



ON A BUSY PERIOD OF DISCRETIZED GI/GI/∞ QUEUE

Submitted to"Aplikace matematiky"

1982

1. INTRODUCTION

The busy period, time when at least one customer is served, of the queueing system with infinitely many servers is known only in special cases. In ref.'1' for the M, $GI_{/\infty}$ queue it is solved by a way of solving of the partial differential equation of the first order. The simpler method based on the recurrent events is used in ref./4' for this queue. The limit distribution of the busy period in $GI/D_{/\infty}$ and $M_{/}GI_{/\sim}$ queues is studied in refs.'1.8'. The busy periods of order n of the $GI/D_{/\infty}$ queue are investigated in /3.6'. The Laplace transform of a cycle, time between two neighbouring beginnings of the busy periods for the $GI/GI_{/\infty}$ queue, can be found in ref.'^{4/}.

The busy period of the discretized queueing systems with infinitely many servers plays an important role, for example, in the blob length measurement in track chambers by the automatical scanning device in high energy physics /2,7/

For the discretized queueing system with the geometric input the Laplace transform of the busy period is determined in ref.^{/5/}, and for a special case of a discretization of M/GI/ ∞ queue the exact probability formulae of the busy period are given in ref.^{/2/}. We note, moreover, that in ref.^{/2/} the discretized queueing system with a group arrivals arised.

In the present paper we deal with a general case of the discretized $GI/GI/ \sim$ queue. We derive the recurrent probability formulae for the busy period. Also the formulae for the idle period (time when none customer is served) and the cycle of a queue are investigated. Finally, the particular case of the queue with a geometric input is treated and the new simple recurrent formulae, derived in a different way as one used above, are given.

2. NOTATIONS AND PRELIMINARY RESULTS

Let us suppose that the customers arrive at the epochs of a discretized renewal process with a step h > 0, and are served immediately upon arrival by one of an infinite number of servers. We denote by T_n the interarrival between the n-th and the n + 1-th customers. The service times, C_n , of customers are assumed to be i.i.d. with the distribution function H(t) = $= P(C_1 \leq 1)$ and they are multipliers of h. For our purposes it suffices to assume that the customers arrive by one, since

Onser state of Phil · · · · ·

l

a group arrivals may be changed by the single one. Indeed, let p_k be the probability that k customers, k=1,2,..., arrive to the queueing system. Then $\widetilde{H}(t) = \sum_{k=1}^{\infty} p_k H^k(t)$ corresponds to

the distribution of the longest service time in the group. Hence the busy period of a queue with the original group arrivals is the same as one in the modified queue with the same input.

The busy period, **B**, is defined as the time when at least one customer is served. The idle period, I, is the time when none customer is served. The sum of the busy and idle periods is the cycle U of the queue, i.e., U=B+I.

The busy and idle periods are dependent, in general. When we have the geometric input, then they are independent. It is clear that due to our assumption the busy (idle) periods are i.i.d.

We will suppose that the busy period begins at the moment t = 0 and h = 1.

Let us put for the searched probability

P(n) = P(B=n), n = 1,2,... (2.1)

Then these probabilities can be evaluted by the chain of the following recurrent formulae (2.2)-(2.15).

Let us denote

W(n,m) = P(B=n, I=m), n,m = 1,2,... (2.2)

Then

$$P(n) = \sum_{m=1}^{\infty} W(n,m), \quad n = 1,2,... \quad .$$
 (2.3)

For $1 \leq k \leq n$ we define

 $W(n,k,m) = P(B=n, C_1 = k, U = m),$ (2.4)

where C1 denotes the service time of the first customer. Hence

$$W(n,m) = \sum_{k=1}^{n} W(n,k,m).$$
 (2.5)

It is simple to prove that

$$W(1,1,m) = P(C_1 = 1, T_1 = m + 1) = P(C_1 = 1)P(T_1 = m + 1) = W(1,m),$$

and (2.6)

$$P(1) = P(C_1 = 1)P(T_1 > 2).$$

Analogically for n=2 we have $W(2,1,m) = P(C_1 = 1)P(T_1 = 1)W(1,m),$ $W(2,2,m) = P(C_1 = 2)(P(T_1 = m+2) + P(T_1 = 1)W(1,m)).$ (2.8) For $n \geq 3$ we continue stepwisely

$$W(n,1,m) = P(C_1 = 1)P(T_1 = 1)W(n-1,m).$$
(2.9)

Let $2 \leq k \leq n - 1$, then

$$W(n',k,m) = P(C_1 = k)(P(T_1 = k)W(n-k,m) + \sum_{i=1}^{k-1} P(T = k-i) \times (2.10)$$

$$\times$$
 A(n,k,m,i)),

where

$$\{\frac{k-i+r}{2}\}$$

A(n,k,m,i) = $\sum_{r=1}^{\infty}$ B(n,k,m,i,r). (2.11)

and B(n,k,m,i,r) is the probability that B = n, $C_1 = k$, $T_1 = i$, and from the service times of the second and the following by him customers, r cycles are created of the total length n-i without account of the service time of the first customer, Therefore we have

$$B(n,k,m,i,r) = \Sigma W(j_1,k_1) \dots W(j_{r-1},k_{r-1})W(j_r,m), \qquad (2.12)$$

where the summation runs over the set of the integers j_i, k_i , for which $1 \le j_1 \le k_1, \dots, 1 \le j_{r-1} \le k_{r-1}, n-k \le j_r, j_1 + k_1 + \dots, +$ $+ j_{r-1} + k_{r-1} + j_r = n-i$ If, finally, k = n, then $W(n,n,m) = P(C_1 = n)(P(T_1 = n+m) + \sum_{i=1}^{n-1} P(T_1 = n-i)) \times (2.13)$

where

$$\begin{bmatrix} \frac{i+1}{2} \\ A(n,n,m,i) = \sum_{r=1}^{\infty} B(n,n,m,i,r), \qquad (2.14)$$

and

(2.7) ·

 $B(n,n,m,i,r) = \Sigma W(j_1,k_n) \dots W(j_r,k_r).$

Here the summation runs over the set of the integers j_i , k_i with $1 \le j_1 \le k_1, \dots, 1 \le j_{r+1} \le k_{r-1}, m \le k_r, j_1 + k_1 \neq \dots + j_r + k_r = n+m+i$.

2

3

1

For the practical employment of the formulae (2-1)-(2.12) we change the summation ad infinitum in (2.1) by the finite one according to the following simple way.

It is clear that

$$P(n) = \sum_{k=1}^{n} W(n,k,.), \qquad (3.1)$$

where

 $W(n,k,.) = \sum_{m=1}^{\infty} W(n,k,m) .$

Then

$$W(1,1,\cdot) = P(C_1 = 1)P(T_1 \ge 2) = P(1), \qquad (3.2)$$

$$W(2,1,.) = P(C_1 = 1)P(T_1 = 1)P(1),$$
(3.3)

$$W(2,2,.) = P(C_1 = 2)(P(T_1 \ge 3) + (P(T_1 = 1)P(1)).$$

If $n \ge 3$, then

$$W(n, 1, \cdot) = P(C_1 = 1)P(T_1 = 1)P(n - 1), \qquad (3.4)$$

and for $2 \le k \le n-1$ we have

$$W(n,k,\cdot) = P(C_1 = k)(P(T_1 = k)P(n-k) + \sum_{i=1}^{k-1} P(T_1 = k-i) \times (3.5)$$

$$\times A(n,k,\cdot,i))$$

where

$$\begin{bmatrix} \frac{k-a+1}{2} \end{bmatrix}$$

A (n, k, .., i) = $\sum_{r=1}^{\infty} B(n, k, .., i, r),$
(3.6)

and

$$B(n,k,.,i,r) = \sum W(j_1,k_1) \dots W(j_{r-1},k_{r-1})P(j_r). \qquad (3.7)$$

Here the summation is the same as in (2.12), and the $W(j_i, k_i)$ are determined by (2.5). ∞

For
$$k=n$$
 we put $W(n,n,\cdot) = \sum_{m=1}^{\infty} W(n,n,m)$, where $W(n,n,m)$

are evaluted by (2.13),

If, for example, the service times are bounded, then for sufficient large $n_0 W(n, n, m) = 0$, $n \ge n_0$, m=1, 2, ...

Note. Knowing W(n,m) we can determine the probability law of the idle period P_1 (m) = P(I = m)

١

$$P_{1}(m) = \sum_{n=1}^{\infty} W(n, m), \quad m = 1, 2...$$
 (3.8)

Analogically for the distribution of the cycle of a queueing system, $P_{II}(k) = P(U = k)$, we have

$$P_{U}(k) = \sum_{\substack{n + m = k}}^{N} W(n, m), \quad k = 2, 3... \quad .$$

$$1 \le m, n$$
(3.9)

4. THE GEOMETRIC INPUT

When the interarrival times of customers are distributed according to the geometric law

$$P(T_1 = m) = (1-p)p^{m-1}, m = 1,2,...,$$
 (4.1)

where 0 , then the busy and idle periods are independent,and the probability of the idle period has the same geometric $distribution as <math>T_1$.

Due to this independence, we can, using the methods for a distribution law determination of the busy period in a special case of the queueing system from $^{/2/}$, simplify the formulae (2-1)-(2.13) and (3.1)-(3.7), respectively.

Let us denote by A an event that the busy period begins from t=0. Because of the geometric input, which can be enlarged to the whole time axis, we have that P(A) = 1-p. Let us put $P_0(k) = P(C_1 = k, A)$, k = 1, 2, ... Then

$$P_0(k) = P(C_1 = k)(1-p), k = 1,2,...,$$
 (4.2)

and for k=0 we define

٠.,

$$P_0(0) = p$$
. (4.3)

We denote the conditional probability in question, P(B = n/A), by P(n) and the joint probability P(B = n, A) by PP(n). Clearly P(n) = PP(n)/(1-p).

Let $\overline{W}(n,k) = P(B=n, C_1 = k, A)$, then

$$PP(n) = \sum_{k=1}^{n} W(n,k), \quad n = 1,2,..., \quad (4.4)$$

and W(n,k,.) = W(n,k)/(1-p), where W(n,k,.) is an expression from Section 3.

Applying the analogical reasonings from $^{/2/}$ we obtain the following recurrent formulae (4.5)-(4.11) for the busy period distribution law.

4

5

$$\vec{W}(1,1) = P_{0}(1) P(0) ,$$

$$PP(1) = \vec{W}(1,1) ,$$

$$(4.5) ,$$

$$\vec{W}(2,1) = P_0(1) PP(1),$$

$$\vec{W}(2,2) = P_0(2)(P_0(1) + P_0(2))P_0(0),$$

$$PP(2) = \vec{W}(2,1) + \vec{W}(2,2).$$
Let us put
$$S(k) = \sum_{i=0}^{k} P_0(i), \quad k = 0,1,2,...,$$

$$SS(k) = \prod_{i=0}^{k} S(i), \quad k = 1,2,...,$$

For the general case n > 3 we define

i = 0

 $\overline{W}(n,1) := P_0(1)PP(n-1).$ (4.7)

The detailed investigation of properties $\overline{W}(n,k)$ shows us that between them there are the following recurrent relation ships.

For $2 \le k \le n-1$ we introduce the next helpful notations

$$\overline{B}(n, k-1, 1) = S(1) PP(n-k) + \sum_{i=2}^{n-k+1} \overline{W}(n-k+1, i), \qquad (4.8)$$

and for $2 \le j \le k-1$

$$\overline{B}(n, k-1, j) = S(j) \overline{B}(n, k-1, j-1) + \sum_{i=j+1}^{n-k+j} \overline{W}(n-k+j, i) .$$
(4.9)

Finally, we have

$$\overline{W}(n,k) = P_0(k)\overline{B}(n,k-1,k-1),$$

$$\overline{W}(n,n) = P_0(n)SS(n-1),$$
(4.10)

and

P(n) = PP(n)/(1-p), (4.11)

For the distribution ${\rm P}_{\rm U}$ of the cycle U of the queue with the geometric input we have

$$P_{U}(m) = \sum_{i=1}^{i} P(i) (1-p) p^{m-i-1}, m = 2,3,...$$
 (4.12)

The detailed comparison of the formula (4.11) with (2.3), shows us that they are the same. We note that the Laplace transforms and the expectation values of the busy period and the cycle of the queue with the geometric input are determined in^{/5/}, where the method of recurrent events was used to determine the number of customers served during the busy period.

REFERENCE

- Афанасьев Л.Г., Михайлов И.В. Предельное распределение периода занятости в системах G/D/∞ и M/G/∞ в условиях большой загрузки. Матер. Всесоюзного симп. по статистике случайных процессов, 1973, 12-15, Изд.КГУ, Киев.
- Dvurečenskij A., Kuljukina L.A., Ososkov G.A. JINR, E10-82-312, Dubna, 1982, p. 1-10.
- 3. Dyurečenskij A. JINR, E10-81-312, Dubna, 1982, p.1-10.
- 4. Двуреченский А., Ососков Г.А. ОИЯИ, 5-82-631, Дубна, 1982.
- 5. Двуреченский А. ОИЯИ, Р5-82-662, Дубна, 1982, с. 1-6.
- 6. Glaz J. J.Appl.Probab., 1981, 268-275.
- 7. Кулюкина Л.А. и др. ОИЯИ, Р5-1143, Дубна, 1977, с. 1-25.
- Михайлова И.В. Предельное распределение для системы в условиях большой загрузки. Труды НИИМ ВГУ 20, Воронеж, 1975, с. 12-13.
- -X

Received by Publishing Department on December 13,1982.

| You can receive by post the books listed below. Frices in US 9. including the packing and registered postage p-12965 The Proceedings of the International Conference on Systems and Techniques of Analytical Comput- ing and Their Applications in Theoretical Symposium on the Proceedings of the International School on Nuclear Physics. p4-80-305 The Proceedings of the UL International School on Nuclear Structure. A lasher 110 and the VII All-Union Conference on Charged Farticle Accelerators. Dubna, 1970. p4-80-305 The Proceedings of the International School on Nuclear Structure. A lasher 1980. p4-80-305 The Proceedings of the International School on Nuclear Structure. A lasher 1980. p4-80-532 Nuclear Structure. A lasher 2000 of the VII All-Union Conference on Charged Farticle Accelerators. Dubna, 1980. p2-82-643 Proceedings of the International Seminar on High Energy Physics. p1.2-81-738 Proceedings of the International Seminar on Solocide Problems in Statistical Theory. Dubna, 1981. p1.2-82-727 Proceedings of the II International Seminar on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p2-82-664 Proceedings of the II International Symposium on Solocide Problems in Statistical Recharks. p3-82-664 Proceedings of II II International Symposium on Solocide Problems | WILL | YOU FILL BLANK SPACES IN YOUR LIBRARY? | | |
|--|----------------------|--|--------|---|
| including the packing and registered postage p-12965 The Proceedings of the International School on the Problems of Charged Particle Accelerators for Young Scientists. Mink, 1979. p11-80-31 The Proceedings of the International Conference on Systems and Techniques of an alphane 1979. p2-80-80-271 The Proceedings of the International Symposium on Proceedings of the VI International School on Nuclear Structure. Alushts, 1980. p2-81-543 Proceedings of the International Conference on the Problems of Mathematical Standard Conference on Control Problems of the VI International Conference on Problems of the VI International Symposium on Solected Proceedings of the VI International Symposium on Solected Problems in Statistical Machanels. p2-81-543 Proceedings of the II International Symposium on Solected Problems of Statistical Symposium on Solected Problems of Statistical Symposium on Solected Problems on Statistical Symposium on Solected Problems of the Symposium School Nuclear Structure. Alushts in Statistical Machanels. p2-81-546 Proceedings of the VI International Symposium on Solected Problems of the Symposium Statistical Machanels. p2-82-566 Proceedings of the Symposium on Solected Problems of Solective Machanels. p2-82-566 Proceedings of the Symposium of the Meeting on Invertise- Problem of Alushter Structure Statistical Machanels. p2-82-566 Proceedings of the Symposium of the Meeting on Invertise- Problem of Solective Machanels. Dubna, 1932. p2-82-566 Proceedings of the Symposium of the Symposium of the Symposium of the Symposium of the Meeting on Invertise- Problem of Solective Machanels. Dubna, 1932. p2-82-566 Proceedings of the Symposium of the Meeting on Invertise- Problem of Solected Collective Mechaels of Acceleration. p3-82-8644 Proceedings of the Symposium of the Symposium of the Meeting on Invertise- Problem of Solecter Problems of Solecter Problems of Acceleration. p3-82-82-86 | You can re | ceive by post the books listed below. Prices - in t | US \$, | • |
| p-12865 The Proceedings of the International School on the Problems of Charged Particle Accelerators and Perticle Accelerators and Period and Period and Period and Period and Period Accelerators and Period | i | ncluding the packing and registered postage | | |
| by size. bubs, 1973. by size. bubs, 1973. c) different bubs, 1980. d) d | D-12965 D11-80-13 | The Proceedings of the International School on the Problems of Charged Particle Accelerators for Young Scientists. Minsk, 1979. The Proceedings of the International Conference on Systems and Techniques of Analytical Comput- ing and Their Applications in Theoretical | 8.00 | Двуреченский А., Ососков Г.А. E5-82-855 О периоде занлтости дискретной системы массового обслуживания |
| build, 1973. build, 1973. build, 1973. build, 1974. build, 1981. build, 1981. | D4-80-271 | Physics. Dubna, 1979. The Proceedings of the International Symposium on Few Particle Problems in Nuclear Physics. | 8.00 | GI/GI/∞ B работе изучается задача определения распределения периода занятости /т.е. периода, когда обслуживается хотя бы один за-казчик/ дискретной системы массового обслуживания с бесконеч-ным числом каналов обслуживания. Кроме того, изучаются период простоя и цикл системы. Получены рекуррентные формулы, и в час ном случае геометрического входа определены более простые рекуррентные формулы. Эти проблемы возникают при определении дискретной длины сгустков в трековых камерах в физике высоких энергий. |
| Proceedings of the VII All-Union Conference on Charged Particle Accelerators. Dubna, 1980. D4-80-572 N. Kolesnikov et al. "The Energies and Balf-fives for the 4 - and β-Decays of Transfermium Elements" D2-81-543 Proceedings of the VI International Conference on the Problems of Mathematical Simulation in Nuclear Physics Researches. Dubna, 1980. D1, 2-81-728 Proceedings of the VI International Seminar on High Energy Physics Dubna, 1981. D1, 2-81-728 Proceedings of the VI International Seminar on Bisched Problems in Statistical Mechanics. Dubna, 1981. D1, 2-82-72 Proceedings of the II International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1982. D2-82-664 Proceedings of the Meeting on Investigation the Problems of Chargement and Phenomena in High Energy Physics. Dubna, 1982. D9-82-664 Proceedings of the Symposium on Polarization Symposium on Selected Physics. Dubna, 1982. D9-82-664 Proceedings of the Symposium on Proceedings of the Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1982. D9-82-664 Proceedings of the Weeting on Investigation Phenomena in High Energy Physics. D9-82-664 Proceedings of the Weeting on Investigation. Dubna, 1982. D9-82-664 Proceedings of the IV International Symposium on Proceedings of the Symposium on Proceedings of the Meeting on Investigation. Dubna, 1982. D9-82-664 Proceedings of the Weeting on Investigation. Dubna, 1982. D9-82-664 Proceedings of the Weeting on Investigation. Dubna, 1982. D9-82-664 Proceedings of the IV International Symposium on Proceedings of the Meeting on Investigation. The Proceedings of the Symposium on Proceedings of the Symposium on Proceedings of the Weeting on Investigation. D9-82-664 Proceedings of the Weeting on Investigation. D9-82-664 Proceedings of the IV International Symposium on Proceedings of the Symposium on Proceedings of the Symposium on Proceedings of | D4-80-385 | The Proceedings of the International School on Nuclear Structure. Alushta, 1980. | 10.00 | |
| D4-80-572 N.N.Kolesnikov et al. "The Energies and Half-Lives for the e- and β-Decays of 10.00 Transfermium Elements" D2-81-543 Proceedings of the VI International Conference on the Problems of Quantum Field Theory. Alusthat, 1981 10,11-81-622 Proceedings of the International Meeting on Problems of Mathematical Simulation in Nuclear Physics Researches. Dubna, 1980 D1,2-81-728 Proceedings of the VI International Seminar on Selected Problems in Statistical Mechanics. Dubna, 1981. D1,2-82-277 Proceedings of the II International Symposium on Selected Problems in Statistical Mechanics. Dubna, 1981. D2-82-568 Proceedings of the Meeting on Investiga- tions in the Field of Relativistic Nuc- lear Physics. Dubna, 1982 D9-82-664 Proceedings of the Symposium on the problems of Collective Methods of Acce- leration. Dubna, 1982 D3,4-82-704 Proceedings of the IV International | | Proceedings of the VII All-Union Conference on Charged Particle Accelerators. Dubna, 1980. 2 volumes. | 25.00 | |
| D2-81-543Proceedings of the VI International Conference on the Problems of Quantum Field Theory. Alushta, 1981Padota выполнена в Лаборатории вычислительной техники и автоматизации ОИЛИ.10,11-81-622Proceedings of the International Meeting on Problems of Mathematical Simulation in Nuclear Physics Researches. Dubna, 19809.00D1,2-81-728Proceedings of the VI International Seminar on High Energy Physics Problems. Dubna, 1981.9.50D17-81-758Proceedings of the VI International Seminar on Selected Problems in Statistical Mechanics. Dubna, 1981.9.50D1,2-82-27Proceedings of the International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1981.9.50D2-82-568Proceedings of the Relativistic Nucc- lear Physics. Dubna, 198215.50D9-82-664Proceedings of the Symposium on the Problems of Collective Methods of Acce- leration. Dubna, 19827.50D3,4-82-704Proceedings of the YI International9.20 | D4-80-572 | N.N.Kolesnikov et al. "The Energies and Half-Lives for the \mathfrak{o} - and β -Decays of Transfermium Elements" | 10.00 | |
| 10,11-81-622 Proceedings of the International Meeting on Problems of Mathematical Simulation in Nuclear Physics Researches. Dubna, 1980 D1,2-81-728 Proceedings of the VI International Seminar on High Energy Physics Problems. Dubna, 1981. D17-81-758 Proceedings of the II International Symposium on Selected Problems in Statistical Mechanics. Dubna, 1981. D1,2-82-27 Proceedings of the International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1981. D2-82-568 Proceedings of the Meeting on Investiga- tions in the Field of Relativistic Nuc- lear Physics. Dubna, 1982 D9-82-664 Proceedings of the Symposium on the Problems of Collective Methods of Acce- leration. Dubna, 1982 D3,4-82-704 Proceedings of the IV International | D2-81-543 | Proceedings of the VI International Conference on the Problems of Quantum Field Theory. Alushta, 1981 | 9.50 | Работа выполнена в Лаборатории вычислительной техники и автоматизации ОИЯИ. |
| D1,2-81-728 Proceedings of the VI International Seminar on High Energy Physics Problems. Dubna, 1981. D17-81-758 Proceedings of the II International Symposium on Selected Problems in Statistical Mechanics. Dubna, 1981. D1,2-82-27 Proceedings of the International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1981. D2-82-568 Proceedings of the Meeting on Investigations in the Field of Relativistic Nuclear Physics. Dubna, 1982 D9-82-664 Proceedings of the Symposium on the Problems of Collective Methods of Acceleration. Dubna, 1982 D3,4-82-704 Proceedings of the IV International | 10,11-81-622 | Proceedings of the International Meeting on Problems of Mathematical Simulation in Nuclear Physics Researches. Dubna, 1980 | 9.00 | Препринт Объединенного института ядерных исследований. Дубна 1982 |
| D17-81-758 Proceedings of the II International Symposium on Selected Problems in Statistical Mechanics. Dubna, 1981. D1,2-82-27 Proceedings of the International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1981. D2-82-568 Proceedings of the Meeting on Investigations in the Field of Relativistic Nuclear Physics. Dubna, 1982 D9-82-664 Proceedings of the Symposium on the Problems of Collective Methods of Accelearation. Dubna, 1982 D3,4-82-704 Proceedings of the IV International | D1,2-81-728 | Proceedings of the VI International Seminar on High Energy Physics Problems. Dubna, 1981. | 9.50 | Dvurečenskij A., Ososkov G.A. E5-82-855 On a Busy Period of Discretized GI/GI/∞ Queue The problem of determining the distribution of the busy period, i.e., of the time when at least one customer is server of the discretized queueing system with infinitely many server is investigated. Moreover, the idle period and the cycle of |
| D1,2-82-27 Proceedings of the International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1981. D2-82-568 Proceedings of the Meeting on Investigations in the Field of Relativistic Nuclear Physics. Dubna, 1982 D9-82-664 Proceedings of the Symposium on the Problems of Collective Methods of Acceleration. Dubna, 1982 D3,4-82-704 Proceedings of the IV International | D17-81-758 | Proceedings of the II International Symposium on Selected Problems in Statistical Mechanics. Dubna, 1981. | 15.50 | |
| D2-82-568Proceedings of the Meeting on Investiga- tions in the Field of Relativistic Nuc- lear Physics. Dubna, 1982a queue are studied. The recurrent formulae are determined and in particular case of a queue with the geometric input simpler recurrent formulae are given. Those problems arise in the discrete blob length determination in track chamber in high energy physics.D3.4-82-704 Proceedings of the IV International9.20 | D1,2-82-27 | Proceedings of the International Symposium on Polarization Phenomena in High Energy Physics. Dubna, 1981. | 9.00 | |
| D9-82-664 Proceedings of the Symposium on the Problems of Collective Methods of Acce- leration. Dubna, 1982 9.20 D3.4-82-704 Proceedings of the IV International 9.20 | D2-82-568 | Proceedings of the Meeting on Investiga- tions in the Field of Relativistic Nuc- lear Physics. Dubna, 1982 | 7.50 | a queue are studied. The recurrent formulae are determined and in particular case of a queue with the geometric input the |
| D3,4-82-704 Proceedings of the IV International | D9-82-664 | Proceedings of the Symposium on the Problems of Collective Methods of Acce- leration. Dubna, 1982 | 9.20 | in the discrete blob length determination in track chambers in high energy physics. |
| School on Neutron Physics. Dubna, 1982 12.00 The investigation has been performed at the Laboratory Computing Technique and Automation, JINR. | D3,4-82-704 | Proceedings of the IV International School on Neutron Physics. Dubna, 1982 | 12.00 | The investigation has been performed at the Laboratory of Computing Technique and Automation, JINR. |