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A fast channel assignment scheme based on power control in wireless ultraviolet networks☆

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ABSTRACT

The Ultraviolet (UV) Non-line-of-sight (NOLS) communications are becoming a research hotspot in recent years. For wireless UV networks, there are some well-known existing issues such as network connectivity, power control and channel assignment. In this paper, a Fast Power Control and Channel Assignment scheme (FPCCA) is proposed to reduce interference and save energy. Firstly, the FPCCA is compared with the traditional channel assignment which without power control. It is proved that the approach of FPCCA can save energy more than 10%. Then, the FPCCA is both applied in the UV and Wireless Mesh Networks (WMN). The performance of FPCCA with different angles and network traffic loads is simulated and analyzed. When the traffic load is fixed, the performance metrics of FPCCA in UV are better than that in WMN. Meanwhile, the FPCCA not only ensures the quickness and accuracy of channel assignment, but also saves energy and improves the throughput.

1. Introduction

The employment of Ultraviolet (UV) light for communications is an intriguing notion that has been studied for decades. The transmission in this region (particularly from 200 nm to 280 nm), also known as the solar-blind band, exhibits some unique characteristics [1]. Within this band, the background noise caused by solar radiation is blocked by the earth's atmosphere effectively [2]. Due to the scattering and absorption of the UV light, emitted from the sun, by the atmosphere in this region, there is basically little or no solar interference for the manmade UV systems. In addition, due to the strong extinction coefficient (high scattering, high absorption) of air in this range, it is difficult to detect these signals from a long distance [3]. Roughly speaking, UV communications meet both commercial and military applications needs. Aircraft landing aid under low visibility conditions, public building surveillance, and environmental monitoring around chemical industries are some commercial applications. Military applications include UV guidance, UV warning and ground-to-air communications. Obviously, more applications will emerge in the near future due to the continuous evolution of this new communication technology [4].

Due to the scattering and absorption of the UV light, there is a serious attenuation of UV communications. Energy consumption is the transmission power of a typical wireless UV node. Non-line-of-sight (NOLS) UV transmitters have limited

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Table 1
The research status at home and abroad about UV communications.

Time	Institution	Research content
1939	U.S. Navy	Research on performance of UV source, detector and filter.
1986	M.Geller, G. B. Johnson	Design a short distance communication system of solar-blind UV [8].
1999	Beijing Institute of Technology	A set of experimental prototype using low pressure mercury lamp is designed.
2004	BAE Systems North America	Establish an unattended sensor network of solar-blind UV [9].
2010	University of California	A MAC protocol for outdoor UV networks [10].
2011	Xi'an University of Technology	Realize voice and image communication using UV LED as light source.
2011	University of Athens	Connectivity issues for Ultraviolet UV-C networks [1].
2012	Beijing University of Posts and Telecommunications	Diversity reception technology in NLOS UV communication system.
2013	Beijing Institute of Technology	Application of MIMO technology in UV communications [11].
2014	Beijing University of Posts and Telecommunications	Research on comparison of LDPC and RS channel coding in UV communication systems [12].

effective coverage and, hence, a dense node distribution is required to cover a large geographical area. Under this assumption, the connectivity of UV networks is a strong indication of the network reliability and robustness. Power control and channel assignment are two important methods to enhance the connectivity of the UV networks. Power control means intelligently selecting transmit power in a communication system to achieve good performance [5]. The algorithms of power control are used in many contexts, including cellular networks, sensor networks, wireless Local Area Networks (LAN) and Wireless Mesh Networks (WMN). In literature [1], connectivity issues for UV-C networks is presented and the power control is used to meet the network connectivity. Efficient channel assignment is a key issue in guaranteeing network connectivity, and mitigating the adverse effects of interference from the limited number of channels available to the networks. The channel assignment problem has been proved to be NP-hard, and there are several strategies for channel assignment in WMN, such as dynamic, static, and quasi-static. PSO (Particle Swarm Optimization) [6] algorithm was put forward by Dr Kennedy and Eberhart in 1995. It is a new intelligent Optimization algorithm by imitating the behavior of birds Swarm. The algorithm is easy to implement and has the advantage such as fast convergence speed. PSO is a global stochastic evolutionary algorithm. It tries to find optimal regions of complex searching space through the interaction of particles in the population. Channel allocation [7] is a issue of discrete optimization, the traditional PSO algorithm is not suitable for the discrete problem. However, if the iterative formula of position and velocity can be improved, the effect on solving discrete optimization will be obvious.

There has been a long history of research in UV communications. Most of the researches about UV at home and abroad are presented in Table 1. Taking into account the UV, many authors have discussed the influence of node density, transmitted power and communication rate on network connectivity, respectively. The research only considers the theoretical formula, but the choice of sender power dynamically is not mentioned [1]. A dynamic and distributed scheduling method using power control in sensor networks is proposed [13] and it has been proved that power control is one of the most important approaches used to maximum network capacity. Moreover, power control strategy also can be used in artificial neural network [14]. In the literature [15] a Channel Allocation Method based on Particle Swarm (CAM-PS) in wireless UV networks is adopted. High power was taken to ensure the network connectivity issues without considering the energy consumption of UV communications. The earlier work was focused on the power control in ad hoc and WMN. An attractive feature of UV communications is its ability of implementing NLOS links, so it is really a matter to determine the power according to the angle between the different nodes in the UV networks. On the other hand, a lot of researches have done in the channel assignment for multi-radio, multi-channel in WMN. The authors researched the issue of connectivity and minimize interference, and then different channel assignment strategies were introduced to improve the network performance [16]. Nevertheless, the channel assignment strategies proposed in the previous literature were only applied in Free Space Optical (FSO) communications. In order to increase the network throughput, the approach called joint channel assignment and routing was investigated [17]. In addition, the two methods of multicast channel assignment [18] and channel assignment based on PSO [19] were studied in other literatures. However, UV communications are closely related to angle, so the influence of angle on channel assignment will be deeply analyzed.

In this paper, the power control and channel assignment are combined. A Fast Power Control and Channel Assignment scheme (FPCCA) in wireless UV networks is implemented. Given that the influence of the angle on communications in the process of power control, the suitable angle is selected by the relative position between each nodes to reduce the energy consumption. Considering the influence of conflict matrix caused by the space angle, sector division is adopted to deal with the conflict. We propose FPCCA algorithm which is compared with CAM-PS. The simulation results show that the approach of FPCCA can save energy more than 10%. Moreover, the FPCCA algorithm is applied both in the UV and WMN. We can conclude that it is more significance to use FPCCA in UV rather than in WMN. Meanwhile, it can ensure the quickness and the accuracy of channel assignment in wireless UV networks as well as saving energy and improving the throughput of the networks.

The rest paper is organized as follows. Section 2 introduces channel allocation based on Discrete Particle Swarm Optimization (DPSO) briefly. Section 3 gives a short description of the network model, outlines the problem of channel assignment and constraint conditions necessary for our analysis. In addition, performance metrics of the algorithm are

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