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3. INFORMATION TECHNOLOGIES, AUTOMATION AND ROBOTICS

RESEARCH OF TRAFFIC CHARACTERISTICS IN MULTISERVICE NETWORKS

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Abstract. *The purpose of this work is to study the nature of the incoming and outgoing traffic of multiservice networks for all types of service, divided into classes and subclasses.*

The object of the research is the process of researching the nature of the incoming traffic and outgoing traffic of multiservice networks by classes and subclasses of services.

The subject of this research is traffic generated by services in packet-switched networks.

Based on the analysis of existing methods, the R/S method was chosen to solve the problem of identifying the nature of traffic based on the determination of the Hurst exponent. The research data of incoming and outgoing traffic for all types of services for all studied periods, namely days of the week, months and half a year, indicate that the generated traffic is self-similar.

The data obtained as a result of the study can serve as the basis for the design of modern networks, can be used to solve an urgent problem - the development of an analytical model of the NGN service provision management system, taking into account the self-similarity of traffic, which makes it possible to determine the quality indicators of services by classes and subclasses.

Key words: *multiservice networks, classes and subclasses of services, Hurst exponent, incoming and outgoing traffic, self-similarity, R/S method.*

INTRODUCTION

Recently, there has been a progressive development of the info-communication industry, which contributes to the active implementation of various innovations. The Global Information Infrastructure (GII) is being developed as a global information network for the mass service of the planet's population based on the integration of global and regional information and telecommunication systems, as well as digital television and radio broadcasting systems, satellite systems and mobile communications. One of the most important tasks in the field of info-communications is to find ways of developing modern networks towards the networks of the future. The Next Generation Network (NGN) is a concept for building multiservice communication networks that can effectively support the entire range of existing applications and services, providing the necessary scalability and flexibility, personalization, which allows you to respond to new requirements for functionality and bandwidth. IMS (IP Multimedia Subsystem) is a software and hardware complex that is a key component of almost all next generation IP networks that support SIP telephony (Session Initiation Protocol) applications, and is designed to provide standardization of multimedia services in all interconnected networks. The design and implementation of multiservice networks must be carried out in such a way as to ensure efficient management of large amounts of information. Achieving such goals is possible only by organizing research on various factors affecting network performance. With the advent of multiservice networks such as NGN, IMS, Triple Play Services appear and, accordingly, a new type of traffic. Currently, the list of services has grown significantly, which has led to an increase in traffic generated by the services. In this regard, an urgent question arises of determining the presence of the effect of self-similarity of traffic containing requests for services [1]. Recent studies of the traffic of multiservice networks prove that it has a special fractal structure and has the property of self-similarity, stored at different time intervals. Self-similar traffic properties lead to the fact that even with a small volume of traffic, there can be sharp bursts of traffic. The main reason for the specific properties of traffic, according to many researchers, is the presence of information feedback and the use of flow control protocols. The study of the statistical properties of real traffic showed the presence of "heavy tails" of the distribution and long-term dependencies. This phenomenon is not described in the classical theory of teletraffic with Poisson and Markov distribution and can affect losses and QoS (Quality of Service) mechanisms. Taking into account the growth of services, considering the importance of the issue of determining the quality indicators of services by type - "Triple Play Services" as well as the transition to distributed management of the provision of services in IMS networks, the task of determining the properties of incoming and outgoing traffic generated by services of various classes and subclasses is certainly an urgent issue.

LITERATURE ANALYSIS

The characteristics of any technical system, the efficiency of its functioning are laid down at the design stage. The properties and viability of the future system depend on the design methods, on the adequacy of the mathematical models used in this. It is known that design errors lead to negative results and large economic losses.

With the development of multiservice networks, it becomes necessary to organize new research in this area to ensure the correct operation of the network.

Studies of traffic transmitted in telecommunication systems were carried out by such researchers as D.V. Ageev. [2], Roslyakov A.V. [3], Tsibakov B.S. [4], W. Willinger [5], Fedorov M.L. [6] and others, show that the statistical characteristics of traffic differ from those accepted in the classical theory of teletraffic [2]. In the Traffic Research based on statistical methods of analysis of the most popular social networks [7]. The analysis of the obtained data on the number of active users and the traffic volume of the studied networks was carried out. The data obtained allows us to assess the popularity of various social networks and assess their share of traffic in comparison with other Internet services. The result of the research is the proof of the self-similar properties of social network traffic. This leads to the fact that the use of traditional methods for calculating the parameters of telecommunication systems and their probabilistic-time characteristics, based on Poisson models and Erlang's formulas, gives unreasonably optimistic results, leading to an underestimation of the load. Based on the results of the research carried out, it can be argued that the use of the idea that the combination of a large number of streams from independent sources of information leads to a process described by a Poisson stream is not true. Thus, recent studies of multiservice telecommunication systems have shown that the use of models of self-similar processes makes it possible to more accurately describe the traffic transmitted in these systems.

In terms of self-similarity, it is possible to simulate network traffic, which allows you to start predicting server behavior in the future, predict loads, optimally manage server resources, get a model of server behavior in critical situations, and much more.

It should be noted that at present, the issues of determining the nature of the traffic of multiservice networks created by individual classes and subclasses of services have not been sufficiently studied, which is especially important in multiservice networks with distributed control.

OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of the research is the process of researching the nature of the incoming traffic and outgoing traffic of multiservice networks by classes and subclasses of services.

The subject of this research is traffic generated by services in packet-switched networks.

Self-similarity refers to the repeatability of the load distribution over time at different scales. If the set of values of the self-similarity function (showing signs of self-correlation) is divided into equal groups, and then summed up the values within the groups, then the set of sums will obey the same correlation function, and the output data [9].

In contrast to Poisson processes, self-similar processes are characterized by the presence of aftereffect: the probability of the next event occurring depends not only on time, but also on previous events (prehistory). This means that the number of current events may depend on the number of previous events in remote periods of time [8]. Therefore, one of the main properties of a self-similar process is a slowly decreasing dependence between traffic volumes at different times.

A self-similar process is often explosive (burst), which manifests itself in the presence of emissions at a relatively low rate of flow of events. Time-localized congestions cause significant packet loss, even if the total demand for servicing all flows is far from the maximum permissible values [9], since calculations of the required parameters of modern networks use only averaged traffic properties. In particular, for a self-similar packet flow, with an increase in the size of the buffer at the input of the network processor, the probability of losses falls much more slowly than for the exponential law used in classical teletraffic models [10].

Self-similarity is determined by the Hurst parameter. The Hurst parameter H, called the parameter (coefficient) of self-similarity, is in the range $0<H<1$ and is a key measure of self-similarity, or rather a measure of the duration of the long-term dependence of the stochastic process. It should be noted that in the case of $0.5<H<1$, one speaks of the persistent behavior of the process, or that the process has a long memory. In other words, if for some time in the past there was a positive increase in the process, that is, there was an increase, then in the future, on average, there will be an increase. Persistent stochastic processes show clearly pronounced tendencies of change with a relatively small "noise". In the case of $0<H<0.5$, one speaks of an anti-persistent process. Here, high process values follow low ones and vice versa. In other words, the probability that at the $i + 1$st step the process deviates from the mean in the opposite direction (relative to the deviation at the i-th step) is as high as the parameter H is close to "0" [11].

Currently, the most used methods for calculating the Hurst exponent are the following methods: Whittle's aggregate estimate, periodogram method, absolute moment method, dispersion method and R/S method.

The aggregated Whittle estimate provides a more accurate estimate of the Hurst index H. It is used in the case of studying a long time series. The idea is to combine data, create new, shorter series [12].

The periodogram method refers to nonparametric spectral analysis. The method consists in calculating a periodogram for a self-similar random process. The main disadvantage of this method is the large amount of computations when constructing an estimate for the Hurst exponent [13].

The method of absolute moments is used with a small amount of calculations, since only in this case it gives sufficiently accurate results [14].

The dispersion method consists in the statistical assessment of the reliability of the manifestation of the dependence of the effective trait on one or more factors. Using this method, statistical hypotheses are tested with respect to the means in several general populations that have a normal distribution. It should be noted that the method gives a very rough estimate of the Hurst exponent; therefore, it can be used only to assess the presence of self-similarity in the process under study [15].

The R/S method is used to check for a long-term relationship in a dataset. One of the main advantages of the R/S method is that, unlike many widespread statistical criteria, it is not based on any assumptions about the organization of the original data (about what distribution law they obey). This is the most important factor when investigating phenomena for which the deliberate falsity of Gaussian approaches has been confirmed by numerous studies. The R/S formula allows you to determine, for different periods of time, the swing will be greater or less than what you would expect in the case when each individual item of the output does not depend on the previous one. If the spread differs from the expected, then the exact consistency of the data is important: a series of high or small moments shift the extreme values further than if they occurred by pure chance [16].

It was decided to choose the R/S method, since this method allows you to operate with a large amount of data, and also gives results with a sufficiently high accuracy. In addition, this method is characterized by step-by-step detailing and a well-formalized algorithm. The R/S method allows you to identify and eliminate short-term dependence and is the most optimal in comparison with all described above. SYSTAT Autosignal software was selected for the Hurst exponent calculation and plotting. This program fully automates the signal analysis process. The product takes full advantage of an intuitive graphical user interface to simplify every aspect of the operation, from importing data to outputting results.

RESULTS

The work examines 6 subclasses of services: video hosting, video broadcasting, Ip-telephony, telephony, data 1, data 2, combined into 3 classes of video, speech, and data. The classes are combined into a single aggregated traffic (Fig. 1). Traffic was recorded for 5 months by 6 services every minute for incoming and outgoing traffic.

Fig. 1. Types of services

Analysis of incoming traffic

Incoming data traffic for all types of services was analyzed by day of the week, month and half year. Table 1 shows data on the average intensity of incoming traffic by days of the week, on the basis of which the degree of self-similarity of incoming traffic was calculated.

Table 1. Average intensity of incoming traffic by days of the week

Incoming	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
Monday	32689	1482	13093	3063	3264	1033	34172	16157	4297	54627
Tuesday	26942	628	13411	2531	2533	664	27571	15942	3198	46712
Wednes	24193	464	10112	1940	2396	447	24657	12052	2843	39553
Thursday	21473	496	13250	1864	2511	589	21969	15114	3100	40184
Friday	20876	406	35143	1623	2280	470	21282	36767	2751	60801
Saturday	9860	212	9842	973	1161	259	10072	10816	1420	22310
Sunday	9314	143	9185	936	1156	395	9315	10122	1551	20983
Average	20763	527	14862	1847	2185	551	21291	16710	2737	40738
Min	9314	143	9185	936	1156	259	9315	10122	1420	20983
Max	32689	1482	35143	3063	3264	1033	34172	36767	4297	54627

Figures 2.a and 2.c. provided incoming traffic for service Monday 1_1 and aggregated. Figures 2.b and 2.d show the ratios of the log R/S to the log *n* periods of service 1_1 and aggregated traffic, respectively.

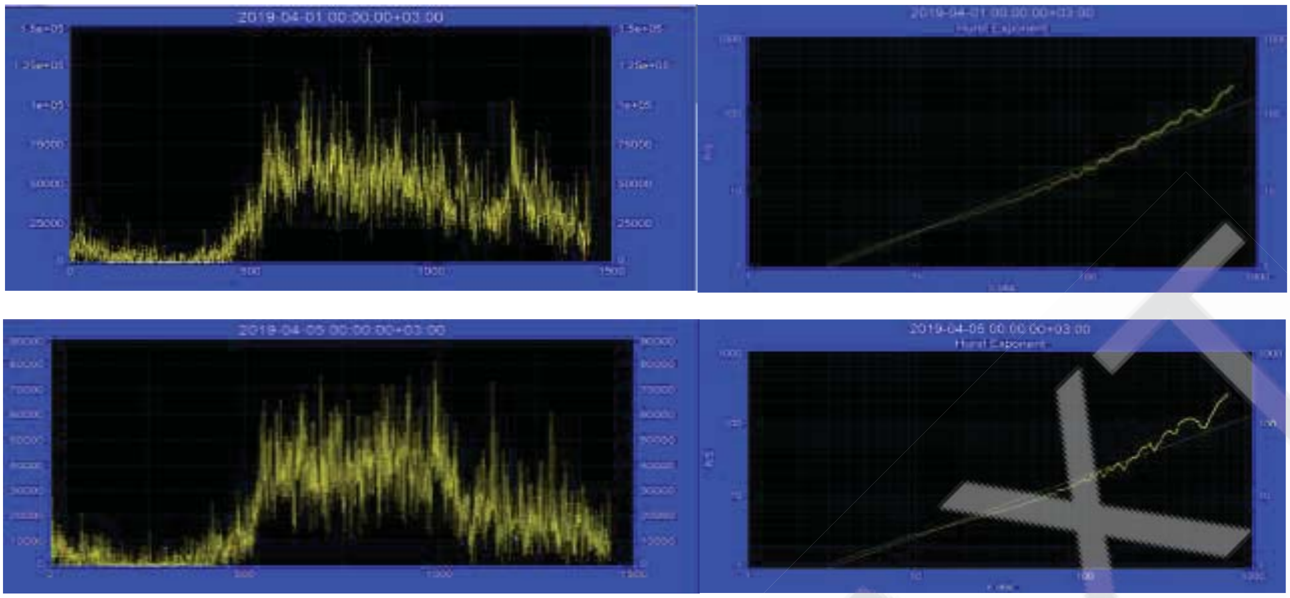

Fig. 2. The intensity of incoming traffic and the ratio log R/S to the log *n* periods during the week:
a - monday traffic intensity of service 1_1, b - monday ratio log of service 1_1,
c - friday intensity of aggregated traffic, d - friday ratio log of aggregated traffic

Similar studies were performed for all types of traffic for the indicated periods. The results of the analysis of the studies obtained, namely, the value of the Hurst exponent by days of the week of incoming traffic are given in table. 2.

Table 2. Hurst index of days of the week of incoming traffic

Incoming	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
Monday	0,87	0,86	0,83	0,86	0,86	0,82	0,88	0,85	0,86	0,88
Tuesday	0,84	0,78	0,85	0,87	0,85	0,78	0,84	0,87	0,85	0,87
Wednes	0,88	0,73	0,88	0,8	0,83	0,74	0,88	0,88	0,82	0,9
Thursday	0,82	0,69	0,9	0,85	0,87	0,76	0,82	0,9	0,84	0,89
Friday	0,83	0,76	0,95	0,79	0,82	0,74	0,83	0,95	0,82	0,95
Saturday	0,81	0,71	0,85	0,75	0,78	0,65	0,89	0,85	0,77	0,82
Sunday	0,73	0,6	0,8	0,69	0,72	0,74	0,73	0,79	0,76	0,8
Average	0,82	0,73	0,86	0,8	0,81	0,74	0,83	0,87	0,81	0,87
Min	0,73	0,6	0,8	0,69	0,72	0,65	0,73	0,79	0,76	0,8
Max	0,87	0,86	0,95	0,87	0,87	0,82	0,89	0,95	0,86	0,95

According to the initial data (table 1) and the results of the program (table 2). Fig. 3, the generated graphs of the ratios of the values of the intensity of the incoming traffic and the Hurst index for the week are provided.

Fig. 3. Graphs of the relationship between the Hurst exponent and the intensity of incoming week traffic: a - graph of service 1_1, b - graph of aggregated traffic

Figures 4.a and 4.c show inbound traffic for 2_1 service and aggregated traffic for month. Figures 4.b and 4.d show the ratios of the log R/S to the log *n* periods of service 2_1 and aggregated traffic, respectively.

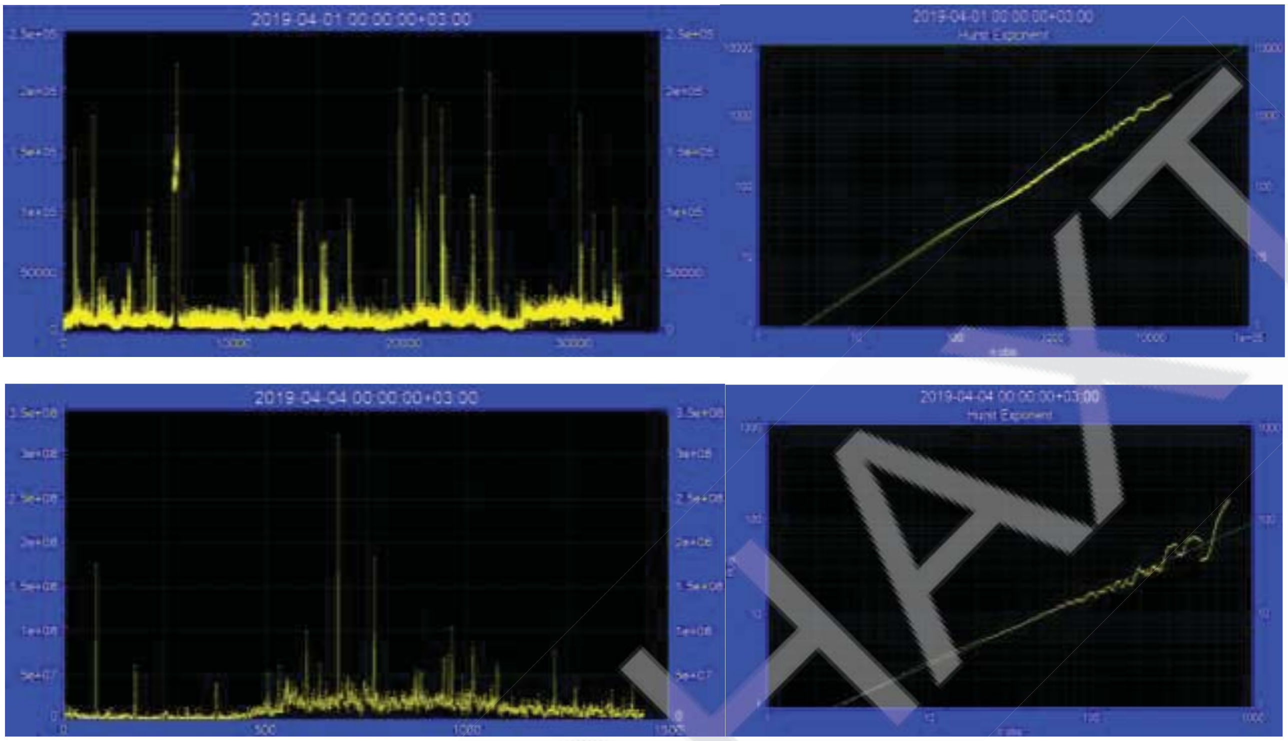

Fig. 4. The intensity of incoming traffic and the ratio of the log of R/S to the log *n* periods for month:

a - graph of traffic intensity of service 2_1 for April, b - ratio of logarithms of service 2_1 for April, c - graph of aggregated traffic intensity for April, d - ratio of logarithms of aggregated traffic for April

Table 3 shows data on the average intensity of incoming traffic by months, on the basis of which the calculations of the degree of self-similarity of incoming traffic were carried out.

Table 3. Average monthly intensity of incoming traffic

Incoming	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
April	18917	922	13923	1917	2078	944	19839	15841	3023	38705
May	17283	1287	17682	1389	1649	606	18571	19072	2255	39899
June	16076	556	9447	1324	1411	492	16632	10772	1903	29307
July	18751	693	11299	1378	1620	392	19443	12677	2013	34134
August	17105	318	11345	1197	1524	359	17427	12542	1884	31849
Average	17626	755	12739	1441	1656	558	18382	14180	2215	34778
Min	16076	318	9447	1197	1411	359	16632	10772	1884	29307
Max	18917	1287	17682	1917	2078	944	19839	19072	3023	39899

Similar studies were performed for all types of traffic for the indicated periods. The results of the analysis of the studies obtained, namely, the value of the Hurst exponent by months of incoming traffic are given in table. 4.

Table 4. Hurst index for months of incoming traffic

Incoming	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
April	0,85	0,91	0,88	0,9	0,84	0,8	0,85	0,89	0,85	0,8
May	0,88	0,81	0,97	0,89	0,87	0,77	0,76	0,99	0,79	0,86
June	0,84	0,9	0,88	0,89	0,85	0,85	0,85	0,89	0,87	0,85
July	0,77	0,81	0,82	0,79	0,76	0,73	0,73	0,86	0,76	0,73
August	0,82	0,88	0,9	0,81	0,8	0,79	0,82	0,89	0,82	0,79
Average	0,83	0,86	0,89	0,85	0,82	0,78	0,8	0,9	0,81	0,8
Min	0,77	0,81	0,82	0,79	0,76	0,73	0,73	0,86	0,76	0,73
Max	0,88	0,91	0,97	0,9	0,87	0,85	0,85	0,99	0,87	0,86

According to the input data (table 3) and the results of the program (table 4). Fig. 5, graphs of the ratios of the values of the intensity of incoming traffic and the Hurst index by months are provided.

Fig. 5. Graphs of the relationship between the Hurst exponent and the intensity of incoming traffic for a period of months:
a - service schedule 2_1, b - aggregated traffic schedule

Figures 6.a and 7.a show inbound traffic for a half year of service 3_1 and aggregated traffic. Figures 6.b and 7.b show the ratios of the log R/S to the log *n* periods of service 3_1 and aggregated traffic, respectively. Table 5 shows the data on the average intensity of incoming traffic for half a year.

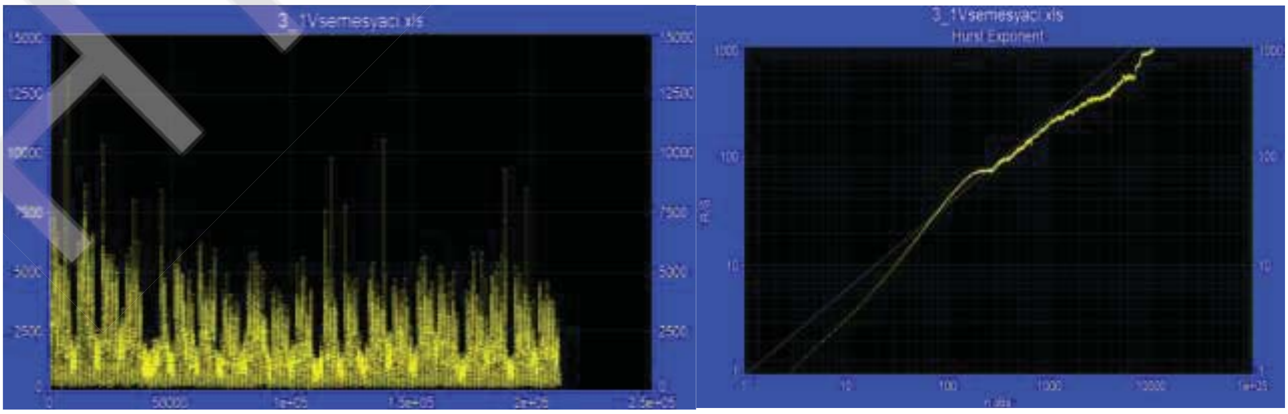

Fig. 6. Intensity of incoming traffic and the ratio of the log R/S to the log *n* periods for half a year:

a - Graph of traffic intensity of service 3_1, b - ratio of log of service 3_1

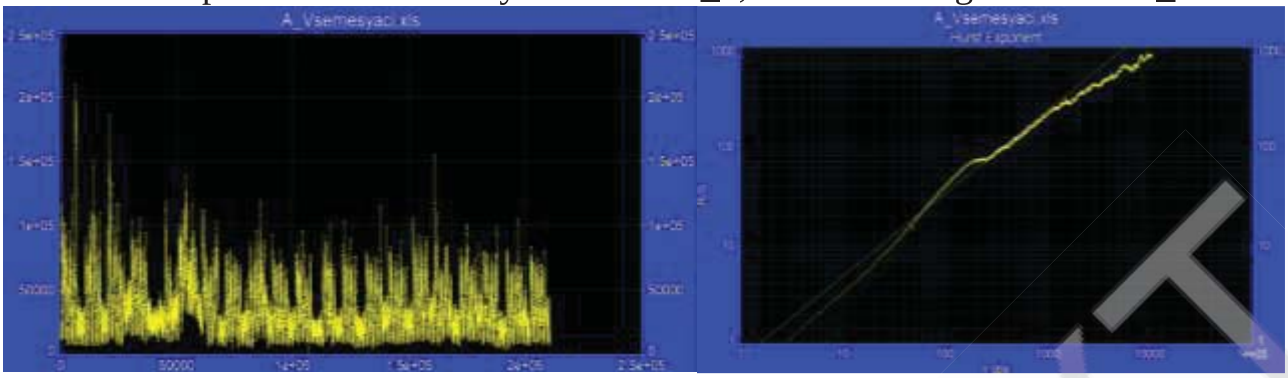

Fig. 7. Intensity of incoming traffic and the ratio of the log R/S to the log *n* periods for half a year:
a - Graph of intensity of aggregated traffic, b - ratio of log of aggregated traffic

Table 5. Average intensity for a half year of incoming traffic

Incoming	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
Half year	17652	775	12818	1450	1671	565	18430	14268	2227	34924

Similar studies were performed for all types of traffic for the indicated periods. The results of the analysis of the studies obtained, namely, the value of the Hurst exponent during for half a year of incoming traffic are given in table. 6

Table 6. Average Hurst index for half a year of incoming traffic

Incoming	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
Half year	0,79	0,86	0,89	0,83	0,78	0,78	0,8	0,89	0,82	0,83

According to the input data (table 5) and the results of the program (table 6). Fig. 8 shows the generated graph with the ratios of the values of the intensity of the incoming traffic and the Hurst index for half a year.

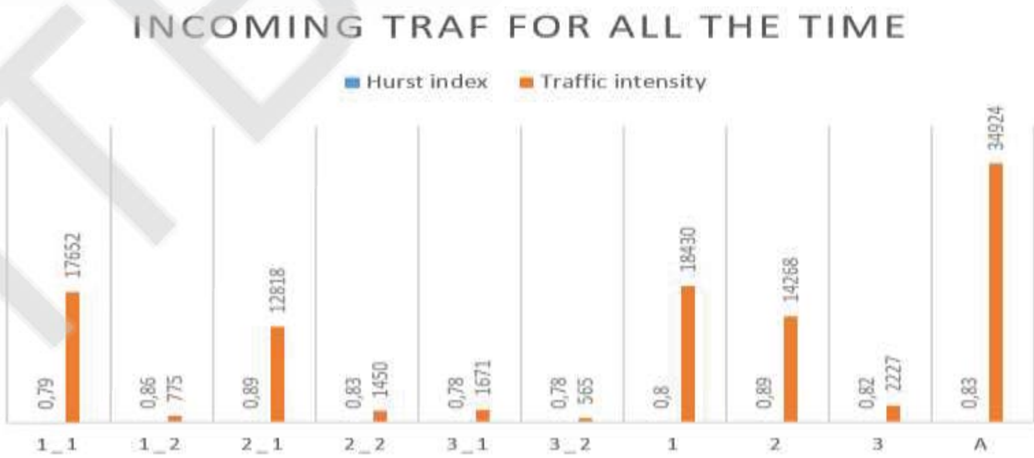

Fig. 8. Schedule of incoming traffic during for a half of year

Analysis of outgoing traffic

Table 7 and table 8 show data on the average intensity of outgoing traffic by days of the week, on the basis of which the degree of self-similarity of outgoing traffic, which were averaged.

Table 7. Average intensity of days of the week of outgoing traffic by service

Outgoing	1_1	1_2	2_1	2_2	3_1	3_2
Monday	14277496	3867745	1335402	382038	2415631	78336
Tuesday	13802844	6703504	1829938	282139	1783975	70965
Wednesday	9841066	1482290	1088606	267145	1731010	61846
Thursday	7551645	2106735	1317160	274049	1885164	65955
Friday	7557935	1913027	3993590	264119	1762344	61398
Saturday	3607002	935590	1254226	130334	858486	34600
Sunday	3209310	608180	1139412	127492	854412	33138
Average	8549614	2516724	1708333	246759	1613003	58034
Min	3209310	608180	1088606	127492	854412	33138
Max	14277496	6703504	3993590	382038	2415631	78336

Table 8. Average intensity of days of the week of outgoing traffic by classes and aggregated traffic

Outgoing	1	2	3	A
Monday	18145240	1717440	2493968	22356648
Tuesday	20506348	2112078	1854941	24473368
Wednesday	11323357	1355752	1792857	14471966
Thursday	2763228	1591210	1951120	13200711
Friday	9470962	4257710	1823742	15552415
Saturday	4542592	1384561	893087	6820241
Sunday	3815377	1266905	887550	5967183
Average	10081015	1955094	1671038	14691790
Min	3815377	1266905	887550	5967183
Max	20506348	4257710	2493968	24473368

Figures 9.a and 10.a show outbound traffic for service Monday 1_1 and aggregated. Figures 9.b and 10.b show the ratios of the logarithm R/S to the logarithm *n* periods of service 1_1 and aggregated traffic, respectively.

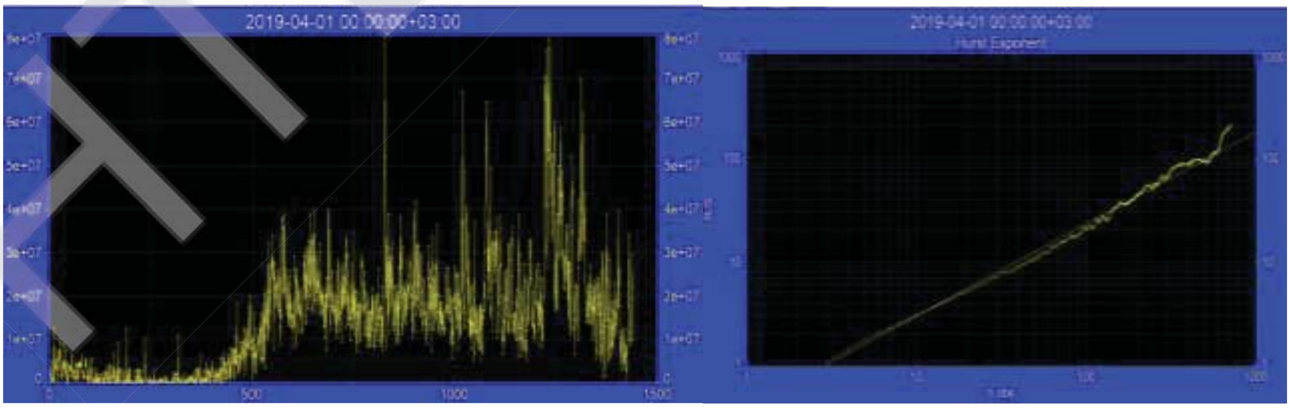

Fig. 9. Intensity of outgoing traffic and the ratio of the log R/S to the log *n* periods during the week:
a - monday traffic intensity of service 1_1, b - monday ratio of log of service 1_1

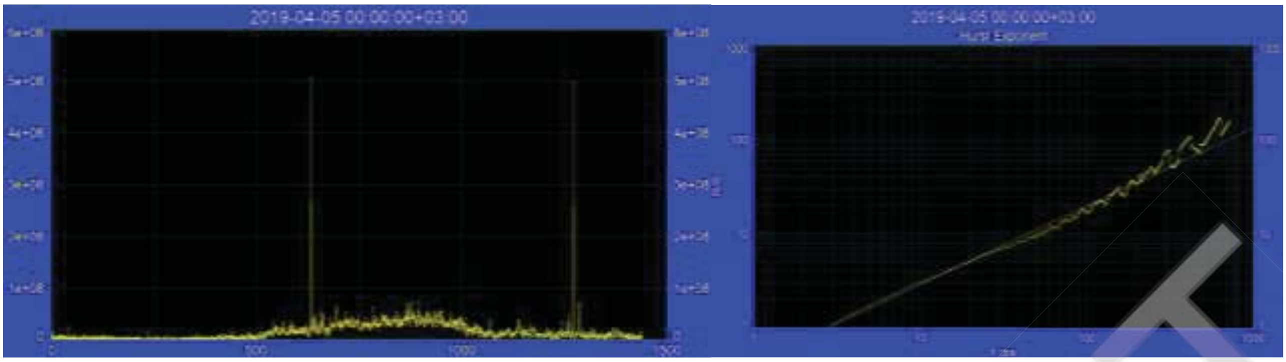

Fig. 10. Intensity of outgoing traffic and the ratio of the log R/S to the log of *n* periods during the week:
a - friday aggregated traffic, b - friday ratio of log of aggregated traffic

The results of the analysis of the studies obtained, namely, the value of the Hurst exponent by days of the week of outgoing traffic are given in table 9.

Table 9. Hurst index of days of the week of outgoing traffic

Outgoing	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
Monday	0,88	0,75	0,8	0,85	0,86	0,76	0,84	0,83	0,86	0,85
Tuesday	0,84	0,69	0,81	0,83	0,84	0,74	0,8	0,79	0,84	0,8
Wednesday	0,89	0,69	0,82	0,81	0,81	0,71	0,88	0,83	0,82	0,89
Thursday	0,79	0,55	0,75	0,86	0,92	0,7	0,72	0,77	0,91	0,75
Friday	0,89	0,63	0,94	0,81	0,82	0,71	0,78	0,94	0,82	0,82
Saturday	0,81	0,61	0,84	0,77	0,78	0,63	0,76	0,84	0,78	0,77
Sunday	0,73	0,6	0,77	0,71	0,71	0,65	0,71	0,78	0,71	0,74
Average	0,83	0,64	0,81	0,8	0,82	0,7	0,78	0,82	0,82	0,8
Min	0,73	0,55	0,75	0,71	0,71	0,63	0,71	0,77	0,71	0,74
Max	0,89	0,75	0,94	0,86	0,92	0,76	0,88	0,94	0,91	0,89

According to the initial data (table 7 and table 8) and the results of the program (table 9). Fig. 11, the generated graphs of the ratios of the values of the intensity of the outgoing traffic and the Hurst index for the week are provided.

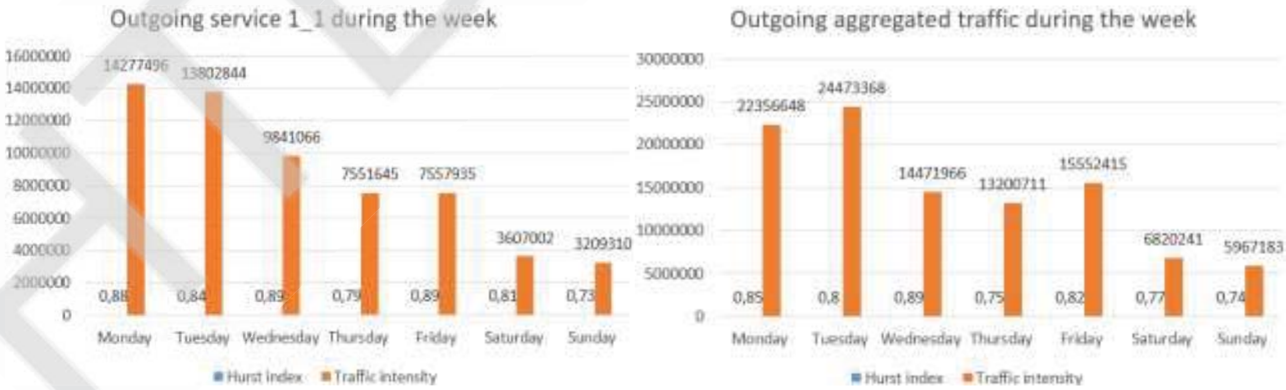

Fig. 11. Graphs of the ratio of the Hurst index to the intensity of outgoing traffic for the week: a - service schedule 1_1, b - aggregated traffic schedule

Table 10 and table 11 show the data of the average intensity of outgoing traffic by months, on the basis of which the calculations of the degree of self-similarity of the outgoing traffic were carried out, which were averaged.

Table 10. Average intensity of months of outgoing traffic by service

Outgoing	1_1	1_2	2_1	2_2	3_1	3_2
April	6848211	2950433	1539518	239993	1510084	59132
May	6297403	3892890	2221623	201536	1258184	60203
June	6071831	2562871	1162344	188707	1182083	53954
July	7415060	2400076	1249788	224290	1389870	55262
August	5906313	1665928	1326280	207824	1293116	55049
Average	6507764	2694440	1499911	212470	1326667	56720
Min	5906313	1665928	1162344	188707	1182083	55049
Макс	7415060	3892890	2221623	239993	1510084	60203

Table 11. Average intensity of months of outgoing traffic by classes and aggregated traffic

Outgoing	1	2	3	A
April	9798029	1779506	1569217	13147204
May	10189595	2423155	1318385	13931241
June	8633396	1351043	1236037	11219909
July	9814223	1474064	1445130	12733441
August	7573193	1534081	1348161	10453100
Average	9201687	1712370	1383386	12296979
Min	7573193	1351043	1236037	10453100
Макс	10189595	2423155	1569217	13931241

Fig. 12.a and 12.c show outbound traffic for 2_1 service months and aggregated traffic. Fig. 12.b and 12.d show the ratios of the log R/S to the log *n* periods of service 2_1 and aggregated traffic, respectively.

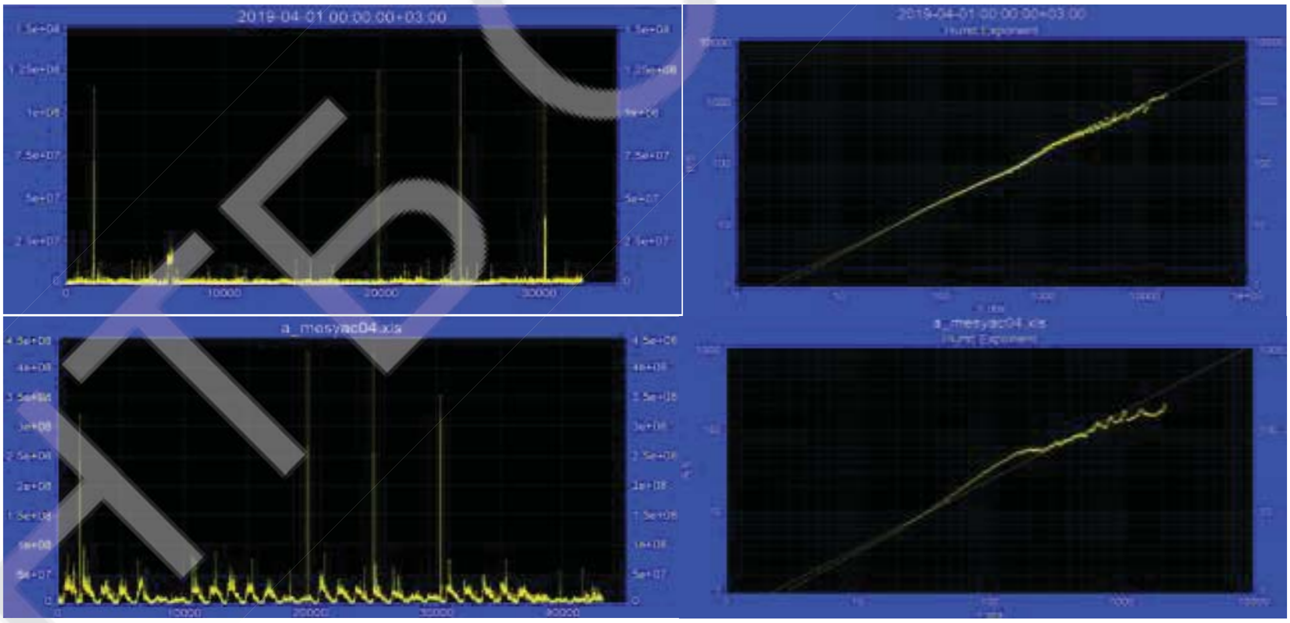

Fig. 12. Intensity of outgoing traffic and the ratio of the log R/S to the log *n* periods for months:
a - graph of april traffic intensity of service 2_1, b - april ratio of log of 2_1, c - april graph of aggregated traffic, d - april ratio of log of aggregated traffic

The results of the analysis of the studies obtained, namely, the value of the Hurst exponent by months of outgoing traffic are given in table 12.

Table 12. Hurst index of months of outgoing traffic

Outgoing	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
April	0,89	0,7	0,79	0,83	0,84	0,84	0,8	0,81	0,84	0,82
May	0,9	0,68	0,96	0,86	0,86	0,88	0,8	0,94	0,73	0,82
June	0,87	0,77	0,81	0,83	0,84	0,91	0,85	0,83	0,84	0,83
July	0,76	0,62	0,78	0,75	0,75	0,86	0,85	0,83	0,84	0,79
August	0,84	0,62	0,87	0,8	0,8	0,84	0,76	0,87	0,8	0,8
Average	0,85	0,67	0,84	0,81	0,81	0,86	0,81	0,85	0,81	0,81
Min	0,76	0,62	0,78	0,75	0,75	0,84	0,76	0,81	0,73	0,79
Max	0,9	0,77	0,96	0,86	0,86	0,91	0,85	0,94	0,84	0,83

According to the initial data (tables 10 and table 11) and the results of the program (table 12). Fig. 13 shows the generated graphs of the ratios of the values of the intensity of outgoing traffic and the Hurst index by months.

Fig. 13. Graphs of the ratio of the Hurst index and the intensity of outgoing traffic for a period of months:

a - service schedule 2_1, b - aggregated traffic schedule

Fig. 14.a show the outgoing traffic for the half-year service 3_1. Fig. 14.b show the ratios of the logarithm of R/S to the logarithm of n periods of service 3_1. Table 13 and table 14 show the data on the average intensity of outgoing traffic for half a year, on the basis of which the calculations of the degree of similarity of the outgoing traffic were carried out, which were averaged.

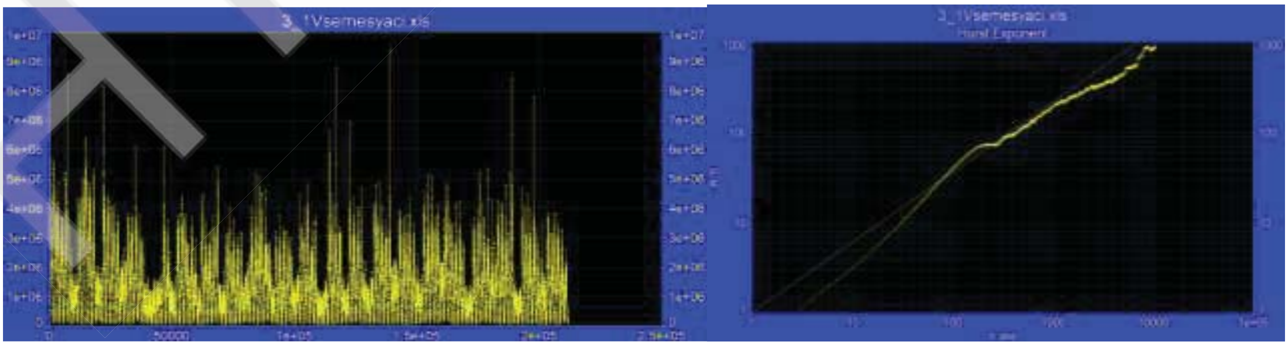

Fig. 14. Intensity of outgoing traffic and the ratio of the log R/S to the log of *n* periods for a half-year:

a - Graph of traffic intensity of service 3_1, b - ratio of logarithms of service 3_1

Table 13. Half-year average intensity of outgoing traffic by service

Outgoing	1_1	1_2	2_1	2_2	3_1	3_2
Half year	6535989	2740860	1509954	212662	1335014	56737

Table 14. Half-year average intensity of outgoing traffic by classes and aggregated traffic

Outgoing	1	2	3	A
Half year	9277072	1722616	1384781	12383083

Similar studies were performed for all types of traffic for the indicated periods. The results of the analysis of the studies obtained, namely, the value of the Hurst exponent for half a year of outgoing traffic are given in table 15.

Table 15. Hurst index for a half of year of outgoing traffic

Outgoing	1_1	1_2	2_1	2_2	3_1	3_2	1	2	3	A
Half year	0,83	0,71	0,85	0,77	0,77	0,86	0,82	0,86	0,78	0,83

According to the initial data (table 13 and table 14) and the results of the program (table 15). Fig. 15 shows the generated graph of the ratio of the values of the intensity of outgoing traffic and the Hurst index for half a year.

Fig. 15. Schedule of outgoing traffic during for a half of year

CONCLUSIONS

As a result of the study of incoming and outgoing traffic for all types of services – video, speech and data, namely - video hosting, video broadcasting, Ip-telephony, telephony, data 1 and data 2 for all studied periods, namely: days of the week, months and half a year defined the following:

- the Hurst index of incoming traffic by service subclass and in all time periods varies from 0.6 to 0.97;
- by class, the Hurst exponent varies from 0.73 to 0.99;
- for aggregated traffic - varies from 0.73 to 0.95;
- in turn, in outgoing traffic by service, the Hurst index varies from 0.55 to 0.96;

– by class, the Hurst exponent varies from 0.71 to 0.94;
– for aggregated traffic - varies from 0.74 to 0.89.

Research data of incoming and outgoing traffic for all types of services for all periods under study indicate that the generated traffic is self-similar.

The data obtained as a result of the study can serve as the basis for the design of modern networks, can be used to solve an urgent problem - the development of an analytical model of the NGN service provision management system, taking into account the self-similarity of traffic, which makes it possible to determine the quality indicators of services by classes and subclasses.

Based on the results of this study, it is possible to simulate network traffic, which allows you to start predicting server behavior in the future, predict loads, optimally manage server resources, obtain a model of server behavior in critical situations, and the like.

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