Combinatorial considerations for switching systems carrying multi-channel traffic streams

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Abstract

This paper presents a combinatorial analysis of limited-availability groups to which the mixture of different multi-channel traffic streams is offered. The availability distributions of an exactly determined number of subgroups has been derived for traffic streams of various classes. The determined distributions enable calculation of blocking probabilities in multi-stage switching networks carrying different multi-channel traffic streams by the effective availability method. The paper defines the components of effective availability and gives procedures for their determination in the case of multi-channel traffic. In this paper, two calculation methods are derived, one used for point-to-point selection, and the other for point-to-group selection. The results of analytical calculations are compared with the results of digital simulation of three-stage switching networks. The proposed formulae can be used in the analysis of ISDN and B-ISDN systems.

Key words: Telecommunication switching, Combinatorial method, Blocking probability, Accessibility, Time division switching, Switching network, Multiple service network.

On détermine la distribution de sous-groupes accessibles dans ce faisceau pour des appels de classes de trafic différentes. Cette distribution rend possible le calcul de la probabilité de blocage dans le réseau de connexion qui écoule ce trafic intégré. Pour ce calcul, on utilise la méthodologie d'accessibilité effective. On présente les définitions des composantes de l'accessibilité effective ainsi que les méthodes d'évaluation dans le cas de trafic multicanaux. Dans cet article, on établit deux méthodes de calcul, l'une est destinée aux réseaux de connexion fonctionnant par sélection point-à-point, l'autre est destinée aux réseaux fonctionnant par sélection point-à-groupe. Les résultats du calcul analytique de la probabilité de blocage sont comparés aux résultats de simulations numériques de réseaux à 3 étages. Les méthodes proposées peuvent être appliquées à l'analyse des systèmes RNIS et RNIS à large bande.

Mots clés: Commutation télécommunication, Méthode combinatoire, Probabilité encombrement, Accessibilité, Commutation temporelle, Réseau connexion, Réseau multiservice.

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Résumé

Cet article présente l'analyse combinatoire d'un faisceau à accessibilité limitée et avec trafic multicanaux.

ANALYSE COMBINATOIRE DES SYSTÈMES DE COMMUTATION ÉCOULANT UN TRAFIC MULTICANAUX

References (46 ref.).
I. INTRODUCTION

The ISDN (integrated services digital network) switching systems carry a mixture of different multi-channel traffic streams on the basis of channels having a bit rate of 64 kbit/s. The mixture consists of some traffic classes which demand a multiple number of channels for servicing their calls. The B-ISDN (broadband integrated services digital network) will be designed by employing the SDH (synchronous digital hierarchy) and ATM (asynchronous transfer mode) transmission type technique. These networks will carry a mixture of different traffic streams, involving all types of the services offered. The basic problems associated with the description of future B-ISDN systems, from the viewpoint of traffic theory, result from the necessity of serving various types of traffic sources by the network. The bit rate of emitting the packets by single sources can be changed from 64 kbit/s (voice) up to 155 Mbit/s (high definition TV). In principle, the classification of traffic sources in a broadband network is reduced to distinguishing the CBR (constant bit rate) sources and the VBR (variable bit rate) sources. The CBR sources have the defined values of emission rate, while the VBR sources require a greater number of parameters to describe the emitted streams.

To define the loads introduced into networks by the VBR sources, it is proposed to determine the so-called equivalent bandwidth for particular classes of traffic streams generated by the sources [1] and [2]. An assignment of some constant bit rates to the VBR sources enables evaluation of traffic characteristics of the switching systems in the B-ISDN network by means of methods worked out for the multi bit rate-circuit switching [1]. According to these trends, to describe the B-ISDN switching groups and nodes, among others in [3, 4, 5, 6, 7 and 8], models of the full-availability group carrying a mixture of different multi-channel traffic streams are used [9, 10, 11], or models of the limited-availability groups carrying such streams are employed [12]. Similarly in [5], calculations of switching networks proposed for B-ISDN switching nodes are reduced to calculations of switching networks with multi-channel traffics. In this context, results of studying the switching systems carrying a mixture of different multi-channel traffic streams are very appropriate. The problems of performance evaluation of switching networks with multi-channel traffics have also been considered in [13, 14, 15, 16, 17 and 18 and 19].

Jacobaeus' method [20] has been adapted for the calculation of the two- and three-stage switching networks in the papers [8, 15, 19, 21 and 22]. In this method, inter-stage and outgoing groups were approximated by the model of full-availability group carrying multi-channel traffic streams [9]. For calculation of the switching networks carrying multi-channel traffic streams, methods based on the analysis of channel graphs were applied in [14 and 18]. In [5, 8 and 17], three-stage switching network has been reduced to a single-stage system. Distribution of busy channels in such a system is calculated from the modification of recurrently determined distribution of busy channels in a full-availability group [9]. This modification consists in introducing to distribution of busy channels, blocking factors of multiplexed inter-stage links. However the methods mentioned above are intended exclusively for calculations of three-stage switching networks.

A limited-availability group is a group divided into some identical subgroups. The system services a call – only when this call can be entirely carried by the channels of an arbitrary single subgroup. Limited-availability groups were the subject of many analyses in scientific papers, e.g. [4, 12, 23, 24 and 25]. In [26] an approximate simple method of calculating the blocking probability in these groups is mentioned.

On the basis of the distribution of busy channels derived in [26] for limited-availability groups, other characteristics of such groups are combinatorially derived in this paper, among others the distributions of available subgroups for various multi-channel traffic streams.

The latter portion of this paper is devoted to the calculations of multi-stage switching networks carrying a mixture of different multi-channel traffic streams, and to employing a point-to-point or a point-to-group selection. The distributions of availability of multiplexed links in the digital switches were derived. The rules were worked out for exchanging a multi-stage switching network carrying the different multi-channel traffic for an equivalent model of a switching network carrying a single-channel traffic. An exchange such as this, is a basis for the analysis of multi-stage networks by means of well-proven methods of effective availability.

A basic parameter of these methods is the term effective availability. It was introduced in [27 and 28] for two-stage networks, and extended in [29] for multi-stage networks. Effective availability is defined as the availability in a multi-stage switching network in which the blocking probability is equal to the blocking probability of a single-stage network (grading) with the same capacity of the outgoing group and at analogous parameters of the offered traffic stream. Effective availability is strictly associated with the term average availability. This term determines the average number of switching network outgoing links available for a given first-stage switch. Average availability has a magnitude close to effective availability, and in most cases is used as its nearest approximation.

The concept of effective availability leads to the following calculation algorithm of losses in switching network carrying single-channel traffic. Firstly, the effective availability is calculated, then the blocking probability in a switching network using one of the well-known formulae determining blocking in a grading. In earlier works, Palm-Jacobaeus loss formula (PJ formula) [20, 30] has been applied for this purpose. However this formula leads to the overestimation of blocking proba-