Proceedings of the 2014 Winter Simulation Conference
A. Tolk, S. Y. Diallo, I. O. Ryzhov, L. Yilmaz, S. Buckley, and J. A. Miller, eds.

AN IP VPN NETWORK DESIGN AND DIMENSIONING APPROACH USING ANALYTICAL-SIMULATION MODELS WITH INCREMENTAL VALIDATION

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ABSTRACT

The development of networks for converged services including voice, video and data over the same infrastructure requires appropriate planning and dimensioning. This work presents a methodology, based on discrete event simulation, that supports the dimensioning and planning of IP multi-service links with QoS requirements. One key aspect is the type of traffic considered: stream, which has strict time and bandwidth requirements (e.g., VoIP), and elastic, which tolerates a certain delay (e.g., FTP, TELNET and HTTP). Another key aspect is the validation of the simulation model. In the absence of actual data, an approximate and proven analytical model was used for comparison and validation. The validated simulation model can be incremented step by step in order to be used in more complex scenarios. Although we show the application of the method in a pre-defined case for the elastic traffic, the steps to be followed in a more general case are quite similar.

1 INTRODUCTION

The integration of services such as audio, video and data in the same network based on IP (Internet Protocol) increases the concern with QoS. The complete integration of multiple service types over a single IP network presents new challenges because of the inhomogeneity of traffic from various services (Tome, Ursini and Mincov 2008; Trindade, Medrano and Lavelha 2003). The consideration of all the features from all applications must be avoided, as this may lead to a complex dimensioning/planning process. Additionally, uncertainties in statistics and in traffic forecasts are generally larger than the errors due to certain characteristics of applications. Thus, the different applications may be grouped in some classes of services according to their QoS requirements. When planning a multi-service IP network we must adopt a more pragmatic approach, as recommended by Riedl, Bauschert and Probst (2000). The main contribution of this work is an incremental method for modeling data packet networks, based on simulation that is initially validated by an analytical model, and on the evolution of the simulation model subsequently step by step to take into account more complex scenarios.

2 MODELING APPROACH

It is essential to the performance evaluation of traffic that we consider Quality of Service (QoS) requirements, due to the characteristics of the services offered by the network. To apply the QoS concept it is important to separate the traffic into two main types: stream and elastic. In order to evaluate the behavior of a multi-service data network in terms of QoS, with respect to variations in traffic demand, we use a typical network scenario as illustrated in Figure. 1. This figure also shows the idea of evolving from a simple model, which is analytically validated, to a more complex and realistic model.

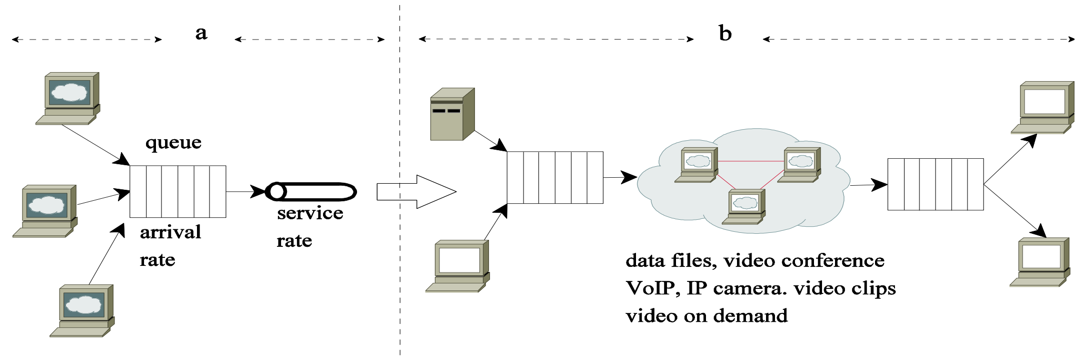

Figure 1: a) Multi-service network topology as a single link b) Multi-service packet switch network topology

This work primarily focuses on the dimensioning of elastic models (data files). To verify whether the simulation models were consistent with the known elastic analytical models of type M/G/R/PS (Riedl, Bauschert and Probst 2000), sixteen simulation models were tested, being eight with hyperexponential distribution and another eight with Pareto distribution. In general, the results were satisfactory. As an example, the analytical M/G/R/PS model of a link with 240 kbit mean file size yielded a 4.98 s sojourn time. The corresponding simulation models resulted in [4.86-5.57] s (hyperexponential) and [4.91-5.03] s (Pareto) confidence intervals. To demonstrate the approach, we evolved the basic simulation model with several increments, one at a time. For example, the first increment included other sixteen extended models derived from the validated ones. These incremented models could not be calculated analytically by the M/G/R/PS (e.g. either because of the Weibull arrival or the two separated data streams), but had their sojourn time estimated by simulation instead. For instance, for a 240 kbit mean file size with Pareto distribution and Weibull arrival distribution, the estimated confidence interval for sojourn time changed to [11.24-14.51] s.

CONCLUSION

The analytical models were validated by simulation models and vice versa. Due to the fact that the analytical models are very limited for the general characteristics of packet networks, we have proposed to increase the validated simulation models step-by-step. Therefore, simulation models were validated with small but significant changes in relation to the analytical models. This design and planning approach may also be applied to more specific applications following similar steps.

ACKNOWLEDGEMENTS

We would like to thank FAPESP/UNICAMP-FAEPEX 2011/17339-5 and CNPq #310980/2012-7 grants.

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