Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

Special Issue

LIMITARY REQUEST QUEUE CHOICE MATHEMATICAL MODEL FOR THE REAL TIME STREAMS TRANSFER BY MEANS OF THE MOBILE AD HOC NETWORK RADIO CHANNEL

K.O. Polshchykov[1,*], S. A. Lazarev[2] and A. D. Zdorovtsov[3]

[1]Associate Professor of Information Systems Department, Belgorod State University
Candidate of technical sciences, associate professor

[2]Deputy Director at the Institute of Engineering Technologies and Sciences, Belgorod State University, candidate of economic sciences

[3]Programmer at the Telecommunications Office of the IT Department, Belgorod State University

Published online: 24 November 2017

ABSTRACT

The mathematical model for the limitary request queue choice for real time streams transfer by means of the wireless self-organized network radio channel is offered. For quality assessment of the multimedia traffic transfer it is offered to use probability of the radio channel request service reservation productivity. The model reflects dependence of channel resources reservation requests service probability on parameters of these inquiries and radio channel parameters. The model is based on the mass service theory mathematical apparatus, probability-and-time graphs and the generating functions use. It is shown that on the basis of the offered mathematical model it is possible to carry out the limitary request queue choice for reservation of a radio channel productivity which allows increasing significantly the probability of high-quality real time streams transfer.

Keywords: Mobile ad hoc network, mathematical model, real time flows, requests queue.

Author Correspondence, e-mail: polshchikov@bsu.edu.ru

doi: http://dx.doi.org/10.4314/jfas.v9i7s.121

1. INTRODUCTION

Mobile Ad Hoc Networks (MANET) have the decentralized changeable structure (Basagni et al., 2004, Konstantinov et al., 2017) allowing to carry out transfer of voice messages and video streams in the conditions of dynamic network topology (Konstantinov et al., 2016, Polschykov, 2012). For ensuring high-quality delivery of multimedia information the preliminary resources reservation initiated by user request inflow for real time streams transfer on the relevant channels is provided in data transmission networks (Polschykov et al., 2013). The alarm RSVP protocol (Resource ReSerVation Protocol) allows reserving resources of telecommunication canals for real time applications (Awduche et al., 2001).

Intensity of user request inflow for real time streams transfer changes in a random way (Polschykov et al., 2015). At increase of this intensity in network the temporary deficiency of channel resources is observed. It causes emergence of refusals in service for the user inquiries. At decrease in the specified intensity network loading decreases, channels work in the underloaded mode. As a result network channels are loaded unevenly in time which leads to their inefficient use (Polschykov et al., 2010). The inquiries which were refused could be buffered and served later when the available resources necessary for real time streams transfer are released in the channel. However appropriate means in modern networks, including MANET, are not provided (Polschykov, 2013).

The possibility of buffering a large number of inquiries, on one hand, can improve quality of service (Quality of Service, QoS) because in this case the smaller number of users will be refused in real time streams transfer. On the other hand, the bigger number of inquiries will be in queue, the longer the expectation of service inquiries by users will; that will lead to decrease in the QoS level. Thus, researches at the limitary request queue choice for real time streams transfer on MANET radio channel are urgent.

2. QoS INDICATORS FOR THE REAL TIMETRAFFIC

The existing standards offer the indicators system characterizing the information streams transfer quality (Konstantinov et al., 2015). Package delays and their variations (jitter) are of great importance for the real time traffic transfer QoS assessment. At the same time the small share of the lost packages is allowed [8]. In the course of reserving and granting the channel productivity needed for high-quality multimedia information transfer the admissible values of the specified indicators are provided automatically. In these conditions for QoS assessment the sizes characterizing efficiency of the resources necessary reservation for real time streams transfer are required. As an indicator it is possible to use the request service probability for the real time stream transfer:

$$\Omega = 1 - \frac{\lambda_\xi}{\lambda}, \qquad (1)$$

where λ_ξ – intensity of unsuccessful attempts to carry out reservation of the channel capacity for real time streams transfer; λ – intensity of the incoming requests for the channel capacity reservation for real time streams transfer.

Unsuccessful attempts to carry out the channel resources reservation, the possibility of which an indicator Ω considers, can be divided into two types. The unsuccessful attempt of the 1st type (Q-attempt) takes place in case the request receipt time for the channel resources reservation queue length for the inquiries expecting release of the required capacity equals to extreme value *m*. The unsuccessful attempt of the 2nd type (E-attempt) is caused by the fact that the user on own initiative refuses the real time stream transfer because of unacceptably long expectation of the inquiry service.

The specified types of unsuccessful attempts influence user dissatisfaction with the quality of the inquiries service differently. Researches showed, that one unsuccessful attempt of the 2nd type is negatively estimated by users equally to several unsuccessful attempts of the 1st type. In this sense it is possible to claim that E-attempt weight in γ times more Q-attempt weight. Thus, intensity definition

λ_ξ is carried out taking into acgraph the weight of this or that unsuccessful attempt.

3. PROBLEM DEFINITION

Let for real time streams transfer to MANET the channel resources reservation be provided. In receiving the corresponding route inquiry from the user in which each channel productivity necessary for the real time stream transfer is reserved previously is formed. In one of the most loaded channels of the formed route the queue of requests for reservation of the channel productivity necessary for the corresponding real time streams transfer is organized. For reservation of this productivity inquiries which average intensity of receipt from one user equals λ are formed. Besides, the following sizes are set: C - the channel capacity; L - the channel productivity demanded for high-quality real time stream transfer; τ – average duration of one real time stream transfer; λ_Σ – total intensity of the requests for reservation of the channel productivity incoming from users for real time streams transfer; θ – admissible waiting time for user of service request for reservation of the channel capacity.

Assumption: time interval between receiving requests for resources reservation of the set channel and duration of the real time stream transfer are distributed under the exponential law. Restriction: the relation of the 2nd type unsuccessful attempt weight to the of the 1st type unsuccessful attempt weight is natural number in limits $2 \le \gamma \le 8$.

It is required to receive value dependence Ω from parameter *m* in an analytical look.

4. MATHEMATICAL MODEL DEVELOPMENT

It is offered to apply the mass service theory mathematical apparatus, probabilistic and time graphs and the generating functions to the solution of an objective. The probabilistic and time graph modeling service of requests for reservation of the radio channel productivity at $\gamma = 2$, is presented in figure 1.

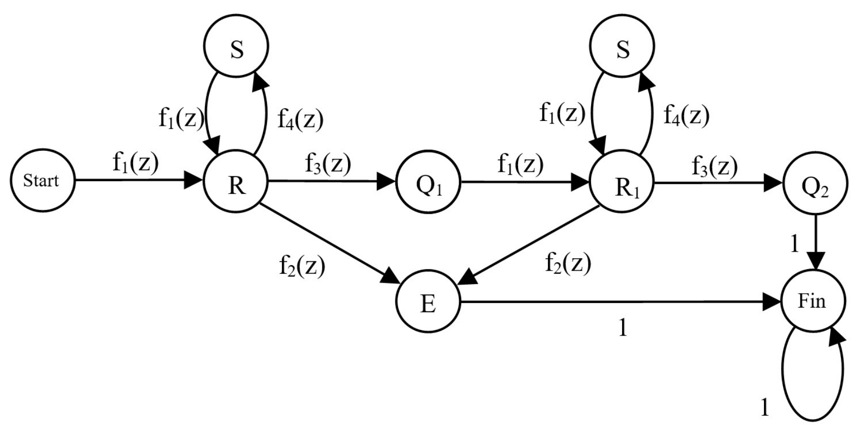

Fig.1. The graph modeling for the request service reservation productivity of a radio channel at $\gamma = 2$.

Graph nodes model the following states: "Start" - an initial state; "R" - arrived request for reservation of the radio channel productivity before implementation of any unsuccessful attempt; "S" - the arrived inquiry will be served; "E" - there was an E-attempt; "Q1" - occurred the first Q-attempt; "R1" - arrived request for reservation of the channel capacity after implementation of the first Q-attempt; "Q2" - occurred the second Q-attempt; "Fin" - a final state.

Transitions between the specified states are modeled by the graph's edges. The following functions correspond to edges of the graph:

$$f_1(z) = z^{\frac{1}{\lambda}}, \tag{2}$$

$$f_2(z) = P_E z^{\theta}, \tag{3}$$

$$f_3(z) = P_Q, \tag{4}$$

$$f_4(z) = (1 - P_E - P_Q) z^{\frac{1}{\lambda}}, \tag{5}$$

where P_E – probability of E-attempt;

P_Q – probability of Q-attempt.

Expression for determination of the value P_E is possible to receive on the basis of a formula for probability calculation that the inquiry will remain unserved in the system with expectation:

$$P_E = \frac{\beta}{\alpha} \cdot \frac{\frac{\alpha^n}{n!} \sum_{s=1}^{m} \frac{s\alpha^s}{\prod_{l=1}^{s}(n + l\beta)}}{\sum_{k=1}^{n} \frac{\alpha^k}{k!} + \frac{\alpha^n}{n!} \sum_{s=1}^{m} \frac{\alpha^s}{\prod_{l=1}^{s}(n + l\beta)}}, \tag{6}$$

where

$$\alpha = \lambda_{\Sigma} \tau, \tag{7}$$

$$\beta = \frac{\tau}{\theta}. \tag{8}$$

For calculation of radio channels number it is possible to use expression:

$$n = \frac{C}{L}, \tag{9}$$

Value n shows how many streams of real time it is possible to transfer at the same time with the acceptable quality on a radio channel of network.

Expression for determination of value P_Q is possible to receive on the basis of a formula for calculating the probability that the inquiry will remain unserved in system with restriction on queue length:

$$P_Q = \frac{\frac{\alpha^n}{n!} \cdot \frac{\alpha^m}{\prod_{l=1}^{m}(n+l\beta)}}{\sum_{k=0}^{n} \frac{\alpha^k}{k!} + \frac{\alpha^n}{n!} \sum_{s=1}^{m} \frac{\alpha^s}{\prod_{l=1}^{s}(n+l\beta)}}, \qquad (10)$$

By means of equivalent columns transformations the presented in figure 1 comes down to the elementary look (figure 2).

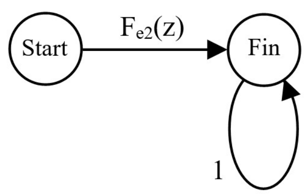

Fig.2. The graph after equivalent transformations

The making function $F_{e2}(z)$ can be found using formula:

$$F_{e2}(z) = f_1(z) F_2(z), \qquad (11)$$

where

$$F_2(z) = \frac{f_2(z) + f_3(z) f_1(z) F_1(z)}{1 - f_1(z) f_4(z)}, \qquad (12)$$

where

$$F_1(z) = \frac{f_2(z) + f_3(z)}{1 - f_1(z) f_4(z)}. \qquad (13)$$

The average time during which γ unsuccessful attempts of the 1st type or one unsuccessful attempt of the 2nd type will be made, can be calculated by means of expression:

$$T_{\gamma} = \left. \frac{dF_{e\gamma}(z)}{dz} \right|_{z=1}. \qquad (14)$$

Intensity of unsuccessful attempts to carry out reservation of the channel productivity for real time streams transfer is value, opposite to T_{γ}:

$$\lambda_{\xi} = \frac{1}{T_{\gamma}}. \qquad (15)$$

Having determined value λ_{ξ}, the request service probability for reservation of the channel productivity necessary for the real time stream transfer can be calculated using formula (1). From formulas (6) and (11) it is visible that probabilities P_E and P_Q depend on the extreme length of the inquiries queue. Therefore the analytical expressions received as a result of modeling reflect dependence of an indicator Ω to the value m.

5. MATHEMATICAL MODEL APPLICATION

The developed mathematical model can be applied to the choice of extreme length for queue of requests for reservation of channel productivity for real time streams transfer.

For the basic data presented in table 1 on formulas (1) - (15) calculations of an indicator are executed

Ω.

Table 1. Basic data for estimated experiments

Parameters	Value	Units of measure
C	4	Mbps
L	1	Mbps
τ	0,1	hour
λ_{Σ}	50	1/hour
θ	0,4	hour
λ	5	1/hour

In reality value γ practically does not depend on time. The most changeable within a day is value

λ_Σ. Therefore the right choice of extreme length of inquiries queue in the conditions of intensity change for their receipt is of great importance. In figures 3-5 curve corresponding dependences $\Omega(m)$ are presented, provided that $\gamma = 2$ and various values λ_Σ.

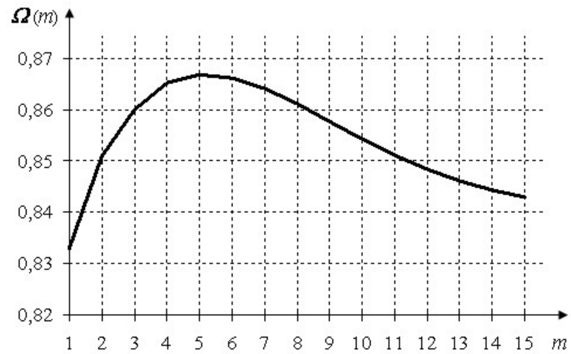

Fig.3. Dependence schedule $\Omega(m)$ provided that $\lambda = 50$ (1/hour).

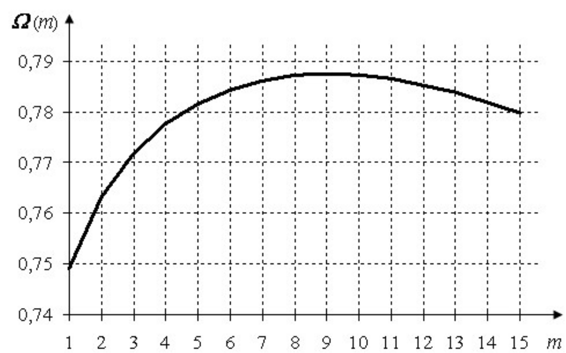

Fig.4. Dependence schedule $\Omega(m)$ provided that $\lambda = 75$ (1/hour).

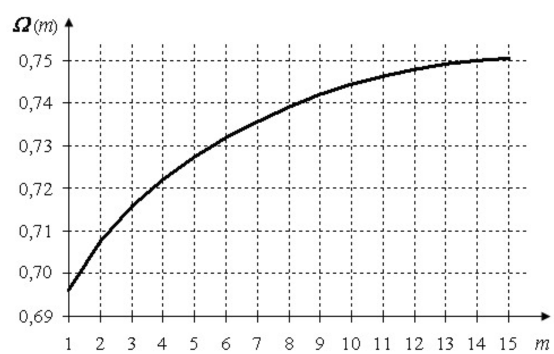

Fig.5. Dependence schedule $\Omega(m)$ provided that $\lambda = 100$ (1/hour).

On the basis of these schedules data it is recommended by which values m obtained we are to choose the various λ_Σ values. These data are contained in table 2.

Table 2. Basic data for estimated experiments

Preset value λ_Σ, 1/hour	The recommended value m
50	5
75	9
100	15

Calculations showed that the choice of rational values which is carried out on the basis of application of the offered mathematical model, will allow to increase the request service probability for the real time stream transfer by 3,9%-12,8%.

6. DISCUSSION AND CONCLUSION

In practice, a correct selection of a maximum length request queue is very important for Mobile Ad Hoc Networks within the change of their arrival intensity. The mathematical model was developed to estimate the quality of request servicing for the reservation of channel resources necessary for the transmission of real-time flows. The model is based on the use of the mathematical apparatus of queuing theory, probability-time graphs and generating functions. It reflects the dependence of request servicing probability for the reservation of channel resources on the parameters of these requests and a telecommunication channel. A model allows you to select the maximum length of a queue for a channel capacity reservation in order to transfer real-time flows to MANET. Based on the proposed model application, depending on the load intensity in a network, it is possible to determine the recommended values of memory resources allocated for incoming request buffering. Buffered requests for the transfer of real-time streams can be serviced later, when the resources necessary for subsequent transmission of the corresponding streams are free in the channel. The calculations showed that the choice of rational values of a queue maximum length, carried out on the basis of the proposed mathematical model application, will increase the probability of servicing requests for real-time stream transmission by 3.9% -12.8%.

The research was carried out under the financial support of RF Education and Science Ministry, project: 2.5681.2017/8.9.

7. REFERENCES

Basagni, S., Conti, M., Giordano, S. and Stojmenovic, I., 2004, Mobile Ad Hoc Networking. IEEE Press, 461.

Konstantinov, I., Polshchykov, K. and Lazarev, S., 2016, Algorithm for Neuro-Fuzzy Control of Data Sending Intensity in a Mobile Ad Hoc Network for Special Purpose. Journal of Current Research in Science, 4, 105–108.

Polschykov, K., Kubrakova, K. and Odaruschenko, O., 2013. Methods and Technologies Analysis of the Real-Time Traffic Transmission Requests Servicing. World Applied Programming, 3(9): 446–450.

Konstantinov, I., Polshchykov, K., Lazarev, S. and Polshchykova, O., 2016. The Usage of the Mobile Ad-Hoc Networks in the Construction Industry. Proceedings of the 10th International Conference on Application of Information and Communication Technologies (AICT), pp. 455–457.

Rvachova, N., G. Sokol, K. Polschykov and J. Davies, 2015. Selecting the intersegment interval for TCP in Telecomms networks using fuzzy inference system. Proceedings of the Sixth International Conference "2015 Internet Technologies and Applications (ITA)", pp: 256-260.

Konstantinov, I., Polshchykov K. and Lazarev, S., 2017. The Algorithm for Neuro-Fuzzy Controlling the Intensity of Retransmission in a Mobile Ad-Hoc Network. International Journal of Applied Mathematics and Statistics, 56(2): 85–90.

Polschykov, K., 2012. Functional model of data flows intensity control in the mobile radio network of the special setting. Scientific Herald of the DSEA, 1: 127–135.

Konstantinov, I., Lazarev, S., Polshchykov, K. and Mihalev O., 2015. Theoretical aspects of evaluation of the corporative portal network traffic management. International Journal of Applied Engineering Research, 10(24): 45691–45696.

Polshchykov, K., Zdorenko, Y. And Masesov, M., 2015. Neuro-Fuzzy System for Prediction of Telecommunication Channel Load. Proceedings of the Second International Scientific-Practical Conference "Problems of Infocommunications Science and Technology (PIC S&T)", pp. 33–34.

Awduche, D., Berger, L., Li, T., Srinivasan, V. and Swallow, G., 2001. RSVP-TE: Extensions to RSVP for LSP Tunnels. RFC 3209.

Polschykov, K., Olexij, S. and Rvachova, N., 2010. The Methodology of Modeling Available for Data Traffic Bandwidth Telecommunications Network," Proceedings of the X

International Conference “Modern Problems of Radio Engineering, Telecommunications and Computer Science (TCSET)”, p: 158.

Konstantinov, I., Lazarev, S. and Polshchikov, K., 2015. Simulation model of information flows transmission in mobile ad-hoc network for special purpose. Belgorod State University Scientific Bulletin, 13: 156–163.

Polshchykov, K., 2013. Synthesis of neuro-fuzzy systems of data flows intensity control in mobile ad-hoc network. Proceedings of the 23rd International Crimean Conference “Microwave and Telecommunication Technology (CriMiCo)”, pp. 517–518.

Konstantinov, I., Polshchykov, K., Lazarev, S. and Polshchykova, O., 2017. Model of Neuro-Fuzzy Prediction of Confirmation Timeout in a Mobile Ad Hoc Network. CEUR Workshop Proceedings. Mathematical and Information Technologies, 1839: 174–186.

How to cite this article:
Polshchykov K O, Lazarev S A, Zdorovtsov A D. Limitary request queue choice mathematical model for the real time streams transfer by means of the mobile ad hoc network radio channel. J. Fundam. Appl. Sci., 2017, *9(7S), 1317-1327.*