OPTIMIZATION OF THE NUMBER OF SPECIAL EQUIPMENT (AUTOMATIC LADDER AND AUTOMATIC LIFT) IN FIRE AND RESCUE UNITS

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Abstract. The article deals with the issues of ensuring the optimal number of special equipment (car ladder and car lift) of fire and rescue units for the elimination of fires in multi-storey buildings. To ensure the incoming call flow, a queuing system of the probability theory section is used.

Keywords: system, model, mass maintenance, special equipment, queue theory, queue, call.

ОПТИМИЗАЦИЯ КОЛИЧЕСТВО СПЕЦИАЛЬНОЙ ТЕХНИКИ (АВТОЛЕСТНИЦЫ И АВТОПОДЪЁМНИКА) В ПОЖАРНО-СПАСАТЕЛЬНЫХ ЧАСТЯХ

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Аннотация. В статье рассмотрена вопросы обеспечения оптимального количество специальной технике (автолестница и автоподъемник) пожарно-спасательных частей для ликвидации пожаров на многоэтажных домах. Для обеспечения входящего потока вызовов используется система массового обслуживания раздела теории вероятностей.

Ключевые фразы: система, модель, массовое обслуживания, специальная техника, теория очередей, очередь, вызов.

ЁНҒИН-ҚУТҚАРУВ ҚИСМЛАРИДА МАХСУС ТЕХНИКА (АВТОНАРВОН ВА АВТОКЎТАРГИЧ) СОНИНИ ОПТИМАЛЛАШТИРИШ

Аннотация

Мақолада кўп қаватли биноларда ёнғинларни бартараф етиш учун ёнғин-қутқарув бўлинмаларининг махсус жиҳозлари (автомонарвон ва

автокўтаргич) оптимал сонини таъминлаш масалалари кўриб чиқилган. Кирувчи қўнғироқлар оқимини таъминлаш учун эҳтимоллик назарияси бўлимининг навбат тизими қўлланилади.

Калит сўзлар: тизим, модел, оммавий хизмат кўрсатиш, махсус жиҳозлар, навбатлар назарияси, навбат, қўнғироқ.

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Introduction

Queuing systems are the objects of studying the theory of queuing in the probability theory section. The queuing system (QS), consisting of queuing networks, considers a variety of systems designed to serve the mass flow of requirements of a random nature. Scientists in the field of queue theory have developed relatively simple mathematical models that allow us to study many externally different real-life maintenance processes in fire and rescue units, transport, military, computer networks, etc. The final goal of the methods developed in the theory of queuing is to find the rational structure and parameters of the service system, the organization of service, providing a given quality. [1]

Methods

The purpose of this study is to develop recommendations for the rational construction of QS (optimal distribution of special equipment in case of fire), rational organization of their work and regulation of the flow of calls to ensure high efficiency of QS functioning [2].

The queuing theory section studies phenomena that are random in nature, when individuals or objects use limited means. Sometimes, due to random fluctuations, the number of requirements may exceed the available funds, and some requirements will be forced to either wait for service in the queue, or refuse service altogether. Both the first and the second leads to undesirable expenses.

In the queuing system, in which, on the one hand, there are mass requests for the performance of any types of services (calls to fire and rescue units on alarm in case of "fire"), and, on the other hand, there is satisfaction of these requests (provision of fire and rescue car ladders and car lifts).

Each queuing system includes a number of service devices – channels (car ladder and car lift) of service.

At the entrance of the CFR, one or more streams of requests (fire requests, fire extinguishing requirements) are received, requiring the same type

services.

The main elements of the queuing system in fire and rescue units are:

1) incoming call flow;

2) queue;

3) service channels;

4) outgoing flow of serviced requirements.

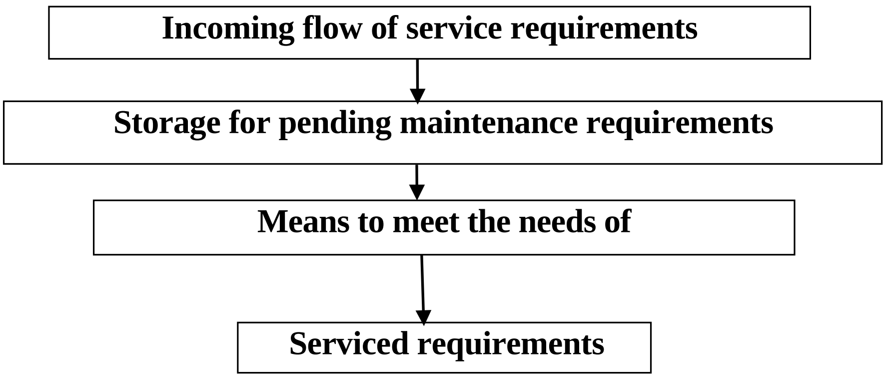

Figure 1. General scheme of the maintenance process

If some of the calls to the dispatching service of the fire and rescue units of the district about a fire that have entered the system are not serviced for some reason, then they form an outgoing stream of unserved requirements. [3]

At the time of receipt of the next call about the fire and the duration of its maintenance are not exactly set and represent random variables.

The random nature of the call flow and the time of their service leads to uneven loading of channels (for extinguishing fires in multi-storey buildings with car ladders and car lifts) and the formation of queues.

The period from the moment of receipt of the request to the QS and before the start of service is called the service waiting time.

The waiting time for maintenance in conjunction with the maintenance time is the time the requirement stays in the system.

Examples of a queuing system for a fire and rescue unit:

1. Functioning of the fire and rescue unit with special techniques for extinguishing fires.

2. The functioning of the dispatching service of the units on the "signal" fire alarm, requirements – car ladders and car lifts that require extinguishing a fire in a multi-storey building.

3. Automated information systems; requirements – extinguishing fires in a short time without casualties and economic damage.

4. Dispatching service on duty; requirements – the earliest dispatch of special equipment on calls (the first, second or third call according to the complexity of the fire).

6. Computer operation in time–sharing mode; requirements - programs processed by the computer.

Descriptions of the operation of the queuing system of fire and rescue units must be set:

1) A model of the incoming flow of requirements (calls for fire elimination), including a probabilistic law that determines the sequence of moments of receipt of service requirements and the number of requirements in each next receipt (both individual and group requirements can be received).

2) Service discipline – the principle according to which the requirements coming into the system are selected from the queue for service. For example:

– first come – first served;

– the last to arrive – the first to be served;

– random selection of applications;

– selection of applications according to the priority criterion;

– limitation of the waiting time for the moment of service.

3) The service mechanism, including the probabilistic distribution of the duration of service, the number of simultaneously serviced calls, the probability of failure of the servicing special equipment.

The QS has a certain efficiency of functioning that allows it to cope with the flow of calls. The effectiveness depends on the parameters of the QS:

– the nature of the flow of applications,

– the number of service channels (the number of the car ladder and the car lift),

– the performance of special equipment for the elimination of fire,

– the rules of the organization of work.

To achieve this goal, the tasks of the TMO are set, which consist in establishing the dependencies of the efficiency of the functioning of the CFR on its parameters. [4,5]

A call flow is a sequence of events following one after another at some random points in time (for example, a call flow to the dispatching service of a fire and rescue unit on duty). The flow is characterized by intensity λ – the frequency of occurrence of events or the average number of events entering the QS per unit of time.

A call flow can be the simplest (or stationary Poisson) if it is both stationary, ordinary and has no consequences. The simplest flow as a limit arises in the theory of random processes as naturally as in probability theory, the normal distribution is obtained as a limit for the sum of random variables: when superposing a sufficiently large number of n independent, stationary and ordinary flows (comparable to each other in intensities λi (i = 1,2,...,n)) we get a flow close to the simplest with an intensity λ equal to the sum of the intensities of incoming flows, i.e. [2]:

$$\lambda = \sum_{i=1}^{n} \lambda_i \qquad (1).$$

The term "Poisson" in this study means that if

1-3 the number of calls to the fire and rescue unit falling on any fixed time interval will be distributed according to Poisson's law [1].

Figure 2 shows a diagram on the Ot time axis of a simple call flow in the dispatcher service on duty as an unlimited sequence of random points (Fig. 2).

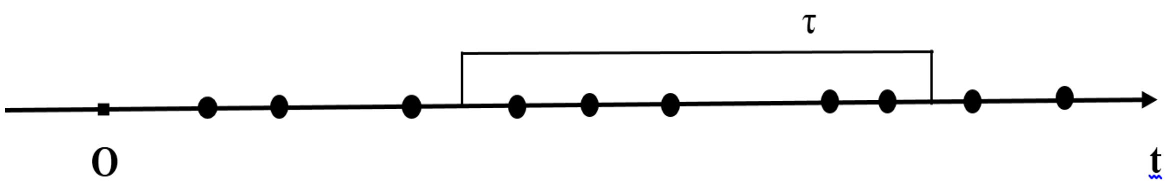

Figure 2. Diagram of an unlimited sequence of random points in the event stream.

In the scheme, a random variable X expresses the number of calls (fires, accidents and other emergencies) that fall for an arbitrary period of time τ. The value of X is a random variable and is distributed according to Poisson's law. To do this, divide the time interval τ into n equal elementary segments $\Delta t=\tau n$. The mathematical expectation of the number of events falling on the elementary segment Δt is obviously equal to $\lambda\Delta t$, where λ is the intensity of the flow (since the average of λ points falls per unit length). According to the property of the ordinariness of the flow, the probability of hitting the elementary (i.e. small) a segment of two or more calls. Therefore, the mathematical expectation $\lambda\Delta t$ of the number of points falling on the site Δt will be approximately (up to infinitesimal of the highest order at $\Delta t\to 0$) equal to the probability of one point falling on it [1,5].

We will consider the elementary segment Δt "occupied" if a flow event appeared in it, and "free" if it did not appear. The probability that the segment $\Delta t=\tau n$will be "occupied" is equal to $\lambda\Delta t=\lambda\tau n$, the probability that it will be "empty" is equal to 1−λτ.

The number of occupied elementary segments, i.e. the number X of events over the entire time interval τ, can be considered as a random variable having a binomial distribution law according to the Bernoulli formula [2,4]:

$$P(X=m)=C_n^m\left(\frac{\lambda\tau}{n}\right)^m\left(1-\frac{\lambda\tau}{n}\right)^{n-m} \quad (2).$$

With an unlimited increase in the number of elementary segments Δt, i.e. with $n\to\infty$, $P=\frac{\lambda\tau}{n}$ → 0 with a constant value of the product $np=n\frac{\lambda\tau}{n}=\lambda\tau$, the binomial distribution tends to the Poisson distribution with the parameter $a=\lambda\tau$:

$$P_m(\tau)=\frac{(\lambda\tau)^m}{m!}e^{-\lambda\tau} \quad (3).$$

From this property of Poisson's law – to express a binomial distribution with a large number of experiments and a low probability of an event - comes its name, often used in statistical textbooks: the law of rare phenomena.

In particular, the probability that no events will occur during the time $\tau(m=0)$ is equal to [1,5]:

$$P_m(\tau)=e^{-\lambda\tau} \quad (4).$$

The complexity of the fire and the time of its maintenance by fire departments are intercorrelated values. However, when justifying the necessary number of forces and means of the fire service, such a temporary characteristic as the time of the development of the fire before reporting it to the fire and rescue service unit (RSU) is not taken into account. This is due to the fact that this time characteristic does not relate to the time when the RSU unit is busy with call service, but it has a significant impact on the time of localization and liquidation of the fire, that is, its duration [3]. It is possible to determine this time characteristic only by the calculation method, based on the situation that has already developed by this time. Moreover, the fire extinguishing manager (FEM) can assess the situation on the fire only after arriving at the place of the call. On the other hand, if the FEM had data on the time of the development of the fire before the message at the time of receipt of the call, it becomes possible to assess the state of the parameters of the head of the fire department () by the time of arrival of the GPS unit. Therefore, it is necessary to conduct a simulation of the time of fire development before reporting it to the dispatching service on duty (DSD) according to the initial information. [6]

Conclusions:

Based on the analysis of the functioning of the fire and rescue service, territories and settlements, the study of existing theoretical and practical approaches to assessing the state of their fire safety, the choice of a system analysis as the main means of research, providing a comprehensive solution to the problems of mathematical modeling (queuing theory) in emergency situations (fires, accidents, etc) [3]. In accordance with the existing factors for assessing the effectiveness of the optimal distribution of fire-rescue equipment in the garrison units, algorithmic schemes for its research, their determination, the values of the time characteristics of the arrival and extinguishing of fire by special fire-rescue techniques have been developed. The methodology of systematized processing and analysis of parameters of incoming calls to the dispatcher service on duty has been developed, criteria for evaluating the effectiveness of elements of the fire and rescue unit and the rational distribution of special fire and rescue equipment during a fire have been established.

The recommendations developed in the study, obtained based on the use of the proposed methodology, allowed: to identify shortcomings in the organization of the functioning of special fire-rescue equipment of fire-rescue units, calculations, data processing and analysis, to predict the parameters of fire elimination with subsequent modeling of the functioning of the involved units of fire-rescue units in accordance with the established criteria.

References

1. Abaev A.V., Butyrin O.V. Algorithmic support of the procedure for optimal allocation of fire service resources// Information technologies and problems of mathematical modeling of complex systems: Collection of scientific papers. Issue 6. - Irkutsk: IrGUPS, 2008. - Pages. 116 - 120.

2. Brushlinsky N.N. Modeling of operational activities of the fire service M.: Stroyizdat, 1981. - Pages 23 - 26, 96, 104.

3. Wentzel E.S. Operations research tasks, principles, methodology - M.: Nauka 1988. - 208 p. - Pages 11-23.

4. Wentzel, E.S. Operations research / E.S. Wentzel. – Moscow : "Soviet Radio", 1972. – 552 p.

5. Джафаров, К. А. Методы оптимальных решений : задачи управления запасами, очередью и конфликтами: учебное пособие: Новосибирский государственный технический университет. – Новосибирск : Новосибирский государственный технический университет, 2018. – 112 с.

6. Джафаров, К. А. Методы оптимальных решений : учеб. пособие - Новосибирск : Изд-во НГТУ, 2014. - 76 с.