A MACHINE LEARNING BASED NETWORK MONITORING AND MANAGEMENT SYSTEM

Tan Phan-Xuan, Eiji Kamioka

Graduate School of Engineering and Science, Shibaura Institute of Technology

{nb15507, kamioka}@shibaura-it.ac.jp

ABSTRACT

Recent years have witnessed a significant development of the many real-time Internet applications which requires the guarantee of real-time quality in the underlying network. Hence, the network administrators have to take into consideration optimizing their system capacity to achieve a particular level of service quality measured by the user's perspective. Although traditional network monitoring and management tools have effectively worked well for monitoring individual technology components, they have not provided an accurate performance evaluation scheme or a framework to guarantee the quality of service for the end-users. Therefore, a new approach to effectively quantify the network service quality and to provide the maximized quality of service from the viewpoint of end-users is required. This study proposes a machines learning based network monitoring and management system that allows the network system to automatically evaluates and optimizes its performance following the requirement of end-users service quality. The proposed system consists of two main processes, that is to say, (1) training process and (2) performance evaluation-adjustment process. In the first process, the quality of a particular multimedia application transmission in the network is quantified and trained by using Pseudo-Subjective Quality Assessment (PSQA). This process utilizes Random Neural Networks (RNN), technique which performs the task of quantifying network service quality automatically, accurately and efficiently. In the second process, based on the trained data, a network service performance is evaluated and the performance is adjusted to meet the end-users requirement. In this paper, the architecture of the proposed system will be stated. Subsequently, the effectiveness of the proposed system will be discussed by the results obtained from a preliminary evaluation experiment. Finally, the conclusion and future work of this study will be mentioned.

Keywords: Network management, machine learning, QoS, QoE.

1. INTRODUCTION

The network system now is becoming larger, more complex for supporting more applications and more users. The increase in network complexity makes the task of managing and monitoring network more difficult.

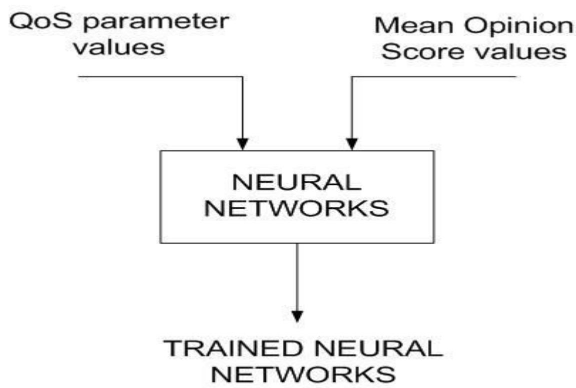

Fig. 1 Training process

In the conventional approach, the maintenance and configuration of network devices, server and services, as well as continual monitoring of all the devices within the network, are the critical elements of a network management system. By using management and monitoring tools such as Solarwind, Cacti, CiscoWork, administrators could obtain a holistic view and correct understanding about their system's state. Therefore, administrators could make the right decisions to ensure the stabilization, efficiency and promise a better performance for application traffic transmitted. However, to cope with the quick development of real-time applications technologies, QoE-based network

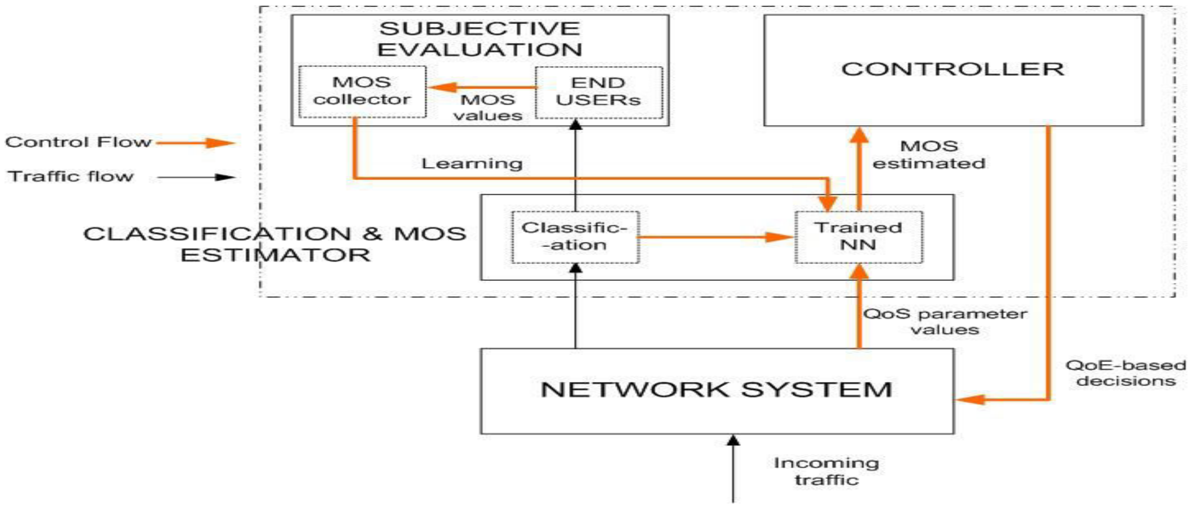

Fig. 2 Performance evaluation-adjustment framework

management and monitoring should be considered as a new approach in which the network system automatically modify itself to maximize the service quality perceived by end-users.

In this paper, we propose a framework to manage network system by means of integrating the automatic quantification of the quality of multimedia flows transmitted over packet networks with auto-configuration on network devices. This framework performs two processes, called training process and performance evaluation-adjustment process. We conducted an experiment in the training process to match the sets of quality-affecting parameter values to corresponding Quality of Experience (QoE) values. This paper is structured as follow. The related works are discussed in Section 2. Section 3 describes the propose system. Section 4 and 5 describe a testbed of training process and the result evaluations. Finally, section 6 presents our conclusions and future works.

2. RELATED WORK

Samir Mohamed & Gerardo Rubino (2002) provided a method to automatically quantify the quality of video flows by using Artificial Neural Network (NNs). Based on previous study, Gerardo Rubino (2005) and Rubino, G, et al. (2006) described a method that is a hybrid between and objective evaluation called Pseudo Subjective Quality Assessment (PSQA) to quantify the quality of multimedia application delivering on the internet in an automatic way, accurately and in real-time. In PhD thesis, Mariyam Mirza (2012) proposed a machine learning based approach in network performance analysis. The authors introduced analysis based on Support Vector Machines (SVM), a powerful, state of the art machine learning technique, as a new and better design point in the spectrum of analysis methods for network performance problems involving classification and prediction. This comes from a motivation of the need for analysis methods that can cope with increasingly complex and difficult to analyze computer networks where the complex relationship between large numbers of affected parameters exists. Seppanen, et al. (2014) presented a generic QoS/QoE framework for enabling quality control in packet-switched networks. In this framework, the user's satisfaction could be directly applied to the network management in real-time through the data acquisition level, monitoring level and control level. However, this proposed framework familiar with ISP-driven framework rather than user side. Besides, a framework called Cognition-Based Networks (COBANETS) has been proposed (Zorzi, et al., 2015) to combine machine learning techniques with the emerging network virtualization paradigms. The authors expect that it is possible to actuate automatic optimization and reconfiguration strategies at the system level. The authors also provided some preliminary examples of the potential of such an approach. Nevertheless, COBANETS has been known as a conceptual framework existed many challenges need to handle.

3. PROPOSED SYSTEM

In this section, we propose a system that enables to manage and monitor network system in an automatic and effective way based on the real-time application quality perceived by end-users. The system is structured by two major processes: training process and performance evaluation-adjustment process.

Fig. 1 shows the training process, the input data is represented by the sets of different values of quality-affecting parameters. In this case, we considered three kinds of network parameters that have most influence on quality of video. They are delay, jitter and packet loss. Different set of QoS parameter values will obtain different levels of influence on quality of application flows transmitted over network. Therefore, it also brings the different levels of satisfaction to user as output following the scale of 5-scores of Mean Opinion Score (MOS) (ITU-R, Recommendation BT 500-11, 2002). The input and output are placed in Neural

Network (NN) training tool. The result is a trained NN that matches a set of QoS parameters values to MOS value.

The performance evaluation-adjustment process is performed by the framework in Fig. 2. Accordingly, the designed framework consist three components: Classification & MOS Estimator (CME), Subjective Evaluation, and Controller. This framework allows network to manage performance by itself by means of evaluating service quality, configuring network devices.

(1) Classification and MOS Estimator (CME)

CME is responsible for two tasks: Classification and calculating MOS values.

- Classification: Receives incoming traffics and put them into suitable traffic classes with different priorities. Simultaneously, it provides the knowledge about traffic to trained NN and keeps delivering this traffic to the end users which located in Subjective Evaluation component.
- Trained NN: By applying the trained function from the training process, trained NN could produce estimated MOS corresponding to the values of QoS parameters, and traffic information. It also performs training tasks continuously after receiving MOS values following feedback from Subjective Evaluation component.

(2) Subjective Evaluation component

The end users play a centric role in this component by providing their perceived quality. After experiencing the

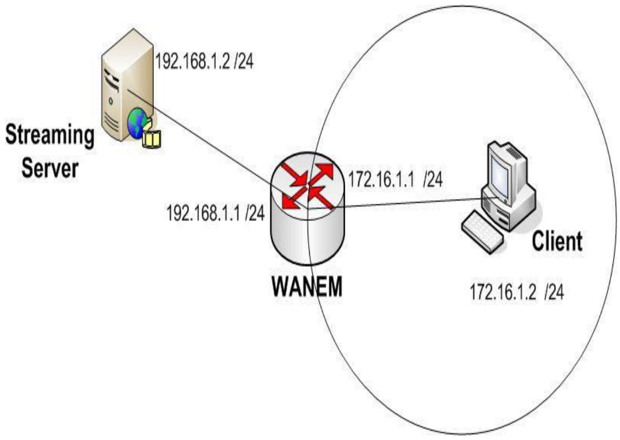

Fig. 3 Experimental topology

service, user could evaluate the quality of application according to the scale of 5 scores of MOS, which might become new input data for learning phrase as learning feedback to Trained NN.

(3) Controller component

Controller is the most important component in quality self-management purpose which has the right view about the performance of the network system in a particular time based on estimated MOS. Therefore, the right decisions should be made by Controller in order to enhance the performance of network system or to promote the MOS to higher values in case of estimated MOS less the acceptable MOS values. The QoE-based decisions could be operated by changing the configuration of network devices.

4. EXPERIMENT

The experiment is conducted like Fig. 3 to establish a function to describe the relation between values of QoS parameters and perceived quality generated by users. The experiment was conducted following two steps:

4.1 Data collecting and cleaning

We collected the sample data by deploying a testbed which including a VLC streaming server, WANEM soft router, and VLC client. At the beginning, VLC streaming server started to stream movie “Le Petit Nicolas 2009” with video codec H.634 via HTTP, port 8080. Five users participated in this experiment by watching specific sequences of movie and provided their evaluation scores in case of at WANEM soft router, we changed the values of packet loss, delay, and jitter. For each set of the values of QoS parameters as input data, a set of MOS values are generated as output data. In this experiment, we obtained 21 sets of input data corresponding 21 video sequences transmitted via WANEM soft router. Then, we cleaned data by divided them to the maximal value in both of input and output data.

4.2 Training NN

In this step, input and output data were added to 10-hidden layer neural network on Matlab. After training, we obtained a dataset of Mean Squared Error.

5. EVALUATION

The results in Figure 5 illustrate a good result which describes relation between collected MOS (output) and

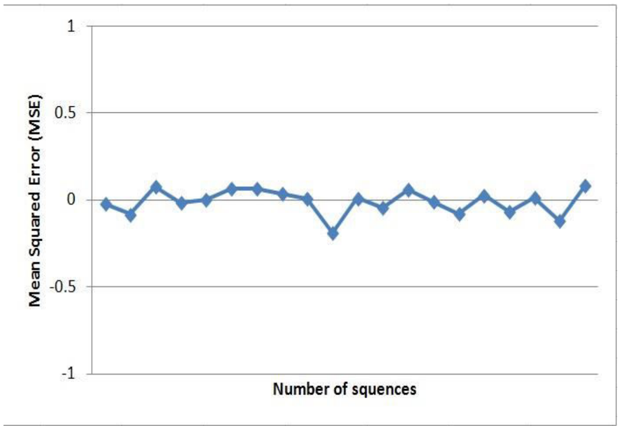

Fig. 4 Mean Squared Error

predicted MOS in training process. Accordingly, output and predicted MOS are close to each other. Furthermore, Fig. 6 also provides a Mean Squared Error (MSE) values have been estimated during training process which nearly equal to 0. It means that the accuracy of training process is as high as we expected.

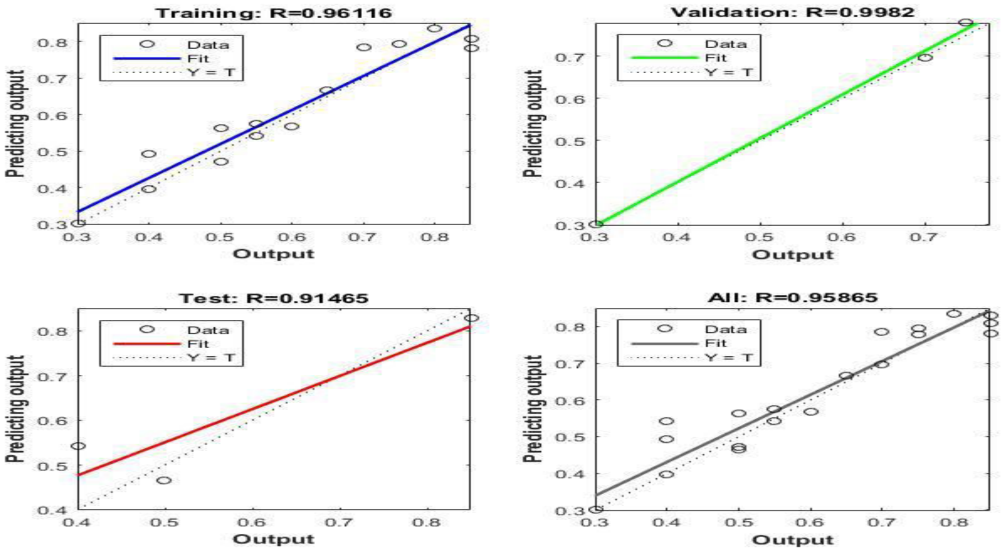

Fig. 5 Relation between predicted MOS and collected MOS

CONCLUSION

In this paper, a machine learning based network management and monitoring has been proposed. This approach could be carried out by two main processes: training process and performance evaluation-adjustment process. Through our proposed system, the MOS could be predicted when real-time application transmitted via packet network and network system also is expected to react by auto-reconfigure network device to maximize the service quality for end-users.

In the future, more input data should be placed into training process to enhance the accuracy of trained NN. We also focus on improving the performance evaluation-adjustment framework by taking into account more quality-affecting parameter such as type of end devices, the mobility of users

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Phan Xuan Tan received the B.E (2009) in Electrical-Electronic Engineering from Military Technical Academy, M.S (2013) in Computer and Communication Engineering from Hanoi University of Science and Technology. Currently he is PhD student at Shibaura Institute of Technology (SIT), Japan. His research interest is Quality of Experience (QoE), Networking, Machine learning.

Eiji Kamioka is a professor at Shibaura Institute of Technology. He received his B.S, M.S and D.S degrees in Physics from Aoyama Gakuin University. Before joining SIT, he was working for SHARP Communication Laboratory, Institute of Space and Astronautical Science (ISAS) as JPSP Research Fellow and National Institute of Informatics (NII) as Assistant Professor. His Current Research Interests encompass Mobile Multimedia Communications and Ubiquitous Computing