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РАСПРЕДЕЛЕННЫЕ КОМПЬЮТЕРНЫЕ И ТЕЛЕКОММУНИКАЦИОННЫЕ СЕТИ: УПРАВЛЕНИЕ, ВЫЧИСЛЕНИЕ, СВЯЗЬ (DCCN-2016)

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В трех томах

Архитектура, методы управления, моделирования и проектирования компьютерных сетей

Том 1

Материалы Девятнадцатой международной научной конференции

Россия, Москва, 21–25 ноября 2016 г.

Москва
Российский университет
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2016

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Research and development company
“Information and networking technologies”

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Under the general editorship
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2016

**Федеральное государственное бюджетное учреждение науки
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В научном издании представлены материалы Девятнадцатой международной научной конференции «Распределенные компьютерные и телекоммуникационные сети: управление, вычисление, связь» по следующим направлениям:

— Оптимизация архитектуры компьютерных и телекоммуникационных сетей;
— Управление в компьютерных и телекоммуникационных сетях;
— Оценка производительности и качества обслуживания в беспроводных сетях;
— Аналитическое и имитационное моделирование коммуникационных систем последующих поколений;
— Беспроводные сети 4G/5G и технологии сантиметрового и миллиметрового диапазона радиоволн;
— RFID-технологии и их применение в интеллектуальных транспортных сетях;
— Интернет вещей, носимые устройства, приложения распределенных информационных систем;
— Распределенные системы и системы облачного вычисления, анализ больших данных;
— Вероятностные и статистические модели в информационных системах;
— Теория очередей, теория надежности и их приложения;
— Математическое моделирование высокотехнологичных систем;
— Математическое моделирование и задачи управления.

Сборник материалов конференции предназначен для научных работников и специалистов в области теории и практики построения компьютерных и телекоммуникационных сетей.

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Performance Modeling of Finite-Source Cognitive Radio Networks Using Simulation

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1. Introduction

Cognitive radio has emerged as a promising technology to realize dynamic spectrum access and increase the efficiency of a largely under utilized spectrum. In a cognitive radio network (CRN), a cognitive or secondary users (SUs) are allowed to use the spectrum by primary users (PUs) as long as the PUs do not use it. This operation is called opportunistic spectrum access [1]. To avoid interference to PUs, SUs must intelligently release the unlicensed spectrum if a licensed user appears [3].

In this paper we introduce a finite-source queueing model with two (non independent) frequency channels. According to the CRN modelling the users are divided into two types: the Primary Users (PUs) have got a licensed frequency,which does not suffer from overloading feature. The Secondary Users (SUs) have got a frequency band too, but suffers from overloading. A newly arriving SU request can use the band of PUs (which is not licensed for SUs) if the band of SUs is engaged, in the cognitive way: the non-licensed frequency must be released by the SU when a PU request appears. In our environment the band of the PUs is modelled by a queue where the requests has preemprive priority over the SUs requests. The band of the SUs is described by a retrial queue: if the band is free when the request arrives then it is transmitted. Otherwise, the request goes to the orbit if both bands are busy. We assume that the radio transmission is not reliable, it will fail with a probability p for both channels. If happens then the request retransmission process starts immediately [3].
Hence, it should be noted that the novelty of this work is that we create a new model to analyze the effect of distribution of inter-event time on the mean and variance of the response time of the PUs and SUs. In several combinations of the distribution of the involved random variables and using simulation we compare the effect of their distribution on the first and second moments of the response times illustrating in different figures.

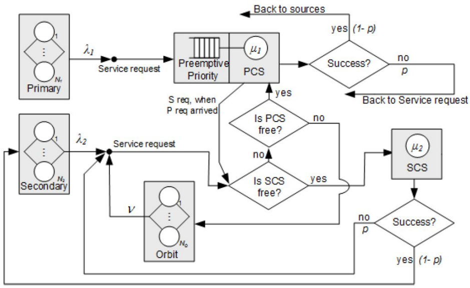

Figure 1. A priority and a retrial queue with components

2. System Model

A Fig.1 illustrates a finite source queueing system which is used to model the considered cognitive radio network. The queueing system contains two interconnected, not independent sub-systems. The first part is for the requests of the PUs. The number of sources is denoted by N_1. In order to analyse the effect of the distribution, these sources generate high priority requests with hypo-exponentially and hyper-exponentially distributed inter-request times with parameter λ_1. The generated requests are sent to a single server unit (Primary Channel Service - PCS) with preemptive priority queue. The service times are supposed to be also hypo-exponentially and hyper-exponentially distributed with parameter μ_1. The second part is for the requests of the SUs. There are N_2 sources,the inter-request times and service times of the single server unit (Secondary Channel Service - SCS) are assumed to be hypo-exponentially and hyper-exponentially distributed random variables with parameters λ_2 and μ_2 respectively.

A generated high priority packet goes to the primary service unit. If the unit is idle, the service of the packet begins immediately. If the server is busy with a high priority request, the packet joins the preemptive priority queue. When the unit is engaged with a request from SUs, the service is interrupted and the interrupted low priority task is sent back to the SCS. Depending on the state of secondary channel the interrupted job is directed to either the server or the orbit. The transmission through the radio channel may produce errors, which can be discovered after the service. In the model this case has a probability p, and the failed packet is sent back to the appropriate service unit. When the submission, is successful (probability *1-p*), the requests goes back to the source.
In case of requests from SUs. If the SCS is idle, the service starts, if the SCS is busy, the packet looks for the PCS. In case of an idle PCS, the service of the low priority packet begins at the high priority channel

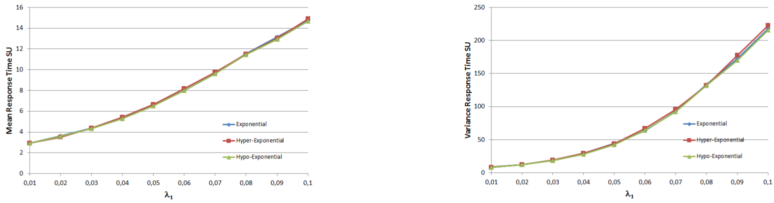

Figure 2. The effect of inter-request time distribution of the PUs on the variance and mean response time of SUs vs λ_1

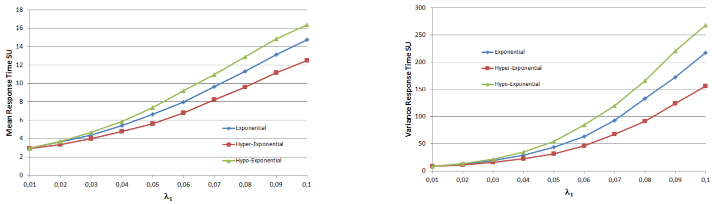

Figure 3. The effect of service time distribution of the PUs on the variance and mean response time of SUs vs λ_1

(PCS). If the PCS is busy the packet goes to the orbit. From the orbit it retries to be served after an exponentially distributed time with parameter ν. The same transmission failure with the same probability can occur as in the PCS segment.
The Figure 1 shows the functionality of the system.

In order to analyse the effect of the distribution of the inter-event times, we used simulation and standard methods to calculate the mean and variance of the response time of the PUs and SUs. the following figures illustrates that effect [2][4].

The figure 2 shows that the distribution of the inter-arrival time of the primary packets has no effect on the mean and variance of response time of the secondary users knowing that the inter-request time of the SUs and the service time of both servers units are exponentially distributed. The other operation mode is where the service time of the primary server unit is hyper-exponentially, hypo-exponentially distributed and the inter-arrival time of PUs and SUs, the service time of the secondary server are exponentially distributed. The figure 3 shows that the value of the mean response time and variance is greater when the service time is hypo-exponentially distributed.

Table 1

Numerical values of model parameters

No.	N_1	N_2	λ_1	λ_2	μ_1	μ_2	ν	p
Fig.2	10	50	x - axis	0.03	1	1	20	0.1
Fig.3	10	50	x - axis	0.03	1	1	20	0.1

The numerical values of parameters are collected in Table 1.

3. Conclusions

In this paper a finite-source retrial queueing model was proposed with two bands servicing primary and secondary users in a cognitive radio network. Primary users have preemptive priority over the secondary ones in servicing at primary channel. At the secondary channel an orbit is installed for the secondary packets finding the server busy upon arrival. The simulation was used to carry numerical calculations illustrating the effect of the distribution of the inter-events times on the first and second moments of the response time.

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