Space-Based Information Integrated Network Technology and Performance Analysis Based on Cognitive Radio

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Abstract. In the demonstration and construction process of the space-based remote sensing, communication, navigation and information integration network, there are several problems such as: the network system architecture is complex, the information fusion efficiency is low and the anti-jamming ability is poor and so on. Based on space-based cognitive radio technology, the paper proposed the method to optimize and enhance the space-based information network performance by adding cognitive satellite nodes in the network. Mathematical modeling and performance analysis results show that the space-based cognitive integrated information network can optimize network configuration, improve the task affect speed, use the data resources efficiently. Meanwhile, the method can enhance the anti-jamming performance of the entire space-based information network greatly.

Keywords: Space-based · Integrated information network · Performance analysis · Cognitive radio

1 Introduction

Recently, the number of terrestrial internet and mobile users of China become a world leader with the rapid development of information network construction. However, the development of the space-based information network, the internet and the mobile communication network is very uneven, showing “weak space strong ground” characteristics. In the space-based, Although China has initially built Beidou navigation and position system, earth observation and remote sensing system, data communication relay system in the space, while each system can form internal space-based network. However, since the beginning of the construction of major systems is relatively independent, the satellite types are relatively simple, there is no inter-satellite network, the space-based information network can not give out the comprehensive performance efficiently.

With the rapid development of network technology, especially the emergence of inter-satellite links (ISL), space-based information system gradually to form network [1]. During this time we worked a lot of top-level design of space-based information network and general structure research, divided system functional specifications, and defined the system composition and function [2]. Typical space-based information

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network systems in foreign include the Iridium system, Advanced EHF satellite communication systems, global position system (GPS) and so on. We focused on information integration of the space-based systems of communication, navigation and remote sensing in China.

Although we have a good foundation in the space-based information network, and have made many useful ideas and concepts of space-based information fusion of three networks, it is necessary to solve single information network system itself and also to solve the new problems posed by the integration of three information networks. Currently, the space-based information network argumentation problems mainly as follows: the complex network architecture, the long task response time in network, low allocation efficiency of resources within the network, the poor environmental adaptability, weak anti-interference ability and so on [3]. Therefore, new means and methods to demonstrate and optimize the space-based information network system are urgently needed.

Based on cognitive radio technology, the paper proposed a new method to build cognitive network nodes in the network [4], which can optimize the network architecture, improve the system response time, optimize the resources allocation, and enhance the anti-jamming capability of the entire network greatly [5].

2 Space-Based Cognitive Radio Technology

Cognitive radio is an intelligent wireless communication system which can sense and learn the spectral characteristics of the surrounding. According to adjust the specific transmission parameters such as transmit power, carrier frequency, modulation, etc. in real time, the internal states can adapt to the external input radio incentives, which can achieve high reliability and efficiency use of spectrum resources whenever and wherever in communication system.

Based on the traditional cognitive radio, space-based cognitive radio technology can use their own learning and reasoning ability, to deploy the available network resources adaptively, fusion the network-wide data effectively, response rapidly and complete the tasks efficiently by cognitiving tasks intelligently and learning surrounding wireless environment quickly. Meanwhile, it can greatly improve the anti-jamming performance in the space-based information network [6].

At the same time, the space-based remote sensing, communication, navigation and integrated information network systems are very complex, we need to analysis the system performance adding the cognitive nodes before and after. System performance analysis process contains a number of uncertainties, such as fuzzy comprehensive evaluation, artificial neural networks and so on [7]. In this paper, we carry out theoretical mathematical model and analysis the space-based cognitive-information network performance [8].

3 Space-Based Cognitive-Integrated Network Technology and Performance Analysis

With the strong demand and rapid develop of space-based integrated information network, it's necessary to build the integrated network quickly. At this stage, the space-based integration information network system mainly uses the "local distribution station, network in the space" mode [9]. With the support of terrestrial network systems, we focus on building space-based backbone network, space-based access network, space-based remote sensing network and space-based space-time reference network. The network can propose information acquisition, transmission and temporal reference services by the inter-satellite link connection. The space-based integrated information network architecture shown as Fig. 1 [10].

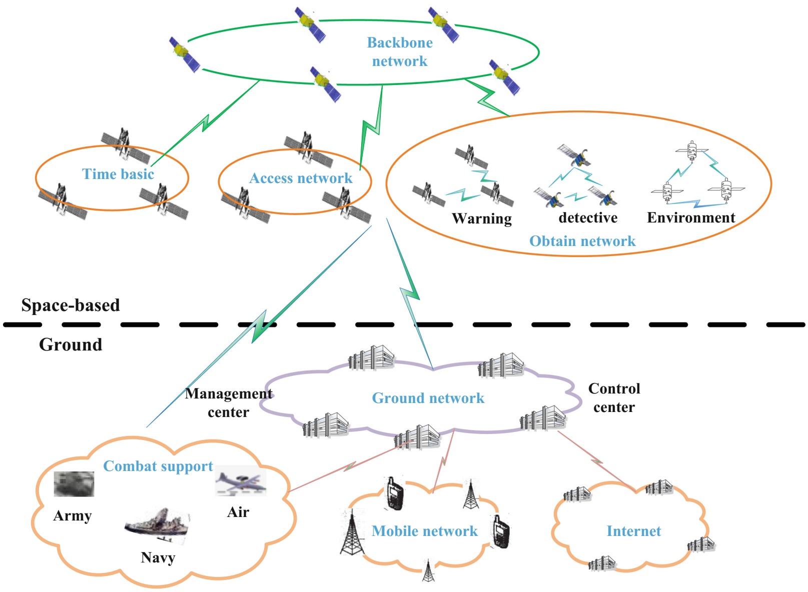

Fig. 1. Space-based integrated information network architecture

Of course, it's necessary to build the space-based integrated information network depending on the existing space-based equipment and facilities. Therefore, the space-based information obtain network based on remote sensing network, the space-based space-time reference network based on navigation network, the space-based backbone network and access network based on communication network to construct and demonstrate.

3.1 Space-Based Cognitive-Integrated Network Technology

Based on cognitive radio technology, we can optimize the integrated information network architecture to increase the flexibility and efficiency of the whole network system. The space-based cognitive-integrated information network architecture shown as below (Fig. 2):

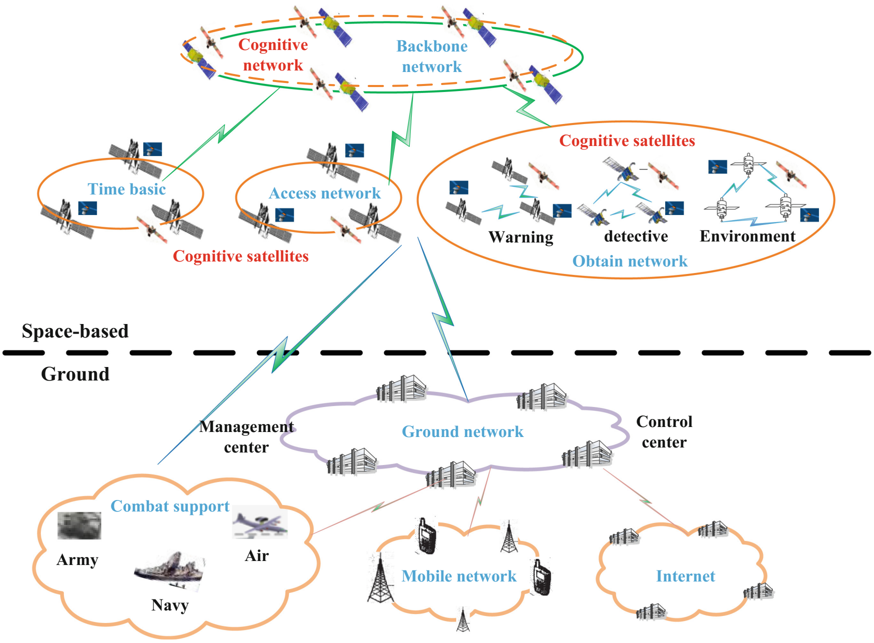

Fig. 2. Space-based cognitive-integrated information network architecture

As we can seen, although the space-based integrated information network is powerful, it's architecture is quite complex. The network is unable to maximize the throughout performance apparently if only building ISLs among several independent information networks. The space-based cognitive-integrated network has the following main functions: the network can respond to external tasks quickly and efficiently in order to provide services to users on demand; based on satellite data and external tasks, the network can adjust the internal data by allocating resources dynamically, which can complete the tasks efficiently in a higher data fusion rate; according to sense the external environment and interference in real time, the network can avoid interference or use the undisturbed resources to complete the tasks by planning in advanced [11].

3.2 Space-Based Cognitive-Integrated Network Performance Analysis

The space-based integrated information network is built of remote sensing, communication and navigation network, so the network performance analysis indicators include data fusion capability, task execution efficiency and robustness of the network and so on except the remote sensing, communication and navigation indicators.

Take the average response time for example, we compared the system performance between the space-based integrated information network and cognitive-integrated information network. The method is divided into the following steps [12]:

(1) Space-based integrated information and cognitive-integrated information data from STK simulation;
(2) Choose 10 agencies/experts to process and evaluate the index values. Set the dimensionless credibility of 10 agencies are a1 = 0.95, a2 = 0.90, a3 = 0.70, a4 = 0.95, a5 = 0.85, a6 = 0.80, a7 = 0.80, a8 = 0.75, a9 = 0.85, a10 = 0.90. The judgment values of 10 agencies are p1 = 0.1, p2 = 0.1, p3 = 0.09, p4 = 0.08, p5 = 0.1, p6 = 0.11, p7 = 0.1, p8 = 0.12, p9 = 0.08, p10 = 0.09.
(3) We analyze the performance of space-based integrated information network firstly, Table 1 is the normalization allocation table of 10 agencies in space-based remote sensing network.

Table 1. Space-based integrated information network normalization allocation

	Excellent	Good	Average	Bad	Poor	Uncertain
*y*1	0.19	0.19	0.285	0.19	0.095	0.05
*y*2	0.27	0.18	0.18	0.09	0.18	0.1
*y*3	0.21	0.28	0.105	0.07	0.035	0.3
*y*4	0.095	0.19	0.38	0.19	0.095	0.05
*y*5	0.17	0.255	0.17	0.17	0.085	0.15
*y*6	0.08	0.32	0.16	0.16	0.08	0.2
*y*7	0.08	0.16	0.24	0.16	0.16	0.2
*y*8	0.3	0.225	0.075	0.075	0.075	0.25
*y*9	0.34	0.17	0.17	0.085	0.085	0.15
*y*10	0.18	0.18	0.315	0.135	0.09	0.1

(4) Select the performance analysis methods, we can obtain the excellent/good/average/bad/poor/uncertain results after 9 synthesis according to mathematical models and probability distribution function, the results are: (0.2466, 0.3354, 0.2762, 0.0833, 0.0525, 0.006).
(5) 10 agencies evaluate the importance of the impact indicators independently, Table 2 shows the importance and the important coefficient of the average remote sensing response time.
(6) Repeating this process, we can obtain the integrated system performance evaluation results are (0.2327, 0.3611, 0.2543, 0.1027, 0.0452, 0.004), the excellent degree is 23.27%, good degree is 36.11%, average degree is 25.43%, bad degree is 10.27%, poor degree is 4.52%.

Similarly, we can obtain the integrated system performance evaluation results of space-based cognitive-integrated information network are (0.2740, 0.3857, 0.2507, 0.0655, 0.0206, 0.0035).

Table 2. Importance factor of average response time

	Most important (0.30)	Middle value (0.24)	Very important (0.18)	Middle value (0.15)	Important (0.09)	No important (0.04)
y1	✓					
y2	✓					
y3	✓					
y4		✓				
y5		✓				
y6	✓					
y7			✓			
y8		✓				
y9		✓				
y10	✓					

According to space-based integrated information system performance analysis method, we can obtain the integrated network and cognitive-integrated network analysis as follow (Fig. 3):

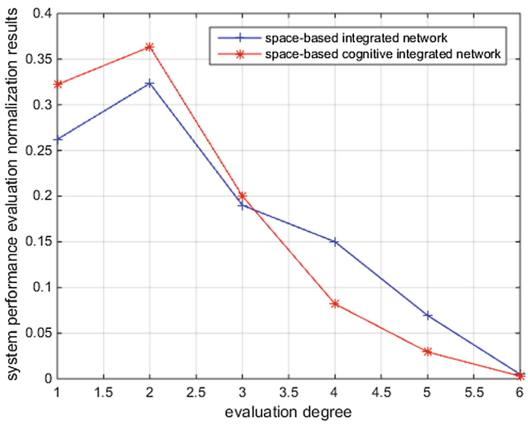

Fig. 3. System performance evaluation normalization results

From the figure we can see that the excellent and good results of space-based cognitive-integrated information network are better than space-based integrated network, bad and poor results have a greater degree of decline, the overall system performance is developed greatly.

In addition, the anti-jamming performance of space-based cognitive-integrated information network is shown as follow [13]. We can see that the error rates of cognitive-integrated information network have a obvious decline compared with integrated information network (Fig. 4).

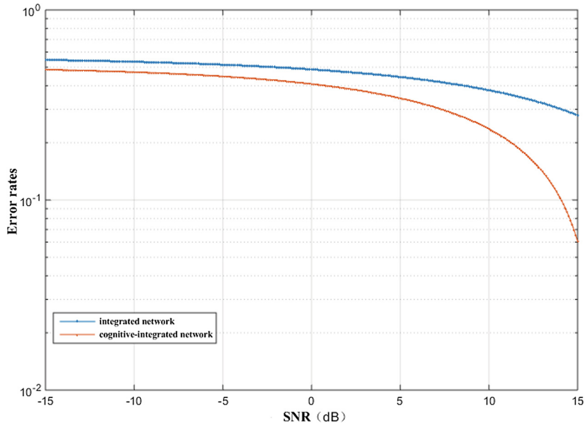

Fig. 4. Error rates results

4 Conclusion

In this paper, we proposed a new method to develop the system performance of integrated information network based on cognitive radio technology. According to constructing cognitive backbone network and adding cognitive satellite nodes in the network architecture, we can response the tasks rapidly, complete the data fusion effectively and develop the whole network system performance finally. In addition, adding the cognitive radio nodes can improve the anti-jamming performance greatly in the space-based information network.

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