Adaptive and Occupancy-based Channel Selection for unreliable Cognitive Radio Networks

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Adaptive and occupancy-based channel selection for unreliable cognitive radio networks

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Nous présentons une stratégie dynamique pour le choix de canaux dans un réseau radio cognitif. Notre stratégie se base essentiellement sur l'estimation de l'occupation du canal radio provoquée par l'activité des nœuds primaires plus prioritaires sur les canaux en questions. Notre technique, et grâce à une écoute permanante sur les canaux, dote les nœuds cognitifs de la capacité d'inférer les canaux les plus adaptés à une communication cognitive. En effet, notre stratégie permet d'assurer une fiabilité accrue dans les communications en évitant les canaux surchargés. Par des simulations, nous validons notre contribution en montrant qu'elle assure un taux de paquets remis en succès, dans différents scénarios, largement supérieur au cas où le choix de canaux s'effectue aléatoirement. Par ailleurs, nous montrons également que notre stratégie permet un nombre supérieur de voisins sur chaque canal que le contexte aléatoire. Cela constitue un résultat prometteur en faveur de son utilisation dans un contexte multi-saut en présence d'un algorithme de routage.

1 Introduction

Due to limited available spectrum and fixed spectrum assignment policy in today's wireless networks, radio spectrum is used inefficiently. To counter this issue, Cognitive Radio Networks (CRNs) are designed to allow cognitive radio (CR) nodes (i) utilizing free parts of unlicensed spectrum as well as (ii) opportunistically exploiting licensed frequency bands in silent periods of licensed users, called primary radio (PR) nodes [ALVM06, MM99].

Note that the traffic pattern of primary users is of key importance here : if we know that a particular channel is heavily used by a PR node and it tends to occupy it for a long period of time, that channel would be less likely available for a CR node. Because of this PR's high time occupancy, the usability of the channels by CR nodes becomes uncertain. In addition, since PR nodes operating over different channels have different activity patterns, depending on the technology they are using and the environment characteristics, a hardly predictable and time-variant occupancy can be also perceived. Thus, it is essential and, however, extremely challenging to correctly select channels allowing reliable communication among CR nodes as well as channels that increase the number of CR receivers. This constitutes the goal of this paper.

In this paper, we present a new strategy for *adaptive and occupancy-based channel selection* in CRNs. Our strategy empowers CR nodes with the ability to infer, based on information regarding PR occupancy, the less occupied channel to use. CR nodes then use the proposed strategy to select channels for transmission and overhearing. Hence, by exploiting overhearing and PR occupancy properties, our strategy allows not only increasing the network reliability – since less PR-occupied channels will be selected – but also the delivery ratio – since a high number of CR nodes will overhear the selected channel.

2 Adaptive and occupancy-based channel selection

We are considering an ad-hoc infrastructure-less architecture of Cognitive Radio Network. In this architecture, only CR-CR communications will occur. Cognitive Radio (CR) nodes are highly frequency agile. Due to PR activity over every channel, intermittent connectivity of links occurs, requiring CRNs to be highly opportunistic. CR nodes are able to communicate over multiple channels. Within the network, two nodes can communicate if they use at least one common channel and if they are within the transmission range of each other. The spectrum used by PR and CR nodes consists of N Channels $C = \{1, 2, 3, \ldots, N\}$, where channels availability for CR nodes is highly time variant and dependent on the PR activity variability over every channel.

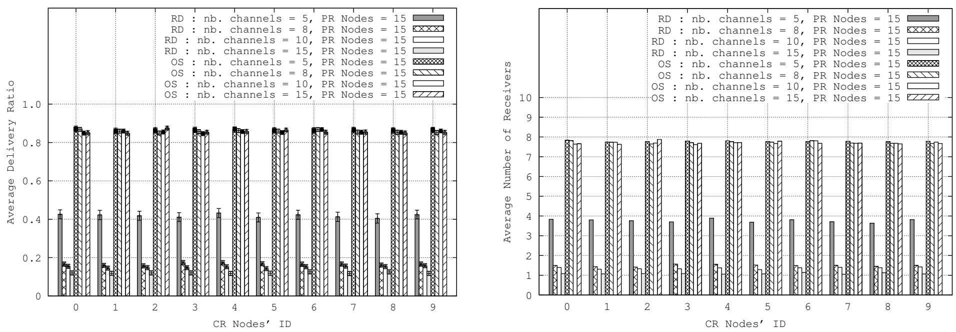
After sensing the channels in the CRN, each CR node makes a list of detected channels in the network. Each CR node then classifies the sensed channels in a decreasing order of availability, and selects for transmission and/or overhearing the best weighted channel. Channels' weight $P_{channel}$ is calculated based on PR *and* CR nodes' occupancy :

$$P_{channel} = e^{-PROccupancy} \times CROccupancy$$
$$CROccupancy = 1 - PROccupancy$$

Since PR and CR occupancy are inversely proportional, selection of the less occupied channel by PR nodes also implies the selection of the most used channel by CR nodes. Hence, the use of the best channel given by the highest value of $P_{channel}$ allows improving network reliability as well as increasing the delivery ratio.

3 Simulation Results and Conclusion

To assess the performance of the proposed approach, two performance metrics are evaluated : (i) the average delivery ratio, which is ratio of packet received by a particular CR node over total packets sent in the network and (ii) the average number of receivers, which is the real quantity of receivers per node id. In order to simulate message losses, a probability of receiving a message is assigned to each channel. Results shown below are generated for an average of 500 simulations, along with 95% of confidence interval, for a network of 10 CR nodes.



(a) (b)

FIG. 1: Average delivery ratio and number of receivers in a CRN, for random (RD) and our adaptive strategy (OS).

Fig. 1 compare random (RD) and our strategy (OS) results for the delivery ratio and number of receivers of these two strategies, as a function of the CR nodes' ID. The results show how the number of channels impacts the average delivery ratio and the average number of receivers for the two strategies. In particular, by selecting the channel with highest $P_{channel}$, CR nodes are trying to access best channel in terms of occupancy, for transmitting and overhearing. Hence, as shown in Fig. 1, our strategy considerably increases the delivery ratio and the number of receivers. Our strategy guarantees the delivery of 80% to 85% of messages, contrarily to less than 45% to 40% for the random strategy (cf. Fig. 1(a)). Note that the increase of the number of channels has a negative impact on the delivery ratio for the random strategy. This is due to the fact that the probability of a CR node to randomly select for overhearing, the same channel that another CR node has randomly selected for transmitting, decreases with the increase of the number of channels. Moreover, our strategy guarantees from 38% to 40% more nodes reception than with the random strategy (cf. Fig. 1(b)). Our solution increases the delivery ratio and the number of receivers since it selects the channel with low primary activity and have a high probability to encounter overhearing CR nodes.

In summary, our experiments reveal that, by increasing the number of channels, our proposed strategy considerably increases the average delivery ratio and the average number of receivers, when compared to the random strategy. In addition, contrarily to random strategy, our proposed strategy guarantees obtaining high delivery ratio proportional to the number of available channels. This shows how good our strategy is in allowing CR nodes taking profit of available channels.

Références

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