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Packet Loss Probability Dependence on Number of ON-OFF Traffic Sources in OPNET

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Introduction

During the last years the characteristics of the network have changed. The research of real network traffic shows that it has self-similar behavior and can be described by fractals of data on a wide range of time scale. The fractal behavior leads to large amounts of traffic which in it's turn induces delays or losses of packets. MBAC should give the best effort within the finite network capacity. As the measure of MBAC efficiency in the paper the buffer overflow probability is used. It has to be mentioned that the well-known queuing model with finite capacity M/M/1/K was traditionally used for buffer overflow probability estimation. This kind of model can only be used if the data traffic has Poisson distribution law. Since the traditional Poisson traffic model doesn't support the bursting behavior of traffic, it can not be used for the purposes of finding overflow probability for the buffer of real network equipment. So, there is a necessity to create an accurate queuing model to estimate the buffer size in the device, suitable for real traffic.

Another issue concerns to the model of the traffic simulation. The well-known model for the self-similar traffic generation is ON-OFF model. However, the number of the ON-OFF sources raises an issue in traffic generation. Ii is the influence of the ON-OFF source number on the network characteristics. Another issue is the dependence of the queuing model parameters, on the source number. The buffer overflow probability dependence on ON-FF source number.

ON-OFF model

The simulation of the self-similar traffic is based on the ON-OFF model. Originally it was suggested by Mandelbrot [3]. This method is based on superposition of many independent and identically distributed ON-OFF sources.

In the present paper by the ON-OFF source model, we mean a model where the ON- and OFF-periods strictly alternate. The ON- and OFF-period sequences are independent from one another. The network measurements show the reason to assume that in real traffic the OFF-period is longer then ON-period.

In general, the ON- and OFF-periods do not need to have the same distribution. The ON-periods are independent and identically distributed. ON-period corresponds to active time period. During that time transmitted packets are separated by a small time. It is reasonable to assume that packet sizes within a period remain constant. The ON period is named to packet "train". OFF-period corresponds to silent period, when no packet is transmitted.

The ON-OFF model was chosen for our simulation as it has been shown in the literature that self-similar network traffic can be generated by multiplexing several sources of Pareto-distributed ON- and OFF- periods.

The ON-OFF model was implemented using the OPNET simulation software. The Fig. 1 presents an example of three ON-OFF generators and a queue. Each source sends bursts with random duration distributed by Pareto distribution. In our ON-OFF model, the number of sources is fixed for each scenario.

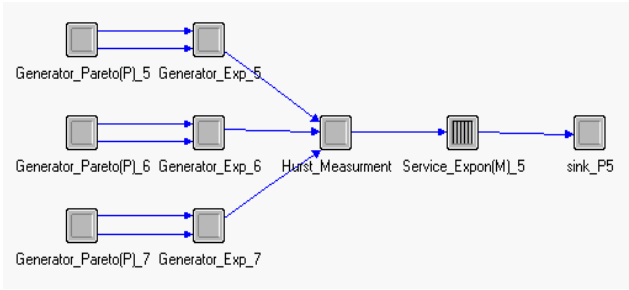

Fig. 1. ON-OFF Traffic generators modelled in OPNET environment

The traffic generated by sources is independent and identically distributed. In the paper the following approach is used. The total intensity generated by all sources is the constant value through the all scenarios and does not depend on the source number. It means, that the traffic intensity of the each source is in inverse ratio to the number of source. While the number of sources increases the intensity of each individual source decreases and vice

verse.

The results, gained during the simulation, shows that characteristic of the traffic do not depend on the number of sources. The results are presented in the Fig.2. The results of the experiments show that for all values of the target H, the estimated H stabilizes from 10 sources which are consistent to the results of Jeong, McNickle, & Pawlikowski (1999).

For the evaluation of the influence of the ON-OFF source number on the buffer overflow probability queuing parameter it is necessary to use the queuing model with finite capacity. The following section presents the estimation of the buffer size.

Buffer size estimation

The buffer size plays critical role for the network performance. The proper size of the buffer maintains Quality of Service (QoS) requirements within limited network capacity for as many users as possible. To get benefits the accurate model for the buffer size calculation should be used.

In the paper the size of the buffer were chosen according to the Y. Koh and K. Kim (2005) [1]. According to the Y. Koh and K. Kim (2005) [1] the loss probability $P_{K_{LOSS}}$ of the GI/M/1/K theorem by Choi, B. Kim & I.Wee (2000) can be written in closed form as following:

$$P_{Loss}^{K} = \left(1 - \frac{\alpha(\alpha-1)}{\rho} M^{\frac{\alpha}{2}-1} e^{M/2}\right) \times \left[\sqrt{M} W_{-\frac{\alpha+1}{2},\frac{\alpha}{2}}(M) - W_{-\frac{\alpha}{2},\frac{1-\alpha}{2}}(M)\right] \sigma^{K}, \quad (1)$$

where $M = \frac{(\alpha-1)(1-\sigma)}{\rho}$ and $W_{\eta,\xi}(\phi)$ - Whittaker's function.

It is important to keep in mind that this is an asymptotic result and it may not give feasible solutions for small values of the parameters involved.

The Fig.3 presents the evaluated size of the buffer by the Y. Koh and K. Kim (2005) [1] model for the overflow probability $P = 10^{-5}$.

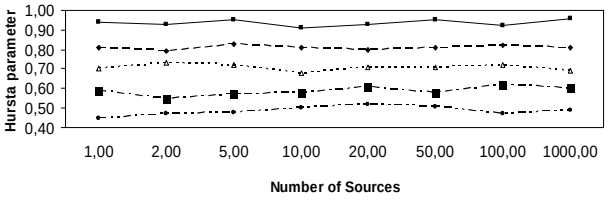

Fig. 2. Hurst parameter dependence on number of ON-OFF sources

Simulation

Generally speaking, the idea of the AC is to admit as much as possible of the sessions with guaranteed QoS (Quality of Service). The present study suggests that the guaranteed QoS can be provided by the definition of buffer overflow probability.

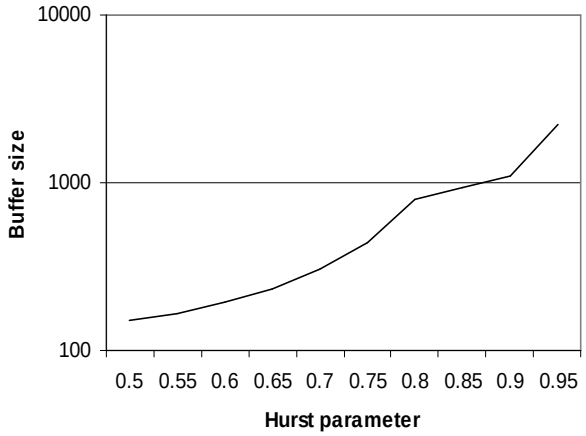

Fig. 3. Buffer size dependence on the Hurst parameter

For the buffer overflow probability evaluation the simulation method were used. The results were gained in OPNET simulation software.

The Fig.4 presents buffer overflow dependence on the number of ON-OFF sources, where each source presents a session while ON period exists. Interesting result can be obtained from the figure. The simulation shows that the buffer overflow probability decreases while the number of the ON-OFF sources grows from 1 to 10. It is necessary to emphasize that the summarized traffic of the sources does not depend on the number of sources. It is necessary to keep in mind, that interarrival rate of the each source is in inverse ration to the number of sources, The result of the OPNET simulation was confirmed by the GPSS simulator. GPSS simulator returned similar results that overflow probability depends of the number of ON-OFF sources.

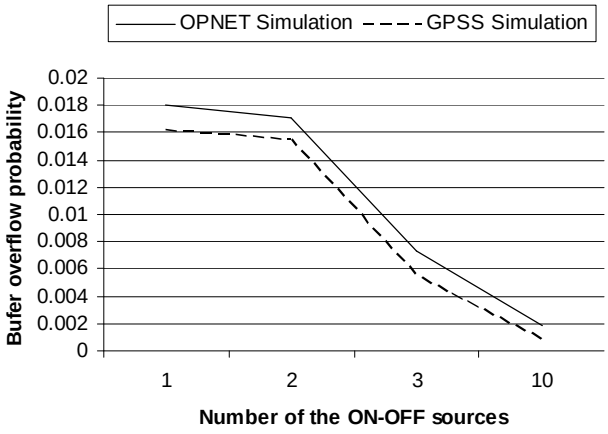

Fig. 4. Buffer overflows probability dependence on ON-OFF sources number. The overflow probability correspond to scenario with Hurst equal to 0.75

It is not shown in the figure, but for the same scenario overflow probability starts to increase when the number of the ON-OFF sources goes up from 10-20. The figure presents the buffer overflow probability for the α=1.5

(H=0.75) and the number of the ON-OFF sources are 1; 2; 3; 10.

As it was mentioned in the section above, the Hurst parameter does not very on ON-OFF sources. It means that during the simulation the Hurst parameter for each number of the source was approximately the same. The phenomenon when the buffer overflow probability decreases while ON-OFF sources increase can be perfectly used in MBAC algorithm to provide better network utilization and to gain better effort.

Machine repairman

The results gained during the simulation shows that is the total traffic intensity would be the constant value the buffer overflow probability decreases while the number of ON-OFF sources increases. Even the result gained with OPNET simulation software were proved by results by GPSS simulation the analytical model should be presented.

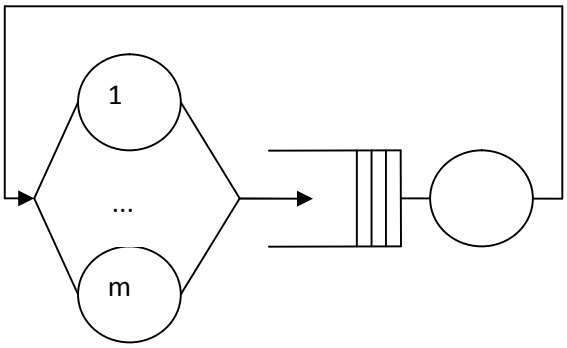

Fig. 5. Machine repairman model

Machine repair man model, that is presented in the Fig.5, is a special case of the birth-death process. This model is useful in the modelling of interactive computer systems where an individual terminal user issues a request at the rate λ whenever it is in the "thinking state". If j out of the total of M terminals are currently waiting for a response to a pending request, the effective request rate is then

$$(M - j)\cdot\lambda \ . \qquad (2)$$

The request completion rate is denoted by μ.

The machine repairman model was chosen as the appropriate analytical description the ON-OFF model. The repair-man machine with the finite number of sources and infinite queue length is well described in L. Klienrock [10]. The interarrival rate in the model presented in the L. Klienrock [10] has the exponential distribution. In our case the queue size has finite length and the interarrival rate of the each source decreases proportionally to the number of the sources. For that case, the overflow probability could be estimated as following:

$$\pi = \pi_0 \cdot \left[M \cdot \left(\frac{\lambda}{(\mu \cdot M)} \right)^k \cdot \prod_{i=0}^{k-1} (M - i) \right], \qquad (3)$$

where

$$\pi_0 = \frac{1}{\sum_{k=0}^{K} \left[M \cdot \left(\frac{\lambda}{(\mu \cdot M)} \right)^k \cdot \prod_{i=0}^{k-1} (M - i) \right]}. \qquad (4)$$

The M corresponds to the number of the sources and $\frac{\lambda}{M}$ corresponds to the interarrival rate of the each source.

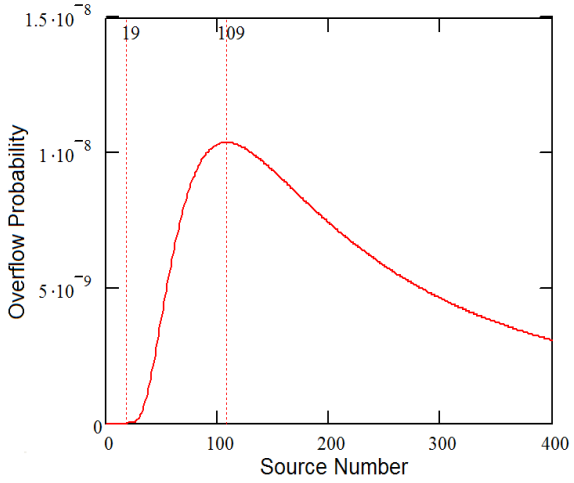

Fig. 6. Overflow probability dependence on the source number

The Fig. 6 presents the overflow probability dependence on number of sources. From the Fig. 5 it is clearly seen that there is clear dependence in the buffer overflow probability and the number of the sources. The analytical model for the repair-man machine with Pareto distributed interarrival packet rate is not presented in the paper. Nevertheless, we assume that the overflow probability for the repair-man machine with Pareto distributed interarrival rate would have the similar behaviour such a case with exponential distribution has.

Conclusion and future research

In the paper ON-OFF source number influence on the traffic and queuing model parameters are presented.

In the paper the following of the ON-OFF sources model is used. The interarrival rate of the each independent source depends on the number of sources. The arrival rate is in inverse ratio to the number of sources. This approach provides the scenarios with constant value of the total traffic intensity.

As it was shown in this paper the traffic characteristics is invariant to the number of the ON-OFF sources that is in consistency with reports presented by different authors.

The investigation of the queuing model parameter dependence on the ON-OFF source number is evaluated in the paper. The results shows that the overflows probability queuing model parameter depends on the number of ON-OFF sources. The overflow probability decreases while the ON-OFF sources number increases.

Implications of this finding can guarantee very high utilization of the MBAC algorithm.

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M. Kulikovs, E. Petersons. Packet Loss Probability Dependence on Number of ON-OFF Traffic Sources in OPNET // Electronics and Electrical Engineering. – Kaunas: Technologija, 2008 – No. 5(85). – P. 77–80.

For the last years the characteristics of the telecommunication networks traffic have changed. It happened due to spreading of multimedia-based services. Many research works show that nowadays traffic has self-similar behavior. The traditional queuing models do not take into account the long-range dependence of the self-similar traffic. This raises an issue of the development of the efficient MBAC model that would be adequate for the real traffic. The efficiency of the MBAC model was evaluated according to overflow probability. The paper presents results gained during the evaluation of the queuing model with the input traffic with self-similar characteristics. For the estimation of the model the OPNET simulation software was used. The self-similar traffic was generated using ON-OFF model. The results indicated that buffer overflow probability depends on ON-OFF traffic sources. Implications of the current study and directions for future research are discussed. Ill. 6, bibl. 10 (in English, summaries in English, Russian and Lithuanian).

М. Куликовс, Е. Петерсонс. Исследование величины вероятности потери данных при применении OPNET // Электроника и электротехника. – Каунас: Технология, 2008. – № 5(85). – С. 77–80.

Предложен способ создания пакета данных с использованием модели MBAC. При исследованиях потоков данных применена программа OPNET. Потоки данных генерируются на основе ON-OFF модели. Теоретические и экспериментальные результаты показали, что величина вероятности зависит от перегрузки и количества источников потоков. Описываются направления дальнейших исследований. Ил. 6, библ. 10 (на английском языке; рефераты на английском, русском и литовском яз.).

M. Kulikovs, E. Petersons. Paketų praradimo tikimybės priklausomybės nuo ON-OFF tipo duomenų srauto šaltinių skaičiaus tyrimas naudojant OPNET // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2008. – Nr. 5(85). – P. 77–80.

Pastaruoju metu telekomunikacijų tinklų duomenų srautų charakteristikos pakito. Tai įvyko dėl plintančių daugialypės terpės paslaugų. Daugelis tyrimų rodo, kad modernūs duomenų srautai pasižymi savaiminiu panašumu. Sudarant tradicinius eilių sudarymo modelius neatsižvelgiama į priklausomybę nuo savaiminio panašumo duomenų srautų. Dėl to kyla poreikis sukurti efektyvų MBAC modelį, kuris būtų adekvatus realiems duomenų srautams. MBAC modelio efektyvumas vertintas pagal perteklinės apkrovos tikimybę. Pateikti eilių sudarymo modelio tyrimo rezultatai. Tyrime naudota modeliavimo programa OPNET. Savaiminio panašumo duomenų srautas sugeneruotas naudojant ON-OFF modelį. Rezultatai parodė, jog buferio perkrovos tikimybė priklauso nuo ON-OFF tipo duomenų srauto šaltinių skaičiaus. Pateikiamos išvados bei aptariamos tolesnių tyrimų kryptys. Il. 6, bibl. 10 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).