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IMPROVING RELIABILITY OF FANET WITH TIME RESERVATION

One of the ways to increase the reliability of FANETs − time reservation − is analyzed. An example of a mathematical model of the data collection process by the FANET shows the effectiveness of the application of this approach.

Using time redundancy is an effective way to increase the reliability of FANETs. In the case of temporal redundancy, time required to perform a technical task is longer than the minimum required [1]. In this case, there are two possible options for using FANET nodes:

- when the received data is considered lost in the event of a failure;
- when real-time data transfer is performed.

Let us consider the first variant in more detail. Assume a node failure leads to the loss of data accumulated by it until the moment of a failure. In this case, the data will still be transmitted in full amount, if, after the failure, the recovery of the node will take place, and the remaining time will be sufficient to start the collection of data from the beginning, and complete it at the set time. At the same time, it is possible to assume the occurrence of several failures. After each of them, the node is restored and each time the data collection starts from the beginning, and this will be continued until the data collection is fully executed or the resource is exhausted.

As the characteristics of the reliability of a FANET node with time redundancy, it is advisable to choose the following:

- the probability $P(t, V)$ of performing data collection in the amount of V at the given time t;
- the average time $T_{t,V}$, which is used to collect V data at a given time interval t.

For a better understanding of the foregoing, let us consider the definition of these characteristics in the following example. Assume the data to be collected by the FANET is measured by the amount of V.

Verifying the functionality of the FANET node is performed at the end of the data acquisition time interval [2]. If the first check determines the absence of a failure, then the operation is considered to be successfully completed. Otherwise, the node is restored (for simplicity we will assume that it is performed instantly and with the probability $P(0)=1$), and data collection starts from the beginning, after which a second check is performed, etc.

According to this data collection mode, the following distribution (Table 1) can be built.

Table 1 – Received distribution row

t_i	V	$2V$	...	nV
P_i	p	$(1-p)p$	...	$(1-p)^{n-1}p$

where t_i denotes possible values of the time of the data collection process ($i = 1,2,...,n$);

P_i is the probability of execution of data collection process in time t_i;

$P=P(V)$ is the probability of a node failure during the time interval V.

Since data collection can be performed during the time V, or during $2V$ etc., and events $t_p=t_i$ (t_p is random time of the data collection process) are inconsistent, then, using the addition theorem of probability, we obtain:

$$P(t,V)=p+(1-p)p+...+(1-p)^{n-1}p.$$

Using the formula for the sum of geometric progression, we finally obtain:

$$P(t,V)=1-(1-p)^n.$$

Here it should be emphasized that the result obtained coincides with the formula for the loaded (n-1)-fold reserve. However, in this case, the necessary reliability is ensured by no additional inclusion of the backup nodes of the FANET, and due to the allocation of additional time for the operation of one node.

The average time spent collecting data by the amount of V at the given time interval t can easily be determined in the form of a mathematical expectation of the random variable t_p, i.e. the random data collection time, and without the output in the final form is equal to:

$$T_{t,V} = V \bullet \frac{1-(1-p)^n(1+np)}{p}.$$

CONCLUSIONS

In this paper, it is shown that the use of time redundancy is an effective way to increase the reliability of FANETs. Directions of further research are the inclusion of calculation of an energy component during planning of FANET operation.

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