EFFECT OF DATA TRAFFIC PATTERNS ON QoS PARAMETERS

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ABSTRACT

In the design and management of data communication networks the appropriate choice of traffic model that would reflect the exact pattern of the users' traffic has always been an issue of study. In the literatures different models have been presented. This work presents the comparison of several data traffic models (most popularly used in the literatures) on the basis of their influence on the quality of service (QoS) parameters. It is intended that this comparison would place at the disposal of researchers the data traffic models that would assist in making effective worse-case or best-case analysis of data communication systems. Object oriented computer simulation modeling technique provided the general platform necessary for such level of comparison. In this work MATLAB simulink simevent simulation environment was employed. The results present exponential distribution as the traffic model to be employed for worst-case analysis while Gamma distribution is for best-case communication systems analysis.

INTRODUCTION

The selection of the appropriate data traffic source model for a given network analysis is an important issue that may mar or make a successful design, implementation and management of data networks. Data networks require detailed characterization of the traffic offered for transmission in order to efficiently and effectively allocate resources to it [1]. The level of accuracy that may be attained in the analysis of data networks largely depends on the precision with which the traffic is modeled. The more precise the models the less tractable they become mathematically. This is the more reason why this work directs its attention to comparing the data traffic models that are popularly presented in the literature with the view to recommending the traffic models that would assist network researchers in making effective worse-case or best-case decision on data communication resource utilization [2]. The comparison was done using the general platform provided by object oriented computer simulation technique – MATLAB.

While the characterization of voice users is fairly straight forward, the traffic generated by packet data users is highly dependent on the application and has a high degree of burstiness [3]. Currently, the most widely used data applications are the e-mail, web browsing, file downloading/ uploading using file transfer protocol, the wireless application protocol and the short message services [4, 5]. Having considered the different traffic arrival processes that have been used to model traffic in the literature, the ON-OFF process is preferred [5, 6, 7, 8, 9, 10]. In this work, the ON-OFF process was implemented on the basis of some popular statistical distributions such as exponential, geometric, bernoulli, gamma, weibull and lognormal.

The traffic and node models were developed and then the models simulated for the influence of the traffic patterns on QoS parameters such as buffer occupancy, delay, loss, and throughput.

3.1 TRAFFIC MODEL

Data network traffic model was popularly characterized using ON-OFF process mainly because it reflects the notion of self-similarity [6, 10]. Therefore, in this work traffic modeling was based on the ON-OFF process. The modeling of the data traffic consists of two parts - the arrival process for user activities and the process describing the activity phase [5]. For most of the data applications the arrival process has been modeled using the ON-OFF process or the Poisson process. The activity phase model differs from one application to the other.

The traffic model was designed and translated into computer simulation model using the MATLAB simulink environment. Using the simevent in the simulink of the MATLAB the traffic model is translated into the simulation model in figure1 – traffic pattern generator. Event-based random number generator blocks were employed and the distribution needed for the model specified. The generator blocks in each case, was connected to time-based entity generator which produces required output traffic.

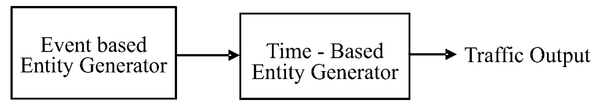


Figure 1: ON-OFF traffic generator

The total traffic intensity generated by all the traffic sources was a constant value through all the scenarios. The ON-OFF traffic patterns were generated by employing the respective distribution functions for Exponential, Geometric, Bernoulli, Weibull, Lognormal and Gamma sources [1, 2, 11, 12, 13, 14]. Therefore, each source generated a traffic stream according to an ON-OFF model. The distributions of the traffic generated by each source were independent and identically distributed.

3.2 NETWORK MODEL

An entire communication network has severally been shown to be modeled as a single network node [15]. The node was defined to simply consist of traffic sources, buffer and server. The path-combiner was employed in the simulation modeling in order to ensure that the arriving traffic has equal probability of being served in a random manner. The server uses a service discipline of first-in-first-out (FIFO). The simulation model is presented in figure 2.

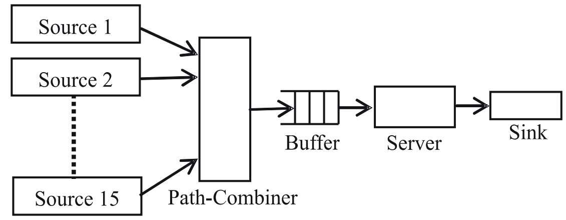


Figure 2: Network Model

3.3 SIMULATION AND RESULTS

The computer simulation model in figure 2 was simulated in the Simulink environment.

During simulation, traffic sources were varied between 1 and 15 independent sources for the six different traffic patterns used. Therefore, the ON-OFF duration within a uniform traffic pattern for each of the fifteen sources differed. The data flow from each source is composed of packets with variable lengths. The queue is serviced by a server working at a fixed service rate for all the distributions. Each queue is served on a FIFO basis.

While the number of sources was varied between 1 and 15, the buffer size was maintained constant at 10. The server is a single server with a service rate that was exponentially distributed. The model, figure 2, was simulated for the influence of the traffic patterns on buffer occupancy (average queue length), delay, loss, and throughput.

Results were obtained for each of the six traffic patterns (distributions). The effect of the buffer for the average queue length, packet delay, packet loss, and throughput were plotted against number of sources (traffic intensity) for each of the distributions.

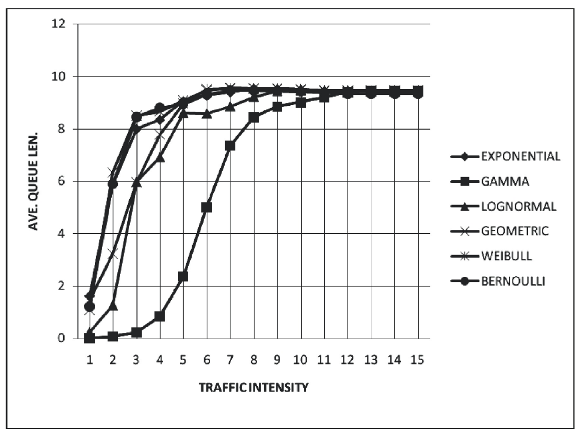
Average Queue Length and Average Waiting in the Queue (Delay)

Figures 3 and 4 are similar and presented the effect of traffic patterns on the queue length and on delay for the six distributions. Results show that Exponential, Geometric, and Bernoulli distributions, have followed almost the same behaviour. For traffic intensity equal to unity average queue length and delay were low but as the traffic intensity increased the queue length and delay increased at a fast rate and, generally, stabilized as the traffic intensity reached ten.

For the Weibull and Lognormal distributions the average queue length increased gradually as the traffic intensity increased. And as the number of sources increased to five the Weibull distribution behaved like the other three first mentioned distributions, while for lognormal, the average queue length and delay tended to the same behaviour as the traffic intensity increased to nine.

Figure 3: Average Queue Length versus Traffic Intensity

The Gamma distribution has a slightly different behaviour from the above distributions in that the average queue length and delay increased at a slower rate



and only behaved like the other distributions when the traffic intensity increased to twelve. At low traffic intensities the behaviour of the distributions varies while at high traffic intensities they behave alike. Therefore, it is shown that Gamma distribution has the lowest buffer occupancy and delay, while Geometric and Bernoulli have the highest occupancy and delay.

Figure 4: Average Waiting (Delay) versus Traffic Intensity

Throughput

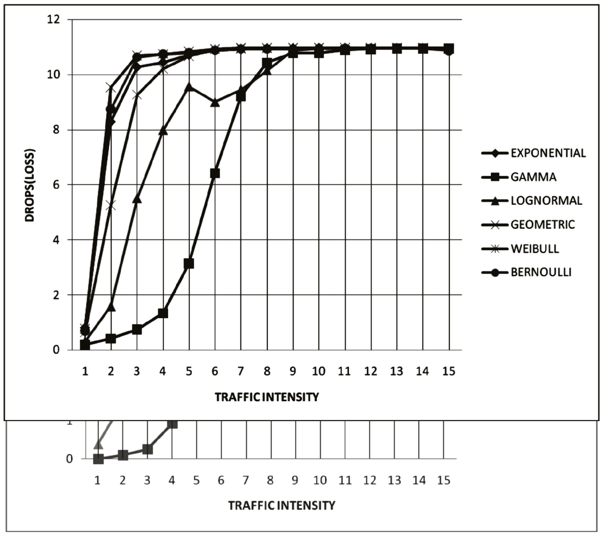


Figure 5 presented the relationship between traffic intensity and throughput for the traffic patterns. Throughput increased for Exponential, Geometric, Bernoulli, and Weibull distributions from the unit traffic intensity to when the traffic intensity increased to two. As the traffic intensity increased to three the throughput for these distributions increased and remained at their respective levels even as the traffic intensity increased to fifteen. The throughput for Log-normal distribution increased with traffic intensity from one to four. With the increase in the traffic intensity from four the throughputs for all the distribution maintain a constant value.

At low traffic intensities the behaviour of the distribution vary while at high traffic intensities they behave alike. Therefore, it is shown that Gamma distribution has the highest throughput; while Exponential has the lowest followed by Geometric and Weibull distributions.

Figure 5: Throughput versus Traffic Intensity

4.4 Average Loss (Drops)

For the average loss the results generated with each of the distributions were plotted against traffic intensity as presented in

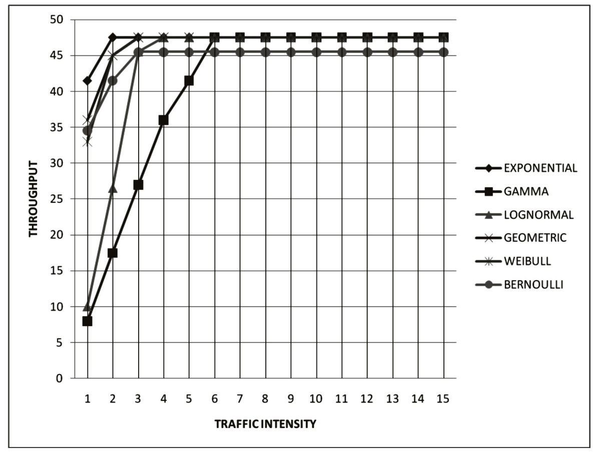


figure 6. The average loss with the Exponential, Geometric and Bernoulli distribution is the same from the unit traffic intensity to fifteen. The Weibull distribution tended to be slightly different while Lognormal distribution showed a different behaviour as shown in the graph. When the traffic intensity increased to nine, loss remained constant with further increase for all the distributions, including gamma.

At low traffic intensities the behaviour of the distribution vary while at high traffic intensities they behave alike. Therefore, it is shown that Gamma distribution has the lowest Loss, while Geometric and Bernoulli have the highest followed by Exponential Distribution.

Figure 6: Drops (Loss) versus Traffic Intensity

5.1 Conclusion

This work considered different traffic distribution patterns - Exponential, Bernoulli, Geometric, Gamma, Lognormal, and Weibull for analysis. The results of the analysis show that Gamma and Lognormal show better delay, throughput, average queue length and packet loss performance than the other four distributions. This implies that the two distributions may be considered when there is need for best-case network analysis and the rest of the other distributions employed for the worst-case analysis. The effect of the traffic patterns on the network vary at low network traffic load while at heavy traffic load the effects of the six distributions converge. Weibull distribution tended to behave like the conventional Poisson distribution.

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