QoS optimization based Core Network Distribution Strategy For B5G Non-terrestrial-network (NTN)

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Abstract

In the vigorous era of fully promoting commercialization of 5G technology, in order to further optimize coverage and service quality, a large number of scholars and technicians have turned their research focus to the 6G era based on large-scale LEO satellite constellations. According to the advantages of wide coverage and low delay of large-scale LEO satellite constellation, this paper proposes a 6G network deployment scheme. Aiming at the key characteristic of the separation of user plane and control plane in 5G technology, a dynamic decision scheme of user plane and control plane based on node reuse method is proposed. In addition, an efficient networking scheme with access network and core network coexisting in a single orbit plane is realized.

1. Introduction

With the commercialization of 5G technology, the academic research status of 6G technology is rising day by day [1]. Among the many potential development directions, LEO satellite has rapidly become an indispensable key technology in 6G mobile communication because of its excellent characteristics of wide coverage, low delay and distributed payload [2]. In particular, the advantages of LEO small satellites can fully compensate for the difficulties of 5G core network in remote areas as well as mountains, rivers, lakes and seas. Especially with the rise of commercial satellite constellations [3], many domestic research institutions, universities and commercial companies have gradually entered the research stage of 6G satellite networking. At present, the three mature commercial constellations abroad are StarLink, OneWeb, and TeleSat, while in china large-scale constellations such as "Hongyan" and "Hongyun" are still in the technical verification stage [4]. Although LEO satellite constellations have many academic research contents on 5G satellite networking at present, their contents are mainly based on the data interaction between satellite communication and ground 5G network [5], lacking the deep integration of space and sky networking solutions. Therefore, this paper proposes a 6G networking deployment scheme based on large-scale satellite constellation, and uses the resource reuse method to realize the dynamic decision-making scheme of user plane function and control plane function.

Firstly, according to the requirements of mobile communication for ground area coverage, the basic orbital topology of Walker constellation is proposed [6]. The design of track parameters mainly depends on the key parameters such as traffic hotspot area, communication delay and networking capability. Secondly, it inherits the key technology of separating user plane and control plane in 5G technology, and proposes the architecture that the access network data node and core network control node share the same track plane in 6G network. The function of the satellite node is dynamically adjusted according to the real-time status of the satellite node by using the method of resource reuse. Relying on software defined radio(SDR) technology, each satellite node can undertake user interface data transmission function and core network control function respectively when facing different task requirements. Finally, a complete satellite networking deployment architecture for 6G communication is designed.

2. Orbit Topology

The satellite constellation topology for 6G networks have the advantages of wide coverage, low delay and high efficiency, so Walker constellation with sufficient symmetry must be the first choice [7]. The so-called Walker constellation is that it has M circular orbits evenly distributed on the Earth's surface, and the equatorial plane M is equally divided around the north-south axis. P satellites are evenly distributed on each orbital plane, and the orbital height of each satellite is h (km). The design of the whole constellation is determined by the parameter set Walker (M, P, h, i), where M * P represents the total number of satellites in the whole constellation and also determines the ground coverage capability. The orbit height h determines the satellite ground transmission distance, and affects the channel fading and transmission delay of the earth transmission.

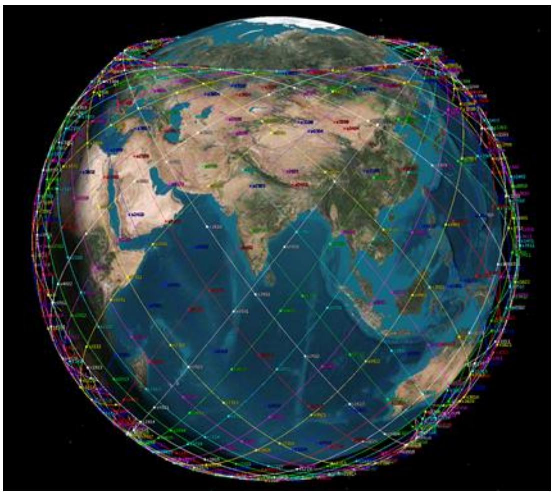

Figure 1 Walker constellation topology

3.Network Topology

6G communication based on large-scale satellite constellation gives consideration to the advantages of LEO satellite constellation and the core functions of 5G technology [10]. For LEO satellite constellation, wide coverage capability is one of the most important advantages. As mentioned in the previous section, building a fully symmetrical large-scale satellite constellation can realize the functions of access node and relay node at the same time. For 5G technology, the core technologies such as network slicing, SDN architecture and user interface sinking must be the key links to ensure the quality of service.

According to the three business scenarios of 5G technology: enhanced mobile broadband, ultra-high reliability and ultra-low delay communication and Internet of Things. In 6G technology, three corresponding service functions are designed: broadband communication, low delay communication and multi access communication. The above three types of services have different requirements for satellite resources, respectively corresponding to link bandwidth, end-to-end delay and access multiplexing. After the service is initiated, in the control plane of the core network, the physical resources are reasonably allocated according to different business scenarios, and the control parameters are fed back to the access network nodes through the bearer network to achieve data transmission.

4.Distribution Strategy

Based on the above analysis, it is set that large-scale satellite constellation is realized by working nodes, management nodes and inter satellite links. According to different business scenarios, the management node needs to allocate different resources on the working node and the inter satellite link, and the resources between the inter satellite link and the working node are mutually constrained. Solar radiation is the only energy source of satellite, and the load capacity of satellite nodes is limited by the residual energy. Therefore, the adaptability of any satellite to the working node and management node changes with the change of its resources. The management node needs a lot of computing power, so it needs high residual energy. In addition, there is a high frequency of data interaction between the working node and the management node, so the distribution density requirements for the core network control plane are different according to the number of users and the number of business services in the coverage area. Based on the above practical requirements, we propose a node dynamic planning scheme based on star cluster management.

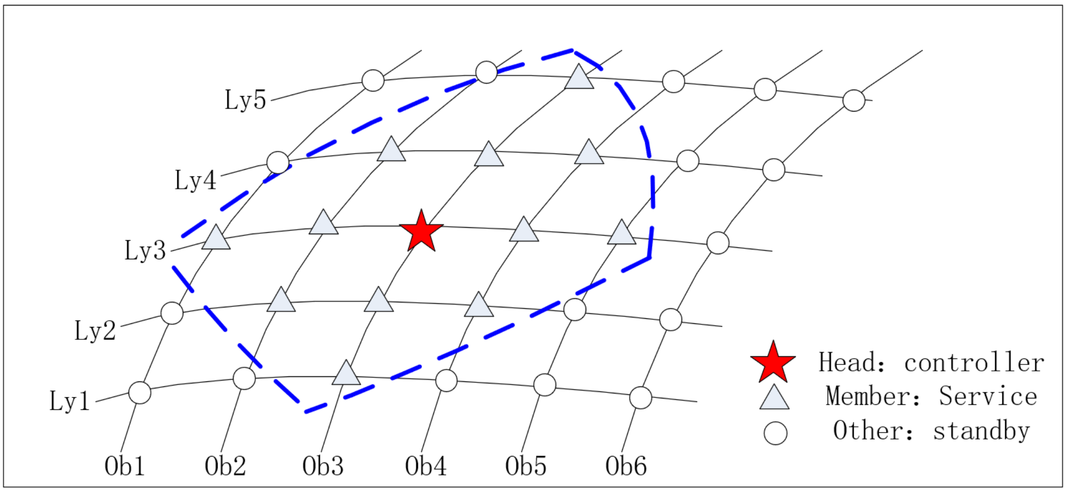

Figure 2 Schematic Diagram of Clustered Satellite Nodes

As shown in Figure 2, it is a schematic diagram of local orbit, including six orbital planes and five phase planes, with a total of 30 isomorphic satellites. A satellite node with rich remaining resources is defined as the cluster head node to realize the core network control surface function for the working nodes in the entire cluster, and the cluster member node is the working node to undertake the access network function and the user surface data interaction function of the core network. The nodes outside the cluster are independent of the cluster, and their cluster head nodes assume the control function.

Cluster head node is the center of the cluster, and the working node with control surface service requirements within r=2 hops is defined as cluster member node. The value of r is determined by the density of ground services and the business scenario: when there are more ground services, the higher the demand for the core network control surface functions, the higher the demand density of cluster head nodes, and the corresponding r decreases. On the contrary, when the ground traffic is less, the corresponding r increases; For the three different types of service requirements, the distance between the control surface function and the access network node is also different. A working node can be a cluster member node of multiple clusters at the same time, but a cluster head node can only manage one cluster.

According to the satellite node capacity, ground service requirements and space channel environment, cluster head nodes and their cluster members are selected periodically to form a 6G cluster. Information interaction between clusters is realized by cluster head nodes, and information is transmitted through virtual channels formed by non cluster heads.

5. Network design

According to the above analysis and design, we can get the constellation topology with global cluster management. In Figure 3, the local coverage of the north latitude/east longitude area is shown.

In Figure 3, there are 20 orbital planes and 22 phase planes, which correspond to the orbital topology of the Eastern Hemisphere. There are 440 satellites in total. Through the autonomous clustering process, 28 cluster head nodes and 412 cluster member nodes have been generated. Each management node controls 15 working nodes on average, and the average number of hops in the management range is 2. The cluster size is different according to the difference of ground access requirements and service classification. The high dimension land area has a large access volume and a large business demand, so the management hops r of the star family is small. On the contrary, the users in the low latitude ocean area are sparse, so there are fewer distributed management nodes. Moreover, due to the high dynamic characteristics of satellites, the period of 500km LEO satellites is 90 minutes, and the time scale of a single satellite's coverage of the earth is 10 minutes. In order to meet the business requirements of relatively stable geographical location, the deployment and scheduling of satellite clusters need to be updated with a period of several minutes.

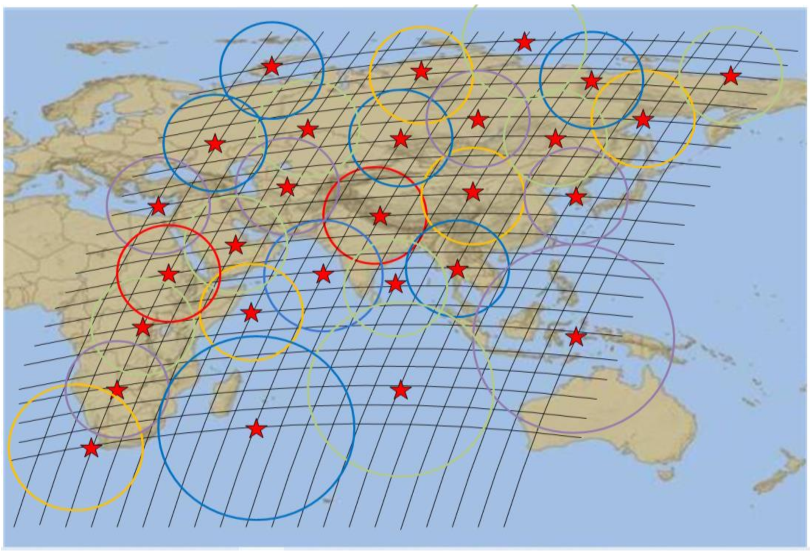

Figure 3 6G Networking Design

6. Conclusion

According to the above design, a 6G networking scheme for large-scale satellite constellation can finally be realized. The whole constellation is composed of management nodes and work nodes. According to the topology and the dynamic changes of ground users, the whole network adaptively and dynamically decides the functions undertaken by each node. Finally, to meet the 6G networking architecture with satellite constellation as the background.

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