CMC MSU IPI RAN PTMS PFUR

XXXI International Seminar on Stability Problems for Stochastic Models

and

VII International Workshop "Applied Problems in Theory of Probabilities and Mathematical Statistics Related to Modeling of Information Systems"

and

International Workshop "Applied Probability Theory and Theoretical Informatics"

Book of Abstracts

2013

Faculty of Computational Mathematics and Cybernetics
Moscow State University
(CMC MSU)

Institute of Informatics Problems
Russian Academy of Sciences
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Peoples' Friendship University of Russia
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23 – 27 April
Moscow, Russia

Book of Abstracts

Edited by
Prof. Victor Yu. Korolev and Prof. Sergey Ya. Shorgin

Moscow
Institute of Informatics Problems,
Russian Academy of Sciences

2013

XXXI International Seminar on Stability Problems for Stochastic Models (ISSPSM'2013), VII International Workshop "Applied Problems in Theory of Probabilities and Mathematical Statistics Related to Modeling of Information Systems" (APTP + MS'2013) and International Workshop "Applied Probability Theory and Theoretical Informatics" . Book of abstracts. – M.: IPI RAN, 2013. - 135 p. - ISBN 978-5-91993-020-4.

The book includes the abstracts of communications submitted to the XXXI International Seminar on Stability Problems for Stochastic Models (ISSPSM'2013), associated VII International Workshop "Applied Problems in Theory of Probabilities and Mathematical Statistics Related to Modeling of Information Systems" (APTP + MS'2013) (Spring Session) and International Workshop "Applied Probability Theory and Theoretical Informatics".

XXXI Международный семинар по проблемам устойчивости стохастических моделей (ISSPSM'2013), VII Международный рабочий семинар "Прикладные задачи теории вероятностей и математической статистики, связанные с моделированием информационных систем" (APTP + MS'2013) и Международный рабочий семинар "Прикладная теория вероятностей и теоретическая информатика". Сборник тезисов. – М.: ИПИ РАН, 2013. - 135 с. - ISBN 978-5-91993-020-4.

В сборник включены тезисы докладов, представленных на XXXI Международный семинар по проблемам устойчивости стохастических моделей (ISSPSM'2013), VII Международный рабочий семинар "Прикладные задачи теории вероятностей и математической статистики, связанные с моделированием информационных систем" (APTP + MS'2013) (весенняя сессия) и Международный рабочий семинар "Прикладная теория вероятностей и теоретическая информатика".

ISBN 978-5-91993-020-4

formation transmission systems, operating in random environment, has been considered in [5, 6].

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Development of the semi-Markov stock management model with a discrete set of states and a random delay of delivery

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This paper examines the stochastic semi-Markov stock management model of some goods with possible deficit. The flow of the applications for this product is determined as Poisson stream with the intensity λ.The amount of product in the system can take discrete values in the range $[-N_1, N_0]$, where N_0, $N_1 > 0$ are predefined integers. Value N_0 - is the highest level of real stock. The amount of stock in the range $[-N_1, N_0]$ characterizes the deficit when bids for the good are accepted for registration. Applications received at the time when the deficit is set to $(-N_1)$ are lost. The decisions are taken at the time of replenishment. If at this moment the state of the process is equal to i then the level of reserve for next query is determined as r_i where $-N_1 \leq r_i \leq i-1$. Next time when the process hits the value r_i new level of reserve r_{i+1} is set. And so on. Random time τ between the moment of the order and the moment of replenishment has a specified distribution $H(x)$. The size of replenishment is random and it has discrete distribution with probabilities $\beta_{kj}^{(0)}$, $\beta_{kj}^{(1)}$,$-N_1+1 \leq k \leq r_i - 1$, $j > 0$.

Replenishment procedure is designed in the way that the basic process is transferred from the state (k) which it takes directly before the replenishment to the state j, $j = 1, \ldots, N_0$ the shortage of product is always filled in.

Let us introduce random processes describing the functioning of the system. Let $\xi(t)$ – the basic process that describes the level of stock at the moment t. The set of spaces is determined as $X = \{-N_1, -N_1+1, \ldots, -1, 0, 1, \ldots, N_0\}$. Denote $\{t_n^{(0)}, n = 0, 1, \ldots\}$ - sequential moments of replenishment; $t_0^{(0)} = 0$; $\xi_n^{(0)} = \xi(t_n^{(0)} + 0)$ - the state of the process directly after replenishment. We introduce a random process $\xi^{(0)}(t)$ determined by the ratios $\xi^{(0)}(t) = \xi_n^{(0)}$ when $t_n^{(0)} \leq t \leq t_{n+1}^{(0)}$. From now the process $\xi^{(0)}(t)$ will be referred to as the "maintainer". The set of states for this process is $X^{(0)} = \{0, 1, \ldots, N_0\}$, $\{\xi_n^{(0)}\}$ and it constitutes the embedded Markov chain for the main process.

Denote p_{ij}, $i, j, = 0, 1, \ldots, N_0$ transition probabilities of Markov chains, embedded in main semi-Markov process $\xi^{(0)}(t)$.

$$p_{ij} = P(\xi_{n+1}^{(0)} = j \,|\xi_n^0 = i), i, j = 0, 1, \ldots, N_0$$

Adduce explicit form for transition probabilities for unembedded Markov chain:

1) Let i - to be afixed state, $0 \leq r_i \leq i$, $i, j = 0, 1, \ldots, N_0$

$$p_{ij}^{(I)} = \sum_{k=0}^{r_i} \beta_{kj}^{(0)} \int_0^\infty \frac{(\lambda x)^{r_i - k}}{(r_i - k)!} e^{-\lambda x} dH(x) + \sum_{k=-N_1+1}^{-1} \beta_{kj}^{(1)} \int_0^\infty \frac{(\lambda x)^{r_i - k}}{(r_i - k)!} e^{-\lambda x} dH(x) +$$

$$+ \left[\sum_{k=r_i+N_1}^{\infty} \int_0^\infty \frac{(\lambda x)^k}{k!} e^{-\lambda x} dH(x) \right] \beta_{-N_1,j}^{(1)}. \tag{1}$$

2) Let i -to be a fixed state, $r_i = -N_1+1, -N_1+2, \ldots, -1$

$$p_{ij}^{(II)} = \sum_{k=-N_1+1}^{r_i} \beta_{kj}^{(1)} \int_0^\infty \frac{(\lambda x)^{r_i - k}}{(r_i - k)!} e^{-\lambda x} dH(x) +$$

$$+\sum_{k=r_i+N_1}^{\infty}\int_0^{\infty}\frac{(\lambda x)^k}{k!}e^{-\lambda x}dH(x)\beta^{(1)}_{-N_1,j}. \quad (2)$$

3) Let i-to be afixed state,$r_i = -N_1$
Because $-N_1$ is the minimum level of stock in the system we get ratio:

$$p^{(III)}_{ij} = \beta^{(1)}_{-N_1,j}. \quad (3)$$

Let us obtain the equation for the stationary probabilities of embedded Markov chain. Note that the transition probabilities p_{ij} for each fixed value i depends on the values r_i.

So, let us fix the control parameters corresponding to the statesof embedded Markov chain $(r_0, r_i, \ldots, r_{N_0})$. For each kind of set $(r_0, r_i, \ldots, r_{N_0})$, expression for the transition probabilities are determined by ratios (1)-(3). For a given set $(r_0, r_i, \ldots, r_{N_0})$ define the following set S_0, S_1, S_2, that represent a subset of the states $(0, 1, \ldots, N_0)$.

$$S_0 = \{i \in \{0, 1, \ldots, N_0\} : r_i \geq 0\};$$
$$S_1 = \{i \in \{0, 1, \ldots, N_0\} : -N_1 + 1 \leq r_i \leq -1\};$$
$$S_2 = \{i \in \{0, 1, \ldots, N_0\} : r_i = -N_1\};$$

Then the system of equations for stationary probabilities takes the form:

$$\pi_j = \sum_{i\in S_0}\pi_i p^{(I)}_{ij} + \sum_{i\in S_1}\pi_i p^{(II)}_{ij} + \sum_{i\in S_2}\pi_i p^{(III)}_{ij} \; j = 0, 1, \ldots, N_0$$

Next step is to obtain the indicators of quality management the semi-Markov model, which depends particularly from the stationary distribution.

The estimation of ruin probability in multivariate collective risk model

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In actuarial mathematics great importance has always been given to estimations of ruin probability of insurer. The multivariate collective risk model allows to consider the dependence between claims of different fields of insurance, operated by insurance company. Claims happened in different fields of insurance are mutually dependent very often, that affects the process of changing the value of the insurance reserve. The process of reserve changing can usually be presented in a form:

$$U(t) = u + c \cdot -S(t) \;,$$

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