Modeling and Simulation of Traffic in High Speed Networks Based MMPP

Afshin Shaabany, Fatemeh Jamshidi, Soona Shaabani

Islamic Azad University, Fars Science and Research Branch, Shiraz, Iran
afshinshy@yahoo.com, Fjamshidi59@yahoo.com

Abstract: One of the non-self-similar models which is capable of modeling self-similar traffic in networks and always attracts attention of researches is MMPP process. In other words, this model can produce bursty traffics in data and video networks. In this paper, accuracy and preciseness of adapting MMPP on voice, data and video traffics are studied and the efficiency of input process of MMPP into high speed networks is reviewed based on queue model of MMPP/D/1. Then by means of advanced and MMPP-based algorithms such as LAMBDA, data and video fractal traffics are synthesized based on original trace and their efficiency are compared. We correct the algorithms in a manner that the coordination impreciseness resulted by the change in parameters of self-similar traffic, in particular, HURST parameter fades out. Our strategy for correcting the above algorithm is as follows: Whereas the number of MMPP states in adjustment process is low, we may not be able to cover all original packet trace. Therefore, if the number of MMPP states increases, we can solve the efficiency.

[Afshin Shaabany, Fatemeh Jamshidi, Soona Shaabani. **Modeling and Simulation of Traffic in High Speed Networks Based MMPP.** *Rep Opinion* 2014;6(11):69-79]. (ISSN: 1553-9873). http://www.sciencepub.net/report. 11

Keywords: LAMBDA, MMPP process. HURST parameter, Traffic in high speed networks.

1. Introduction

Generally, LAMBDA algorithm divides the traces frequently from maximum to minimum observation into MMPP rates, allocates each sample trace to the corresponding state in MMPP, produces generic matrix and finally, produces MMPP packets. Therefore, algorithm has three basic parts as below.

- **Calculating MMPP rates based on desired traffic trace**

In the first part, rates or states of MMPP are calculated based on the desired traffic trace. Thus, it is understood that despite Ryden algorithm (Andersson, 2000), which uses the estimation method of maximum similarity to calculate MMPP parameters, the number of rates or states is unknown at the beginning and it is considered a good point. For the purpose of calculating MMPP rates, λ_i's shall be selected where $i = 1,...,N$ and $\lambda_1 \geq \lambda_2 \geq ... \geq \lambda_N$. Based on this algorithm, λ_1 covers the largest observation. It has been determined that most observations are between $\lambda + \alpha\sqrt{\lambda}$ and $\lambda - \alpha\sqrt{\lambda}$ where α has a desired quantity and is called "width parameter'. The presupposed quantity for α is 2. Therefore, $\lambda_1 + 2\sqrt{\lambda_1}$ covers the maximum trace:

$$\lambda_1 + 2\sqrt{\lambda_1} = peak\ \ of\ \ the\ trace \quad (1)$$

The result of (1) is $\lambda_1 = (\sqrt{1+peak} - 1)^2$

On the other hand, the lower boundary of original trace and covered by λ_1, that is $\lambda_1 - 2\sqrt{\lambda_1}$, shall be the higher trace and covered by λ_2, that is $\lambda_2 + 2\sqrt{\lambda_2}$:

$$\lambda_2 + 2\sqrt{\lambda_2} = \lambda_1 - 2\sqrt{\lambda_1} \quad (2)$$

Therefore, we gain: $\lambda_2 = (\sqrt{\lambda_1} - 2)^2$

The algorithm continues repeatedly until λ_N reaches to the minimum point of observation.

- **Allocation of sample trace to MMPP**

In this part of algorithm, every point from the original trace is allocated to the corresponding state in MMPP. For the purpose of producing transition probability matrix of Markov chain, suppose that our observation is $\{x_i, i = 1,2,...,T\}$. The relation between x_i and phases of Markov chain, $\{\varphi_i, i = 1,...,N\}$, is as below:

$$\lambda_j - \alpha\sqrt{\lambda_j} < x_i \leq \lambda_j + \alpha\sqrt{\lambda_j} \Rightarrow \varphi_i = j \quad (3)$$

Therefore, $p = (P_{ij})$ is the transition matrix for phase process and it is gained in the following equation:

$$p_{ij} = \frac{Number\ of\ \ transitions\ from\ \ i\ to\ j}{Number\ of\ \ transitions\ out\ of\ \ i} \quad (4)$$

Notice that the generic matrix of Markov chain, $Q = (q_{ij})$, is resulted by reducing similar matrix from P.

- **Assessing the efficiency of MMPP/D/1**

In this section, queue modeling that in which, input is a compound of simulated sound estimated with MMPP model resulted from LAMBDA algorithm, is studied and analyzed. The aforementioned queue has constant rate of service because the size of packets in Aggregated traffics has been considered with a constant length. Thus, the resulted queue is MMPP/D/1.

Figure 1. indicates the traffic sent from 120 sound resources modeled by OPNET, in 5000 seconds. The horizontal lines in the figure are gained rates by means of LAMBDA algorithm and this indicates the estimated MMPP has 4 states.

Figure 2. indicates MMPP trace produced by LAMBDA algorithm based on the original trace.

To test the rate of adaptation of MMPP trace on the original trace, diagram Quantile- Quantile (Q-Q) is used. In this diagram, the points of the original trace are placed on the horizontal axis and points of adaptation process on the vertical axis. The straighter curve indicates the more precise adaptation. In Figure 3., it is observed that generally, the diagram goes on a straight line.

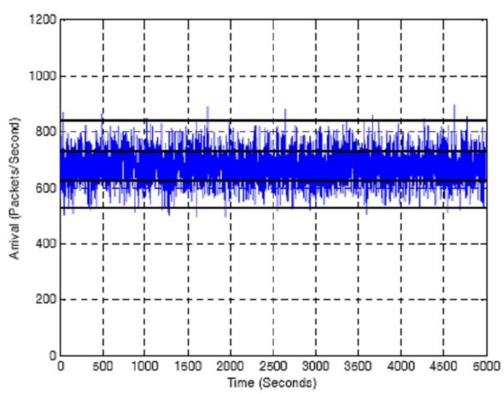


Figure 1. The Trace Produced with Integration of 120 Sources of ON-OFF

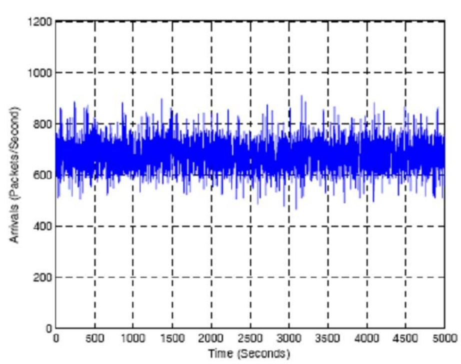


Figure 2. Adapted MMPP Model of ON-OFF Sources

To test the efficiency, two diagrams of "mean queuing delay" and "Packet Loss Rate" based on Utilization factor is used. Utilization factor or traffic density is defined based on the input rate, and it is gained by variation in rate of service, results are shown in Figures 4. and 5. The delay efficiency of packets in MMPP trace, as it is observed in the figures, is highly achieved in upper traffic loads. It is also true regarding the Packet Loss Rate which uses the capacity of 25-packet buffer.

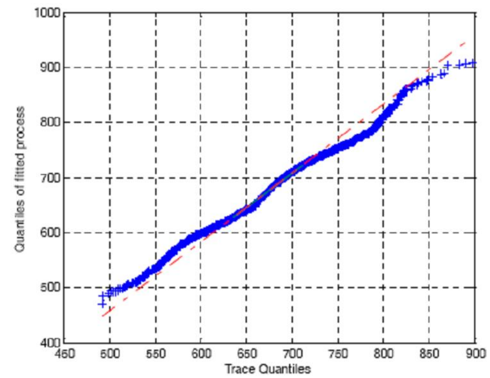


Figure 3. Q-Q Diagram of Sound Traffic and MMPP Model

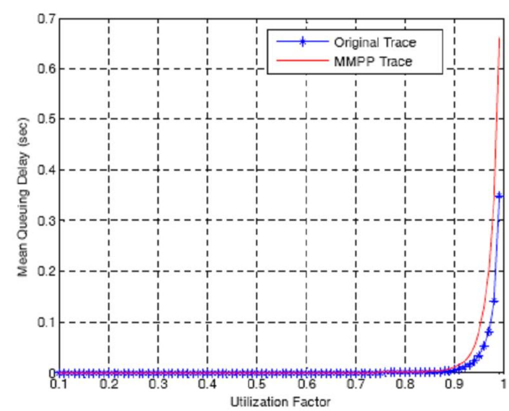


Figure 4. Mean Queuing Delay and MMPP model

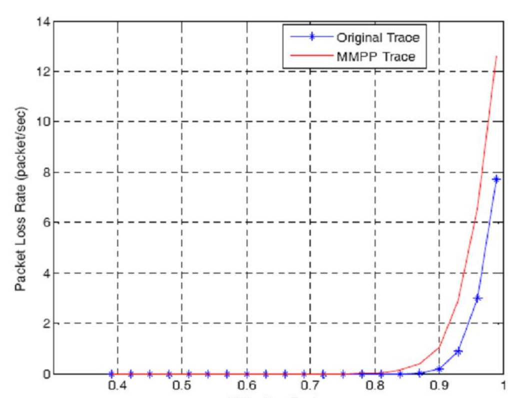


Figure 5. Packet Loss Rate Which Uses the Capacity of 25-Packet Buffer.

Mean queuing delay of adapted trace in traffic less than 95% is precise but in more than 95%, the difference is observable. Based on (Heffes, 1986), in traffic of 82. 87%, the mean delay is 3. 57 second. According to this algorithm original trace delay is 2. 18(ms) and MMPP delay is 5(ms). Therefore LAMBDA algorithm can be a good model for high speed and low density traffics. In adaptation with this algorithm number of MMPP states are 4.

2. Fitting LAMBDA Algorithm and Efficiency Evaluation

Our strategy for correcting the above algorithm is as follows: Whereas the number of MMPP states in adjustment process is 4, we may not be able to cover all original packet trace. Therefore, if the number of MMPP states increases, we can solve the efficiency problems. On the other hand, the number of states shall not exceed from the required limit, because some of the states may see a trace and do not cover others. Thus the number of other states shall be selected in an optimized method. It is possible by means of a feedback from outputs (efficiency curves) and comparing it with original curves. If the difference between efficiency of MMPP and the original trace is great, we decrease parameters of algorithm width and therefore, the number of states increases. Regarding voice packet, 1.6 optimized width parameters were selected and one state was added to the number of MMPP states. In diagrams of figures 6 to 9, we can observe that 5-state MMPP has better efficiency than before.

As it is seen in the following figures, regarding the efficiency resulted from correcting algorithm, we can conclude that:

1- Q-Q curve has become straighter; that is, adjustment is more precise.

2- Queuing delay of packets in MMPP model has become closer to the original efficiency.

3- Packets loss rate in MMPP has also become closer to the original efficiency.

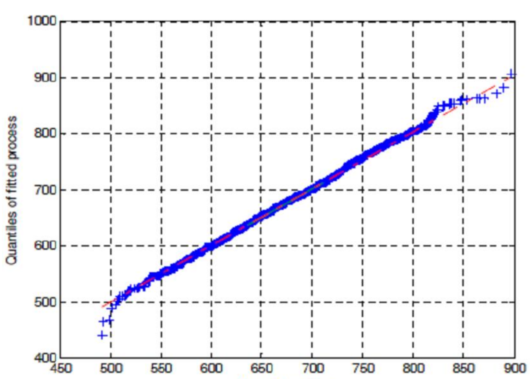


Figure 6. Q-Q Diagram for Voice Packet and Optimized MMPP

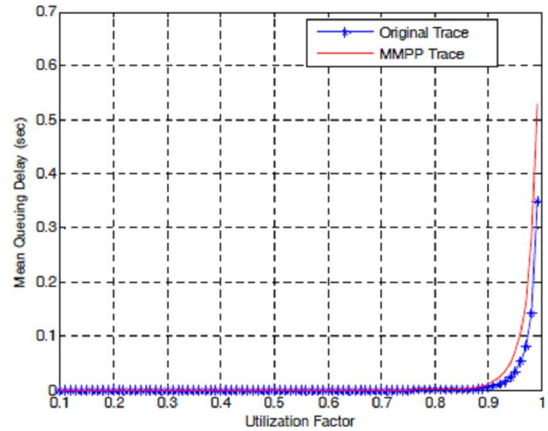


Figure 7. Mean Queuing Delay of Voice Packet and Optimized MMPP Model

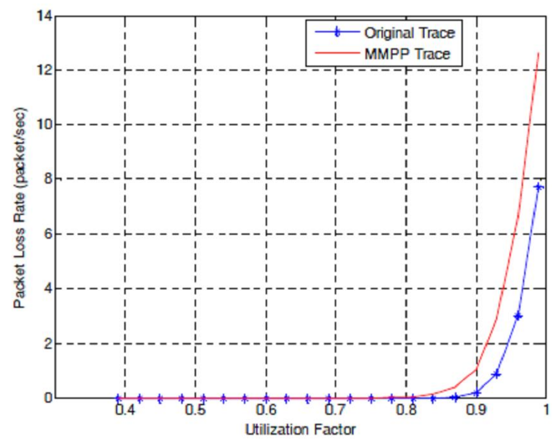


Figure 8. Packet Loss Rate and Improved MMPP

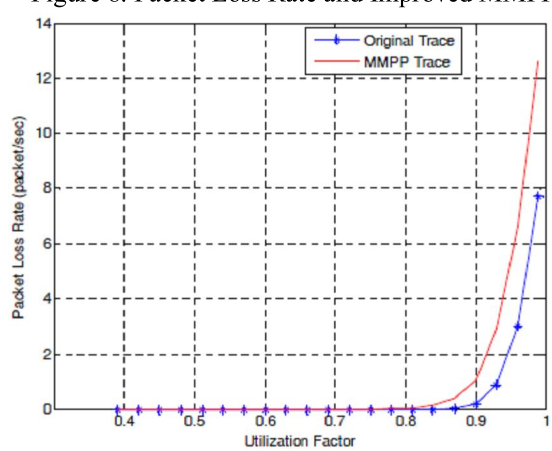


Figure 9. Packet Loss Rate and Improved MMPP Model (25 packets)

Furthermore, it shall be considered that packets delay is more important than packets loss for voice services. Thus, the fitted LAMBDA algorithm can offer a good model for estimating original trace.

3. Effect of Hurst Parameter on Efficiency of LAMBDA Algorithm

In previous section, we reviewed LAMBDA algorithm to adapt MMPP based on voice packet and we saw, this algorithm can be fitted in a way that efficiency of MMPP is achieved more acceptable.

Here, we review the efficiency of the said algorithm on fractal traces of data and produced in OPNET. Such traces are individuated with Hurst parameters. The below figures show the traces.

As it is observed, the rate of burstiness of these traces is much greater than voice traces. In the references (Mogollon, 2007, Bali , 2007), LAN traces usually have Hurst parameters of about 0.7 and WAN traces have Hurst parameters of about 0.8.The efficiency of LAMBDA algorithm is greatly sensitive to changes in Hurst parameters. This dependency is more in efficiency of queuing delay. However, measuring efficiency of packet loss rate in MMPP, mostly follows original traces with much care. Figures 11. and 12. accordingly compare Mean queuing delay with Hurst parameter ranging from 0.7 to 0.775 and 0.8 to 0.85. Utilization factor also ranges from 0.1 to 1.

Certainly, MMPP, in general, estimated lower delay of the original trace. Although this estimation is optimized, it is not true and we are searching for more close proximity. Of course, it shall be considered that the estimation of MMPP delay in utilization factor less than 0.8 is very closer to the original model and follows the behavior especially at the curve.

4. Correcting LAMBDA Algorithm and Evaluating its Efficiency

As we saw, mean queuing delay in MMPP with $H>0.775$ and high traffic, estimates the lower efficiency of the original trace. To overcome such problem, it shall be first known, when it happens. If for example, we consider the trace in Figure 13. with $H=0.85$, that in which, rates have been estimated by LAMBDA algorithm, it is observed that the mean arrival rate is changed by time intervals and some of the rates, for example, thicker line, are not observed in the mean of area trace. If only one state has been allocated to the aforementioned rate, the mean time calculated in this state, to model the data points, becomes very little at the beginning, and at end of the trace it gets very much. It is solvable by LAMBDA$^+$ algorithm (a type of corrected and optimized LAMBDA algorithm).

LAMBDA$^+$

This algorithm will give better result when the trace length is shorter. The main idea of LAMBDA$^+$ is that, we change the number of states (rates) which is calculated by the change in the width or α parameter in the algorithm. Therefore, we decrease (increase) the numbers of inappropriate (appropriate) rates which are not (are) visited by the whole trace. So, we test a great number of α, for obtaining its optimized quantity. To relatively improve it, a feedback can be obtained from the mean queuing delay. Therefore, its difference with the efficiency of the original trace in each stage shall not be greater than $1+\varepsilon$ and lower than $1-\varepsilon$. If not, we change α, the width parameter, based on Hurst parameter. It has been observed that the width parameter shall be taken greater and smaller or equal to 2 accordingly, in $\text{Hurst}>0.775$ and $\text{Hurst}<0.775$. Of course, this result is completely logical because in traces, where the dependency effect is more, refer to wide or self-similar scale, and higher Hurst parameters, the packets arrival rate has more changes in comparison with traces, where the dependency effect is less in wide scale. Therefore, in such situations, we reduce the number of rates (states) of MMPP which are used by the whole trace. Figure 14. shows the flowchart for LAMBDA with continuous lines and the flowchart of corrected LAMBDA$^+$ algorithm with dot matrix.

Next figures compare the efficiency of LAMBDA with the corrected algorithm of LAMBDA$^+$. It shall be considered that we are attempting to correct the curve of mean queuing delay of MMPP because as it is seen in Figure 13., we observe that the efficiency of packets loss rate of MMPP is very close to the original model.

In $H>0.775$, to achieve more actual results in high productivity coefficient, α shall be remained fixed or reduced for this reason, that in contrast with Figure 13., the mean arrival rate has little changes in long intervals and traces , approximately (increase in states) leads to explosion of space state, especially, in aggregated traffic. For example, if the matrix of generating Q in MMPP process of traffic I is equal to 16, it becomes 18 because of a decrease in α, and the same scenario is done for traffic II, then aggregated traffic is 324-state MMPP ,where $18^2-16^2=68$ states are added. This increases the time of calculation and simulation. Fortunately, algorithms, (for example, Mogollon, 2007 and AlQahtani, 2006), are offered to prevent explosion of space state. Figure 15. shows the mean delay of MMPP by LAMBDA$^+$ with parameters of Table 1. and compares it with efficiency of the produced traces. You will see in general, by increasing the number of states, the efficiency of MMPP gets closer to the original efficiency like voice traffic efficiency. But it is completely different in regard, to traces with

Hurst>0.775 , in this case, the number of states shall decrease when width parameter increases.

In H>0.775 , to achieve more precise results, the number of states shall be decreased based on LAMBDA$^+$. The number of optimized states for traces with Hurst parameters is summarized in Table 3. By having such number of optimized states, the curve of mean delay has been drawn based on LAMBDA$^+$ in Figure 16. and is compared with the efficiency of the original trace. As we expect, the efficiency has been optimized.

Table 1. The Number of States and Optimized Width Parameters for LAMBDA$^+$ Algorithm

H	Optimized states MMPP	States MMPP	Width parameter
0.7	19	16	1.6
0.725	18	16	1.8
0.75	16	16	2
0.775	16	16	2
0.8	14	16	2.4
0.825	12	16	2.8
0.85	11	16	3

5. MMPP Based on Corrected LAMBDA+ Algorithm

In this section, we show that MMPP process can be used for modeling video traffic, while it is a suitable pattern for voice and data. To achieve this goal, we use real sources of video traffic (Onvural, 1994) and analyze two samples of them as television programs and feature film. It is required to mention that the method of compression of traces is MPEG4. The length of time for both of the traces is 60 minutes and the number frames is 24 per second. In other words, there is one frame in every 40 seconds. Also, the amargan of the said traces is summarized in Table 2.

As the parameters in the table indicate, the maximum/mean of byte rate of the feature film is more than TV program. Regarding mean of frame size of the two video traces, the situation is different. Therefore, it indicates that the quality of service and traffic matrixes of the two traces shall be studied individually. In Figure 17. the diagram of video traces has been drawn based on the number of frames.

The accuracy of amargan can be tested in Table 2. Also in both Figures, it is clearly observed that the bandwidth of video traffic is more than data and voice traffic. Then we study the process of adaptation of MMPP with video traffic and evaluate its efficiency. Before it, we shall smooth video traces, because analysis of about 90,000 frames seems difficult and time consuming. Therefore, by maintaining features of traces, we choose the first frame in each second. We can consider the following figures as the smooth and transformed copy of the traces, where MMPP rates caused by LAMBDA$^+$ algorithm with horizontal lines are distinctive. The number of obtained rates (states) for football match and Original sin, accordingly, are 38 and 28 with width parameter of 1.6.

Figure 19., 20., 21 and 22 indicate that the produced traces of MMPP and the diagram of adaptation of (Q-Q) in MMPP and the original one.

As it is observed in the Q-Q, the adaptation of MMPP with the initial linear traces is very precise. Now, by means of LAMBDA$^+$ algorithm and the obtained rate, we evaluate the efficiency of MMPP. As before, the efficiency curve is the mean queuing delay and packet loss rate based on productivity coefficient.

The above figures indicate that MMPP has a remarkable capability in modeling and proximity of video traces as well as precise modeling of data and voice traces. Although the number of Markov chain for MMPP, especially regarding video traffic, increases.

At the end, it is required to be mentioned that in (Marcel, 1981 and Schwefel,2000), MMPP model has been used video traffic with this difference ,from previous MMPP ,where the number of packets (cells) in each frame is described by distributing Gama and ore Pareto (Vishwanath, 2006).

6. Conclusion

Whereas the traffic in data networks is self-similar, in this research, we have answered this question, MMPP with the dependant nature in small scale is capable of modeling self-similar traffic?. In other words, by means of advanced and MMPP-based algorithms, we compared fractal data and video traffic from the initial traces of synthesis and their efficiency. We made innovative attempts to correct algorithms in a manner that. The inaccuracy in adaptation caused by the change of self-similar traffic parameters, especially, Hurst parameters fades out. Our strategy for correcting algorithms was as follows: Whereas the number of MMPP states in adjustment process is 4, we may not be able to cover all original packet trace. Therefore, if the number of MMPP states increases, we can solve the efficiency problems. On the other hand, the number of states shall not exceed from the required limit, because some of the states may see a trace and do not cover others. Thus the number of other states shall be selected in an optimized method. It is possible by means of a feedback from outputs (efficiency curves) and comparing it with original curves. This innovation was possible by adaptation of algorithm and the result of efficiency, in this method; it is possible to increase the adaptability greatly. As it was stated at the beginning of this paper, the traffic in high speed networks is the aggregated traffic and the modeling of aggregated traffic by means of the algorithms, described in this research and the reduction of space state are new subjects in MMPP applications and we can't stop using them in traffic engineering.

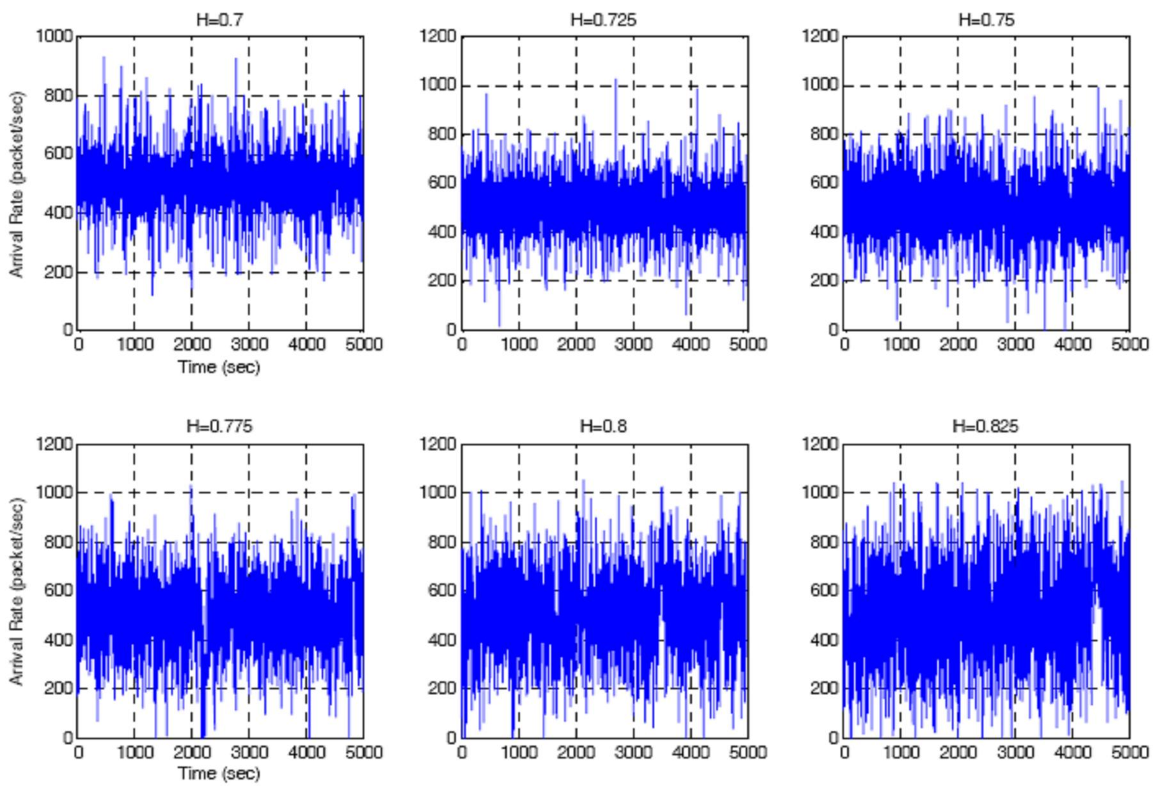
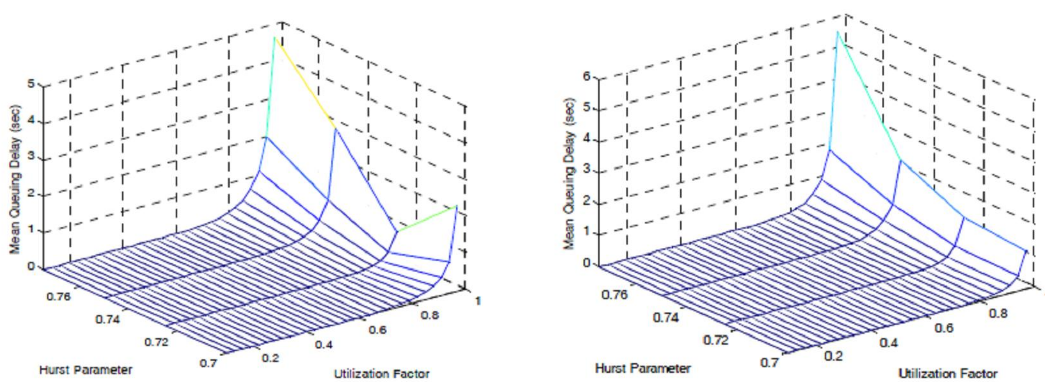
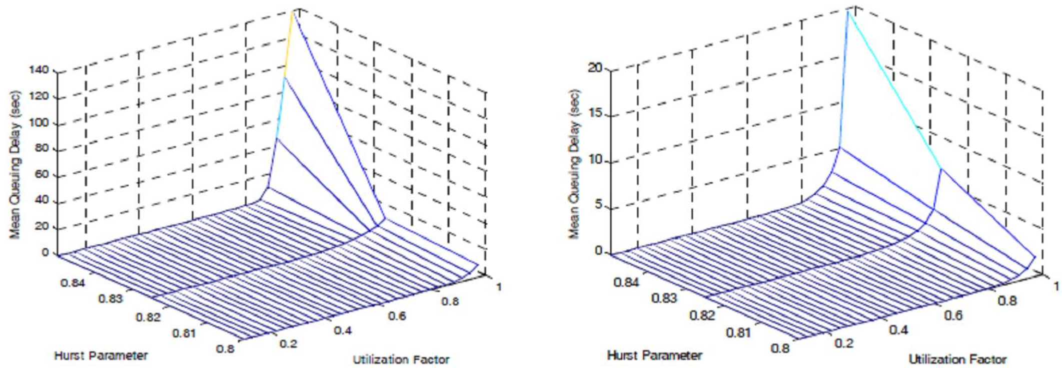


Figure 10. Traces Produces with Hurst Parameters from 0.7 to 0.825



B A

Figure 11. (A) Mean queuing delay in MMPP based on LAMBDA algorithm (B) Mean queuing delay of original trace(0.7 <H<0.775).



B A

Figure 12. (A) Mean queuing delay in MMPP based on LAMBDA algorithm (B) Mean queuing delay of original trace ($0.85<H<0.8$).

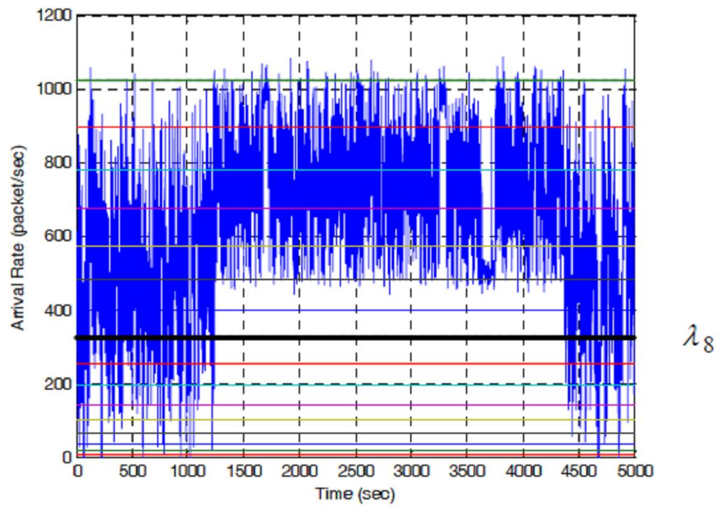


Figure 13. The produced trace with $H=0.85$ and the gained rates by means of LAMBDA algorithm

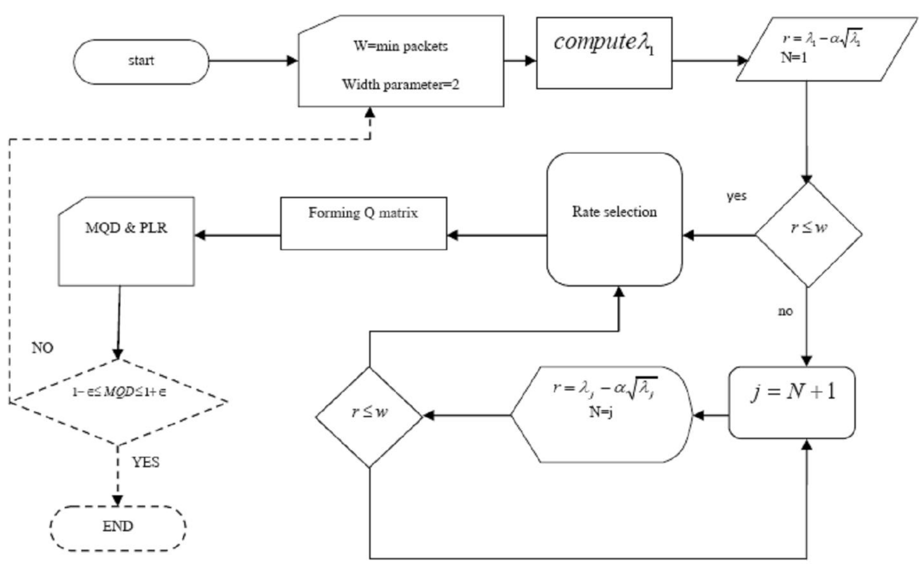
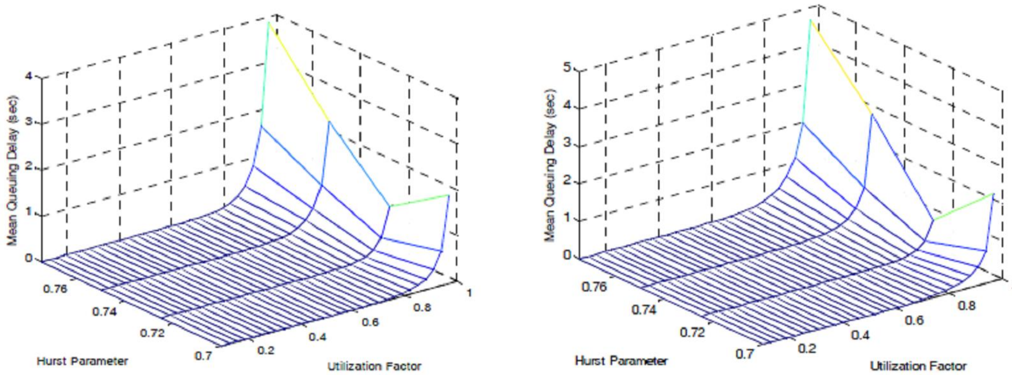
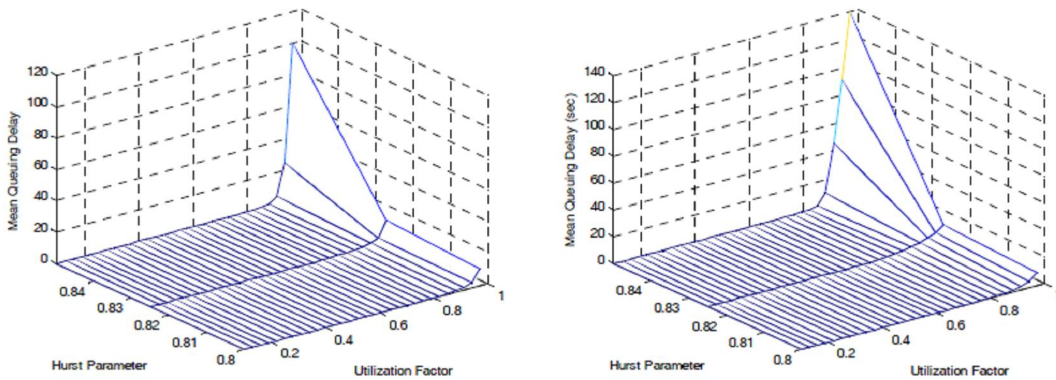


Figure 14. LAMBDA Flowchart with Continuous Line and Corrected Algorithm with Dot Matrix.



B A

Figure 15. (A) Mean Queuing Delay in MMPP Based on LMBDA^{+} (B) Mean Queuing Delay of the Original Trace ($0.7<H<0.775$)



B A

Figure 16. (A) Mean Queuing delay in MMPP Based on LAMBDA^{+} Algorithm (B) Mean Queuing Delay of Original Trace ($0.8<H<0.85$)

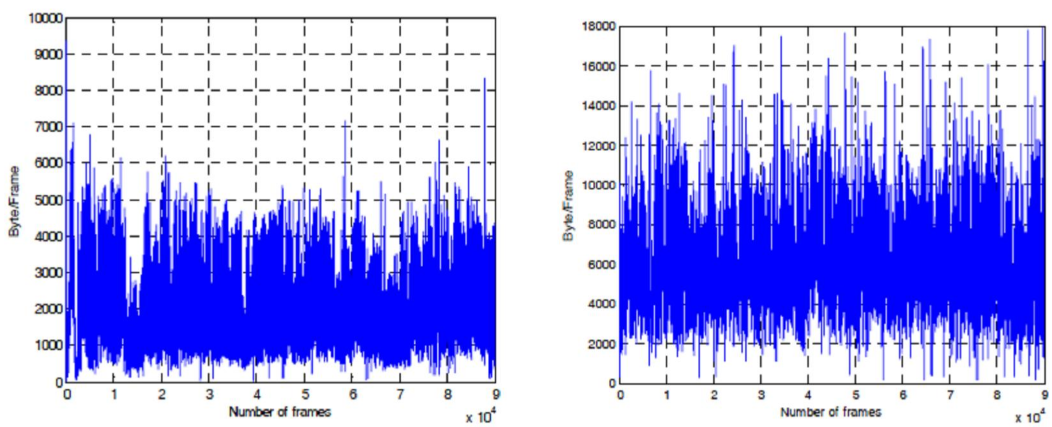


Figure 17. Trace of TV Program (Football Match-on the Left) and Feature Film (Original Sin)

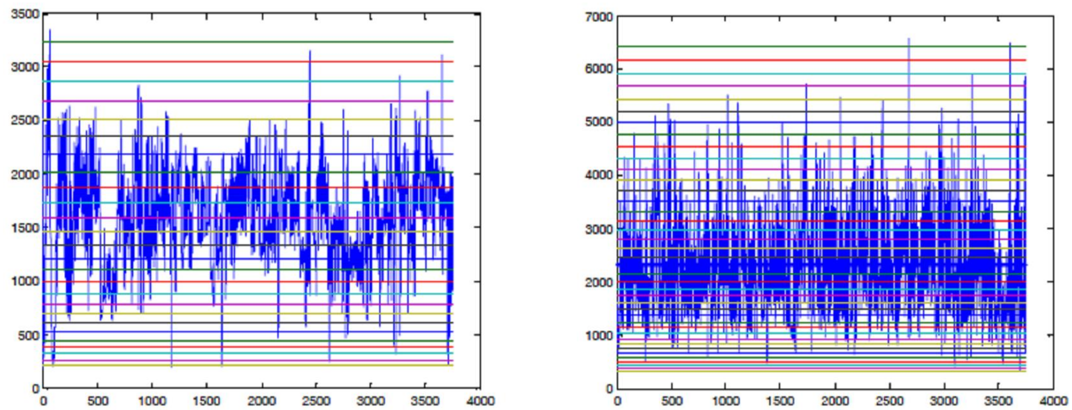


Figure 18. Smoothed Traces of TV Program (Right) and Feature Film (Left)

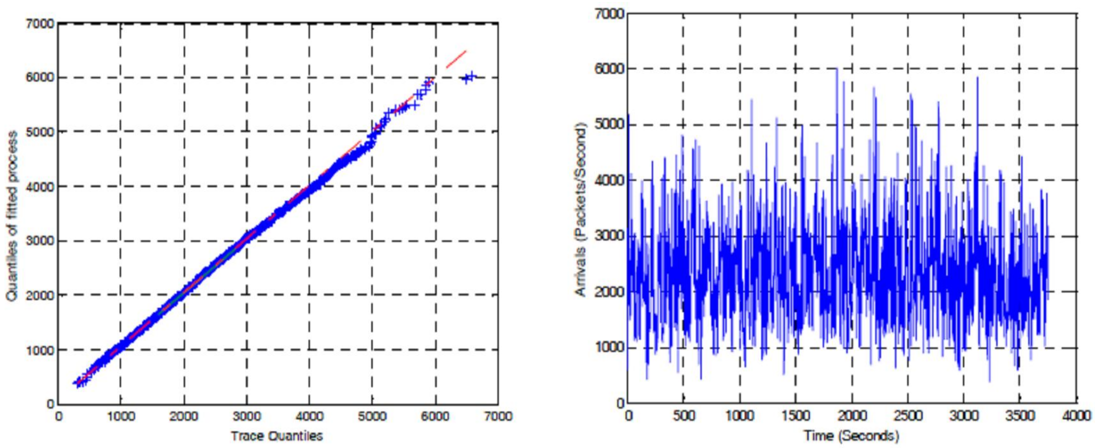


Figure 19. The Produced Trace of MMPP in Video Trace of Football Match and Q-Q Diagram.

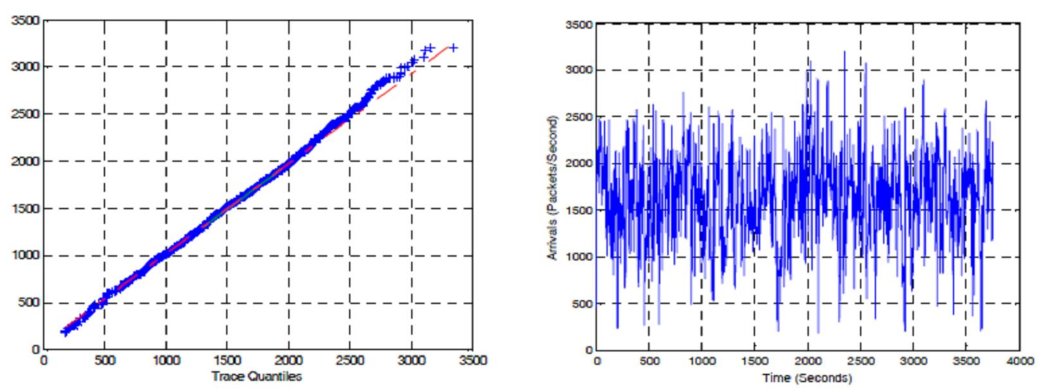


Figure 20. The Produced Trace of MMPP in Video Trace of Original Sin and Q-Q Diagram.

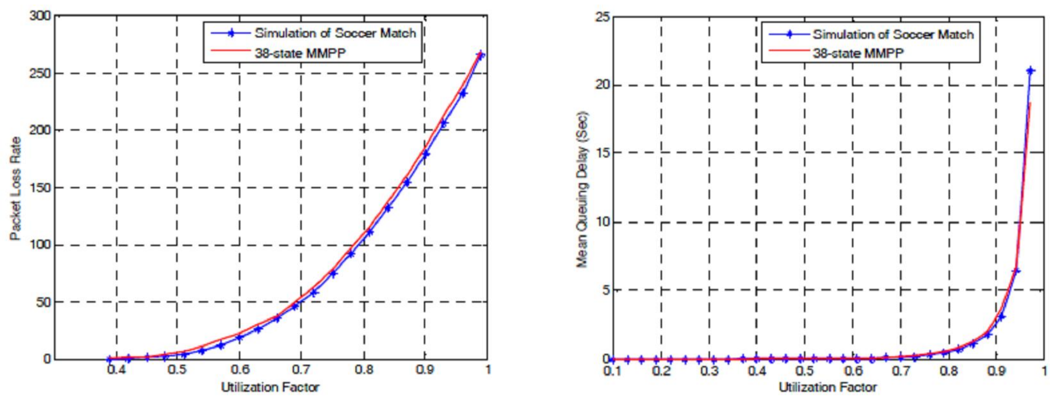


Figure 21. Mean Queuing Delay (Right) and Packet Loss Rate (Left) for Video Trace of Football Match

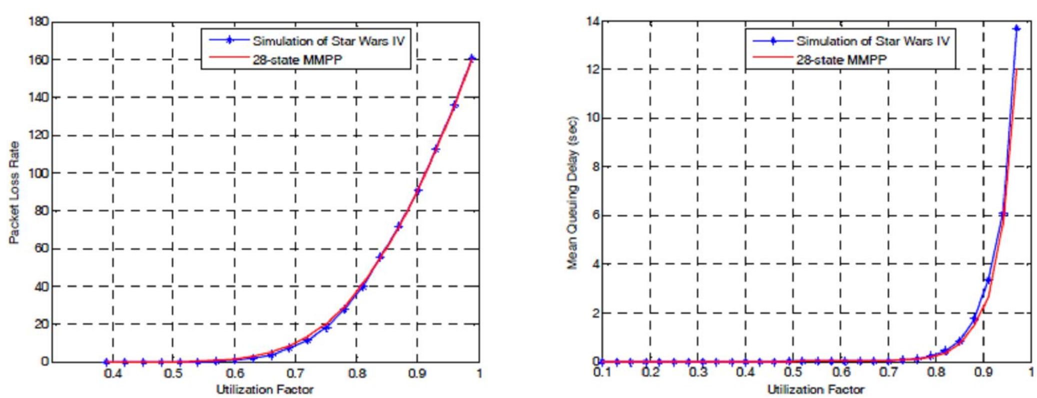


Figure 22. Mean Queuing Delay (Right) and Packet Loss Rate (Left) for Video Trace of Original Sin

Table 2. Amargan Derived from the Samples of Video Traces

Type of video image	Byte/cell	Quantity of frames	Max/Mean of byte rate	Mean of frame size (byte)	Hurst parameter
TV program (football match)	53	89998	3.24	5.5×10^3	0.837
Feature film (Original sin)	53	89998	6.81	1.4×10^3	0.903

Corresponding Author:
Afshin Shaabany,
Islamic Azad University,
Fars Science and Research Branch, Shiraz, Iran.
E-mail: afshinshy@yahoo.com

References

1. Andersson S, Ryden T. Maximum Likelihood Estimation of a Structured MMPP with Applications to Traffic Modeling. 13th ITC Specialist Seminar, 2000, Monterey, CA.
2. Heffes H, Lucantoni DM. A Markov Modulated Characterizationof Packetized Voice and Data Traffic and Related Statistical Muliplexer

Performance. IEEE J. Select. Areas Comm. 1986;4(6):856-868.
3. Mogollon JAM, Aguilar JJP, Ordonez VE, Montesino AFC. Characterization and simulation of the LAN traffic by MMPP model, Revista Facultad de Ingenieria, 2007.
4. Bali S, Frost V. An Algorithm for Fitting MMPP to IP Traffic Traces. IEEE Communications Letters. 2007;11(2):207-209.
5. AlQahtani SA. A Simulation-Based Comparison of MultimediaTraffic Prioritization Schemes for High-Performance Input-Queued Packets Switches. Journal of Computer Science. 2006;2(4):347-354.
6. Onvural RO, Asynchronous Transfer Mode Network: PerformanceIssues, 1994, (Artech House).
7. Marcel F, Neuts. Matrix-Geometric Solutions in Stochastic Models, 1981, (John Hopkins University Press, London).
8. Schwefel HP, Performance Analysis of Intermediate Systems Serving Aggregated ON/OFF Traffic with Long-Range Dependent Properties, 2000, Ph.D. Dissertation, University of Munich, Germany.
9. Vishwanath KV, Vahdat A, Realistic and Responsive Network Traffic Generation, In Proceedings of the Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication, 2006, Pisa, Italy.

11/17/2014