Justification for the decision on loading channels of the network of geoecological monitoring of resources of the agroindustrial complex

K. Polshchykov [1], A. H. T. Shabeeb [2], S. Lazarev [3], V. Kiselev [4]
[1,3,4] Belgorod State University, Belgorod, 308015, Pobedy st. 85, Russia
[2] Lacture in Ministry of education , Vocational Education, Iraq

ABSTRACT

The article is devoted to solving an urgent scientific and technical problem. It consists of developing an algorithm. This is used for estimating the recommended buffer size of requests of transmitting data streams. So, this has been done in a flying self-organizing network. Therefore, it is used to ensure geoecological monitoring of the resources of the agro-industrial complex. However, Studies have shown that to ensure the required quality of data streams transmission. Thus, it is advisable to carry out preliminary reservation of channel performance. Hence, it is possible to increase the likelihood of servicing requests of the transmission of data streams, as well as to increase the load of network channels by buffering incoming requests of the transmission of data streams. So, the developed algorithm makes it possible to substantiate the decision-making to increase the channel load and ensure an acceptable delay in the start of data streams transmission. Therefore, it has been done in a flying self-organizing network. Hence, the studies carried out the correctness of the algorithm and the expediency of its application. However, in practice the process of tuning the channels of a flying self-organizing network has been carried.

Keywords: geoecological monitoring, agro-industrial complex, flying self-organizing network, transmission of data streams, loading of wireless channels.

Corresponding Author:
K. Polshchykov
Belgorod State University, Belgorod
Pobedy st. 85, Russia
Email: polshchikov@bsu.edu.ru

1. Introduction

Geoecological monitoring of the resources of the agro-industrial complex have been provided in some areas that have a strong influence of natural, man-made and anthropogenic factors . It is an urgent task. So,the most problematic is the monitoring of zones of non-centralized water that has been used in conditions of the negative impact of exogenous karst processes [1-6].

In order to ensure geoecological monitoring in such difficult conditions, a flying self-organizing network (Flying Ad-hoc NETwork, FANET) can be used [7-9]. Therefore, in which unmanned aerial vehicles and ground control points function as data transmission nodes. Also, the need to use unmanned aerial vehicles is due to the large size of the controlled territories.

To improve the efficiency of information exchange in FANET. Therefore, an increase in the load of network channels is required. This is achieved by buffering incoming requests of the transmission of data streams. So, providing an acceptable delay in the start of data streams transmission is possible and based on the implementation of the correct choice of the buffer size for the queue of requests arriving in the network [8].

The purpose of the article is to develop an algorithm for estimating the recommended buffer size. So, for the queue of requests transmitting data streams to FANET. It allows you to justify decisions to increase the channel load and ensure an acceptable delay in the start of data streams transmission during geoecological monitoring.

2. Method

The dynamic nature of the network topology should be taken into account in the decisions to increase the channel utilization and to ensure an acceptable delay in the start of transmission of data streams to the FANET [9,11]. For this purpose, we will introduce the concepts of main and additional data streams in relation to a specific channel [12]. The main data streams will include the set of streams that would be transmitted over the channel under consideration when the network topology did not change over time. Due to a change in the network topology. Therefore, the channel as well as the main ones, can also transmit additional data streams. In addition, some of the main streams may not be transmitted over the channel under consideration. Hence, the transmission of certain main and additional streams may stop prematurely.

The following values are set:

T_{req} is admissible average delay of the start of data streams transmission.

K is the maximum number of wireless channels that can be used to transmit the data stream. λ_{base} is the intensity of incoming requests for the transmission of the main data streams.

λ_{add} is the intensity of incoming requests for the transmission of additional data streams.

q_{base} is the probability of absence of requests for transmission of the main data streams due to changes in the network topology.

p_{prem} is the likelihood of premature termination of the data flow due to changes in the network topology.

τ_{req} is the average required duration of data stream transmission in FANET.

R is wireless channel performance that is required for high-quality transmission of one data stream.

n is the maximum number of data streams that can be simultaneously transmitted over a wireless channel with the required quality.

Y is the maximum number that limits the length of the request queue of transmitting data streams over a wireless channel.

It is necessary to develop an algorithm for obtaining the value $m \in [1, 2, \ldots, Y]$. So,the number that should limit the queue length of requests for transmitting data streams will be over FANET channels. Therefore, in order to maximize the load on these channels C_{ut}, the delays in the start of data streams transmission in the network did not exceed the allowable value T_{req}. So, the value m corresponds to the size of the buffer allocated for the queue of requests of transmission of data streams over FANET channels.

Materials and Methods In order to create an algorithm for estimating the recommended buffer size of the queue of requests for transmitting data streams. Therefore, the following models have been developed:

A model of the functioning of wireless channels during transmitting of data streams, which makes it possible to estimate the average channel load [13].

A Model for buffering requests for the transmission of data streams, which makes it possible to estimate the waiting time for the start of transmission of data streams over FANET channels [10-14].

3. Results and discussion

The average utilization of the wireless channel can be calculated by using the formula:

$$C_{ut} = R\overline{n}, \qquad (1)$$

Where $\overline{n}$ - is the average number of data streams simultaneously transmitted over the wireless channel.

So,the value $\overline{n}$ can be obtained by the formula for calculating the average number of occupied servicing devices in the M / M / n / m system under the condition $n > \lambda\tau$ (Baccelli F.,2003).

$$\overline{n} = n - p_0 \sum_{k=0}^{n} \frac{(n-k)(\lambda\tau)^k}{k!} \quad (2)$$

Where p_0 - is the probability that no data stream is transmitted over the FANET channel. Therefore, all service
devices in the M / M / n / m system are free.

Also, the value p_0 can be calculated by using the expression [15].

$$p_0 = \frac{1}{\sum_{k=0}^{n} \frac{(\lambda\tau)^k}{k!} + \frac{(\lambda\tau)^n}{n!} \sum_{u=1}^{m} \left(\frac{\lambda\tau}{n}\right)^u} \quad (3)$$

However, the dynamism of the FANET topology is important.So, the following expression can be used to calculate the intensity of requests for the transmission of data streams over a wireless channel:

$$\lambda = (1 - q_{base})\lambda_{base} + \lambda_{add} \quad (4)$$

Hence, the average duration of a data stream transmission in FANET can be calculated by the formula:

$$\tau = \tau_{req}(1 - p_{prem}) \quad (5)$$

Therefore, by using expressions (1) - (5). So, the computational experiments have been carried out .It has shown that in order to increase the load of wireless channels. Hence, the length of the queue of requests for transmission of data streams should be increased. To find out what values it is advisable to increase the length of this queue. Therefore, a model has been developed for estimating the waiting time for the start of data streams transmission over FANET channels.

In order to obtain an expression for calculating the value T_{del} Therefore ,the average delay in the start of data flow transmission in the FANET. However, it occurs due to the presence of queues of requests for transmission of streams over wireless network channels. Also, the model can be applied to calculate the average waiting time for the start of servicing requests in the M / M / n / system m [15]. By taking into account the possible delay in the start of the data stream of transmission in all K channels that can be used to establish a wireless connection. So, we obtain the formula for the calculation T_{del} under the condition $n > \lambda\tau$:

$$T_{del} = \frac{K\pi}{\frac{n}{\tau} - \lambda}, \quad (6)$$

where π is the probability that n data streams are simultaneously transmitted over the FANET channel. Therefore
,all service devices in the M / M / n / m system are busy.
Then ,the value of π can be calculated using the expression [15].

$$\pi = p_0 \frac{(\lambda\tau)^n}{n!} \sum_{k=n}^{n+m} \left(\frac{\lambda\tau}{n}\right)^{k-n}. \quad (7)$$

Expressions (6) and (7) were used in computational experiments. In the course of experiments, it was found that with an increase in the length of the queue of requests for transmission of data streams over wireless channels. So, the average delay in the beginning of transmission of data streams in FANET also increases. An increasing in the value T_{del} that is undesirable .However, a significant delay in the time of exchange of important information
reduces its relevance and increases the risks of non-fulfilment of certain specific management tasks. In this regard,
it is advisable to limit the value T_{del} to a certain permissible value T_{req} that minimizes these risks.

So, to obtain such a value of m at any the greatest value is achieved C_{ut}, but at the same time .So, the average
delay in the start of data streams transmission does not exceed the allowable value T_{req} .However, an algorithm
was developed, the block diagram as shown in Figure 1. So, the algorithm prescribes the 10 steps below.

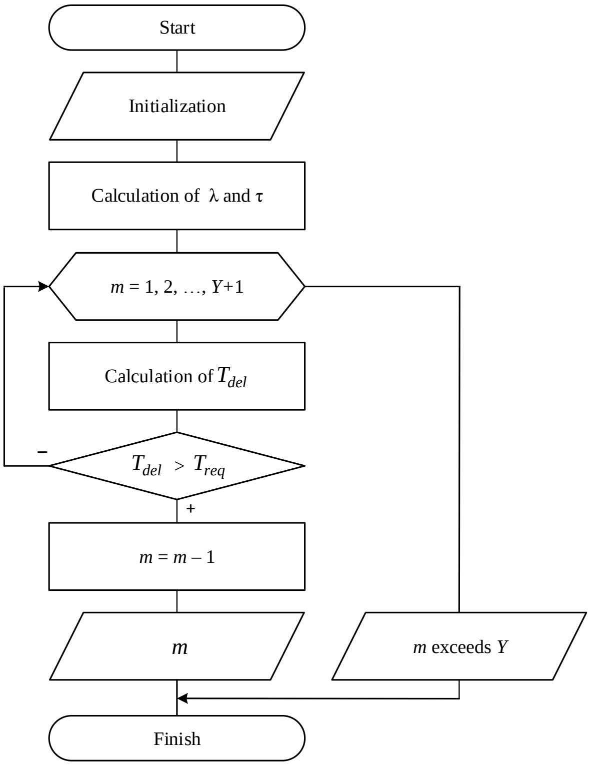

Figure 1. Block diagram of the algorithm for evaluating the recommended values m

Step 1. Initialization is performed (input of initial data and initial values of the values): the values n, K, T_{req}, λ_{base}, λ_{add}, q_{base}, p_{prem}, τ_{req}, R, Y are set and the initial value of the value is set T_{del}.

Step 2. By formulas (4) and (5) the values and are calculated λ and τ.

Step 3. The first time you execute step 3, the value m is assigned the value 1. Each time you repeat step 3, the value m is increased by 1. If m> Y, you go to step 8.

Step 4. The value T_{del} is calculated by formulas (6) and (7).

Step 5. The condition is checked:

$$Tdel \le Treq. \quad (8)$$

Hence,if this condition is met. So, the transition to step 3 is carried out. Otherwise step 6 will be carried out .

Step 6. The current value m is decreased by 1.

Step 7. Data is output that the length of the request queue for transmitting data streams over FANET channels should not exceed the number m . End of the algorithm.

Step 8. Data is output that the length of the request queue for transmitting data streams over FANET channels must exceed the number Y. End of the algorithm.

Thus, as a result of the execution of the algorithm. Therefore, the data on the recommended number is returned. Hence, it limits the length of the queue of requests for transmission of data streams over FANET channels.
In accordance with the algorithm presented above, the computational experiments were carried out to estimate the recommended number of m .So, during the experiments, the initial data presented in Table 1 were used.

Table 1. Initial data for the study of the dependence of the average load of the wireless channel on the value *m*

The quantities	The values	Units
n	15	-
K	10	-
T_{req}	0,01	Hour
λ_{base}	450	Hour $^{-1}$
$\boldsymbol{R}$	88	Hour $^{-1}$
p_{prem}	0,12	-
τ_{req}	0,08	-
τ_{req}	0,025	Hour
R	64	Kbps
m	1, 2, …8	-

For example, table 2 shows the results of one of these experiments.

Table 2. Results of a computational experiment to estimate the recommended number *m*

The quantities	The values	Units
λ	484	Hour $^{-1}$
τ	0,023	Hour
m	4	-

So, experimental studies have shown that the result of the implementation of the proposed algorithm for given initial parameters. Also, data will be obtained that no more than 4 requests should be in the queue for transmitting data streams over FANET channels. However, calculations are carried out according to formulas (1)-(7). Therefore, they indicate that at m = 4.So, the load of network channels increases by 4.84% compared

to the option when FANET does not provide for buffering of incoming requests of transmission of voice streams.
Therefore, execution of the developed algorithm with different initial data corresponding to the real conditions of FANET operation showed that the recommended values m are in the range from 2 to 6. It was found that the channel loading can be increased by an amount from 4.2% to 6.3%. Thus, the studies carried out confirm the correctness of the algorithm and indicate the feasibility of its application. So, in practice in the process of tuning FANET channels.

4. Conclusion

The presented studies are focused on providing geoecological monitoring of the resources of the agro-industrial complex, which are based on the use of FANET. Therefore, the analysis of audio communication processes in FANET showed that to ensure the required quality of data streams transmission. So, it is advisable to carry out preliminary reservation of channel performance. At the same time, it is possible to increase the probability of servicing requests for the transmission of data streams, as well as to increase the load of network channels by buffering incoming requests for the transmission of data streams. Hence, providing an acceptable delay in the start of data streams transmission over FANET channels is possible and based on the implementation of the correct choice of the buffer size for the queue of corresponding requests.
A model of the functioning of wireless channels for packet transmission of data streams has been developed. Therefore, the dynamism of the network topology is important. So, application of the model makes it possible to estimate the average channel load by depending on the buffer size of the queue of requests for transferring data streams to FANET.
Therefore, an algorithm for estimating the recommended buffer size of the queue of requests for the transmission of data streams has been created. So, it allows to justify the decision-making to increase the channel load and ensure an acceptable delay in the start of data streams transmission to FANET.

Acknowledgements

The theory was prepared within the framework of the state task of the Russian Federation FZWG-2020-0029 "Development of theoretical foundations for building information and analytical support for telecommunications systems for geoecological monitoring of natural resources in agriculture”. However, a model of buffering requests for data streams transmission has been developed to this purpose. Therefore, the peculiarities of packet data transmission over FANET channels are important to save. Also, application of the model makes it possible to estimate the average delay in the start of data streams transmission depending on the length of the queue of the corresponding requests. So, this is very necessary to enhance the results that we need in communication systems. Moreover, the build of data or information successfully with suitable channels make the communication system able to work strongly under difficult situations in different fields such as agriculture. Therefore, agriculture considers one of the most important factors in the economy of countries. Therefore, telecommunications systems for geoecological monitoring of natural resources in countries will help them to develop them to the rich future.

References

[1] Vasilyev G.S., Kuzichkin O.R., Grecheneva A.V., Dorofeev N.V., Surzhik D.I. . "Analysis of the combined transfer functions for geotechnical control". International Multidisciplinary Scientific GeoConference SGEM, 2: 43-50,2018.

[2] Kuzichkin O.R., Romanov R.V., Dorofeev N.V., Grecheneva A.V. "Organization and application of information and analytical support for geological monitoring of water use." //OAB Journal 11.1: 20-26,2020.

[3] Romanov R.V., Kuzichkin O.R., Vasiliev G.S., Mikhaleva E.S."The use of the geoelectric method of the express control during the geoecological monitoring of the decentralized water supply."International Multi-Conference on Industrial Engineering and Modern Technologies, (FarEastCon).IEEE, 8934213, 2019.

[4] Vasilyev G.S., Kuzichkin O.R., Romanov R.V., Dorofeev N.V., Grecheneva A.V. "The practice of using a multi-pole electrical installation for monitoring the coastal zone of karst lakes." International Multidisciplinary Scientific GeoConference: SGEM. P. 727,2018.

[5] Radley S., Sybi C.J., Premkumar K."Multi Information Amount Movement Aware- Routing in FANET: Flying Ad-hoc Networks."Mobile Networks Applications, 25: 596–608,2020.

[6] Namdev M., Goyal S., Agarwal R."An Optimized Communication Scheme for Energy Efficient and Secure Flying Ad-hoc Network (FANET)." Wireless Personal Communications, 82,2021.

[7] Khan U., Qureshi I.M., Aziz M.A., Cheema T.A., Shah S. B. H."Smart IoT Control-Based Nature Inspired Energy Efficient Routing Protocol for Flying Ad Hoc Network (FANET)." IEEE Access, 8: 56371-56378,2020.

[8] Konstantinov I., Polshchykov K., Lazarev S., Polshchykova O."Mathematical Model of Message Delivery in a Mobile Ad Hoc Network." Proceedings of the 11th International Conference on Application of Information and Communication Technologies (AICT). Moscow, PP. 10-13,2017.

[9] Konstantinov I., Polshchykov K., Lazarev S., 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: 174-186,2017.

[10] Polshchykov K., Lazarev S., Zdorovtsov A."Multimedia Messages Transmission Modeling in a Mobile Ad Hoc Network."Proceedings of the 11th International Conference on Application of Information and Communication Technologies (AICT). Moscow, PP. 24-27,2017.

[11] Polshchykov K., Shabeeb A.H.T., Lazarev S."Algorithm for receiving the recommended bandwidth of a wireless self-organizing network channel." Periodicals of Engineering and Natural Sciences, 8 (3): 1873-1879,2020.

[12] Polshchykov K.O., Lazarev S.A., Kiselev V.E., Kiseleva E.D. 2019. " Model of real-time flow packet transmission in amobile ad hoc network." Journal of Advanced Research in Dynamical and Control Systems, vol. 11, no.8, pp.2861-2864, 2019.

[13] Konstantinov I.S., Polshchykov K.O., Lazarev S.A., Zdorovtsov A.D. "Mathematical Models for Estimating Radio Channels Utilization When Transmitting Real-Time Flows in Mobile Ad Hoc Network." Journal of Fundamental and Applied Sciences, 9 (2S): 1510-1517,2017.

[14] 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." Journal of Fundamental and Applied Sciences, 9 (7S): 1317-1327,2017.

[15] Bocharov, P., D'Apice, C., Gavrilov, E. and Pechinkin, A., Product form solution for G-networks with dependent service. *RAIRO-Operations Research*, *38*(2), pp.105-119, 2004.