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OPTIMIZATION OF HIGH-THROUGHPUT SATELLITE SYSTEM FOR DATA RELAY SERVICE TOWARDS LEO SATELLITES

Abstract

With the global deployment of giant satellite constellations, the data relay service offered by the existing tracking and data relay satellites could not meet the present needs of various non-GSO satellites. Thus, there comes a concept to build up the commercial high-throughput satellite system for the data relay services specifically towards LEO satellites. The multi-beam satellite would not only offer concurrent access to large number of objects, but can also meet the high data requirements towards the specific coverage of the LEO constellation. However, due to the uneven distribution of demand, the phenomena of traffic jam induced by overprovisioned beams with overload objects, or the waste of resource caused by unprofitable beams with few requirements often occur with the uniform beam layout of regular coverage. An optimization algorithm on the spot beam allocation is necessary to maximize the efficiency of resources toward the service objects. Compared with the conventional K-means algorithm, a modified K-means clustering method is introduced to improve the uniformity of objects in each cluster. Another tricky problem for this kind of high-throughput satellite system is focused on the spectrum issue. Since the ISS (Inter-Satellite Service) spectrum is crowded, whether the conventional band for FSS (Fixed-Satellite Service) (11.7-12.7 GHz, 18.1-18.6 GHz, 18.8-20 GHz and 27.5-30 GHz) can be implemented to inter-satellite applications becomes an issue to be analyzed. In this paper, we introduce a modified K-means method to automatically place the spot centers with appropriate beam widths in line with the density of the traffic demands and realize the uniformity of the beam occupation. The whole process of the system optimization has been demonstrated including the establishment of the low-orbit satellite constellation model, the extraction of the distribution features, and the implementation and evaluation of the modified K-means algorithm. The results have proven the validity of the proposed algorithm. The uniformity of objects per beam can be realized by adjusting the parameters of distance determination matrix and the obligatory minimal number of objects in each beam. The impact of parameter range on the results is also analyzed. For the spectrum issue, the estimation of the co-frequency interference probability will be carried out for both within the cone of coverage and out of the cone of coverage situations. Especially for the area surpassing the contour of earth surface offers more space to satellites in adjacent orbits with line-of-sight propagation towards the GSO satellite, the interference probability will be evaluated.