Joint Underlay/Interweave Spectrum Access Scheme with Reduced Data Loss

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Abstract: In this paper, joint Underlay/interweave power control scheme is discussed to enhance secondary user's throughput and to reduce data loss during collision in a typical spectrum sharing environment. To do so, the conventional data frame structure has been modified by incorporating two sensing slots to avoid sensing results ambiguity. It is shown that proposed scheme has a potential to improve the unlicensed user's throughput and reduce data loss significantly. The numerical results are presented to prove the efficiency of the proposed scheme. Moreover, the performance of proposed scheme is also compared with the state of art spectrum access schemes to validate the results.

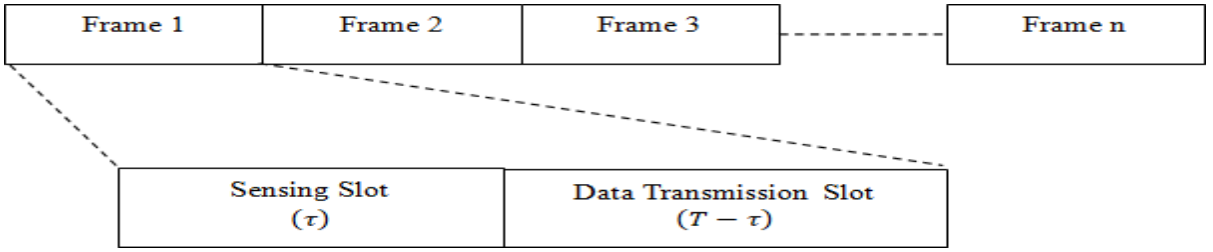
Keywords: Sensing, Hybrid Spectrum Access, Frame Structure, Throughput, Data Loss.

1. Introduction

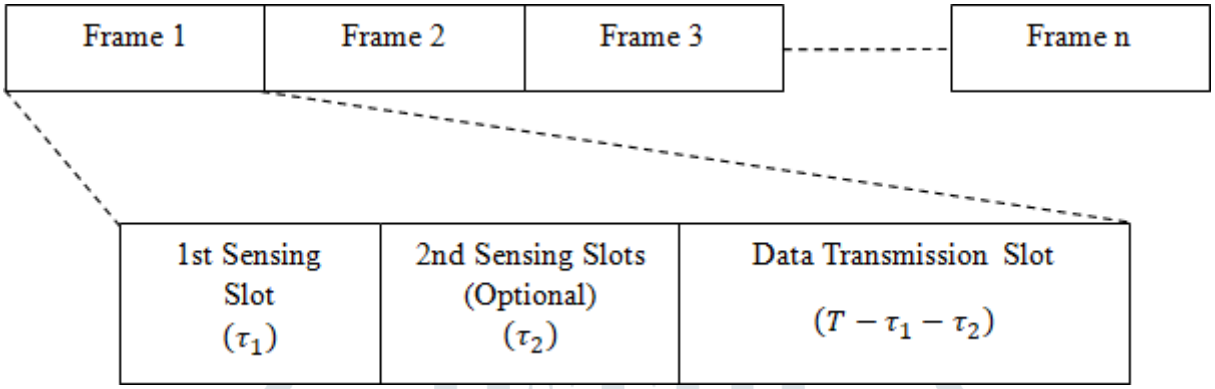
From last few decades, we all have witnessed the tremendous growth in wireless communication that has increased the bandwidth requirements manifolds. However, with traditional spectrum allocation policies, it has become extremely difficult to assign spectrum for new services/ applications. Recently, cognitive radio technology has evolved as a most promising technology that has potential to overcome this situation as it allows the secondary users to use vacant or partial utilized spectrum whenever primary user is not using it [1- 2].Therefore, the basic requirement of this technology is that SU should remain updated with the spectrum occupancy level by primary user all the time. The spectrum sensing plays a very vital role here to know the presence or absence of the licensed user over the channel. Many spectrum sensing techniques have been proposed in this context. However, due to the ease in implementation and no prior knowledge requirement ofPU signal, energy detection (ED) is most commonly used spectrum sensing scheme [3-4]. The performance of the energy detector is measured in term of probability of detection P_d and probability of false alarm P_f and must be high and low, respectively. To meet these requirements, it is anticipated that sensing time must be high for the accurate detection of primary user's signal in a channel.However, long sensing durations reduce the data transmission time and secondary throughput also. To overcome this issue, many researchers have proposed solutions like parallel sensing and transmission [4], improved frame structures [5], hybrid spectrum access [6], threshold adaptation [7] and dedicated channel for spectrum sensing [8] etc. However, to our best knowledge, hybrid spectrum access scheme has not been analyzed much to improve the secondary throughput. Therefore, a modified hybrid spectrum access scheme with improved frame structure has been proposed in this paper.

2. Proposed Frame Structure

Figure 1 shows the traditional frame structure that divides whole frame duration into two timeslots i.e. spectrum sensing slot and data transmission slot [9]. Generally, there exist tradeoff between these two as excessive long sensing duration reduces the transmission time and short sensing duration may leads the probability of miss detection of PU signal and false detection of PU signal under noisy environment. Both situations affect primary and secondary communication system adversely.



(a)



(b)

Fig. 1: (a) Conventional frame structure (b) Proposed frame structure

In this paper, a modified frame structure is proposed for hybrid spectrum access in which transmission frame is divided into three slots i.e. two sensing slots and one data transmission slot (Refer Fig. 1(b)).

3. Performance Evaluation

In this section, simulation results are given to authenticate the proposed scheme. The proposed hybrid spectrum access scheme is also compared with other three schemes proposed in [3], [5] and [6]. The simulation environment considers one PU and multiple SUs placed randomly within the communication range of PU.

Figure 2 compares the secondary throughput of proposed hybrid spectrum access scheme with other three conventional schemes. These schemes are: (i) Conventional spectrum access with single sensing slot (Conv_I)[3] (ii) Conventional spectrum access with double sensing slots (Conv_II)[5], and (3) Hybrid spectrum access with single sensing slot (Hybrid_I) [6]. It has been observed that the throughput achieved by conventional method with one sensing slot is less as compared to the other three methods. This is due to the reason that conventional method allows SU to transmit in a channel on detecting PU absent from it. To overcome this bottleneck, hybrid spectrum access method proposed in [6], allows SU to transmit in underlayand interweave mode based on the presence and absence of PU from channel, respectively.

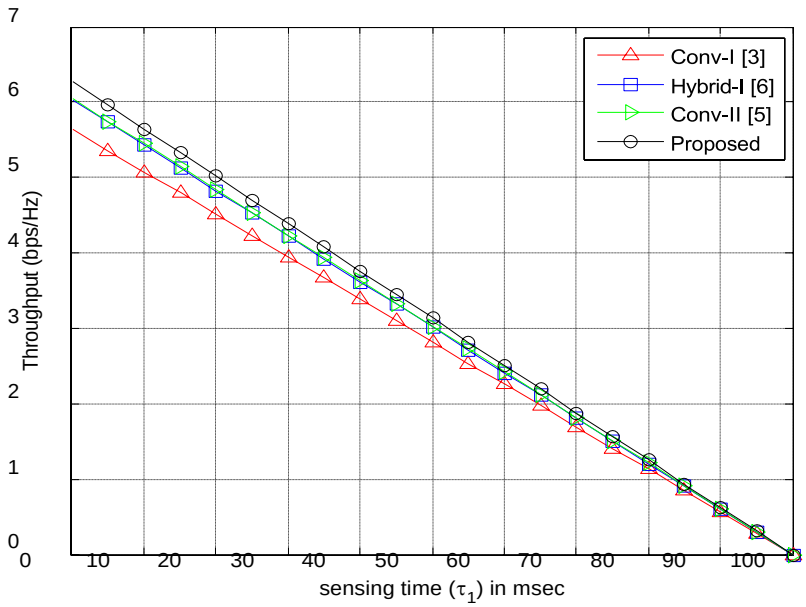


Fig. 2: SU throughput comparison between conventional and proposed schemes

The scheme improves secondary throughput significantly however, similar to [3], no attempt has been made to correct the sensing error.To overcome uncertainties in sensing results, scheme proposed in [5] uses two sensing slots. However, the data transmission is allowed on detecting channel idle only. Since both the sensing slots are of equal duration, the total transmission time reduces significantly, yet the scheme performs equally well as hybrid scheme proposed in [6]. It has been observed that proposed hybrid spectrum access scheme improves SU throughput further by exploiting transmission opportunities more accurately with the help of two sensing slots.

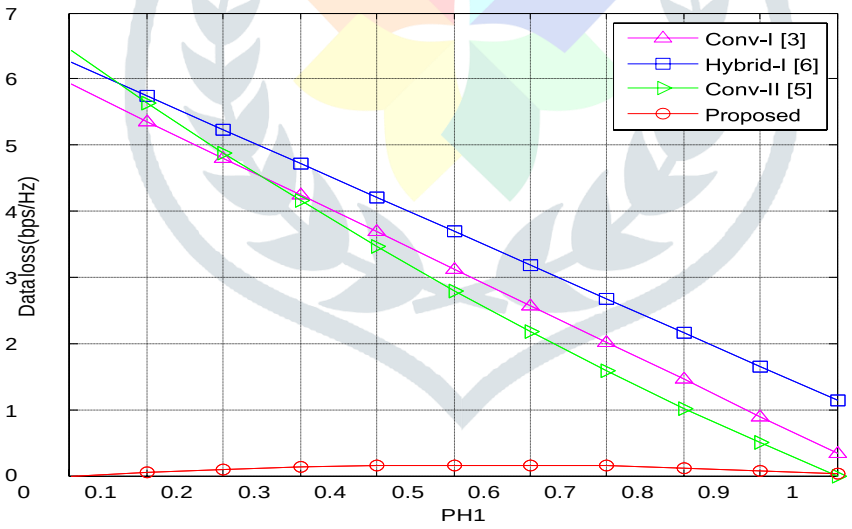


Figure 3: Data loss comparison as a function of PH1.

The data loss occurs in spectrum sharing environment when secondary user transmits at peak power and licensed primary user resumes the channel or when SU is unable to detect the PU

in a channel and transmits at peak power. Figure 3 shows the comparison of the data loss of various schemes as a function of ?. In schemes proposed in [3], [5] and [6], the data loss occurs when SU transmits at peak power and PU appears in a channel and data frame is lost. Thus, the data loss for these schemes is same as their throughput. It has also been observed that the proposed hybrid scheme with two sensing slots has least data loss as compared to the other schemes. It makes the proposed hybrid access scheme more attractive for the next generation communication networks that need high throughput and less data loss simultaneously.

4. Conclusion

In this paper, a modified hybrid spectrum access scheme has been proposed for the efficient utilization of wireless spectrum. The scheme utilizes two sensing slots for the accurate detection of PU in channel and to reduce the data loss. The closed form expression for the achievable secondary throughput and data loss have been derived and compared with other existing schemes with one and two sensing slots. Based on the results, it is concluded that the proposed scheme outperforms all existing schemes in terms achievable throughput and data loss due to sensing errors. Thus, the scheme has potential to reduce data loss significantly that makes it more suitable candidate for next generation networks.

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