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Maximum connectivity-based channel allocation algorithm in cognitive wireless networks for medical applications

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ABSTRACT

With the advent of multimedia and pattern recognition based medical technology, intelligence medical applications in smart hospital, smart clinic, and smart medical for Individual, such as disease diagnosis, rehabilitation, health monitoring, and so on, have received extensive attentions. However, the communication infrastructure of supporting these applications is facing a larger challenge. This paper studies the channel allocation problem in cognitive wireless networks for these medical applications. Channel allocations are of importance for cognitive wireless networks. How to assign the appropriate channels to each cognitive user is fairly challenging. In this paper we study this problem by combining collaborations of network nodes. We take the maximum network connectivity as an optimal objective to build our collaborative channel allocation model. Our approach takes in account the channel idle status and the transmission radiuses of cognitive users. We allocate firstly the idle channel to bottleneck node and assign the suited channels to all other cognitive users as possible. In such a way, we present three channel allocation strategies with the maximum network connectivity via the omni-directional and direction antennas. We also propose the corresponding algorithm to perform the channel allocation for all cognitive users in cognitive wireless networks. Simulation results show that our approach is promising.

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1. Introduction

With the advent of multimedia and pattern recognition based medical technology, many intelligence medical applications in smart hospital, smart clinic, and smart medical for Individual, such as disease diagnosis, rehabilitation, health monitoring, and so on, have received extensive attentions. However, the communication infrastructure of supporting these applications is facing a larger challenge. This paper studies the channel allocation problem in cognitive wireless networks for these medical applications [1,2]. With the increasing adoption and deployment of new wireless technologies and devices, wireless radio spectrum resources becomes a scare source. Current wireless spectrum resources are all allocated to some licensed users, namely primary users, while they do not always utilize these spectrum resources. Thereby we face two main cases: The spectrum resources become fairly lack; the existing spectrum resources are not sufficiently exploited. This has an important impact on the new emerging applications, such as those applications in Refs. [3–6]. How to effectively use the spectrum resource of networks become more important now in current wireless networks [1,7]. Cognitive wireless networks are proposed to perform the dynamic spectrum resource allocation in wireless networks. Channel allocations can improve spectrum resource utility in current wireless networks. However, how to perform the effective channel allocation is still a challenge [2,8].

To improve spectrum resource utility and perform effective channel allocation, Liu et al. studied joint multi-path routing and flow control problem to propose a new distributed Newton's method [9]. Rondinone et al. proposed a new contention-based broadcast forwarding protocol to dynamically select forwarding paths based on their capability in vehicular ad-hoc networks [10]. The new applications and computing approaches as mentioned in Refs. [11–14] bring forth a new challenge for spectrum resource utilization. Additionally, energy efficiency is also an important problem [15,16]. Wong et al. studied the minimal broadcasting problem in multi-hop wireless networks with a realistic physical layer and presented a distributed greedy algorithm to maximize the gain cost ratio of nodes [17]. Game, mobile communication model, graph model [18–20] are also used to improve spectrum utility. In addition, some methods regard maximum network throughput as a objective to carry on channel allocation in cognitive wireless networks [21–24]. They build the corresponding

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model and algorithm based on this optimal objective to try to obtain the optimal channel allocation schemes. As applied in monitoring and augmented reality [25–27], in medical applications, maximum network connectivity is very important to guarantee network reliability and stability. Accordingly, spectrum efficiency in medical applications is also an important challenge. This motivates us to build an efficient channel allocation approach to achieve these goals.

In this paper, we propose a collaborative channel allocation algorithm based on the maximum network connectivity in cognitive wireless networks for medical applications. We study the channel allocation problem in cognitive wireless networks for these applications. Our main contributions in this paper are as follows:

- We discuss and analyze our network model. In our model, cognitive users use omni-directional and directional antennas to send and receive the data packets.. In such a case, the low energy can be used to ensure the communications between nodes. The multi-hop transmission model is proposed. The multi-hop channel allocation problem is formulated.
- We refer to the maximum network connectivity as an optimal objective function to formulate the collaborative channel allocation problem in multi-hop cognitive wireless networks and build the correspond optimal model. Our model takes into account the interferences between cognitive users, between primary users, and between cognitive users and primary users.
- We further derive our channel allocation approach. To arrive at the maximum network connectivity, we build the corresponding channel available matrix, channel interference matrix, channel utility matrix. Furthermore, we propose three channel allocation strategies to allocate the appropriate channel to each cognitive user. We discuss the detailed channel allocation method and present a collaborative channel allocation algorithm for cognitive wireless networks.
- Finally, we conduct a series of numerical experiments to validate our approach. The detailed simulation results are discussed and analyzed in this paper. Simulation results show that our approach is promising and effective.

The remainder is organized as follows. Section 2 introduces related work. In Section 3 we describe the network model and perform problem statement. Section 4 discuss our channel allocation method. Section 5 conducts the numerical experiments and analysis. We conclude our work in Section 6.

2. Related work

We study in this paper how to exploit the collaboration in cognitive wireless networks to allocate channels to cognitive users as appropriately as possible. This mainly includes channel allocations and collaborations.

Channel allocations in cognitive wireless networks has extensively been studied. Li et al. proposed a new channel allocation based on the social relationship and the channel condition, using semi-definite programming to seek the optimal solution of their allocation method [28]. Hao et al. built a joint channel allocation and power control optimal game model and algorithm to reach the lower network interference and balance the network energy consumption [29]. Lee et al. studied the multichannel selection algorithm and scheme using spectrum hole prediction and channel characteristics to improve network performance [30]. Our method takes in consideration the collaboration and the node conditions when allocating the channels. We firstly assign the appropriate channel to the bottleneck nodes.

Collaborations has also been studied in cognitive wireless networks. Liang et al. studied the selection and the prioritization problem of the cooperative opportunistic routing in multi-hop wireless mesh networks and proposed a throughput improvement scheme [31]. Zhang et al. studied the performance for multi-hop relay networks by considering contention overhead of relay nodes in IEEE 802.11 DCF protocols [32]. Chen et al. studied the impact of cooperative routing on balancing the energy distribution among nodes and proposed a new routing scheme to carefully select cooperative relay nodes and assigns their transmission power [33]. Zheng et al. proposed a network controlled spectrum access scheme based on collaborative optimization of spectrum allocation for the entire network [34]. You et al. studied cooperative spectrum sensing techniques and proposed a system model for a TV primary user and multiple Wi-Fi cognitive users [35]. Jung et al. exploited linear programming to obtain the cooperative routing with the lifetime optimization for the wireless sensor network [36]. Our work is related with collaborative-max- sum-bandwidth rule in [34] and we are to compare our approach with it. Jang et al. proposed a effective channel allocation approach to decrease channel sensing and reserve asymmetry for wireless communication based on 8.2.11ac [37]. Almasaeid et al. studied channel allocation problem for cognitive wireless mesh networks based on receiver information [38]. Amini et al. presented an economic framework to perform channel allocation in cognitive wireless mesh networks [39]. We exploit the collaboration to improve the network performance. Different from these methods, our approach considers the idle status of channels and combines the transmission radius of cognitive users in the collaboration process.

In addition, Ding et al. proposed a cross-layer opportunistic spectrum access and dynamic routing algorithm for cognitive wireless networks to maximize network throughput [21]. Tang et al. studied the routing and channel assignment problem in multi-hop and multi-flow mobile ad hoc cognitive wireless networks and presented a cross-layer distributed approach based on joint design to maximize the network throughput [22]. Additionally, random allocation of channels in a cognitive radio network based on maximum throughput analysis was also studied [23]. Lai et al. proposed an optimal symmetric strategy to maximize the total throughput of cognitive users and presented a game-theoretic model to avoid their possible selfish behaviors [24]. We target the maximum connectivity of networks as the optimal objective. Using the collaborations, we seek to obtain the channel allocation schemes with the maximum connectivity.

Dadallage et al. studies joint problem of beamforming, power, and channel allocation in MISO cognitive wireless networks [40]. Han et al. proposed a throughput-efficient channel allocation method to raise the performance of multi-channel cognitive vehicular networks [41]. Qin et al. investigated channel time allocations for fair throughput in wireless mesh networks [42]. Maghsudi et al. proposed a joint channel allocation and power control approach to perform D2D transmission [43]. Zha et al. Investigated network control communication scheme in the two-channel case [44]. Lu et al. analyzed the filtering problem in fading channel [45]. Saifullah et al. studied and presented distributed channel allocation protocols used for wireless sensor networks [46]. Additionally, cooperative load balancing and dynamic channel allocation [47] had been discussed. The hybrid spectrum access [48] was also proposed to solve cognitive network communications. Karaoglu et al. studied the cooperative load balancing problem in cluster-based mobile ad hoc networks and proposed a dynamic channel allocation method [49]. Different from these methods, we use the maximum connectivity of networks to attain the effective channel allocation solution for cognitive wireless networks.

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