Assessment of The Memory Buffer Size in NGN Networks when Transferring Different Traffic Types

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Abstract

The matters are considered related to Poisson distribution- based voice transferred using IP packets, as well related to the assessment of the memory buffer size in NGN networks when transferring self-similar traffics. In order to assess the memory buffer size in these networks, the approaches are proposed based on Poisson distribution- based voice, as well corresponding one- channel classic mass service systems of M/M/1 and M/D/1 types reflecting exponential and deterministic distribution laws of the service time of self- similar traffics.

Keywords: NGN networks, voice traffic, self-similar traffic, memory buffer, memory buffer size, one- channel classic mass service systems.

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Müxtəlif növ trafiklərin ötürülməsi zamanı NGN şəbəkələrində yaddaş buferinin həcminin qiymətləndirilməsi

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Xülasə

IP paketləri ilə ötürülən Puasson paylanmasına əsaslanan nitq və eləcə də özünə bənzər trafiklərin ötürülməsi zamanı NGN şəbəkələrində yaddaş buferinin həcminin qiymətləndirilməsi məsələsinə baxılmışdır. Bu şəbəkələrdə yaddaş buferinin həcminin qiymətləndirilməsi üçün Puasson paylanmasına əsaslanan nitq, eləcə də özünə bənzər trafiklərin xidmət vaxtlarının eksponensial və deterministik paylanma qanunlarını özündə əks etdirən uyğun bir kanallı M/M/1 və M/D/1 növ klassik kütləvi xidmət sistemləri əsasında yanaşmalar təklif edilmişdir.

Açar sözlər: NGN şəbəkələri, nitq trafiki, özünə bənzər trafik, yaddaş buferi, yaddaş buferinin həcmi, bir kanallı klassik kütləvi xidmət sistemləri.

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Оценка объема буфера памяти в сетях NGN при передаче различных типов трафика

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Аннотация

Рассмотрен вопрос оценки объема буфера памяти в сетях NGN при передаче речи, основанная на распределения Пуассона, а также самоподобного трафиков, передаваемые IP-пакетами. Для оценки объема буфера памяти в этих сетях, предложены подходы на основе классических одноканальных системах массового обслуживания типа M/M/1 и M/D/1c соответствующими экспоненциальными и детерминированными законами распределения времен обслуживания.

Ключевые слова: сети NGN, речевой трафик, самоподобный трафик,буфер памяти, объем буфера памяти, одноканальные классические системы массового обслуживания.

Introduction

New generation networks are universal multiservice networks that transfer infinitely many information (voice, data, video and multimedia, etc.) based on NGN packet commutation. This information creates the information flows in the networks. These information flows circulating on NGN networks are characterized by non-homogeneity and non-stationarity [1]. All the information flows exchange falling to the share of the network entry are implemented in the form of IP packets. The traffic transferred by IP packets is characterized by rate of fall (packet/ sec.), average length of the packet (bit, byte), interpacket time gap, traffic intensity (bit/ sec.), lost packets percentage and accidentally accepted packets percentage. We can conveniently classify the traffics transferred on NGN networks with the packet commutation into two groups [2]:

- Poisson distribution- based voice traffic created using IoT device.
- combined traffic with self- similar feature.

Poisson distribution- based voice traffic is characterized by ripple factor, high latency sensitivity, as well low information loss sensitivity. This traffic includes the signs of stationarity, simplicity and post- impact signs [2].

A stationarity sign indicates that the probability characteristics do not depend on the time. It does not depend for these flows on the probability on the falling of certain incidents on the time gap with the length t, as well selection of their benchmark.

A simplicity sign demonstrates the probability of falling two or more incidents on infinitely many short time gap.

Post- impact sign demonstrates that the voice information, falling on the networks entry, fall on this entry not depending of each other.

These features show that the distribution of interpacket gaps in the voice traffic is subject to exponential law, and the packets flow is subject to Poisson distribution. Therefore, the nature of the network traffic had been considered for a long time to be consistent with the Poisson process, and it was modelled in accordance with the Poisson model.

However, as multiservice networks with new packet commutation were created based on modern technologies as time went on, there was the need for the clarification of the nature of the network traffic. This matter was successfully solved by the scientists from leading Universities and Research centres all over the world. Main purpose of the researches was to develop models that characterize the characteristics of network traffic.

The network traffic was widely studied in Boston University, University of Berkeley, University of North Carolina, as well in some Western research and educational institutions. The most interesting work in this field is the research conducted by the of Boston University staff - Mark Crovella and Azer Bestavros [3]. These researches demonstrated that the packets circulating on new networks types fall on its nodes not separately, but as a whole set and are of the leap nature. Thus, based on the results obtained from the measurement of the features of real network resources, these studies proved that the network traffic has self- similar feature. For this purpose, taking into consideration self-similar features of the traffic, it was necessary to review developed network models for different networks using real data. The reviews were implemented both in local and in global networks. During this process, many interesting questions arose related to the formation of the traffic with self- similar feature. The explanation for these questions was given in more detail in the researches conducted by Mark Crovella and Azer Bestavros.

For the first time, high- precision study of the network traffic was conducted by Leland and Daniel Wilson in Ethernet local networks based on hundreds of millions of the packets [3]. These studies proved that the traffic in Ethernet local networks has self- similar feature. Main point was the demonstration of the fact that it was not always possible to model self- similar traffic through Poisson process used in the teletraffic theory.

The fact that the network traffic has self- similar feature was determined also by a number of the scientists studied Ethernet traffic in Bellcore network, such as W. Leland, M. Taqqu, W. Willinger, D. Wilson [3]. It is also was revealed that computational methods based on Markov models and Erlang formulas, which were successfully used in the designing of the telephone networks, lead to unreasonable optimistic solutions for the computer networks and incorrect assessment of the load.

Another one research conducted in this field is the study of Asterisk network traffic by J.A. Taradayev and K.A. Bokhan [3]. Asterisk VoIP telephony server traffic was studied in this research. Main point of the research was determining self- similar feature of the traffic. In order to do it, statistical processing of the data was implemented on selected server using a number of the methods. As a result of the research conducted it was determined based on Hurst exponent that Asterisk network traffic has self- similar feature. Nowadays, the network modelling is successfully implemented taking into consideration self- similar feature of the traffic.

Self- similar feature of the traffic is associated with one of the types of fractal processes, i.e., with the fact that when the scale changes, the correlation structure of self- similar process remains unchanged. Fractality is a feature specific to self- similar processes. Fractal is mathematical structure of any part similar to the whole. Fractal concept was first introduced by Franco-American mathematician Benua Mandelbrot [4]. From mathematical point of view, fractal has fractional (incomplete) value. One of main features of the fractal is its self-similarity, i.e., invariance, in other words, scale invariance. In comparison with purely random process, self- similar process seems less smooth, i.e., more unequal, in other words, has greater dispersion [4]. In such a case, important problems have emerged such as conducting perfect analysis of self- similar processes and developing the algorithms for the synthesis of the network traffic reflecting main features of these processes.

There is a number of such the algorithms nowadays. Thanks to the use of these algorithms, the transmission capacity of main channels of the networks is used relatively economically. When submitting the information flows from different sources on one main channel the frequency band of this channel is allocated to each of the sources by statical or statistical submission method. In such a case, unlike static multiplexing on the frequency band of main channels of the networks, the benefit is obtained equal to certain band during statistical multiplexing. In most cases when analysing self-similar feature of the network traffic statistical multiplexing algorithm is widely used [4].

Experimental studies [5-9] show that the self- similarity of the traffic is formed due to the distribution of the size of transferred document on the network, caching effect, the setting of the users on the file submission, human factor, superposition of variety of the communications in the network, as well combination of many isolated information sources. In addition, self-similar traffic is able to be formed in the network due to the user behaviour, network scaling and reconfiguration, as well autocorrelation in non- Poisson traffic within different time scales. These reasons lead to serious leaps in the traffic intensity in NGN networks. It should be noted that self- similar stochastic processes theory is not as advanced as Poisson processes theory. However, in comparison with Poisson model, self- similar processes model more accurately characterizes the features of the network traffic.

Setting a problem

NGN networks designing is multi- stage process based on Poisson distribution- based speech, as well complex transfer of the traffic with self- similar features. The features of these traffics and the processes occurring when they are transferred separately have significant impact on the memory buffer size of the networks under consideration. In this regard, when designing the networks under consideration, it is necessary to assess the impact of the traffic features on their memory buffer size and to conduct their comparative analysis. Therefore, this research sets the task to assess the memory buffer size of the networks under consideration when transferring Poisson distribution- based voice, as well self- similar inbound traffic and analysing the results obtained. Such the problems are usually solved using mathematical devices such as one- channel classic mass service systems [10-12]. Therefore, in order to assess the memory buffer size in the networks under consideration in this research, Poisson distribution- based voice, as well corresponding one- channel classic mass service systems of M/M/1 and M/D/1 types reflecting the distribution laws of the service time of self- similar traffics were used.

Research objective

Assessing the memory buffer size in MGN networks based on Poisson distribution- based voice, as well corresponding one- channel classic mass service systems of M/M/1 and M/D/1 types reflecting exponential (M type) and deterministic (D type) distribution laws of the service time of self- similar traffics, as well conducting comparative analysis of the results obtained.

Solution of the problem

The memory buffer sizeq_{buf} was assessed based on the method demonstrated in [11]. Based on this method, the memory buffer size of NGN networks is determined as follows, taking into consideration the Hurst exponent characterizing the degree of self -similarity of the traffic:

$$q_{buf} = \rho^{1/2(1-H)}/(1\text{-}\rho)^{H/(1-H)}, \qquad (1)$$

whereat H is Hurst exponent, ρ – shows the network load.

If we solve this formula taking into consideration Hurst exponent H = 0,5, we shall get the following formula for one-channel classic mass service system of M/M/1 type reflecting the feature of Poisson distribution- based voice traffic and the distribution of the distribution of the service time based on exponential law:

$$q_{buf} = \rho(1\text{-}\rho). \qquad (2)$$

Required buffer size in one- channel classic mass service systems of M/D/1 type reflecting self- similar feature of the network traffic and deterministic service time shall be able to determined as follows:

$$q_{buf} = (\rho^{(1/(2(1-H)))}/(1\text{-}\rho)^{(H/(1-H))})\text{-}(\rho^2/2(1\text{-}\rho)^{(H/(1-H))}). \qquad (3)$$

The (3) formula is simplified for the system under consideration at Hurst exponent H = 0,5 and gets the following form:

$$q_{buf} = \rho/(1\text{-}\rho) – \rho^2/2(1\text{-}\rho). \qquad (4)$$

In order to determine required memory buffer size in NGN networks ρ = 0; 0,1; 0,2; 0,3; 0,4; 0,5; 0,6; 0,7; 0,8 and H=0,5; 0,6; 0,7; 0,8 inputs were used based on the (1) – (4)

Formulas and computing experiments were conducted Based on the results of conducted computing experiments, the graph of dependency ρ of required memory buffer size on q_{buf} network load was built (Fig.) and comparative analysis of obtained results was conducted based on this graph.

Conclusion

When ρ network load and H Hurst exponent value increases, the memory buffer size of the network in M/M/1 and M/D/1 models decreases as a whole. When the network load varies within ρ = 0 ÷ 0,6 required memory buffer size values at Hurst exponent H= 0,5, 0,6, 0,7 in M/D/1, and H = 0,5, 0,6 in M/M/1 get very close values. When the network load varies within ρ = 0 ÷ 0,1 and ρ = 0 ÷ 0,4, the memory buffer size values in the networks under consideration at corresponding values of Hurst exponent H = 0,7 and H = 0,8 coincide with the values of the memory buffer size in M/M/1 and M/D/1 models when the network load varies within ρ = 0 ÷ 0,6.

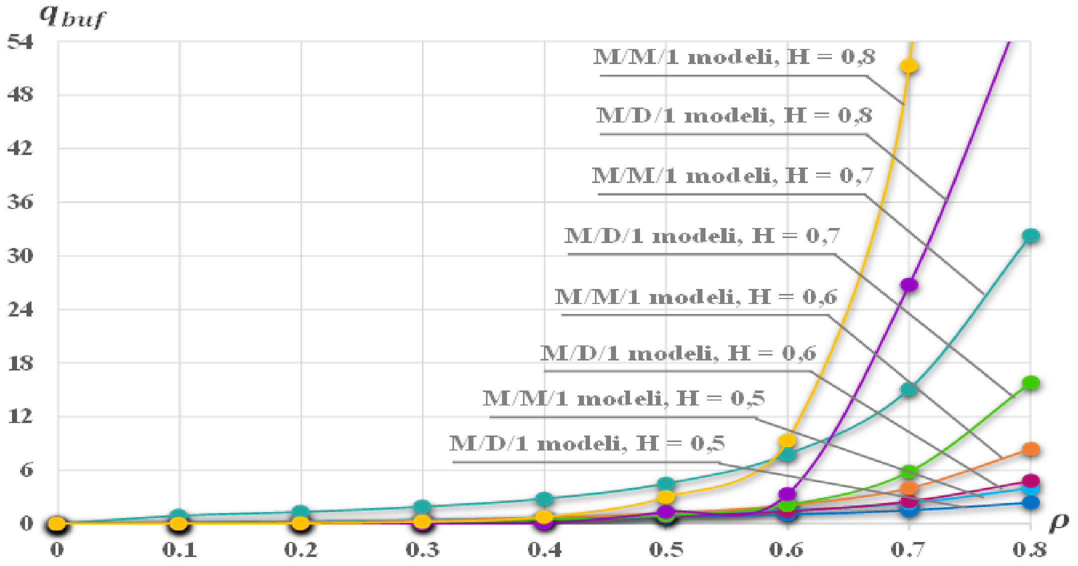

Figure – The dependency of the memory buffer size in NGN networks on the network load

Comparative analysis was conducted of required memory buffer size of the networks in M/M/1 and M/D/1 models at Hurst exponent H = 0, 5 when the network load varied within ρ = 0 ÷0,8 . In such a case, it was registered that, the memory buffer size of the network in M/M/1 model had been increased in average by 22.4% in comparison with M/D/1 model.

Comparative analysis was conducted of required memory buffer size of the networks in M/M/1 and M/D/1 models at Hurst exponent H = 0, 6; 0,7 and 0,8 when the network load varied within ρ = 0 ÷ 0,8. In such a case, it was registered that, in comparison with M/D/1 model, required memory buffer size of the network in M/M/1 model had been increased in average by 27.6%, 43.9% and 74.7% correspondingly at Hurst exponent H = 0, 6; 0,7 and 0,8.

Comparative analysis was conducted of the values obtained at H = 0,6, 0,7 and 0,8 for the memory buffer size of the networks at M/M/1 model network load ρ = 0 ÷ 0,8 and Hurst exponent H = 0,5. As a result of the analysis conducted, it was registered that, in comparison with the values obtained at H = 0,6, 0,7 and 0,8, the memory buffer size in the network at Hurst exponent H = 0,5 had been more by 73,4%, 48,9% and 25,8% correspondingly at the latest Hurst exponent values.

Comparative analysis was conducted of the values obtained at H = 0,6, 0,7 and 0,8 for the memory buffer size of the networks at M/D/1 model network load $\rho = 0 \div 0{,}8$ and Hurst exponent H = 0,5. As a result of the analysis conducted, it was registered that, in comparison with the values obtained at H = 0,6, 0,7 and 0,8, required memory buffer size in the network at Hurst exponent H = 0,5 had been more by 64,4%, 47,3% and 14,7% correspondingly at the latest Hurst exponent values.

The dependency of the memory buffer size of the network in M/M/1 and M/D/1 models on the network load was completely analysed. As a result of the analysis conducted, it was registered that while Hurst exponent values increase in these models, the buffer memory of the network rapidly increases, which is justified by the grouping of homogenous packets and increase degree of the network load by the leap in the models under consideration.

Conflict of Interests

The authors declare there is no conflict of interests related to the publication of this article.

REFERENCES

1. **Osovsky A.V., Kutuzov D.V., Stukach O.V.** Analysis of the models of the traffic generated by IoT devices. Dynamics of systems, mechanisms and machines. Omsk. 2019. Vol. 7. No. 4.-220-226. *(in English)*
2. **Siropyatov O.A., Chechelnitsky V.Y.** Comparative analysis of theoretical approaches to the traffic modelling in terms of the compliance with new generation networks. Informatics and mathematical methods in modelling. 2014. Vol. 4, No. 1. - Pp.57-67. *(in English)*
3. **Taradayev S.A., Bokhan K.A.** Analysis of the traffic self- similarity features in Asterisk network// - Kharkiv: Information processing systems, - 2012, version 2 (100), p. 222-227. *(in English)*
4. **Bitner V.I., Mikhaylova S.S.** Networks of new generation NGN. - M.: Hot Line- Telecom, 2011. - 226 p. *(in English)*
5. **Bukashkin S.A., Buranova M.A., Saprykin A.V.** Study of the statistical features of the multimedia traffic in processing in MPLS network // Radio engineering and telecommunication systems. 2016. No. 4. p. 34-41. *(in English)*
6. **Morgaylov D.D., Ladyzhensky Y.V., Moataz Y.** Modelling of self- similar inbound traffic of the processors in NS-2 system // Informatics and computer technologies - 2012. Section 3. Internet technologies, computer networks and telecommunications. 2012. p. 232-239. *(in English)*
7. **Lozhkovsky A.G.** Queuing theory in the telecommunications: textbook/ A.G. Lozhkovsky. – Odessa: ONAS named after A. S. Popov, 2012 – 112 p. *(in English)*
8. **Samoylov M.S.** Analysis of statistical characteristics of the multimedia traffic of the aggregation node in multi-service network /M.A. Buranova, V.G. Kartashevsjy, M.S. Samoylov// Radioengineering and telecommunication systems. – 2014. – No. 4. – p. 63-69. *(in English)*
9. **Tatarnikova T.M.** Statistical methods for studying the network traffic. Information and control systems, 2018, No. 5, p. 35–43. doi: 10.31799/1684-8853-2018-5-35-43. *(in English)*
10. **Melikov A.Z.** Using queuing models in multi-service wireless cellular communication networks. *HERALD of the Azerbaijan Engineering Academy*. 2009. Vol. 1. No. 1.p. 76-82. *(in English)*
11. **Odoyevsky S.M., Sorokina Y.A., Khoborova V.P.** Variants of calculation of the quality indicators of service of the information flows in the communication centres of multi-service network of military destination //Works of educational institutions of communication. 2016. Vol. 2. No 4. p. 92-99. *(in English)*
12. **Hasanov M.H.** Monitoring of fiber-optic networks. *Herald of the Azerbaijan Engineering Academy*. 2018. Vol. 10. No. 2.p. 78-83. *(in English)*