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T.S. MAMMADOV, M.H. HASRATOVA, G.J. AFANDIYEV

SIMULATION OF REAL CUSTOMER SERVICES IN LIFT SYSTEMS

We consider mathematical models stochastic vertical transportation lift systems with arbitrary values of customer intensity. Such systems have essentially more complicated structure and their investigations by analytical approaches faces with some troubles. Our aim is to construct the model of service systems close to practice in lift-type queuing systems and compare the efficiency characteristics of requirements by computer simulation method for lift systems given for various service rules by modeling a behavior of such systems on a computer and getting numerical results.

Keywords: queueing systems, stochastic, vertical transportation, lift systems

1. Introduction. One of the main tools for investigation of complicated queuing systems is empirical and simulation data and their analysis. By simulation we can get numerical results of the different characteristics of systems. But for taking decisions that are rich in content, it is necessary to have statistical analysis of simulation data [1-3].

Complex usage of analytical and computer methods allow taking a rich in content decisions for queues with complicated structures and making corresponding recommendations for practical applications.

Typical examples of queues with moving servers are elevator systems [4-6].

The mathematical models and modeling on a computer, which confirmed an advantage of the “higher-lower” strategy were constructed and investigated [5; 6]. The construction and investigation of mathematical models of queues with delays as a control function gave unexpected results. Introduction of delays, “HIGHER-LOWER” and others control policies in queues, allowed the diminishment of expectation of waiting time of customers before service in some models.

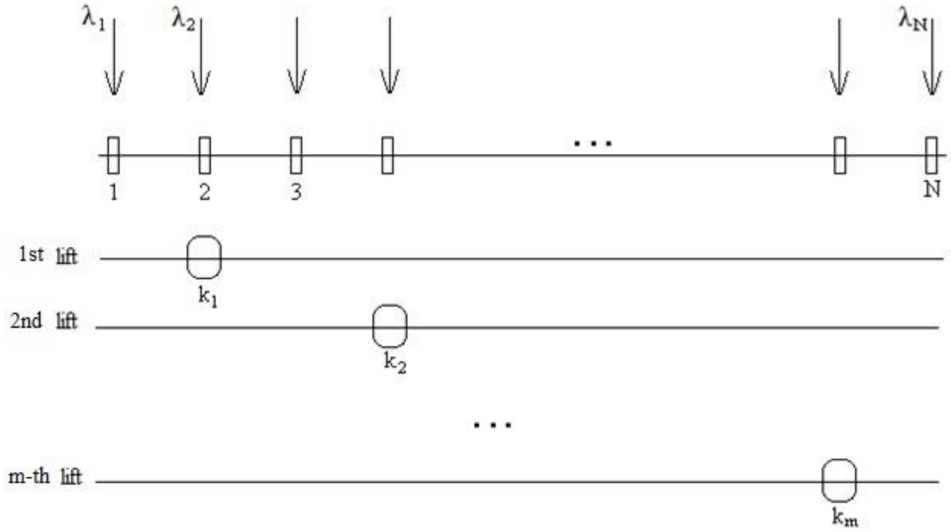
There is another control policy by elevators system “EVEN-ODD”, when one elevator gives service only for “EVEN” and other for “ODD” floors. Comparing of “HIGHER-LOWER” with “EVEN-ODD” showed an advantage of “HIGHER-LOWER” control policy.

Construction of mathematical models of such systems leads needs using of some deep mathematical conception and facts from theory of point processes [7; 8]. Some control problems by these systems were investigated in [9-12].

In the paper, the model of service systems close to practice in lift-type queuing systems has been constructed, and the efficiency characteristics of requirements by computer simulation method for lift systems given for various service rules have been compared by modeling a behavior of such systems on a computer and getting numerical results.

Numerical examples of simulation and graphs, describing of behavior of various parameters are given.

2. Description of model. The public service system consisting of N floor and m elevator moving among these floors is looked (pic. 1). Assumed that, Puasson process with the parameter λ_1 (i = 1,2,…, N) in accordance with the requirements, includes appropriate stream of requirements. The requirements included in first floor choose the floor they went with equal probability ($\frac{1}{N-1}$) among 2,…,Nth floors. But the requirements included in 2,3,…,Nth floors go to the first floor. Transportation of requirements to the floor they directed is implemented through elevators (service devices). The elevators is limited voluminous and move with fixed acceleration (a).



Picture 1

The distance between the floors is considered as fixed quantitative (d). The requirements included in the floors wait for the service of elevator and service is carried out in sequence it came. Elevators wait up to a fixed period of time (τ) (duration of doors remain open) to enter and leave the service device of requirements at the floor they reached.

3. The management terms of elevators. Different management terms of callings of the elevators are available in such kind of systems.

Model A. Calling of the nearest elevator. For the received requirement in a floor, the elevator that is the nearest and meets one of the following 3 terms is sent to that floor:

1) Motionless elevator;

2) The elevator that is moving downward and the floor it directs is below than the given floor;

3) The elevator that is moving from below to upward and the floor it below than the given floor;

Note. Use of the elevator meeting first term for the requirements waiting in different floors does not make any conflict**.** So, according to the first term after direction of elevator to the floor waiting for any requirement use of second and third elevators adequately determines direction of the elevator.

Model B. Calling of all elevators. For received requirement to the floor all elevators are sent meeting one of the terms regardless of distance:

1) Motionless elevator

2) The elevator that is moving downward and the floor it directs is below than the given floor

3) The elevator that is moving from below to upward, empty and the floor it below than the given floor

General effectiveness characteristics of elevator – type systems. One of the indicators of effectiveness is average waiting period of requirements in elevator-type public service systems as in many public service systems (W). The average waiting period of requirements is characterized in itself as total of two waiting periods:

$$W = W_1 + W_2$$

Here**,** $\mathbf{W_1}$ is waiting period of requirements till the service of elevators, $\mathbf{W_2}$ is waiting period of requirements during the service of elevators (holding period of requirement in elevator).

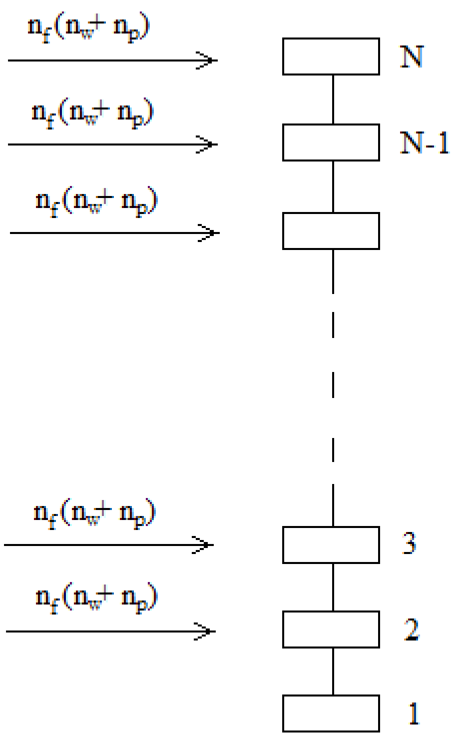
Furthermore, lift services and the general distance of each lift for characterizing the energy consumption costs are also importart as the efficiency index.

Real service condition. It is assumed that there are n_f apartments in the apartment building. n_o pensioners, n_w middle-aged working people, and n_p pupils live in each apartment. We consider three different conditions in the lift service issue:

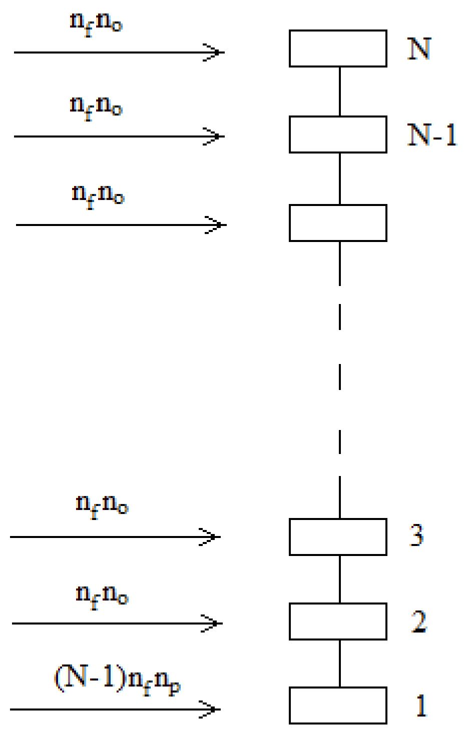
1) The morning condition – the middle-aged working people leave home for going to work, and pupils leave for school. In this case, each i-th (i=2,...,N) floor includes n_f (n_w+n_p) requirements.

2) The afternoon condition – the pupils come back home from school, and the old pensioners leave home for going to the yard. In this case, the first floor includes $n_f n_p$ (N-1) requirements, and each remaining i-th (i=2,...,N) floor includes $n_f n_0$ requirements.

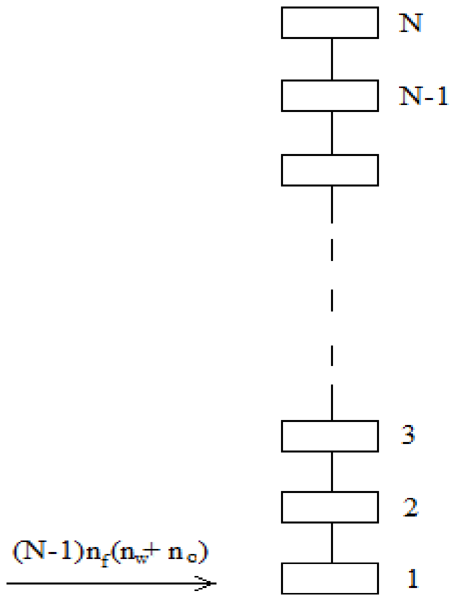
3) The evening condition – old pensioners and middle-aged working people come back home.In this case, the first floor includes n_f (n_w+n_0) (N-1) requirements.



the morning conditionthe



afternoon condition



the evening condition

The graphs of dependence on the number of service units of the efficiency characteristics of the system. In Wolfram Mathematica 9.0 programming language, a special program simulating the work of the above mentioned work by the noted algorithm has been compiled.By means of this program the efficiency caracteristics of the system for the above mentioned lift control strategies have been calculated for certain parameters.

The realization of arrivals. The arrivals which were included into the floor has been generated as the Poisson flow. The Poisson arrival parameter has been taken as

$$\lambda=n_c/3600$$

Here, n_c is the number of arrivals expected to be included in the floor.

General parameters of the models:

The number of the floors N=15
The number of the lifts m=2
The acceleration of lifts a=0.1
The number of appartments n_f =4
The number of the arrivals in the appartments $n_w = n_0 = n_p = 2$
The realization period of the model T=10000
The volume of the lifts lv=5
The duration of doors being open in lifts on the floors where they stop τ=2
The distance between the floors d=1

4. The results of the experiment:

1) The average waiting period of the arrivals. – $W=W(\lambda)$

	The morning condition	The afternoon condition	The evening condition
Model A	28.8832	23.5420	28.0706
Model B	32.0714	25.3575	22.7469

2) The total distance travelled by one lift – $S=S(\lambda)$

	The morning condition	The afternoon condition	The evening condition
Model A	2380.8927	2118.4809	2131.6100
Model B	2794.9259	2769.6093	2496.4500

5. Results:

1. When comparing average waiting time as an indicator of efficiency it becomes clear that in the morning and afternoon conditions Model A outperforms Model B and in the evening condition Model B performs better. It could be explained by that in the morning condition customers come from different floors and service of the nearest elevator performs better. But in the afternoon condition since all customers come from the first floor, so dispatching of all elevators for a call of any customer results with less waiting. In the afternoon condition since both cases happen simultaneously (first half come from different floors, second half come from the first floor) indicators become closer.

2. For the total distance travelled by one elevator in all conditions model A performs better.

3. Such systematical comparison gives an opportunity to build efficient control systems. Since variable control systems performs better.

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T.Ş. Məmmədov, M.H. Həsrətova, Q.C. Əfəndiyev

Lift sistemlərində real xidmətin modelləşdirilməsi

İxtiyari intensivliyə malik müştəri seli ilə stoxastik şaquli lift nəqliyyat sistemlərinin riyazi modellərinə baxılmışdır. Bu sistemlər daha mürəkkəb struktura malik olduğundan, belə məsələlərə analitik yanaşma onların tədqiqatında bəzi problemlər yaradır. Bizim məqsədimiz, liftə xidmət sistemlərinin istifadəsinə yaxın olan kütləvi xidmət sistemlərinin modelini qurmaqdan, müxtəlif xidmət variantları olan lift sistemlərinin kompüter modelləşdirməsi üsulu ilə tələblərin xidmətinin səmərəlilik xarakteristikalarının müqayisəsindən, belə sistemlərinin davranışının kompüterdə modelləşdirilməsi ilə ədədi nəticələrin alınmasından ibarət olmuşdur.

Açar sözlər: kütləvi xidmət sistemləri, stoxastik, şaquli nəqliyyat, lift sistemləri

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Т.Ш. Мамедов, М.Г. Хасратова, Г.Д. Эфендиев

Моделирование реального обслуживания в лифтовых системах

Рассматриваются математические модели стохастических вертикально-транспортных лифтовых систем с произвольными значениями интенсивности потока клиентов. Такие системы имеют существенно более сложную структуру и изучение их посредством аналитического подхода представляет некоторые проблемы. Нашей целью является построение модели систем обслуживания, близкой к используемым в системах массового обслуживания лифтом, и сравнение характеристик эффективности требований методом компьютерного симулирования для лифтовых систем, заданных для различных вариантов обслуживания, путем моделирования поведения таких систем на компьютере и получения численных результатов.

Ключевые слова: системы массового обслуживания, стохастический, вертикальная транспортировка, лифтовые системы

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