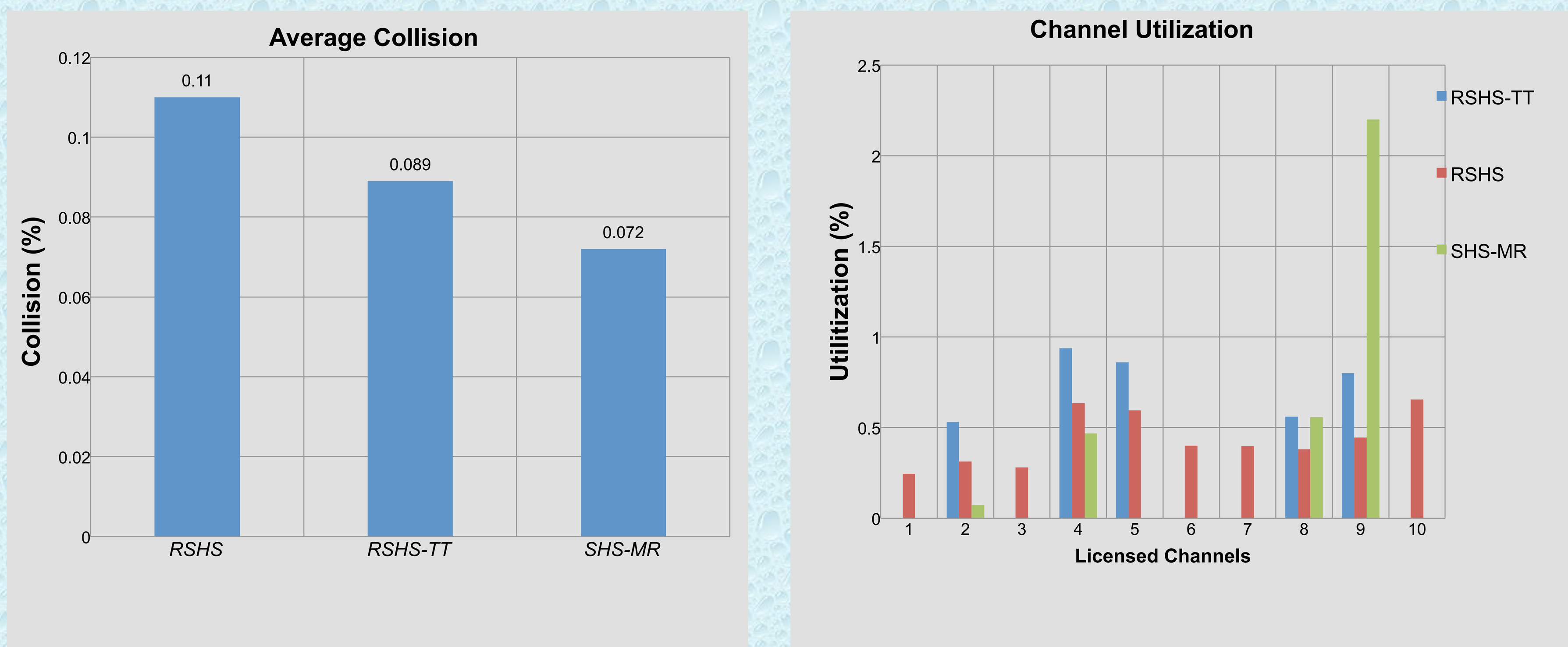
b)

Figure 2 a) RSHS algorithm and b) RSHS-TT algorithm*

* Steps 1 to 7 from a) repeat in RSHS-TT algorithm



a) b)

Figure 3 a) Collision under proposed algorithms b) Channel utilization in 10 licensed channels

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Results and Conclusion

The performance evaluated over 10 licensed channels with different OFF/ON channels' rates through Matlab software. The average collision during specific simulation time (3000ms) the performance analysis shows, SHS-MR algorithm has much more reliability in terms of the collision and disruption to the primary transmission (Figure 3a). Also Figure 3b represents that the licensed channels with maximum transition probability (channel 9) reaches at 2.25% channel utilization which is much more than the rest channels.

References

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