Software Application for QoS Characteristics Calculation

Vladimír Hottmar and Bohumil Adamec

Abstract — **This paper deals with the algorithmization of a software application intended for QoS statistical parameters and characteristics quantification. Empirical probability distribution of packet delays and packet jitters, average values of delays and jitters will be determined. Practical software implementation of QoS calculation methodology in Delphi environment is shown. Subsequently, in the context of the currently used QoS mechanisms, the practical use of obtained results is described. Created software application was tested on a real network segment with RTP voice, RTP video, SMTP and FTP traffic streams. The operating parameters (queue length, proportions of allocate bandwidth) of implemented QoS mechanisms on this network can be optimized based on the results obtained by application.**

Index Terms — **Packet delay, packet jitter, empirical probability distribution of packet delay, empirical probability distribution of packet jitter, Quality of Service – QoS, Voice over IP - VoIP**.

I. INTRODUCTION

CURRENTLY, there are many different emulators of network traffic, but not all of them provide detailed statistical characteristics of the transported packet delays and jitters. However, for a detailed analysis of conditions in a network or for a precise qualitative analysis of operation of the potentially implemented QoS tools, it is necessary to know the empirical probability distribution of packet delays, packet jitters and other additional statistical parameters and characteristics [1], [2].

Because modern traffic emulators that have been used for the emulation purposes do not provide detailed statistical characteristics and information about transported data traffic it was necessary to create additional software application. Most professional traffic emulators provide either globally statistical characteristics or incomplete statistical parameters. Results of modern emulators usually do not include required statistical parameters and characteristics that relate to the individual data streams. Therefore, it was necessary to create auxiliary application that allows obtaining detailed statistical information about individual traffic streams. Created software application is closely related to a research project that deals with the examination of the QoS tools and optimal implementation of these tools to the modern converged packet networks.

For a detailed verification of the results from the research process it was necessary to create described software application. Therefore, described software application is a specific software tool that is not normally described in scientific articles. However, the application can also be used in practice for the purpose of optimal QoS implementation according to the specific customer requirements – this is actually a novelty. A software application in object-oriented programming language Delphi 7.0 was created for purposes of calculation and graphical interpretation of the empirical distributions of either packet delays or packet jitters. Mentioned application is described in this article. Created software application uses two data files containing captured data traffic in two different network nodes, which are usually located on the edge of the analyzed network (Fig. 1).

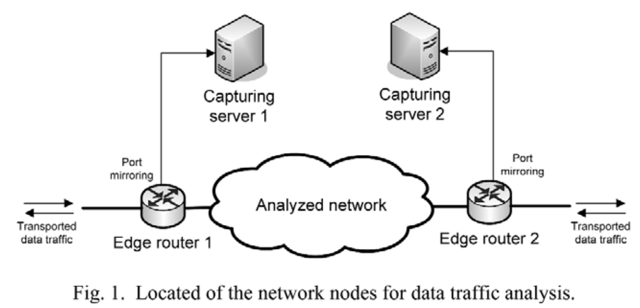

Fig. 1. Located of the network nodes for data traffic analysis.

Obtained statistical characteristics determine on what qualitative level analyzed network segment is able to transport the data traffic. From captured data files is possible to calculate both basic statistical parameters (e. g. average packet delay, average packet loss, average packet jitter) and additional statistical characteristics (e.g. empirical distribution function of delays, maximum delay, minimum delay and so on). All of these statistical parameters and characteristics may relate to packets belonging to a specific data flow that belonging to a specific application (e. g. voice traffic, video traffic and so on) or may relate to the transported packets generally. In the case when all of these characteristics are related

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to the transported data traffic irrespective of the specific data flows of which it consists, we denote these quantities as global characteristics. A more detailed overview about conditions in the network reflects specific characteristics which are related to the specific data flow. On the basis of the results obtained from the created software application it is possible to examine the qualitative level of traffic processing by analyzed network segment and the overall transported data traffic composition.

Qualitative level of data traffic processing can be examined on the basis of the set of statistical parameters and characteristics. These statistical coefficients and characteristics that are related to a particular application indicate the number of discarded packets, maximum, minimum and average packet delay, packet jitter and other basic characteristics. Furthermore, for a detailed data traffic processing review, it is possible to determine the number of packet delays or jitters falling within a certain time interval that is located in the time range between minimum and maximum observed packet delay or packet jitter. The number of these time intervals is a user-defined parameter and the user can adjust it according to his/her needs. In this way the user is able to vary the density and hence the accuracy of the empirical probability distribution.

Another part of created software application allows for determining the composition of the transported data traffic. Based on the transported data traffic composition results it is possible to determine what kind of packets and in what percentage proportions are transported by the network. For instance, according to these results, suitable QoS tool set can be implemented. Individual QoS traffic classes based on of data traffic composition results can be defined and created by the user. Classes are designed to integrate different data streams with identical QoS requirements. The operating parameters for each class can be set according to data traffic composition results and subsequently, these parameters can be corrected according to full statistical results obtained by created software application.

II. Description of Created Software Application

Inputs of the created software application are two data files containing information about the packets captured at two different network nodes. All significant QoS characteristics of network traffic are calculated for interactive RTP voice and video traffic and non-interactive FTP and SMTP data traffic. Packet identification is based on a unique identifier of each packet. Identification of a packet passing through different network nodes is realized using the following parameters:

- Protocol Info – type of packet that is transported in the specific frame in application layer,
- Time – capture moment of the frame corresponding to a specific network node,
- Identification – packet number derived from network layer,
- Protocol Mark – this is Payload Type and Sequence Number derived from application layer in the case of RTP packet or Header Checksum derived from network layer in the case of SMTP or FTP packet.

The described software application creates two groups of arrays. The first array group relates to the server side – this array group is labeled as server. The second array group relates to the client side – this array group is labeled as client. Both array groups consist of four specific sub-arrays that contain the needed parameters and information for the traffic analysis. The first sub-array is labeled as Protocol and specifies the packet type. Based on this information the application decides whether the specific packet is processed or not. The second array is labeled as Time and contains time moments of packet transmission and packet reception. Time characteristics of transported data traffic such as delay, jitter, empirical probability distribution of delay and jitter are calculated based on these parameters. The third array is labeled as ID – Identification and contains identification numbers of all the analyzed packets. These numbers are used for packet identification purposes and to determine concrete packet that passes through different network nodes. The fourth array is labeled as Mark and contains other additional identifiers to uniquely identify transported packet passing through different network nodes.

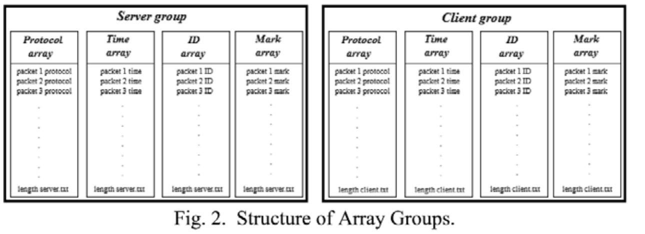

Fig. 2. Structure of Array Groups.

Fig. 2 shows the arrays concept described above.

The size of individual arrays is given by the size of application input data files. Application input data files size depends on the volume of captured data traffic to be analyzed. Specific arrays in the server array group may not have the same number of components as the corresponding specific array in the client array group. This phenomenon is caused mainly by the packet loss in overload network nodes.

However, it is necessary to ensure the same dimensions of all arrays within the individual array group. The same array sizes within individual array group ensure that the comparison and parameter calculation will be done with the data of same packet that was captured in various network nodes.

The created software application provides an overview of the analyzed protocol packets (RTP, FTP, and SMTP) as well as an overview of the complete transported data traffic packets. The software application subprogram result is the total number of transported data packets regardless of their type and number of data packets that are not analyzed such as ARP, EIGRP. Calculation of the parameters mentioned above realizes subprogram labeled as parameter parsing server and subprogram labeled as parameter parsing client (see Fig. 3).

The basic QoS parameter is the average delay of transported data packets. Packet delay is defined as the difference between the time moment of packet reception and

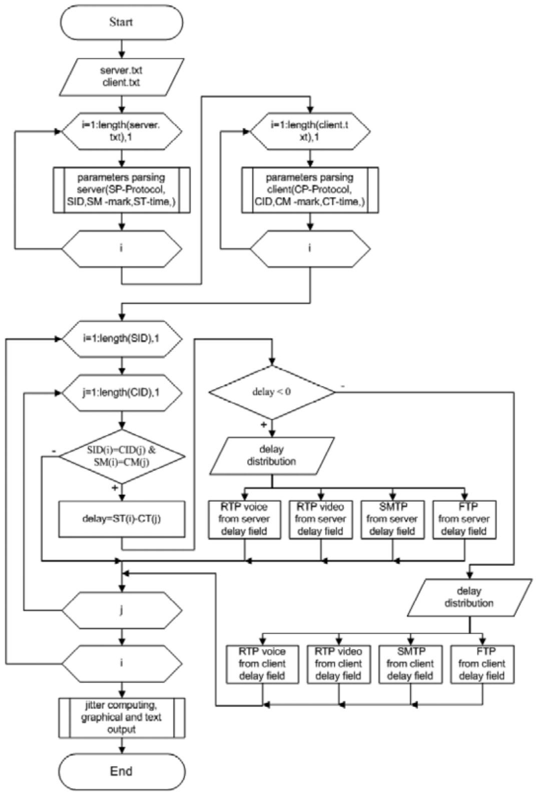

Fig. 3. Software Application Flow Diagram.

time moment of packet transmission. Time moments needed to calculate the delay values are stored in the Month/Day/Year/Hour/Minute/Second/millisecond form.

Subsequently, the values of time moments are converted to integer values that represent these time moments in milliseconds. Next, the packet delays related to particular packets are calculated. Calculated delays are stored in the specific array based on the protocol type. The additional traffic characteristics (average delay, minimum and maximum delay) are calculated based on these parameters. For the calculation of all the statistical parameters and characteristics conventional procedures and formulas were used that are not the main subject of this article. The computational methodology used is described in detail in [2], [5].

The structure of packet delay arrays is show in Fig. 4. Consequently, the delay jitter is calculated. Delay jitter is defined and calculated as the average value of the differences between packet delays. All calculated values are displayed in a numerical and graphical form. Graphical design of result form is show in Fig.5.

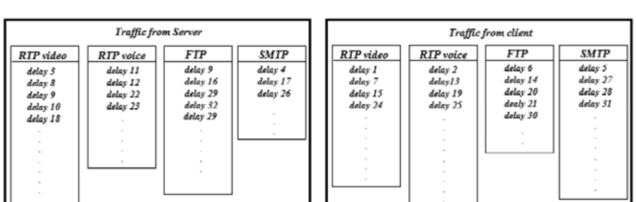

Fig. 4. Packet Delay Arrays Organization.

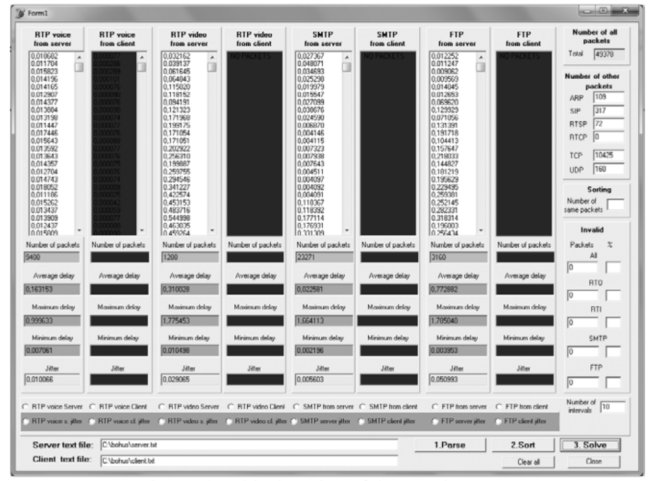
Fig. 5. Graphical Design of the Results Form.

III. Practical Application of the Software Tool

Before the practical implementation of QoS in a real network segment it is necessary to analyze the transported data traffic [3], [4]. In particular it is necessary to determine which types of packets are transported. Next it is necessary to determine percentage proportion of specific packets in the overall transported traffic [5], [6]. This analysis can be realized by the created software application. Some results of concrete traffic analysis are shown in Fig. 6.

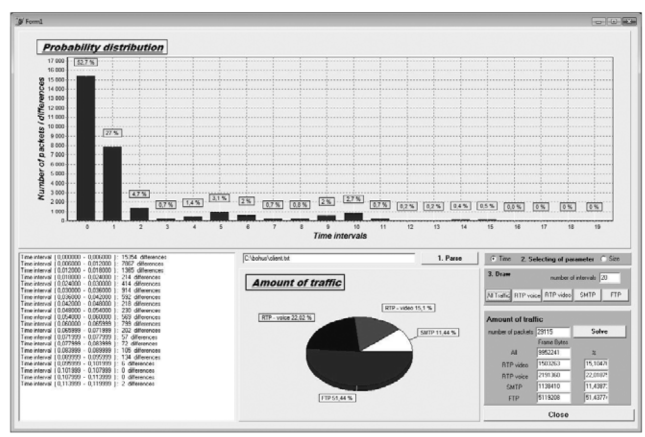

Fig. 6. Results of Traffic Analysis.

This figure shows empirical probability distribution of time differences between time moments of capture of two immediate packets and percentages of specific transported packets belonging to the individual applications. Based on these results it is possible to decide which packets should be processed as a priority [4], [5]. Priority processing of transported traffic can be realized by the different QoS tools (WFQ, CBWFQ and LLQ). Implementation of these mechanisms requires setting their operational parameters – queue length and bandwidth proportion belonging to the specific traffic class [2], [3], [4].

Quantification of operational parameters can be realized based on a mathematical model. Application of the mathematical model requires specific statistical parameters (average packet size, load coefficient and so on) that can be obtained from the results of described software tool. The implementation of the mathematical model and the created software tool has been tested and successfully implemented on a real network segment.

IV. CONCLUSION

The created software application has been used in the real network segment in the context of optimal application of QoS mechanisms. Based on the results obtained from the created software tool, the appropriate QoS mechanisms have been implemented. Implementation of QoS mechanisms has been performed on the basis of the mathematical model and statistical parameters of transported data traffic obtained from the software tool. In this way, it is possible to apply the QoS mechanisms by the deterministic method and not by the trial and error way. Based on the results of the analytical model and created software application the QoS tools implementtation can be optimized [5]. In order to meet the predefined user requirements the operating parameters of applied QoS tools can be optimally adjusted – this fact can be considered as the main benefit.

Compared with commercially available applications, the created software tool provides additionally the detailed statistical analysis of transported data traffic. It provides the basic statistical parameters (total number of transported packets and bytes, total number of transported packets and bytes related to a specific protocol, percentage of transported packets and bytes related to a specific protocol) and additional parameters and relations (empirical probability distribution of packet size, empirical probability distribution of packet size related to a specific protocol, empirical probability distribution of time differences between time moments of capture of two immediate packets and so on).

These statistical parameters and characteristics are very important mainly for optimal application of QoS mechanisms. Furthermore, in addition to average and peak values of packet delays and jitters application also provides the empirical probability distribution of these characteristics. The described application could be extended to the other protocols and applications.

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REFERENCES

[1] Liu, X., Ravindran, K., Loguinov, D., "A queueing-theoretic foundation of available bandwidth estimation: single-hop analysis," IEEE/ACM Transactions on Networking, vol. 15, no. 4, pp. 918–931, 2007.
[2] Hock, N. Ch., Hee, S. B., "Queuing Modelling Fundamentals with Applications in Communication Networks," New York: J. Wiley and Sons, Inc., 2008, ISBN: 978-0-470-51957-8.
[3] Odom, W., Cavanaugh, M., J., "Cisco QoS – Exam Certification Guide", Indianapolis: Cisco Press, 2005, ISBN: 1-58720-124-0.
[4] Chaskar, H. M., Madhow, U., "Fair scheduling with tunable latency: a Round Robin approach," in Proceedings of the IEEE Global Telecommunication Conference (GLOBECOM '99), pp. 1328–1333, December 1999.
[5] Adamec, B., "Design of optimization model for data communication management in Campus LAN", PhD. dissertation thesis, Department of Telecommunications and Multimedia, Faculty of Electrical Engineering, University of Zilina, Zilina, Slovakia, 2010 (in Slovak).
[6] C. W. Chan, Performance Analysis of Telecommunications and Local Area Networks, Kluwer Academic, Norwell, Mass, USA, 2000.

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