Method for Evaluating the Routing Cost in Mpls Network with Regard To Fractal Properties of the Traffic

Abed Saif Alghawli

Abstract*—There has been proposed the method for evaluating the routing cost which is based on the account of fractal properties of the network traffic and pre-set limits for the latency time and the number of lost packets. This method calculates the fractality of the traffic and the value of bursts. Depending on these parameters, the routing costs are recalculated and the optimal one is chosen for transferring. If the traffic is the usual Poisson flow, then the routing is not changed. If the traffic has strong long-term dependence and high bursts, then the routing cost increases in proportion to the value of Hurst exponent and the extend of bursts. The proposed method for evaluating the routing cost with regard to fractal properties of the traffic has been tested on an open platform of graphical simulation of HUAWEI networks in the existing network of "Market-port" company. During the experiment the network parameters have been defined (bandwidth, load capacity of the channels, the number of lost data, transmission delays, fractality) in the real "Market-port" network. Then the network similar to a real one has been modelled and configured in such a way that transmission time, the number of lost packets, the average latency time of the packets in the network coincides with the data having been defined in a real network of "Market-port" company. The source of the implementations of traffic in the experiments was the realization of the real network traffic captured in the network of "Market-port" company and the model implementation generated by these parameters. The studied simulation of the proposed method for evaluating the routing cost in MPLS network has shown that the use of the developed method significantly improves the quality of the service, reduces the transmission losses and permits to load network channels more evenly.

***Index Terms*— MPLS network, traffic management control, routing cost, delays, the quality of the service, fractal traffic.**

I. INTRODUCTION

With the growth of computer networks the intensity of traffic is growing exponentially and then the technologies of switching and routing packets in geographically distributed networks are becoming increasingly important. Also the needs of users are ramping up requiring the access to integrated services in the network and organization of virtual private networks (VPN) and many other essential services.

The increased demand for additional services realizable above the simple IP-access brings substantial profits for ISPs, forcing the developers to search for new ways of combining IP-based and ATM networks.

Manuscript Received on December, 2014.

Abed Saif Alghawli, Salman Bin Abdulaziz University, College of Science and Humanities in Aflaj, Saudi Arabia.

To meet emerging challenges the MPLS (Multiprotocol Label Switching) technology was developed which significantly expands the available prospects of scaling, increases the processing speed of the traffic and allows tremendous opportunities for providing additional services. The widespread occurrence and development of MPLS gives rise to researches, developments and introductions of new methods, which provide the estimation of the characteristics of network interactions. The studies carried out in [1-3] have shown that traffic in MPLS network is multifractal. Basing on the model of the MPLS network and methods of the traffic management control [4-6], the method for evaluating the routing cost based on self-similar traffic structure has been developed, permitting to prevent the network overload when burst of traffic. Also the simulated of the MPLS network has been carried out for evaluating the efficiency of the method of routing costs evaluating.

II. METHOD FOR EVALUATING THE ROUTING COST WITH REGARD TO FRACTAL PROPERTIES OF THE TRAFFIC

In the MPLS architecture there can be an available choice of routes based on individual streams when different threads connecting the same pair of end points can follow various routes. Furthermore, if an overload occurs, the MPLS architecture routes can be changed. Basing on data of the state of channel the routing protocol calculates the shortest paths (the lowest cost of routings) among the input boundary router and the rest of them. The routing cost value c_m is assigned to the communication line m and may depend on several parameters, namely the speed, length, and reliability.

In one communication line m there may be a plurality of channels $\mathrm{y} \in \mathrm{Y}$ of QoS traffic. A set of communication channels for the path $\mathrm{L_y} \in \mathrm{Y}$, $\forall l \in \{1,\ldots,L_y\}$ is determined for every traffic channel.

For the path $\mathrm{L_y}$ the admissible set of paths is set as $\mathrm{P_y} = \{\mathrm{p_y^1},\ldots,\mathrm{p_y^{L_y}}\}$.

Through $\lambda_{\mathrm{P_y}}^{\mathrm{q}}(\mathrm{t})$ it will be denoted that at the moment t the edge router receives the traffic with the intensity λ related to the q-th class of service to be delivered to the output router through any paths of the variety $\mathrm{P_y}$ but without exceeding the predetermined maximum of allowable values of

*Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.*

delay and the maximum percentage of losses.

The cost of the path p_y^l is indicated by C_y^l and is the sum of the costs of communication lines: $C_y^l = \sum_{m \in p_y^l} c_m$. If $x_y^l(t)$ represents the bandwidth sent to a valid path p_y^l of the channel y of the traffic $\lambda_{P_y}^q(t)$, then:

$$\sum_{t \in T; l=1}^{L_y} x_y^l(t) = d_y, \quad \forall y \in Y, \quad \forall l \in \{1, \ldots, L_y\}.$$

The objective function that minimizes the cost of the route on a variety of paths $P_y = \{p_y^1, \ldots, p_y^{L_y}\}$ is as follows:

$$\sum_{y \in Y} \sum_{l=1}^{L_y} C_y^l x_y^l(t) \to \min \qquad (1)$$

In works [1, 2, 7, 8] it is indicated that when the values of the Hurst exponent $H \geq 0{,}9$ or when persistent traffic with normalized scatter $S_{norm} \geq 3$ then the data loss is greater than 5-10%.

When passing through the network traffic with strong fractal properties the timely increase of the communication lines bandwidths is required. To reflect the change in the properties of the self-similar flows, the paths costs C_y^l are updated in regular intervals and are calculated by the formula

$$Cnew_y^l = \begin{cases} C_y^l, & H \leq 0{,}5; \\ C_y^l + (H - 0{,}5)C_0, & 0{,}5 < H < 0{,}9,\ S_{norm} \leq 1; \\ C_y^l + (H - 0{,}5)(S_{norm} - 1)C_0, & 0{,}5 < H < 0{,}9,\ 1 < S_{norm} < 3; \\ C_y^l + C_0, & H \geq 0{,}9 \text{ или } H > 0{,}5,\ S_{norm} \geq 3, \end{cases}$$

where $C_y^l = \sum_{m \in p_y^l} c_m$ is determined in accordance with the objective function (1), the value C_0 is selected by a network administrator in accordance with the network topology. The routing algorithm is unchanged (the path cost is $Cnew_y^l = C_y^l$) if the traffic is usual Poisson process ($H = 0{,}5$) or possesses the antipersistent properties ($H < 0{,}5$). When $0{,}5 < H < 0{,}9$ and small scatter of data ($S_{norm} \leq 1$) then the value C_y^l increases in proportion to the value of the Hurst exponent ($H < 0{,}5$). When the value of the Hurst exponent $0{,}5 < H < 0{,}9$ and a wide scatter of data ($1 < S_{norm} < 3$) then value C_y^l increases in proportion to both characteristics. The cost with the maximum value $C_y^l + C_0$ is obtained when the value $H \geq 0{,}9$ or when persistent traffic with a standard deviation is $S_{norm} \geq 3$.

The estimation of the Hurst parameter is carried out by using discrete wavelet decomposition which allows working in real time [8, 9]. After recalculating the costs of all the paths the announcement of the state of paths is sent among routers.

III. RESEARCH FINDINGS

In order to evaluate the effectiveness of method for evaluating the routing cost in MPLS network, let us present and analyse the simulation results in the HUAWEI medium on the basis of the existing network of "Market-port" company. The constructed network consists of two local networks WIN1 and WIN2, which are combined with a multi computer network and connected to the border routers SW1 and SW2 respectively. The multiservice network consists of internal routers R1, R2, R3, R4, RN1- RN14 (Mikrotik RB / 750 (GL) equipment) and edge routers SW1 and SW2 (Juniper SRX1008 equipment) (Figure 1). The routers RN1- RN14 are adjusted in such a way that the traffic transmission time between routers SW1 and SW2, the number of lost packets and the average response time of packets in the network coincides with the data received in a real network of the "Market-port" company. The measurement of characteristics of the network and the traffic was made at entering and leaving ports of the routers SW1 and SW2. The source of the traffic in the experiments was the realizations of real network traffic captured in the real network of "Market-port" company and the model implementation generated by a multifractal model developed in the work [10].

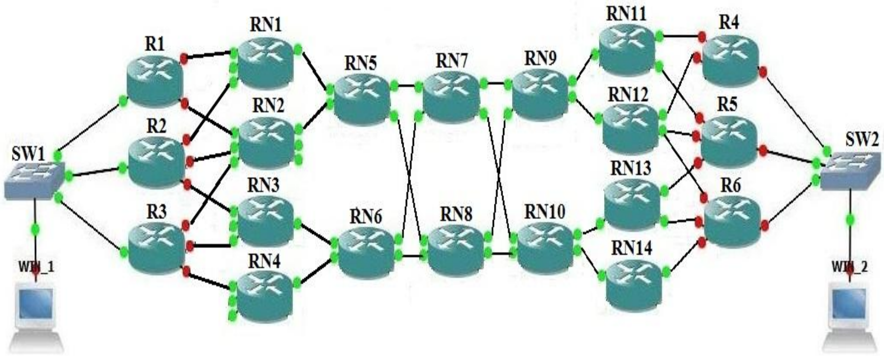

Figure 1. Diagram of the simulated computer network

Figure 2 shows the dynamic changes of communication channel capacity WIN_1-SW1 and MPLS network for incoming multifractal traffic without using additional methods of QoS advancing. Figure 3 shows how the network bandwidth changes when using the method of routing cost evaluation.

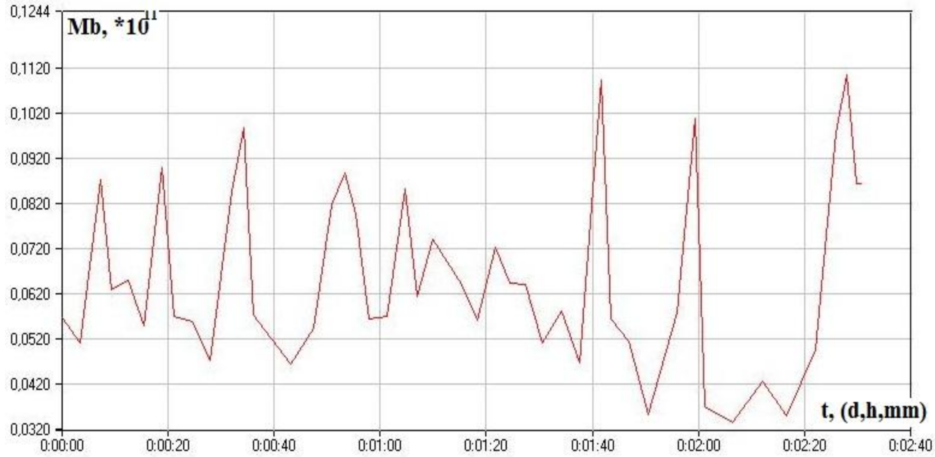

Figure 2. The network capacity without the use of additional methods of QoS advancing

As it is clear from the Figure, the average load of the communication channel is 7Gb/s, with fair amount of bursts. For example, at such time points as 0.35 and 0.55 minutes, 1.45, 1.58 and 2.25 hour. Thus it is seen that the longer the experiment lasts, the more bursts occur. After that, as it is shown by the studies, the system returns to its original state with smaller fluctuations about average bandwidth.

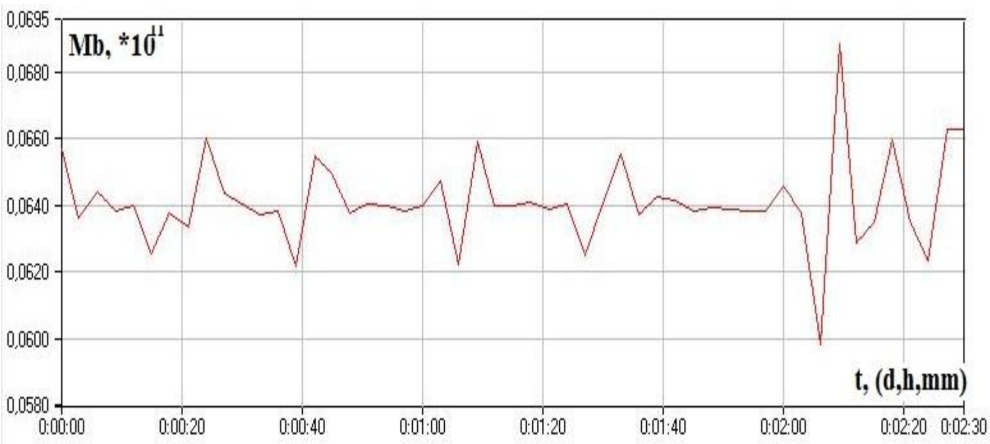

Figure 3. Network bandwidth when using the method of routing cost evaluation

Figure 3 shows that by using the method for evaluating the routing cost the average bandwidth remains at 6.4 Gb/s, however, the burst is observed only at the time point of 2.1 hours and the traffic in the channel is much smoother. Consequently, the loading of the routers when such incoming traffic is more uniform and predictable.

Figure 4 shows the dependence (corresponding to Figure 2) of the amount of lost data in the router SW1, which takes place without the use of additional methods of QoS advancing. Figure 5 shows how the number of losses is reduced when using the method of routing

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

cost evaluation.

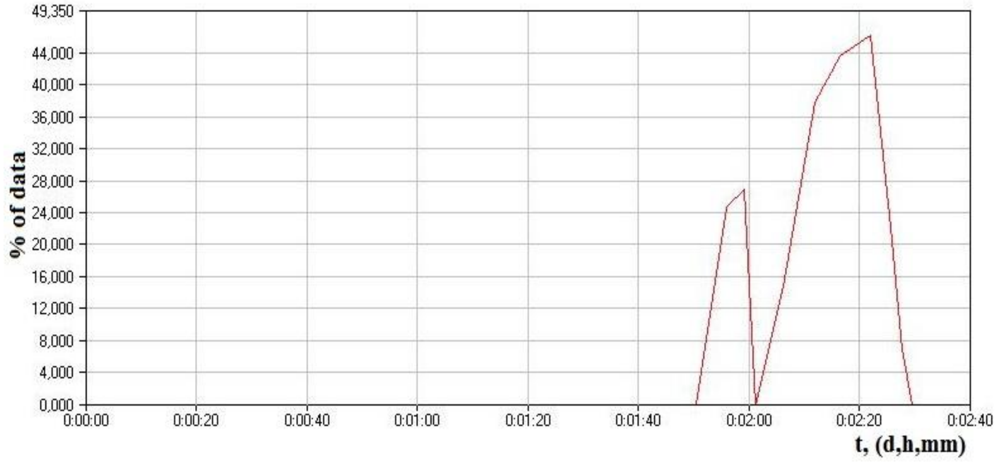

Figure 4. Number of lost data without the use of additional methods of QoS advancing

Eventually the number of lost data, the dynamics of which is shown in Fig. 4, increases as the amount of bursts and spread of values also increases with regard to the average bandwidth (see. Fig.2). It should be noted that the amount of data loss of 46% is unacceptable for all types of traffic.

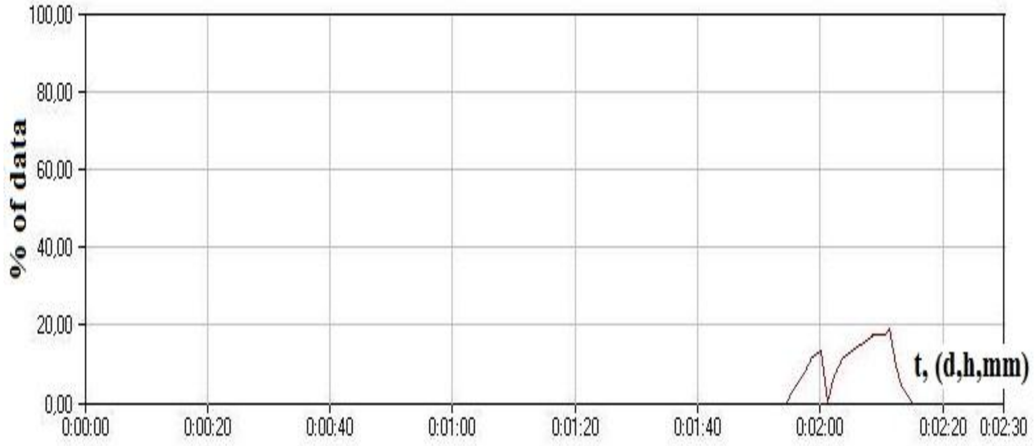

Figure 5. Number of lost data when using the method of routing cost evaluation

As it is seen in Figure 5, when using the method of the routing cost evaluation the number of the lost data is considerably reduced and is equal to 17% and 19%.

Figure 6 shows the scatter of maximum and minimum time of a packet transfer (jitter) between nodes WIN_1 and WIN2 without the use of additional methods of QoS advancing. Figure 7 shows how the scatter is reduced when using the method of routing cost evaluation.

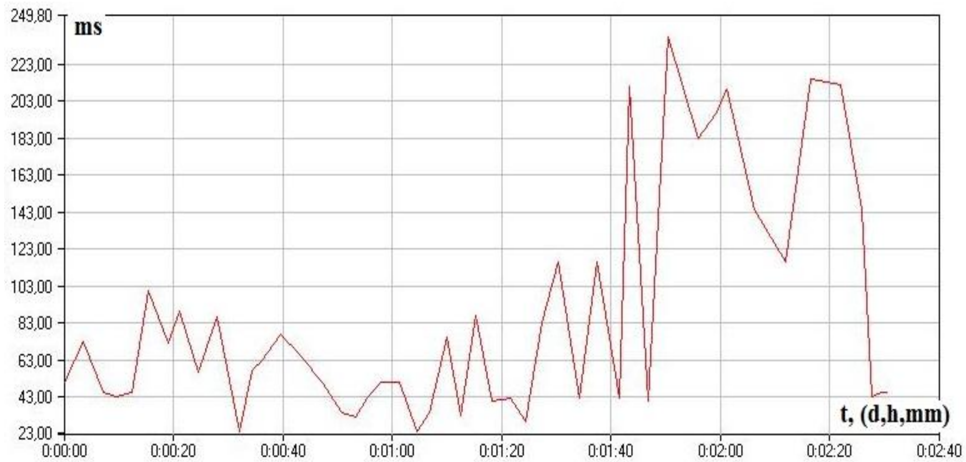

Figure 6. Jitter without the use of additional methods of QoS advancing

Without the use of additional methods of QoS advancing the average scatter of the maximum and minimum time of a packet transfer is 63 ms for 1 h 40 min (Fig. 6). After that the dispersion increases more than two times and becomes 130 ms. These values are not valid for most types of traffic, much less the voice and video traffic

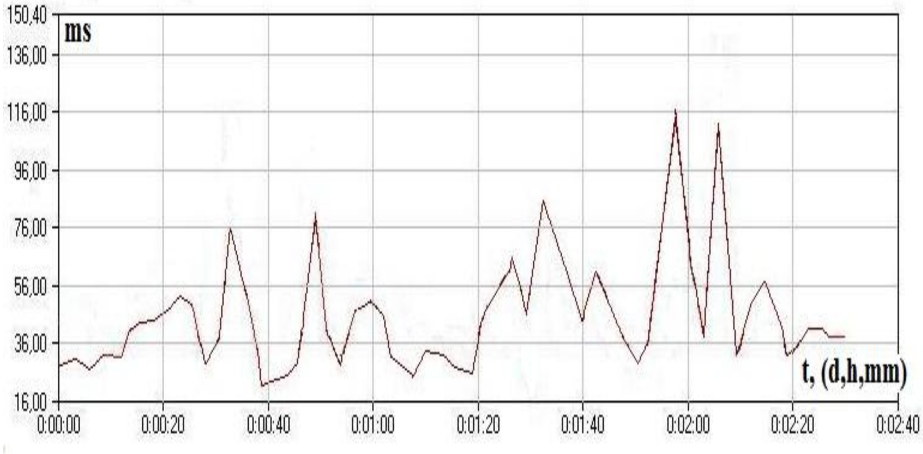

Figure 7. Jitter when using the method of routing cost estimation

Figure 7 shows that when using the method of routing cost evaluation the maximum and minimum time of packets transfer scatter is 40 ms. The peak values greater than 100 ms do not occur.

Table 1 shows the generalized estimations of dynamic dependencies above mentioned that evidence the advantages of the method of routing cost estimation.

Table 1. Average ratings of quality parameters of the network operation

	Average coefficient of the channel loading	Average value of lost data, %	Average value of jitter, ms
Without methods of QoS advancing	0,7	3,6	97
Method of routing cost estimation	0,61	1,8	40

IV. CONCLUSIONS

The paper introduces the method for evaluating routing cost with regard to fractal properties of the traffic. The results of the simulation study showed that with the same volume of information transmitted by SW1 and SW2 nodes the transmission losses of the traffic possessing fractal properties are significantly lower when using the method n of routing cost estimation. Thus, it can be concluded that the use of the worked out method of routing cost estimation significantly improves the quality of the service in the network. However, the application of this method is quite resource intensive and expensive. The following work is planned to consider another method of improving the quality of the service to be less expensive and resource intensive, and compare it to the presented in this paper the method of routing cost estimation. Thus, it is possible to choose a method that can be most appropriate for a particular network.

REFERENCES

[1] Selin Cerav Erbas , Cagkan Erbas. A Multiobjective Off-line Routing Model for MPLS Networks. IEEE transactions on knowledge and data engineering , 2003. P.1-10.

[2] Петров В. В. Структура телетрафика и алгоритмобеспечения качества обслуживания при влиянии эффекта самоподобия : дис. кандидата технических наук : 05.12.13 / Петров Виталий Валерьевич. – М.,2004. – 175 с.

[3] Шелухин О. И. Фрактальные процессы в телекоммуникациях / О. И. Шелухин , А. М. Тенякшев,А. В. Осин // Монография : под ред. О. И. Шелухина.М.: Радиотехника, 2003. – 480 с.

[4] Кириченко Л. О. Влияние методов маршрутизации на качество обслуживания в мультисервисных сетях при самоподобной нагрузке / Л. О. Кириченко, Т. А. Радивилова, Э. Кайали // Восточно-Европейский журнал передовых технологий. – 2011. – 1/2 (49). – С. 15–18.

[5] Радивилова Т. А. Описание модели сети MPLS и методов управления трафиком Т. А. Радивилова, Э. Кайали // Системи управління, навігації та зв’язку. – 2012. – Вип. 3 (23). – С. 184–189.

[6] Зайченко Е.Ю. Комплекс алгоритмов оптимизации сетей с технологией MPLS// Системні дослідження та інформаційні технології-2007.-№4.-с.58-71.

[7] Abdalla Jr H., Soares A.M, Carvalho P. H. P et al, Performance Evaluation of Shortest Path Computation for IP and MPLS Multi-Service Networks over Open Source Implementation. Proceedings of the 11th International Conference on Telecommunications –SAPIR 2004, Fortaleza, Brazil, August 2004.

[8] P. A. S. M. Barreto, “Uma metodologia de engenharia de trafego baseada na abordagem auto-similar para a caracterizacao de parametros e a otimizacao de redes multimıdia,” Ph.D. dissertation, Universidade de Brasılia, 2007.

[9] Kirichenko L. Comparative analysis for estimating of the Hurst exponent for stationary and nonstationary time series // L. Kirichenko, T. Radivilova, Z. Deineko // International Journal "Information Technologies & Knowledge". – 2011. – Vol.5. – P. 371-388.

[10] Kirichenko L. Modeling telecommunications traffic using the stochastic multifractal cascade process // L. Kirichenko, T. Radivilova, E. Kayali // Problems of Computer Intellectualization / ed. K. Markov, V. Velychko, O. Voloshin. – Kiev–Sofia: ITHEA. – 2012. – P. 55–63.