

Preface

Nowadays, mobile service coverage is crucial for economic development. Up to now, there are still a large number of population without mobile service coverage, especially in less developed areas. Moreover, future wireless networks should also guarantee service continuity for emerging applications and heterogeneous networks. On the other hand, the cost of providing ubiquitous coverage has to be taken into account for mobile network operators. Current urban areas are mainly covered by terrestrial cellular networks, while the usage of wireless network in less developed areas, such as remote rural areas, is far less than urban areas. The cost of pure terrestrial coverage quickly becomes unbearable with increasing network requirements for those remote rural areas.

While the terrestrial networks can provide high-speed data service at low cost, satellite-based access is one way to complement the terrestrial-based networks for achieving ubiquitous, 100% geographic coverage. A satellite network is an ideal solution to address such a dilemma. One satellite is able to cover areas of thousands of kilometers in radius instead of several kilometers with a terrestrial base station. The coexistence and cooperation between terrestrial and satellite networks are of great potential in future communication networks. Therefore, investigations of innovative technologies in terrestrial-satellite networks are in great need to reveal their true potentials.

In a typical communication system, transmission and reception are the fundamental problems. We consider the technique of beamforming to achieve multiple access transmission in the terrestrial-satellite network and the interference cancellation reception to mitigate the inter-beam interference as well as intersystem interference. Meanwhile, due to the limited spectrum resources, spectrum sharing will become one critical issue in terrestrial-satellite communication networks, and efficient spectrum sensing techniques are also worthy of being investigated. Finally, taking the interference and limited spectrum resources into account, it is important to design efficient resource allocation schemes to achieve optimal system performance.

Recently, array multi-beam antennas have drawn more attention for the possible application of digital beamforming techniques, which is an efficient transmitting

method for multiple access. By adjusting the weighting factors on antennas, it can steer nulls to mitigate co-channel interferences and form independent beams toward different directions, which contribute to improve the performance of mobile communication systems. We investigated the technique of beamforming in the integrated terrestrial and satellite communication systems we also concluded the main challenges and prospective applications in the integrated terrestrial and satellite systems. Based on beamforming, we proposed a multimedia multicast integrated terrestrial-satellite network, in which base stations (BSs) and the satellite work cooperatively to provide ubiquitous service for ground users. By serving users that require the same contents as a group using multicasting, higher efficiency can be achieved. As a practical application of beamforming in satellite networks, we launched the Smart Communication Satellite (SCS) on 4 Sept. 2014, which is the first low Earth orbit (LEO) mobile communication experimental satellite of China, and the smart beamforming technology was experimented on this satellite. Part of these works is introduced in Chap. 2.

In the terrestrial-satellite networks, inter-network interference may become severe when reusing the frequency in the system. When satellite terminals and base stations transmit signals at the same time with the same frequency, it will cause considerable co-channel interference (CCI) which will significantly deteriorate the system performance. Based on channel estimation and centralized processing, we proposed several interference coordination schemes for different scenarios in the integrated satellite and terrestrial network, which is introduced in Chap. 3.

In fifth-generation (5G) networks, millimeter-wave (mmWave) bands have drawn great attention for the large amount of possible bandwidth. Meanwhile, satellite communications have also shown great interest in the mmWave bands, especially the Ka band. Under such a circumstance, due to the limitation of spectrum resources, spectrum sharing will become one critical issue in terrestrial-satellite communication networks. We investigated the problems of spectrum coexistence between the geostationary (GEO) satellite system and terrestrial systems and between the GEO satellite system and the non-geostationary (NGEO) satellite system, respectively. We first analyzed the interference caused by terrestrial systems and the NGEOSatellite system to the GEO satellite system in two transmission modes and then introduced the concept of protection radius to protect the GEO system. Then, in the scenario of spectrum coexistence between the GEO and the NGEOSatellite systems, we investigated the issue of blind spot where spectrum awareness techniques may fail to identify the spectrum holes. Part of this work is introduced in Chap. 4.

The technique of cognitive radio (CR), which enables dynamic access of spectrum, can improve the utilization rate of the spectrum. To meet the communication need in terrestrial-satellite networks with limited spectrum resources, we investigated the technique of spectrum sensing in this network. The satellite systems having the licensed spectrum are considered as primary users, while the terrestrial systems are regarded as secondary users. We first advanced a strategy for SU to search available spectrums with asynchronous MAC-layer sensing. With this method, SUs need not know the communication mechanisms in PU's network when dynamically accessing. Then, we discussed the asynchronous cooperative spectrum

sensing and derive the optimal sensing parameters under such asynchronous scenario. Also, we proposed a density control mechanism for managing the number of secondary transmitters around one primary receiver in order to guarantee that primary communications are not interfered. Some important ideas are included in Chap. 5.

In terrestrial-satellite networks, the resource allocation problem, such as spectrum resource, time resource, antenna resource, power resource, space resource, orbit resource, etc., will be more complex due to the coupling between resources and the interference. Against this issue, we proposed several resource allocation schemes in different scenarios of terrestrial-satellite communication networks, which can optimize the capacity performance of the entire system. In order to protect the terrestrial users, we introduced the interference temperature limit for the satellite to control the interference caused to BS users. Furthermore, we proposed the concept of the cloud-based integrated terrestrial-satellite network (CTSN), in which both the terrestrial network and the satellite network are connected to the cloud for centralized resource management. Some interesting results are briefly presented in Chap. 6.

Overall, this book aims at giving a comprehensive discussion on the motivation, problem formulation, and research methodology on the transceivers' design and resource allocation in future terrestrial-satellite communication networks.

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