Chapter 32

Heterogeneous Service-Oriented Spectrum Trading

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ABSTRACT

Multiple characters of spectrum resource bring many challenges to spectrum trading. The demanders may not find the full-matching spectrum resource. Meanwhile, the optimal matching strategy cannot be determined if the demanders have different matching ratios. This chapter proposes an algorithm called HSO-ST (Heterogeneous Service-Oriented Spectrum Trading) with the target of maximum matching number under the priority restriction. This algorithm can satisfy as many secondary users as possible. Compared with other spectrum trading strategies, HSO-ST can greatly improve the spectrum demand-matching ratio.

BACKGROUND

Dynamic spectrum access has attracted wide and intensive attention as it is a promising method to solve the spectrum under-utilization problem and will satisfy the rapid-developing spectrum demand in the near future (Qing Zhao & Brian M. Sadler, 2007).

From the technical perspective, cognitive radio can sense the spectrum environment (J. Mitola & Q. Gerald, 1999), then find the unused spectrum and access it opportunistically without interfering the primary user (PU, the licensed user). It contains many complex operations, such as spectrum sensing, power control, spectrum allocation, spectrum handoff and so on. Although the secondary user (SU, the unlicensed user) can share the spectrum resource for free, its communication quality can’t be guaranteed because it has to quit from the spectrum immediately once PU needs the spectrum. PU will not take part in the spectrum sharing process actively because nothing can motivate it to cooperate with SU. So it just cares its benefits.

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From the economic perspective, PU would like to lease or sell the unused spectrum to SU via spectrum trading so that it can gain some profit to counterbalance the cost of getting the spectrum license from the spectrum provider. SU only has to pay something for the spectrum access chance and don’t need to worry about the interference to PU and conflict with other SU. Spectrum trading, which can improve the spectrum efficiency obviously, is an advisable method especially for the users who have high demands for the spectrum quality and do not consider the payment problem.

Some economic models, such as auction and game theory, have been investigated in (K.M.V. Rodriguez & R.Tafazolli, 2005, D.Niyato & E.Hossain, 2007). Price has been paid much attention to as well as strategy. Qian et al. proposed an agent-based spectrum trading model and tried to maximize the profit of the agent as well as to enhance the satisfaction of secondary users (L. Qian, et al., 2011). P.M.Joseph proposed a multiple-dimension auctioning mechanism through a broker and discussed two trading negotiation protocols, merchant and auction (P.M.Joseph, et al., 2011). The broker’s objective is to maximize its own revenue. Duan proposed a cognitive mobile virtual network operator (C-MVNO) which serves as the interface between the spectrum owner and the secondary end-users (B.S. Lingjie Duan, Jianwei Huang, 2011). In the practical application, the primary user and the secondary user both do not want the agent, broker or operator to participate the spectrum trading if they can do it by themselves. The basic reason is that no one would like to share the profit with others if he can’t get obvious advantage.

Tan modeled a non-cooperative pricing game using the profit as the payoff, he also studied the short-term price war and long-term price war (K.Yi Tan & Shamil Sengupta, 2010). Price is the crucial problem of spectrum trading, but it is not enough to concentrate on how to formulate an optimal pricing strategy, in order to maximize the revenue from the perspective of spectrum provider without taking the customer behavior into consideration. In the practical business scenario, the demander also affects the spectrum market as well as the supplier.

Besides the above works, there’re other important papers that address the spectrum trade problem in different perspectives (D Niyato, et al., 2008, 2008, 2009; L Gao, et al., 2011). In the spectrum trading process, the secondary users (SU) pay money, relay help or spectrum information for guaranteed spectrum access opportunities from the primary users (PU). PU can also sell spectrum resource for profit, extensibility of transmission area or more information. Obviously spectrum trading is a win-win spectrum allocation mode which benefits to both of the supplier and the demander while improving the spectrum utilization.

In practical wireless cognitive networks, spectrum resource has some special attributes such as regionality, which make the spectrum service more complicated. The diversity of spectrum service caused by multiple spectrum attributes brings new challenges to spectrum trade. For the secondary users, it is possible that only part of the spectrum resource can meet their demand. Here we use heterogeneous service to define diverse services and the related attributes. Perhaps no spectrum resource can satisfy them completely. For the primary users, only part of the SUs can enjoy the spectrum service provided by them. If it is impossible to achieve the perfect matching of SU and spectrum resource, how to determine the matching order according to the difference between the SUs and how to achieve the maximum matching number under the priority restriction? Little research work relates to this issue. This is the main motivation for our paper. We want to establish an unified and effective model which can solve the above matching problem.