DYNAMIC RESOURCE ALLOCATION SCHEME UNDER TRAFFIC CONDITION IN SATELLITE SYSTEMS

Yu Jia     Zong Peng
(Department of Astronautics, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China)

Abstract As the traffic distribution in China mainland is far from uniform, a new traffic model in China mainland is presented on the basis of per-capita Gross Domestic Product (GDP) and density of population. Based on this characteristic traffic model, a new Traffic Dependent Dynamic Channel Allocation and Reservation (TDDCAR) technique is proposed, the simulation model is built, and the strategies’ performance is evaluated through computer simulation. The simulation results show that, compared to the conventional Fixed Channel Allocation (FCA), TDDCAR estimates the traffic conditions in every spot beam and frequently adjusts the traffic according to current traffic conditions. It has achieved a significant improvement in new call blocking probability, handover blocking probability, and fair index, particularly, in heavy traffic conditions. The building of traffic model in China mainland and the analysis of the simulation results has been a key foundation for the study of resource allocation schemes in the future.

Key words Dynamic channel allocation; Traffic model; Gross Domestic Product (GDP); Density of population; Channel utilization

CLC index TN927

DOI 10.1007/s11767-012-0709-y

I. Introduction

In the satellite world, Low Earth Orbit (LEO) satellite constellation is foreseen as appropriate alternatives to geostationary satellite systems for providing global mobile and fixed services. This non-geostationary system is envisaged to add a flexible and wide-area satellite component to the future Personal Communications Network (PCN) infrastructure. The superior performances of the LEO satellite system have been proposed in several literatures, such as global coverage, low transmission loss, small end-to-end delay and user mobility\(^1\,^2\).

Initially, satellite services are made available in densely populated urban areas, followed by extension to suburban areas, airports, motorways\(^3\,^4\), etc., and finally, rural areas. Progression down this implementation path is largely controlled by the economics and demographics of the region concerned. Due to the large coverage area offered by a satellite beam, which provides equal priority coverage for all areas, the satellite component can be used to complete the coverage of the terrestrial network. Furthermore, aeronautical and maritime users may be solely dependent on the satellite component for the provision of services.

Since the satellite channels are more scarcely available (and, then, more costly) than the terrestrial one\(^5\) (i.e., satellites are power and bandwidth limited), satellite resources in an integrated system have to be carefully utilized. The effectiveness of the satellite’s supportive role will largely be determined by the resource assignment strategy adopted by the network. However, the performances of radio resource management techniques have in the past been evaluated according to some presumed traffic distribution in the spot beam, such as uniform distribution. As the beam of the one satellite usually can cover one or more than one country, the difference in the covered area will lead to the difference in traffic demand, therefore, the uniform traffic distribution model is not suitable for the radio resource management techniques, the

\(^1\) Manuscript received date: January 25, 2011; revised date: March 16, 2012.
Communication author: Zong Peng, born in 1963, male, Professor, Department of Astronautics, Nanjing University of Aeronautics and Astronautics, No. 29 Yudao Road, Nanjing 210016, China.
Email: pengzong@nuaa.edu.cn.
economics and the population should be taken into consideration. Especially, in densely populated areas, an accurate traffic model is of great importance for resource assignment strategy and analysis of user mobility.

In terrestrial cellular mobile systems, it is the mobility of terminals that introduces the necessity of modification to the conventional theory in order to meet the increasing demand of applications for personal communications. However, in the LEO mobile satellite systems, it is the motion of the satellite which introduces some new traffic characteristics. As the velocity of the satellite is much larger than the mobile terminal, the traffic characteristic of the satellite is more complex than the traffic characteristics of the terrestrial cellular mobile systems. Therefore, the traditional traffic model may not be sufficient to characterise some of the traffic features. In this paper, based on the characteristic traffic model in China mainland, a new resource assignment strategy named Traffic Dependent Dynamic Channel Allocation and Reservation (TDDCAR) technique is proposed.

This paper consists of two main parts: the first part concentrates on the traffic volume prediction in Satellite Universal Mobile Telecommunications System (S-UMTS) in China mainland, and the second part analyzes the performance of resource assignment strategy TDDCAR proposed for S-UMTS in an LEO-MSS scenario on the basis of the traffic distribution obtained in the first part. In the analysis, the space segment is assumed to be Iridium system which is made up of 66 LEO satellites, equally distributed over 11 orbital planes, each satellite has multi-spot beam capability. As part of the analysis, a mobility model for inter-beam handovers has been derived. For the sake of completeness, the performance of the proposed TDDCAR technique has also been compared with Fixed Channel Assignment (FCA).

II. Mobile Satellite Traffic Model

1. Computation of traffic volume for satellite users

   The LEO satellite constellation is foreseen as appropriate alternatives to other satellite systems for providing global services, and one satellite usually dose not cover only one country. Due to the inhomogeneity of the communication service all over the world and the obvious difference in traffic between the developed areas and under developed areas, the traffic distribution is highly heterogeneous. Three main steps are involved in predicting the traffic volume for satellite users:

   (1) Determination of the profitability for provision of a service via satellite;

   (2) Determination of the Gross Potential Market (GPM) which can be considered as Gross Domestic Product (GDP);

   (3) Prediction of penetration of the service (Pr), taking into account the take up rate of the service (Tp).

   The three parameters are combined together to give the traffic volume in terms of the number of subscribers:

   \[ N = GPM \times Pr \times Tp \]

   Here, in order to simplify the traffic model, only economic development level (GDP) and rate of the service (density of population) are taken into account.

2. Traffic model in China mainland

   According to the three steps above, based on the per-capita GDP and density of population all over China mainland (one Iridium satellite can exactly cover China mainland), the traffic can be classified into 31 ranks as China mainland has 31 provinces and cities, as shown in Fig. 1.

   \[ \text{Fig. 1 Diagram of China mainland traffic distribution} \]