Energy Efficient Uplink Transmission in CR OFDMA Network Under Fading Channel using Pricing Technique

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***Abstract*— This project investigates the sensing order problem for multi-user and multi-channel cognitive radio networks. The energy-efficient resource allocation in orthogonal frequency division multiple access-based cognitive radio (CR) technologies present great flexibility and practicability for future green wireless communications. To increase the energy efficiency and guarantee the primary transmitter's quality-of service requirement using pricing factor. A linear pricing technique was introduced to handle both the inter-ST coupling - Spectrum competition among secondary users and intra-ST coupling - the relationship between available bandwidth and spectrum allocation. Simulation results demonstrate that the proposed strategy brings high EE. Additionally, by adjusting the pricing factors, a various performance can be achieved by the STs with different priorities. A distributed algorithm is devised to harvest the multi resource and multiuser gains, and the energy-efficient JSAPC is transformed to 1-D pricing-factor profile searching.**

Keywords*— pricing factor, linear pricing technique, orthogonal frequency division multiple access (OFDMA), Cognitive radio networks (CRNs), energy efficiency (EE), JSPAC algorithm.

I. INTRODUCTION

To improving energy efficiency (EE) for wireless communication networks are increasingly critical and has attracted extensive attention from both academic and industrial fields [1].The energy-efficient resource-allocation schemes should be designed for future wireless networks, which promisingly employ both the orthogonal frequency division multiple access (OFDMA) and cognitive radio (CR) technologies. CR important role are improving EE in future green wireless communications.

The electromagnetic radio spectrum is one of the most precious and scarce natural resource. Wireless networks today follow a fixed spectrum assignment strategy, the use of which is licensed by government agencies. This results in a large portion of assigned spectrum being used only intermittently or not at all due to various factors such as amount of traffic load on licensed users or geographical variations. A cognitive radio relies on opportunistic communication between unlicensed or secondary users (SU) s over temporarily unused spectral bands that are licensed to their PUs. CR is an intelligent device that can coexist with licensed users without affecting their quality of service. The primary users actively participate in a non-cooperative game with secondary users by selecting a reasonable interference cap on the total interference they are willing to tolerate. They are rewarded for sharing their licensed spectrum, but are penalized if they do not meet their own target QoS. Consecutively, the secondary users aim to achieve energy efficient transmissions, while not causing extreme interference to the primary users being aware the only feasible sensing information of available transmission for whole CRN is from each single node, we examine network topology of CRN with spectrum map idea for slotted systems with different packet sizes under fading channels in traffic model.

Different from the metric definition based on link connections to neighbors in conventional opportunistic routing, our proposed routing algorithm, Spectrum Aware Opportunistic Routing defines Opportunistic Link Transmission metrics based on both delay and possible connections to neighboring nodes. Current studies provide the potential of the CR technology in energy saving. However, there also exist some challenges for energy-efficient resource allocation in CRNs. For instance, SUs may selfishly compete for the scarce resources (i.e., spectrum and power) to improve their own EE. Furthermore, due to the strict quality of- service (QoS) requirements imposed by PUs, there are some specific connections among SUs [6]. As a result, the previous work focusing on EE in traditional OFDMA systems [10]-[13] cannot be directly used for the energy-efficient design in OFDMA CRNs.

The multiuser gain in EE, we consider uplink energy-efficient transmission in multiuser OFDMA CRNs with the underlay paradigm are shown in Fig. 1, there are multiple secondary transmitters (STs) and a single primary transmitter (PT) sharing the same spectrum. In this paper, Both Primary transmitter (PT) and primary receiver (PR) are PUs and that both secondary transmitter (ST) and secondary receiver (SR) are SUs. . The PT's QoS requirement is described with its SINR threshold, which has been widely used in underlay CRNs [8], [9].

We focus on this scenario mainly due to two reasons. First, for uplink transmission, each individual transmitter is powered by a battery with limited energy, and improving EE is a valid approach to prolonging the equipment’s lifetime. Second, for underlay systems, there is no need for spectrum sensing procedures, and STs can obtain the transmission opportunities without resorting to intricate signal processing and coding [7], [14].

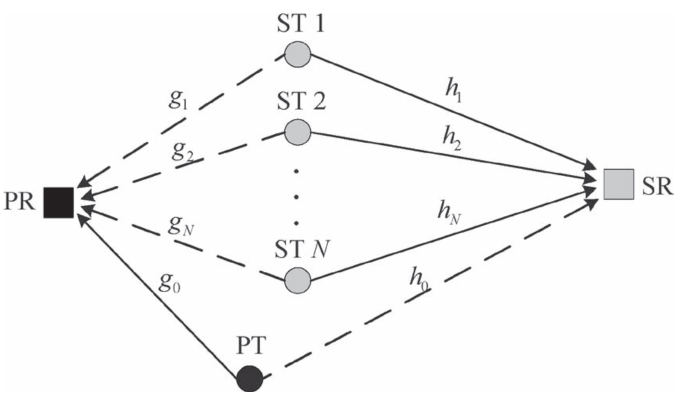

Fig1. Cognitive Radio Network scenario

II. RELATED WORK

In [1] *Gürkan Gür and Fatih Alagoz* et al presents *Green Wireless Communications via Cognitive Dimension*. The escalation of energy consumption in wireless networks directly results in the increase of greenhouse gas emission, which has been accepted as a major threat for environmental protection dramatically reduce energy consumption and carbon footprint. To achieve SUs’ specified SINR targets with minimum transmitted power in multiple antenna systems, *Abraham and Popescu* [18] and *Nguyen and Le-Ngoc* [19] studied the power control game in uplink and downlink communications respectively. Specifically, these two researches can be only applied to interweave CRNs, and to determine spectral holes in space, time, and frequency through perfect sensing [7].

In [21], both PU and SUs joined the game simultaneously, wherever each SU’s are to maximize its own EE by adjusting transmit power and the SINR requirement of each PU cannot be always guaranteed in this work. In this researches mainly focus on the EE-oriented power control strategy. However, our objective is to maximize each ST’s EE in underlay OFDMA CRNs, where both the spectrum resource and transmit power are taken into consideration. In OFDMA systems, there is more degree of freedom to manage radio resources; hence, the JSAPC problem is challenging. In [22], *Gao et al.* have devised a joint cell selection and JSAPC scheme in heterogeneous OFDMA systems from the throughput perspective. Recently, there have been more researches shifting their attention from capacity to EE in OFDMA systems [10]–[13]. In this paper, we consider the underlay OFDMA CRN, where STs attempt to maximize their individual EE without causing performance degradation to PT. In [23], *Wang et al.* have designed an optimal iterative power-allocation algorithm for underlay OFDM-based CRNs, where the EE of SUs was maximized. In [24] *Xie et al*. have designed gradient-based iteration algorithm was proposed to achieve the equilibrium solution and both studies assume that there is only one SU that can be served in each time slot.

III. SYSTEM MODEL

Regard as an uplink OFDMA CRN, somewhere a resulting system coexists with a primary system. In the resulting system, there is N STs desire to transmit data to the general SR^2.Total bandwidth B is divided into K orthogonal sub channel with the bandwidth of

$$B0=B/K. \tag{1}$$

suppose that PT uses all K sub channel and that each sub waterway is completely assigned to at most one ST in each time to avoid intervention among similar STs. Taking only significant desertion into relation, the strait power expand beginning node i to j can be expressed as

$$\frac{\mathrm{P_r}}{\mathrm{P_t}}\mathrm{dB} = 10\log_{10}(\mathrm{L_0}) - 10\alpha\ \log_{10}\left(\frac{\mathrm{d_i^j}}{\mathrm{d_0}}\right) - \psi \tag{2}$$

Someplace $L0 < 1$ is the free-space gain at distance d_0, α is the path-loss exponent, $d_i{}^j$ is the distance between nodes i and j, and ψ is a Gauss-distributed casual unpredictable with zero mean and variance σ^2_ψ. It is assumed that $g0$ is the channel power gain from the PT to the PR, and gn, $n = 1, 2. . . N$, is the channel power gain of the interference link from ST n to the PR.

Additionally, h_n, $n = 1, 2, . . . , N$, presents the waterway power gain from ST n to the SR, and h_0 presents the gain of intervention link from the PT to the SR. Throughout this paper, we assume that these channel influence gains are unchanging for the duration of the primary prepared phase. Denote k as the amount of sub channel in a meeting by ST n, and the SINR for ST n on each sub channel, i.e., γ_n, can be articulated as

$$\gamma_\mathrm{n} = \frac{\frac{\mathrm{P_n}}{\mathrm{k_n}}\mathrm{h_n}}{\mathrm{B_0}\eta_0+\frac{\mathrm{P_0h_0}}{\mathrm{k}}} = \frac{\mathrm{P_nh_n}}{\mathrm{k_nB_0}\eta_\mathrm{n}+\frac{\mathrm{P_0h_0k_n}}{\mathrm{k}}} \tag{3}$$

$$= \frac{\mathrm{P_nh_n}}{\mathrm{b_n}\left(\eta_0+\frac{\mathrm{P_0h_0}}{\mathrm{B}}\right)} = \frac{\mathrm{H_nP_n}}{\mathrm{b_n}} \tag{4}$$

Wherever P_0 and P_n are the put on the air power of the PT and ST n, respectively; $n_0/2$ is the noise power spectrum compactness at the receiver; and $b_n = k_nB_0$, spontaneously, can be regarded as the corresponding bandwidth that is assigned to the ST.

In the same way, on each sub conduit used by ST n, the SINR for the PT, i.e., γ_n 0, can be expressed as

$$\gamma_0^n = \frac{\frac{P_0g_0}{k}}{B_0\eta_0+\frac{g_nP_n}{k_n}} = \frac{P_0g_0}{B\eta_0+\frac{g_nP_nK}{k_n}} = \frac{P_0g_0}{B\eta_0+\frac{g_nP_nB}{b_n}} \tag{5}$$

Additionally, taking into account the transmit power budget of ST *n*, i.e., *PB n* , the allowed maximum transmit power for the ST can be expressed as

$$P_n^{\max} = \min\{\varpi_n^{\text{th}} b_n, P_n^B\} \qquad (6)$$

IV. PRICING BASED MULTI RESOURCE ALLOCATION

Together PT and most imperative earpiece are PUs and with the intention of both STs and secondary headset (SR) are SUs. The PT's QoS prerequisite is described with its SINR doorstep, which has be widely used in underlay CRNs. First, for uplink transmission, each individual transmitter is powered by a battery with some degree of energy, and improving EE is a valid approach to prolong the equipment's existence. Second, for underlay systems, there is no need for spectrum sensing procedures, and STs can obtain the program opportunities without resorting to sophisticated suggestion processing in addition to coding a linear pricing technique is employed to decouple these correlations, whereas this system is generally applied to improve the efficiency of Nash symmetry in wireless supply administration .Finally, a distributed algorithm is devise to harvest the multi resource and multiuser gains, and the energy-efficient JSAPC is transformed to 1-D pricing-factor profile searching.

A.JOINT SUBCHANNEL ALLOCATION AND POWER CONTROL (JSPAC)

A joint sub channel allocation and power control strategy to maximize each individual ST's EE. Due to the scarceness of sub channels and the selfishness of STs, there is a competitive relation among the STs, which is referred to as inter-ST coupling. Meanwhile, to guarantee the PT's QoS requirement, for each ST, there also exists a coupling between the maximum permitted transmit power and assigned sub channels, which is referred to as intra- ST coupling. These coupled relationships significantly make the formulated JSAPC problem complex. In this complexity reduced using pricing based resource allocation scheme is used.

B. JSPAC ALGORITHM FOR K TENDS TO INFINITE

When *K* →∞and *B* is fixed, for each ST, the set of available equivalent bandwidth is compact and convex, i.e., [0, *B*]. In this algorithm to deal with the couplings and to improve the efficiency of NE, we pay our attention to the linear pricing scheme during the initialization of the algorithm, SR announces pricing-factor incremental step sizes $\Delta\tilde{c}_n$, $\forall n \in \mathbf{N}$, to all STs, and additionally, each ST *n* sets its initial pricing factor $\tilde{c}_n$ to $\tilde{c}_0\, n$ and incremental step size εn to $\Delta\tilde{c}_n$. Then, each ST *n* updates its pricing factor $\tilde{c}_n = \tilde{c}_n + \Delta\tilde{c}_n$ and notifies other STs its strategy b^*.

In this algorithm, each ST does not stop updating and notifying until the total bandwidth constraint $N\ {}_n{=}1\ b^*\ n \leq B$ is satisfied. The convergence rate slows down when the pricing-factor incremental step sizes become smaller.

C. JSPAC ALGORITHM FOR K FINITE

Algorithm 2 can be divided into two parts. At first, STs use Algorithm 1. Then, each ST calculates its own marginal EE, decides whether one more sub channel is allowed, and updates the required number of sub channels. The second part of Algorithm 2, the convergence is self-evident because it is a non iterative process. Therefore, the convergence of Algorithm 2 can be also guaranteed. Each ST *n* should compare its own EE gain $\Delta\eta n$ with any other STs.

D. SOLUTION OF JSAPC

The set of available equivalent bandwidth for each ST is discrete. The equivalent bandwidth profile achieved by

$$\widetilde{b^*} = \left(\widetilde{b_1^*}, \widetilde{b_2^*}, \ldots\ldots \widetilde{b_N^*}\right) \qquad (7)$$

The corresponding sub channel profile

$$= \left(\widetilde{k_1^*}, \widetilde{k_2^*}, \ldots\ldots \widetilde{k_N^*}\right) \qquad (8)$$

$$=\left(\left\lfloor \frac{\widetilde{b_1^*}}{B_0} \right\rfloor, \left\lfloor \frac{\widetilde{b_2^*}}{B_0} \right\rfloor, \ldots.., \left\lfloor \widetilde{b_N^*} \right\rfloor\right) \qquad (9)$$

Where, [*x*] denotes the major integer no more than *x*.

$$K_r = K - \sum_{n=1}^{N} \widetilde{K_N^*} \geq 0 \qquad (10)$$

E. PERFORMANCE MEASURES

1].TDMA-FP: The overall transmission period (frame) is divided into *N* time slots, which are due to *N* STs in a round-robin method. In each slot, all sub channels are exclusively used by the corresponding ST, i.e., time division multiple access fixed power (TDMA-FP)

2].TDMA-AP: The overall transmission period is divided into *N* time slots, which are allocated to N STs in a round-robin manner. In each slot, all sub channels are exclusively used by the corresponding ST, TDMA. When transmitting, each ST *n* adaptively adjusts its transmit power according to adaptive power (AP).

3]. FDMA-FP: During the transmission period, all sub channels are equally assigned to *N* STs, FDMA. When transmitting, each ST *N* sets it's transmit power to $P_{\max}$.

4].FDMA-AP: During the transmission period, all sub channels are equally assigned to *N* STs, FDMA. When transmitting, each ST *n* adaptively adjusts its transmit power according to AP.

F. PRICING FACTOR AND PRIORITY

The priority of a class-*i* ST is inversely proportional to *i*, with 1 indicating the highest priority and *Q* indicating the lowest priority. In each ST, the larger pricing factor increment step size may result in larger pricing factor. The larger pricing factor will bring the ST smaller equivalent bandwidth. The STs with a higher priority can apply smaller increment step size to compete for more resource and achieve better performance. Where the STs having higher priority achieve both the higher EE and transmission rate

V. RESULTS AND DISSCUSION

To design cognitive radio which is showned by fig. 2 and N STs are uniformly deployed in a circle area with radius r_s and center is the location of SR. The fig. 3 and fig. 4 shows the JSPAC limits k is finite and JSPAC limits k is infinite

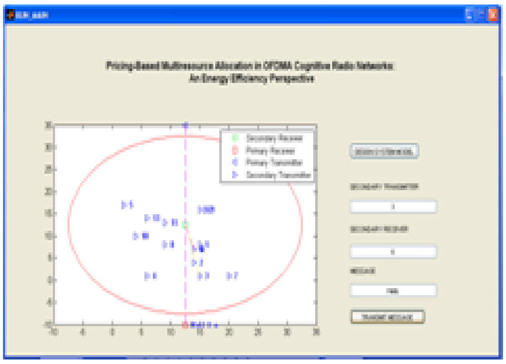

Fig.2. Design of cognitive radio

Joint sub channel allocation and power control (JSPAC) having higher energy efficiency compared to other frequency division multiple access fixed power (FDMA-FP) and frequency division multiple access adaptive power (FDMA-AP) are choosing optimal transmit power and time division multiple access fixed power (TDMA-FP) time division multiple access adaptive power (TDMA-AP) are achieve higher EE.

In addition, because both the subchannels and transmit power can be dynamic exploited by the STs and JSPAC can bring higher EE compared with other four strategies which is showned in fig .5(a) .

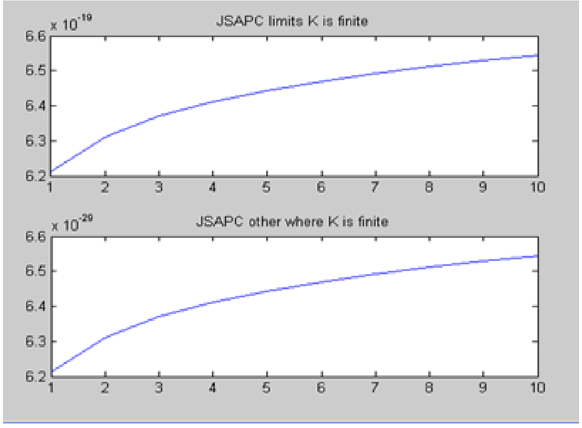

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Fig.3.JSPAC k is finite

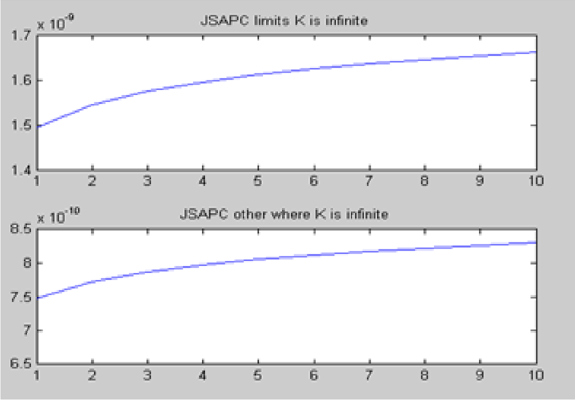

Fig.4.JSPAC k is infinite

Fig. 5(b) JSPAC does not bring the highest transmission rate and JSPAC has approximately 25% less transmission rate than FDMA-FP, it transmits about 1.6 times more data than FDMA-FP are fixed amount of energy to transmit the same amount of data, JSPAC saves around 60% energy.

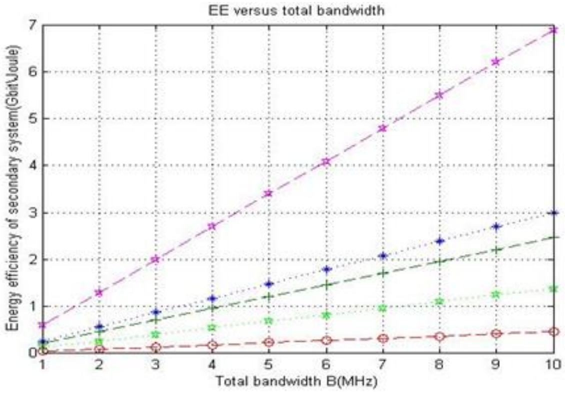

Fig.5 (a) EE versus total bandwidth

Fig 6(a) and Fig 6(b) shows the total EE and transmission rate versus the SINR requirement of primary transmitter. JSPAC does not bring the highest energy efficiency. For each ST implementing FDMA-FP and TDMA-FP, when the

SINR requirement of PT is increased, P_n^{max} becomes smaller and closer to P^*_n therefore using these two schemes, the system EE may increased with the rise of SINR requirement of PT.

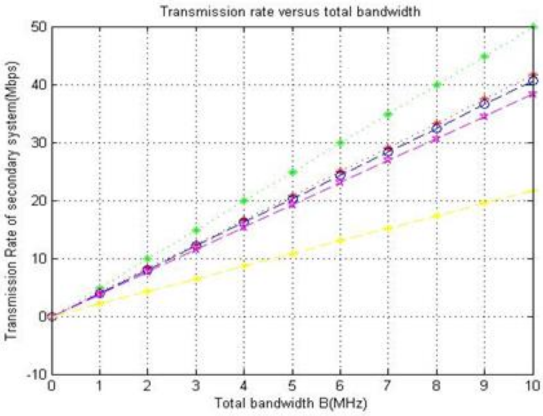

Fig.5 (b) Transmission rate versus total bandwidth

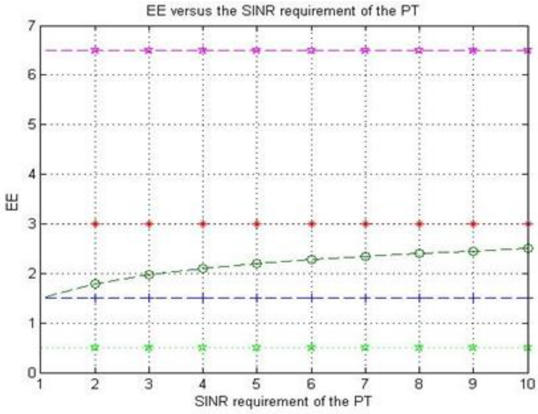

Fig. 6 (a) EE versus the SINR requirement of the PT

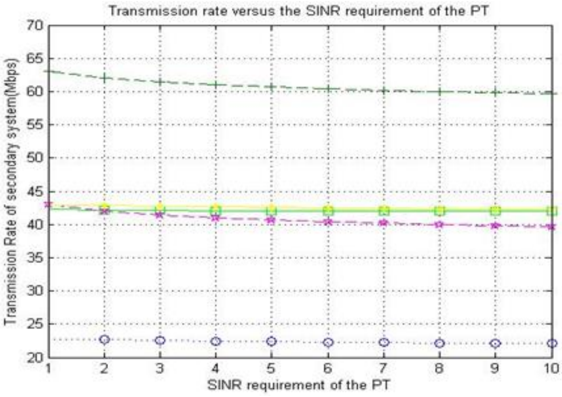

Fig. 6 (b) Transmission rate versus the SINR requirement of the Primary Transmitter (PT).

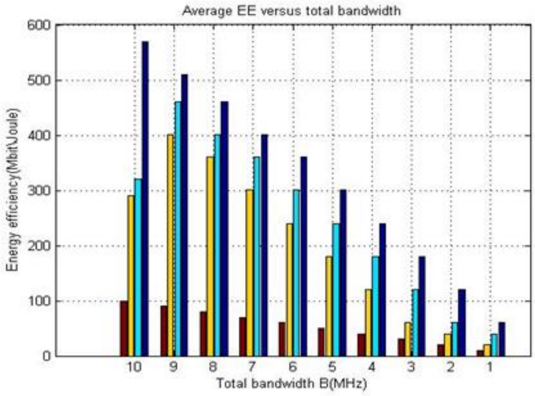

Fig. 7 (a) EE versus total bandwidth

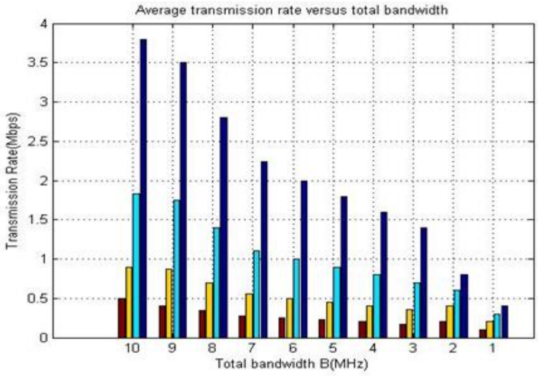

Fig.7 (b) Transmission rate versus total bandwidth.

The secondary transmitter (ST) with higher priority can apply smaller increment step size to complete for more resource and achieve better performance. The ST has about 85% more energy efficiency and the transmission rate which is showned in fig.7 (a) EE versus total bandwidth and the fig 7.(b) Transmission rate versus total bandwidth

VI. CONCLUSIONS

In this project we focus on the sensing order problem for multi-user and multi-channel cognitive radio networks. The energy-efficient resource allocation in OFDMA cognitive radio networks consisting of multiple STs. To maximize the energy efficiency and guarantee the primary transmitter's quality-of service requirement using pricing factor and to maximize each individual ST's EE, we formulated the JSAPC as a mixed-integer multi objective programming with fixed constraints. A linear pricing technique is employed to handle both inter ST coupling and intra ST coupling. A distributed algorithm is devised to harvest the multi resource and multiuser gains, and the energy-efficient JSAPC is transformed to 1-D pricing-factor profile searching. Additionally, by applying smaller pricing factor, the STs with higher priority can compete for more sub channels and achieve both higher energy efficiency and transmission rate.

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