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The Application of the Cognitive Radio in the Aviation Communication Spectrum Management

SHI Yanbin, TAN Zhongji, LI Xu a*

Aviation University of Air force, Changchun, 130022, China

Abstract

It is concerned that the aviation communication system is interfered by the inner and outside interference. Because of the electromagnetic spectrum is limited, it must be controlled and managed in order to use in aviation communication. The cognitive radio(CR) can perceive the electromagnetic environment automatically, search the spectrum holes, and adjust the signal parameters of both sides by communication protocols and algorithms to best situation. This paper discusses the CR and the application in the spectrum management of aviation communications.

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Keywords: Cognitive Radio; Communication; Spectrum Management; Dynamic Spectrum Allocation; Dynamic Spectrum Access

1. Introduction

With the fast development of the wireless communication, especial for the mobile communication, how to use the more and more insufficient spectrum resources become the most important question. At present the general procedure for spectrum resource management on international is implements authorized and the non-authorized frequency management system. Regarding the authorized frequency band, the non-authorized user does not have to use at will. As the result, in certain authorized frequency band, the spectrum use rate is very low, but in certain non-authorized frequency band, the signal is extremely crowded. So the availability ratio of the spectrum resources is extremely imbalanced^[1].

The environment constituted by the any kinds electromagnetic is called the electromagnetic environment, electromagnetic environment refers the all electromagnetic phenomenon exists in the assign

E-mail address: shiyanbin_80@163.com.

place^[2]. The EME (electromagnetic environment) is a form of energy, which is the same type of energy (electrical) that is used by electrical/electronic equipment to process and transfer information. And the generally produces by the nature and the artificial electromagnetic radiation overlaps crowdedly, the numerous and diverse fluctuation, the stochastic disorderly electromagnetic constitution specific electromagnetic environment, is called the complex electromagnetic environment. In the military field, in the specific battlefield space and time scope, interlocks crowdedly by each kind of electromagnetism signal, the reencounter both sides intense electromagnetic countermeasures, each kind from harasses the interference with the frequency weaponry, each kind of civil equipment electromagnetic radiation, the constitution electromagnetic environment is called the battlefield complex electromagnetic environment. The battlefield complex electromagnetic environment can have the quite serious influence to the weaponry potency and the army combat duty. Simultaneously the modern high-tech war request implements the high frequency and the high intensity airborne attack, requests the air unit rapid reaction, and with other services and arms combat teamwork, but all these must depend on the aeronautical communication to safeguard, simultaneously the aeronautical communication system receives own and the outside disturbance more and more receives takes, carries on the plan management to the spectrum is the communications system development objective request.

2. Electromagnetic spectrum management

2.1. The definition of the electromagnetic spectrum management

The electromagnetic spectrum management is any actions and behaviors in order to rationally and effectively uses the electromagnetic spectrum or the satellite orbit resources by the special agency through the laws, administration, and technology or economy methods, also calls the radio management. The electromagnetic spectrum management reveals especially under the complex electromagnetic environment importantly. The electromagnetic spectrum management may be divided into the international electromagnetic spectrum management, the country electromagnetic spectrum management, the military electromagnetic spectrum management as well as the aviation electromagnetic spectrum management according to the management scope and so on.

The characteristics of the electromagnetic spectrum management are shown as follows:

- Electromagnetic spectrum management is one kind of national behavior, the activity is authorized by the governmental agency and the correlation department implement;
- The objects of the electromagnetic spectrum management are kinds of activity for research, the development, and the use electromagnetic spectrum and satellite orbit;
- The final goal of Electromagnetic spectrum management is the maintenance airborne electric order, as well as the guarantee effectively uses the electromagnetic spectrum and the satellite orbit resources reasonably;
- Electromagnetic spectrum management must synthesize utilization the law, administrative, the economical and the technical method, guarantees its final goal to realize.

2.2. The content of the electromagnetic spectrum management

The main contents of the electromagnetic management include: spectrum division, plan, distribute and allocated; Examine and approve the overall arrangement and address of radio station; Monitor and inspect the radio signal; Coordinate and deal with the radio interfere with harmfully; conscious the policy, administrative statute and technical standard of the electromagnetic spectrum management; management of the research, producing, selling and importing of the radio equipments; Responsible for radio

monitoring and supervision work in the whole country, coordinate and deal with the international, domestic radio interference matters; Organize the implementation of radio control in accordance with the law; Participate in bilateral and multilateral international activities of the electromagnetic management of spectrum, etc.

2.3. *The existing problems of the current electromagnetic spectrum management*

At present, the spectrum management basically is one progressive applies from bottom to top, then from the top downward progressive assignment process. The frequency users hand up the application and the demand for electromagnetic spectrum, then the license can be issued by spectrum management structure for specific environment, by this way to safeguard the authority, scientific and feasibility controls, overall prevents and reduction mutually between disturbance^[3]. Generally speaking, the pattern of the spectrum management mainly has following two kinds:

- **Static centralization pattern**

Under this pattern, the spectrum management is centralization, non-real-time, the static management pattern. The spectrum management structure has the spectrum distribution right assign some spectrum resources to user have the frequency of use demand for each, and stipulates the use the time and the situation. This kind of spectrum management pattern reduced the spectrum resources the flexibility and the validity, and the preparatory takes long time, but it is necessary for protection of special department's spectrum right.

- **Limited auto-adapted management pattern**

Under this pattern, the frequency selecting for the best communication quality frequency adaptive from the frequency sets. At present, because of the adaptive ability of the communication network is extremely limited, only restricted in the single network frequency and power adaptive. Adaptive frequency selection mainly has two forms: One kind is the idle channel searching. The both sides of communication select the best quality frequency and establish the communication according to the detective result in the frequency sets; another kind is the adaptive frequency-hopping, the frequency is hopping according to the order which establishes the limited frequencies which assigned in advance, and replace the disturbance frequencies spot by automatic-detection. These two adaptive ways sharpened the system anti-jamming ability in the certain extent, compared to ordinary frequency-hopping communications anti-jamming ability, even if there is only one left frequency spot available theoretically, the both sides communication still might communicate in this frequency. In the single network communication, these two frequency adaptive ways basically can satisfy the demand of the anti-jamming communication, but under the system of nets application condition, needs during the multi-systems of nets to coordinate the spectrum resources the use, carries on the information and resources sharing, these two ways are unable satisfied.

Overall speaking, the current spectrum resource management has a contradiction between the limited spectrum resources and the spectrum waste simultaneously exists.

3. Cognitive radio

Cognition radio is one kind has spectrum sensation ability intellectualization software radio, it can around the automatic sensation electromagnetic environment, seek “the spectrum hole”, and will correspond through the communication protocol and the algorithm the bilateral signal parameter to adjust the optimum condition. Thus it can be seen, not only the cognition radio has the correspondence function, moreover also must have the spectrum detestability, has multi-purpose characteristic^[4]. The cognition radio has become the present wireless correspondence domain a big research hot spot. Because the cognition radio has, the agility nimbly, may the sensation, be possible the cognition, to be able

characteristics and so on network, causes the spectrum resources the management use to move towards the tendency from the static state, from moves towards the intelligence old-fashioned. The flexibility and the agility enable the cognition radio to have the auto-adapted ability. The flexibility is refers to the cognition blower to be possible to change the waveform, redeploys equipment each kind of parameter, the function; the agility is refers may change the equipment work frequency band ability. Cognition ability^[5] is the cognition radio essence characteristic; it through based on the modeling, the motion, the feedback, the lamination algorithm which expressed with the knowledge constitutes the study machine. For instance, in the serious blocking spectrum environment, is unable to depend upon the change frequency to guarantee the normal correspondence, this needs to use methods and so on wide frequency, Orthogonal Frequency Division Multiplexing (OFDM), beam forming, under the current environment, found partial or the overall situation most superior method. The cognition radio study mechanism and the humanity are similar: Sensation, motion, inference, feedback, accumulation knowledge and experience. This is a progressive improvement cognition radio carries out ability circulation. This circulation through network knowledge sharing, the distributional study, makes the cognition radio decision-making, optimized ability even more to strengthen. The cognition radio system is one the network which is composed by the distributional cognition radio node, the network may promote between the cognition node interactive, provides through the multi-spot sensation to the environment is more profound, a more comprehensive understanding, realizes when, frequency, spatial three-dimensional space to radio-spectrum more precise sensation.

4. Dynamic spectrum management based on cognition radio

4.1. Basic process of the dynamic spectrum management

The cognition wireless electric network is a network which is composed by the cognition radio users, distinguishes in the traditional authorized network. The traditional static state frequency allocation way has the cognition radio function network not suitably. This is because the electromagnetic environment changes unceasingly, the cognition radio node examines the idle spectrum unceasingly is also changing; Moreover as a result of the situation, the duty change, user's demand is also changing, is not also same to the idle spectrum use demand. Moreover must realize the completely auto-adapted dynamic spectrum assignment also to have to break the traditional policy, the standard and turning on agreement letter^[6]. Simon Haykin gives based on the cognition radio technology dynamic spectrum management definition: The spectrum management also is called the spectrum assignment, in the transmitting end realization, in the real-time survey current working space wireless environment, according to the survey result, carries on the analysis and the appraisal to the spectrum resources, in definite time and space available spectrum resources, and carries on sharing and the assignment according to certain rule to the spectrum resources.

4.2. Dynamic y spectrum access technology

But along with the fast growth of the radio affairs demand, the wireless spectrum resources appear lacks day by day. The available spectrum resources scarce and the spectrum causes one kind using the efficiency low status question brand-new, the optimized use spectrum resources short-wave communication pattern to become essential extremely^[7,8]. Therefore, arises at the historic moment based on the cognition radio dynamic spectrum turning on technology. According to the definition of IEEE1900.1 standard, DSA is one kind may dynamic choose the work spectrum in certain spectrum use jurisdiction scope, and using the spectrum holes or the white area which in certain time domain, the air zone and the frequency range appears carries on the correspondence the radio technology. DSA is a broad

concept, mainly may divide into dynamic arranges him to use, and opening sharing and the lamination turns on three kinds. The tendency arranges him to use class has still continued to use the present static state spectrum assignment policy basic structure, its main thought was introduces the flexibility to enhance the spectrum use efficiency. At present this model mainly contains two kinds of technologies: Spectrum Property Rights and Dynamic Spectrum Allocation. The spectrum property right may explain in the region scope which for in assigns in the frequency band to transmit the signal right, the prerequisite is in which assigns in the time section as well as assigns to use the spectrum, and the signal power does not surpass assigns the intensity. The spectrum property right may by the time, the region and frequency band these three parameters determined. A dynamic spectrum assignment main consideration question this time user to the host user's disturbance question, between two this time user's disturbance questions, three is between the cognition radio system fairness question benefit and user's^[9].

4.3. Merits of the dynamic y spectrum management based on Cognitive Radio

- Change tradition spectrum management system of nets the spectrum managerial grid with the phenomenon

Which separates with the frequency equipment network, the realization spectrum managerial grid, the spectrum monitoring network with the frequency equipment network three nets gathers one; the spectrum assignment can adapt the duty and the environment change. Because the cognition radio has the spectrum sensation function, can complete through the cognition wireless equipment composition cognition spectrum managerial grid to the local electromagnetic environment monitor and the analysis, replaces the traditional spectrum monitoring network. Real-time, the accurate spectrum sensation data reflected completely locates the electromagnetic environment situation with the frequency equipment, is the traditional spectrum management network is unable to compare. Thus the spectrum management can adapt the environment fast change to carry on the dynamic alignment, maximum limit displays with the frequency electron equipment potency, the electromagnetic spectrum no longer is restricts the electronic equipment performance display the factor.

- Realization spectrum management way big transformation

Transforms by the traditional central static state or the limited auto-adapted spectrum management way into the tendency, the auto-adapted spectrum management way. The spectrum management no longer is a tedious systems engineering, very little needs human's participation, realizes the complete machine assignment, the automaticity is high.

- Spectrum assignment reliability, compatible large enhancement

The traditional static spectrum management way refers to the frequency which matches not to allow changing at will, comes across the thunderbolt to handle with difficulty; the compatibility bad, anti-jamming ability is bad. Using the cognition radio technology spectrum managerial grid, with the frequency equipment unit through way prevention disturbance and so on disturbance estimate, power control occurrences, and when received the disturbance can through the spectrum mobility management mm rapid cut frequency, the safeguard correspondence carry on smoothly.

- iv. spectrum management has realized the network, the intellectualized management

The traditional central static spectrum management way is one kind of top-down bidirectional spectrum management process, needs human's intervention. Needs to carry on the statistics beforehand to the electronic equipment technical parameter, but also must the electromagnetic environment information which locates to the electronic equipment carry on the statistical analysis, then the recombination demand situation carries on the centralism the spectrum plan and the assignment, the automation, the intellectualized degree is not high. But has cognition radio technology spectrum management network each node to be able to locate the electromagnetic environment to carry on the study and the inference,

selects machine the use idle spectrum, through the sharing environment sensation information, the movement assignment algorithm realization spectrum assignment, and the intelligent choice appropriate network standard, establishes the correspondence, the entire process does not need to prepare beforehand. From the spectrum sensation to the correspondence establishment, has realized the network management and the intellectualized operations

5. Conclusion

The approach of the cognition radio technology provided a solution for the contradiction between the incensement of the wireless service day by day and the limited spectrum, and exploited the way for enhance the flexibility and interoperability of the communication facility. But at same time, the cognition radio technology is facing many challenges, the spectrum sensation, the spectrum management and so on many crucial difficult problems proposed in the cognition radio technology must break through extremely, the cognition radio technology could be the future domain research hot spot in communication field.

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