Flow Control and Scheduling Algorithm of Air-Space-Ground Integrated Networks

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Flow Control and Scheduling Algorithm of Air-Space-Ground Integrated Networks

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Abstract. Air-space-ground integrated networks are the combine network of the air, space and ground. The ASG-IIN has the problem of level isolated in Multi-level architecture. This article design an Air-space-ground integrated networks layered independent flow control scheme, based on the Air-space-ground framework, which analyze the problems of satellite network flow control, spacecraft flow control and land mobile communications networks flow control. According to the research of complex networks’ situation of establishment in WIT120, secure campus and sturdy power grid, we obtain a high service flow control demand of blend networks. Basing on the token, game theory and neural network, we put forward a series of new method to control the flow in Air-space-ground integrated networks.

1. Introduction
Space integration network is to build the ground, air and outer space in the information link, so that information can be free transmission in this large capacity of space, that is, space-based, air-based and land-based integrated network. The integration of air and space network can make the original split the network to be effective communication, so that the transmission of information can transform from micro to macro, and achieve all things interconnection.

Different from the traditional single network, it is necessary to improve the network topology, protocol design, signal structure and service capability in many dimensions because of the heterogeneous network, the complexity of the environment, the variation of the span, in order to achieve Ring mixing, software definition airport, adaptive protocol conversion and service scale transformation and other technological innovation[1].

From the foreign trend of development point of view, at present only the United States has the strength to carry out the air-space-ground integration network capacity. As early as 1996, the United States NASA will be years of aerospace monitoring and control in the formation of a considerable scale of the five existing wide-area monitoring and control, constitute the NASA integrated business network. In 2004, NASA published a report on the spatial network architecture and technology, designed the architecture of the integrated information network, including the constituent elements of the architecture, interfaces, network hierarchy models, and communication nodes. The United States presented the Global Information Grid Program (GIG), which aims to provide end-to-end seamless connectivity in 2020. China's air-space-ground integration network, although in the construction, but the distance from the US network construction level there are still differences.

The construction of the air-space-ground integration network is to enable people enter the era of network convergence. A variety of terminal communication integration, promote the formation of new base stations, platforms, services and terminals, bringing new industries and economic benefits, can
greatly expand the field of communications, in the deep sea, forests, deserts and other places can also achieve barrier-free communications.

At present, the research of air-space-ground integration network is mainly focused on hierarchical structure, flow control, system composition and intelligent decision-making, such as multi-group game, SDN, openflow, token bucket algorithm, Kalman algorithm and so on, which have been gradually applied in database management, Planning, power grid systems and other fields. Although the integration of air-space-ground network has a good prospect, but now it also has the following problems.

1) Now, all the researches are to study the single-layer network, not from the three or even multi-layer to think about the overall network architecture problems.

2) Existing systems are for their own network services users. In the future, through integration of air-space-ground after the network, these users should be moved or retained, in the same coverage, the size of the network how to suspend to achieve maximum service is also worth thinking about.

Based on the air-space-ground architecture, we propose a hierarchical and independent flow control scheme for the integration of air and space. The analysis of satellite network flow control, airplane flow control and terrestrial mobile communication network traffic Control the problem. By studying the construction of complex networks in intelligent medical care, safe campus and strong power grid, the demand of high service utility flow control of converged network is obtained. Finally, based on the technology of token, game theory and neural network, a series of new ideas are put forward to control the network traffic.

2. Separate Flow Control of Space Integration System

In order to improve the overall performance of the integrated space network, it is necessary to plan the network, air and ground, and analyze the flow control of satellite network flow control, air traffic control and ground mobile communication network.

2.1. Satellite Network Traffic Control Technology

He Wenqing from Beijing University of Posts and Telecommunications, proposed three kinds of state transition channel models based on Markov chain, and designed a resource management scheme based on wavelet neural network traffic forecasting, which can predict multi-scale long[2]. Ye Yue from Beijing University of Transportatone, proposed a resource allocation mechanism adapted to the satellite network, so that multimedia satellite communications for different levels of users can meet the QoS requirements of the allocation of resources. The technology ensures fairness and effectiveness of resource allocation through stream allocation and broadband allocation [3]. Hei Ning from China Astronaut Research and Training Center, proposed a recursive multi-service broadband GEO satellite network cross-layer flow control algorithm research, multi-service input flow control problem is abstracted into the input rate control mechanism with the buffer threshold optimization problem, effective reduced packet loss and latency for satellite network application layer.

2.2. Airplane Flow Control

Zhao Yifei from China University of Civil Aviation proposed a regional air traffic flow control mathematical model. Using the pushdown algorithm to calculate all flight landing and takeoff times, it is possible to calculate the delay time accurately and to reduce the delay in controlling the regional flights. According to the Eulerian model, the air traffic flow control algorithm based on Eulerian model is proposed. Firstly, the system is optimized by adjusting the linear quadratic optimal control design in the airspace, which can reduce the total flow rate. Xiao Peng from Northwest University of Technology proposed ASAC runway capacity model, the aircraft terminal many aspects of the system capacity assessment. The Markov decision process model and the stochastic dynamic programming method are used to provide a dynamic route planning and selection strategy [4]. A synchronous perturbation stochastic approximation algorithm is used to find the optimal ground wait strategy.
2.3. **Ground Mobile Communication Network Flow Control**

Beijing University of Posts and Telecommunications, Zou De-bin through the multi-scale behavior analysis of wireless packet network traffic, a logarithmic infinite scalable string method in turbulence scale analysis is proposed. Found in GPRS traffic to meet the logarithmic infinite scalable string frame. Meng Shuyuan from Beijing University of Posts and Telecommunications, proposed traffic model with heterogeneous network to match the new features, analyzing the performance parameters of a multi-server queuing system, extending the effective working time unlimited sensor network, more suitable for energy-sensitive and has a centralized control structure of two pairs The network of SINK nodes in the context of fusion. Ren Tiejun from Beijing University of Posts and Telecommunications, analysis DPI / DFI technology mechanisms, access to the overall design of traffic management and control systems. It can realize the comprehensive monitoring of network elements, links and users through the deployment of probe devices on the Gn / Gi interface of the mobile network packet domain, and realize the monitoring and management of the network elements performance and reduce the ineffective load of the network.

3. **High Service Utility Control in Different Areas**

High service utility flow control is widely used in large-scale communication projects in society. By analyzing the flow control problems of intelligent medical care, safe campus and other projects, it can effectively provide technical support and innovation for the traffic control of air and space integrated network.

3.1. **High Service Utility Flow Control for Intelligent Medical**

Liu Qiang from Northern Guangdong People's Hospital Information Center propose a hospital network optimization design, the overall design of the mainstream network core layer, convergence layer and access layer three-tier network architecture to meet the new Emergency Department building existing business network requirements Liu Ning from the Shanghai First Pulmonary Hospital and so put forward a hospital information management system traffic estimation and network traffic control program [5], the effective information system traffic estimates to ensure that information management system data efficiency, fast storage, sharing and safe and reliable sex. Ma Xikun from Nanjing Military Region Nanjing General Hospital proposed a hospital network terminal access control solution, through the implementation of terminal access control, the user's network access behavior to effectively control, making illegal users cannot enter the hospital network to protect the hospital network security.

3.2. **High Service Utility Flow Control for Secure Campus**

Lin Zhixing from Sanming College pointed out that the campus network P2P traffic consumption of a large number of network resources, resulting in network congestion. The maximum speed and bandwidth balance for each user's various applications to meet the needs of more online users at the same time on the Internet. Zhao Zhao from Baoji College of Arts and Sciences, proposed based on different levels to achieve campus network traffic control. By adding a traffic control device between the WAN and the LAN, the campus network hosts access the campus network through the Layer 2 switch and then converge through Layer 3 switches to achieve traffic control. The size of the traffic into the network is limited to a reasonable range to protect the network resources. Xu Wei from Wuhan University of Engineering, proposed flow control room through the unique bandwidth management and allocation algorithm to bandwidth management services to active, effective and intelligent services.

3.3. **High Service Utility Flow Control for Strong Power Grid**

Zhao Yan from National grid electricity to provide a backbone communication network with traffic information flow model calculation method, according to the communication network backbone bearer mode power line communication network can be divided into traffic and IP traffic service, consider a
certain proportion coefficient at concurrent capacity planning, traffic division strict transmission delay requirements, exclusive channel resources. Hu Chao from North China Electric Power University, proposed a micro-grid communication traffic prediction and research, combined with the existing distributed power supply standards and substation automation standards for micro-grid communication message structure, summed up the micro-grid of different messages on the bandwidth Extension requirements [6]. Zhang Qianqian from Tianjin University, a power flow analysis and prediction technology for distribution network is proposed. FARIMA model is used to model and forecast the power communication service of distribution network. FARIMA is established respectively model and simulation to predict traffic.

4. New Flow Control Technology for Space Integrations System
As the integration of air, space, ground network and the existing network has a certain degree of difference, so the need of transmission control, traffic scheduling neural networks and other aspects of innovation exist.

4.1 Air-Space-Ground Integration Network Traffic Control Based on the Token
The token ring network is to determine the transmission authority of the workstation through the token. When the information frame is transmitted on the ring, the information transmission without the token will be stagnated to ensure the high efficiency of the data traffic transmission on the token ring. The working principle is shown in Figure 1.

![Figure 1 Token control of traditional networks](image)

As the integration of air-space-ground network consists of multiple networks, and to achieve collaborative work and effective interoperability, as shown in Figure 2. So the token in the three-dimensional, multi-layer, heterogeneous network transmission need to overcome the following three questions:

1) The Network Priority Assignment of the Token Transmission
When a complex communication service needs to be integrated in the air, ground and space, the multi-network cooperation will be an effective means to realize the optimal allocation of resources, and the transmission service can reach the target node through multiple paths and multiple networks. The transmission of the token needs to take into account the service quality requirements of the communication service [7], the normalized channel quality of each network, and the processing delay of the single network in order to realize effective network transmission control management.

2) Heterogeneous Network Transmission Format Unified
The air-space-ground integrated network consists of ground, air, or space-based, and each network has its own protocol requirements and communication format. On the one hand, it is necessary to ensure that the token of the same service can be received, interpreted and processed in each network. On the other hand, the design of the appropriate frame structure, so that each network can be through the least resources to complete the network distribution processing.
3) Interconnection Security Control Protocol
The security of each network collaboration, the difficulty of a single network than the security control is much more complex. The reliable transmission of the token is that the security authority for each network has been obtained. Therefore, the integration of air and space network needs to solve the single authorization, the whole network of effective design, reduce the complexity of transmission processing.

![Figure 2 air-space-ground integrated network traffic control based on the token](image)

4.2 Air-Space-Ground Integration of Network Traffic Control Based on Game Theory
For the transmission system, the transmission requirements and transmission capacity is a pair of objective contradictions. This introduces the game theory, and provides an effective analysis tool for the analysis of the integration of air, ground and space. Game theory mainly studies the interaction between the stimulating structure of the formula, and the mathematical theory and method of studying the phenomenon of struggle or competitive nature. Therefore, the space between the integration of network conditions, to explore the relationship between demand and the effective relationship between the ability to design the best data transmission program, as shown in Figure 3.

1) Information Transmission Uncertainty and Bandwidth Limited Game
In the air-space-ground integrated network, the information is uncertain, the information path contained in the signal is unpredictable [8]. The noise and unwanted signals of the signal transmission between the foundation and the air, air and space are significantly increased compared with the ground transmission. Between the sky and the air, the noise inside and outside the atmosphere is very large, seriously affecting the transmission of the general signal.

2) Business Delay and Hierarchical Transmission of the Game
The delay is an important quality representation of the communication service. Only the service that has completed the transmission within the agreed time is the effective communication service. As the air-space-ground integrated network is composed of multiple networks, each network needs to have their own transmission delay and processing delay, therefore, need to consider the overall transmission channel from time to time.

3) The Transmission Quality and Transmission Throughput of the Game
The three different levels of information flow in the air-space-ground integrated network are different, and the information flow of the vertical network is different. In the air network, the information transmission of the larger noise, the transmission is also more difficult than the ground network, the need to allocate more resources to protect the transmission of information. The difficulty of terrestrial information transmission is relatively low, but the transmission traffic is larger than that of the space network. The transmission efficiency of the information is also higher, and the information resource allocation of the different levels of network needs to introduce a complete set of architecture Reasonable game theory system to control. It is an important prerequisite to realize the
integration of air-space-ground integrated network information through real-time monitoring of information transmission of different levels of networks to rationally and efficiently allocate limited resources.

![Figure 3 contradictions of air-space-ground integrated network transmission](image)

4.3. Air-space-ground integration network traffic control based on the neural network

Artificial neural network is a mathematical model which mimics the behavioral characteristics of animal neural network and then distributed parallel information processing. This network relies on the complexity of the system, through the adjustment of a large number of nodes directly to each other to achieve the purpose of information processing [9].

Neural network can be unsupervised learning, the data for the network is also good at induction. Space and earth integration of information transmission network has a lot of uncertainty, and let the artificial intelligence and neural network through self-learning to rational allocation of all the workstations of the resources and information transmission efficiency to strain a variety of uncertainties is essential. Through the self-construction of neural networks, information can be relatively reasonable layering and transmission, and greatly reduce the human workload and its errors.

Air-space-ground integration network under the network traffic control involves three levels, a number of plane information transmission between. Such a huge network is well suited for introducing neural networks, artificial intelligence and machine learning. With the flow of all levels of network monitoring data collection, the formation of the initial air-space-ground integrated network traffic transmission database, and then through machine learning and data analysis to build space integration network under the information transmission neural network, through this network to achieve information efficient transmission.

5. Conclusion

This paper introduces the construction of the integrated network of air, space and ground in the current international scope, and shows the importance of China's current construction of air-space-ground integration network. This paper summarizes the advanced technology and problem solving methods of network traffic control in the current level and the high service efficiency flow control technology in the large-scale network information engineering in the society.

Based on the current network traffic control technology, this paper puts forward three innovations of network traffic control technology, which are based on token ring network, game theory and neural network-based integrated network traffic control scheduling algorithm. This three-point innovative scheduling algorithm can effectively enhance the network coverage and transmission capacity.

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