

**Introduction**

Research objective. Research of probabilistic and temporal characteristic of supply control method of data set transfer in data-exchange network (DEN) requires consideration of interconnection switching node (SN). In addition to the above, generally should be considered both the existence of several data flows from other sources and possibility of fault occurrence in operation on each of SN.

Analysis of the well-known publications. The [1] shows the possibility of data set loss on SN under conditions of spike load.

The [2] shows a model which helps to research main probabilistic and temporal characteristics of data transfer process in air traffic ACS net for fixing errors mode by receiver during data transfer through interconnection switching node without denial of service.

The [3] developed a model which helps to research main probabilistic and temporal characteristics of data transfer process in air traffic ACS net for fixing errors mode by receiver with the additional information flow from another sources and switching node problems.

**Purpose of the article.** Analysis of possible switching node influence in air traffic ACS net on the main probabilistic and temporal characteristics of data transfer process in the fixing errors mode by receiver.

**Main material**

Message passing through interconnection SN with checking data sets by receiver and reconstruction of lost or distorted data sets (with encountered error) with the help of retries is considered.

The source gives a message length in $M$ bit which divides into $m$ bit data sets with information part. The total number of data sets generated from the message is $M/m$. Each data set is accompanied by $k_v$ service bit and $r$ check bit. The total length of the generated data set is $n = m + k_v + r$.

Assume that each of the switching nodes, number of which is denoted by $\beta$, in the case of an overflow of input buffers possible denial of service, i.e. data set loss probability $P_{\text{emp}}$.

The duration of the retransmission time-out is proportional to the data set delivery time:

$$T_{TA} = n T_a.$$  

Based on the obtained in the [3] for the calculation formulas of the constraints it may be affirmed that loss of data set on switching node does not affect the accuracy of the transferred data inasmuch as such data sets are retransferred. Thus, possible denial of service on the switching nodes changes the time characteristics of the data transfer process.

The timing based on the obtained in [3] for the calculation formulas of the constraints and analyse the effect of possible losses at switching nodes of the data transfer should be analysed.

According to the nature of distribution, there are two types of errors [4]: uncorrelated, correlated.

**Error model.** It is known that errors in real computer networks (CN) can arise in groups (data sets). Therefore, the evaluation of the pulse-frequency characteristic on the basis of uncorrelated errors can be used for approximate calculations, since it has an approximate character [5].

For a channel with uncorrelated errors, the simplest error model (the Poisson model) is often used. Its properties of computer networks as a source of error are given probability of error in the unit cell codeword – $P_m$. In this case, all errors are considered to be independent. Let the probability of distortion of a single data element in CN is. Then the probability of a correct combination with $n$ elements:

$$P_{pr} = (1 - P_m)^n.$$  

If the properties of error-correcting code applied unknown proportion not found error depends on the
number of parity bits $r$ [9]. The probability of not detecting an error is defined as:

$$P_{no} = \left(1 - (1 - P_{pr})^r\right) \cdot 2^{-r}. \quad (2)$$

**Analysis of time characteristics.** Based on the calculation formulas obtained in [7] for the accepted restrictions, it can be asserted that the loss of packets on the switching nodes does not affect the reliability of the transmitted data, since such packets are retransmitted. Thus, possible failures in the service at the switching node change the time characteristics of the data transfer process.

The time characteristics based on the calculation formulas obtained in [4] for the adopted constraints and the effect of possible losses on the switching nodes on the data transfer process should be analysed:

$$r = 8 \quad i \quad k_a = 8.$$ 

**Fig. 1.** Dependence of the relative average message delivery time on the data set length for:

- $1 - P_n = 10^{-4}, B_{awp}^{BK} = 0; 2 - P_n = 10^{-4}, B_{awp}^{BK} = 10^{-2}; 3 - P_n = 10^{-3}, B_{awp}^{BK} = 0; 4 - P_n = 10^{-3}, B_{awp}^{BK} = 10^{-2}$

- $M = 1000; \eta = 3; \beta = 2$

**Fig. 2.** Dependence of the relative average time of delivery of messages on the probability of distortion of a single element in a computer network when:

- $1 - m = 200, B_{awp}^{BK} = 0; 2 - m = 200, B_{awp}^{BK} = 10^{-2}; 3 - m = 200, B_{awp}^{BK} = 10^{-5}; 4 - m = 500, B_{awp}^{BK} = 0$
The increase in the probability of packet loss at switching nodes leads to an earlier increase in the relative average time of message delivery with a greater number of switching nodes along the route of the packet (Fig. 3).

This statement more evident from the graph, the relative ratio of the average time of delivery if there is loss at the switching nodes relative to the average delivery time without loss of switching nodes (Fig. 4).

In addition, a significant increase in the probability of service failures at intermediate switching nodes leads to a sharp increase in the relative average packet delivery time [6].

**Conclusion**

The analysis of discard probability impact at interconnection switching nodes on temporary characteristics of data transfer process suggests that the increase of this probability leads to the increase of average time of massage delivery for a wide parameters range. Moreover, the impact of data sets loss at switching nodes is inherent for networks with a large number of retransmitting nodes. Special attention should be paid to the fact that even using high quality data lines (with small values of error probability of single element) the loss of data sets at switching nodes can lead to complete termination of information exchange.
Оценка влияния отказов обработки пакетов на временные характеристики процесса обработки данных в межсетях АСУ воздушным движением

С. О. Оберемок, Ю. С. Долгин, С. И. Хмелевский, С. О. Рудь

При передаче информации в сетях автоматизированных систем управления воздушным движением высокая вероятность возникновения долговременных пиковых нагрузок. Целью является проведение анализа влияния возможных отказов на узлах коммутации на основные временные характеристики процесса передачи данных, в режиме обнаружения ошибок получателем. Показано, что увеличение вероятности потери пакетов на промежуточных узлах коммутации приводит к росту относительного среднего времени доставки сообщений для широкого диапазона параметров. Методом является проведение анализа влияния возможных отказов на узлах коммутации на основные временные характеристики процесса передачи данных, в режиме обнаружения ошибок получателем. Показано, что увеличение вероятности потери пакетов на промежуточных узлах коммутации приводит к росту относительного среднего времени доставки сообщений для широкого диапазона параметров.

Ключевые слова: передача данных; узел коммутации; вероятностно-временные характеристики; АСУ воздушным движением; пакет данных; тайм-аут; корреляция; выявление ошибок.

Оценка влияния отказов обработки пакетов на временные характеристики процесса обработки данных в межсетях АСУ воздушным движением

С. А. Оберемок, Ю. С. Долгин, С. И. Хмелевский, С. А. Рудь

При передаче информации в сетях автоматизированных систем управления воздушным движением высокая вероятность возникновения долговременных пиковых нагрузок. Целью является проведение анализа влияния возможных отказов на узлах коммутации на основные временные характеристики процесса передачи данных, в режиме обнаружения ошибок получателем. Показано, что увеличение вероятности потери пакетов на промежуточных узлах коммутации приводит к росту относительного среднего времени доставки сообщений для широкого диапазона параметров. Методом является проведение анализа влияния возможных отказов на узлах коммутации на основные временные характеристики процесса передачи данных, в режиме обнаружения ошибок получателем. Показано, что увеличение вероятности потери пакетов на промежуточных узлах коммутации приводит к росту относительного среднего времени доставки сообщений для широкого диапазона параметров.

Ключевые слова: передача данных; узел коммутации; вероятностно-временные характеристики; АСУ воздушным движением; пакет данных; тайм-аут; корреляция; выявление ошибок.