states of Markov chain, $\phi(\theta) = \begin{pmatrix} \varphi_1(\theta) & 0 \\ 0 & \varphi_2(\theta) \end{pmatrix}$ and $\mathbf{P}$ is the matrix of the state transition probabilities, $\mathbf{P} = \begin{pmatrix} 1-\alpha & \alpha \\ \beta & 1-\beta \end{pmatrix}$. Effective Bandwidth for any MMP has the form:

$$\alpha(\theta) = \frac{1}{\theta}\ln\varphi(\theta) = \frac{1}{\theta}\ln sp\left[\phi(\theta)\mathbf{P}\right] \qquad (27)$$

To determine the MGF $\varphi(\theta)$, we must calculate maximum eigenvalue of $\phi(\theta)\mathbf{P}$.

In the case of MMBP, there are

$$\varphi_1(\theta) = E\left[e^{\theta\cdot a(t)}\right] = q + pe^{\theta} \qquad (28)$$

$$\varphi_2(\theta) = E\left[e^{\theta\cdot 0}\right] = 1 \qquad (29)$$

For the estimation of $\varphi(\theta)$ we have calculate the highest eigenvalue of matrix $\phi(\theta)\mathbf{P} = \begin{pmatrix} \varphi_1(1-\alpha) & \varphi_1\alpha \\ \varphi_2\beta & \varphi_2(1-\beta) \end{pmatrix}$. There is analytic solution :

$$\varphi(\theta) = \left[\frac{(q+pe^{\theta})(1\text{-}\alpha) + (1\text{-}\beta) + \sqrt{D}}{2}\right] \qquad (30)$$

$$D = (q+pe^{\theta})(1\text{-}\alpha)\text{-}(1\text{-}\beta)]^2 + 4(q+pe^{\theta})\alpha\beta \qquad (31)$$

Effective bandwidth for 2-state MMBP is a so-called scale cummulant generation function $\alpha(\theta) = \ln\varphi(\theta)/\theta$

Effective bandwidth uniquely identifies stacionary stochastic process; therefore we can use it searching the parameter processes estimation. At first we calculate statistic Effective Bandwidth from measured data, for the observation process and consequently we estimate the values of process parameters using numerical methods, which EB has an analytical expression, while we can use Mean-square method. The process MMBP has three parameters;therefore its using provides a high flexibility.

In engineering tasks, EB is used for the design of a transport or a telecommunication node capacity, for example,[**?**]. In this case it is not appropriate to use the parameter estimation using Mean-square method, but more efficient is, to create Effective bandwidth, which is the upper limitation of EB estimated by data. If we use so gained process in an analysis or in a simulation of the node, we will achieved the higher capacity as in original flow. We will design the node with a higher safety factor.

6 Numerical Results

We have selected the IPTV process record for the presentation of described approach,expecialy1 channel of Magio. The length of record was 2 minutesy, selecting time slot $ts = 2ms$ we obtained 0/1 packet sequences with average rate $\lambda_{avg} = 0.8647p/ts$ and of course $\lambda_{peak} = 1p/ts$. Next figure shows the short example of the reckord with the length. $1.4s$:

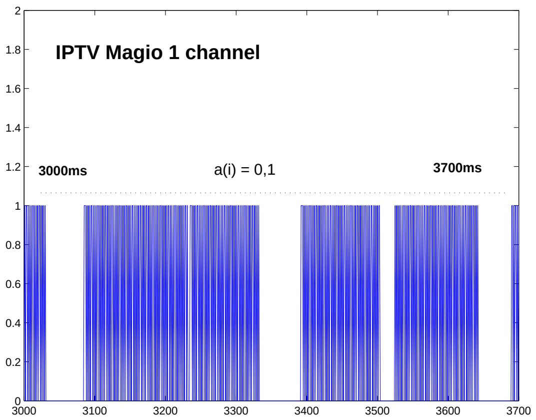

Figure 14: IPTV 0/1 traffic of Maqio channel

The IPTV flow does not correspond to MMRP, estimating parameters α a β we have obtained negative values. We have decided using upper bound of statistical estimate of EB for the determination of MMBP parameters. There are several methods how to estimate EB. We have have decided to estimate probability distribution of increments $p_k = \Pr(a(i) = k)$ where $k = 0, 1, .., 4$ and consequently we changed the scale EB to 0/1 sequences:

$$\hat{\alpha}(\theta) = \frac{1}{\theta}\ln\left[\sum_{k=0}^{4} e^{k\theta}\hat{p}_k\right] \qquad (32)$$

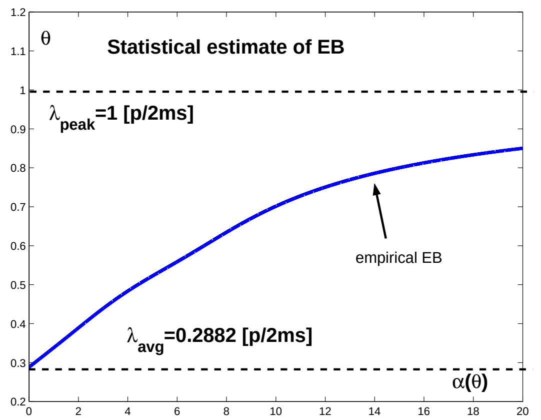

Figure 15: Statistical estimate of EB for IPTV traffic

We use the relation of the mean values equality for the estimation of MMBP parameters:

$$\pi_1 p = \frac{\beta p}{\alpha + \beta} = \lambda_{avg} \Rightarrow \beta = \frac{\lambda_{avg}\alpha}{p - \lambda_{avg}} \quad (33)$$

We use numerical methods for compute the minimum upper bound of Effective Bandwidth of IPTV traffic.

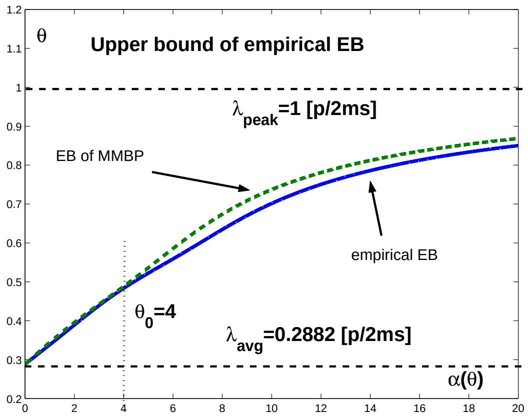

Figure 16: Comparation between IPTV and MMBP

Values of estimated parameters:

$$\alpha = 0.9121, \quad \beta = 0.5115, \quad p = 0.8022 \quad (34)$$

We can see in the figure, after $\theta = 4$ we can consider the equality of analytical form of MMBP EB and statistical estimation of IPTV EB.

Parameter θ is so called space parameter. If we consider the arrival process entering into some single server queue (queueing system with one link), parameter θ is directly depending on a maximum delay d_{max} events waiting in queue, and on probability of lost p_{lost} events in the moment, when queue will fill. If arrival process has EB $\alpha(\theta) = \ln \lambda(\theta)/\theta$, than for θ is valid ([6]):

$$\theta = \lambda^{-1}\left[\frac{\ln p_{lost}}{-d_{max}}\right] \quad (35)$$

For MMBP process:

$$\theta = \ln\left[\frac{p_{lost}^{-1/d_{max}} - 1 + \beta + p_{lost}^{1/d_{max}}(p-1)}{p(1-\alpha) + p(\alpha+\beta-1)p_{lost}^{1/d_{max}}}\right] \quad (36)$$

For normally used values d_{max} a p_{lost} for IPTV does not exceed parameter θ value 2. In this case we can replace examined IPTV traffic by process MMBP.

Generally if we use flow with EB upper limitation of original real flow, in analysis and simulation of a system, we obtain the oversized results depending on tha fact, how close the upper bound original flow of EB we obtained.

7 Conclusion

We have tried to analyse the basic model of 0/1 bit sequences, from Bernoulli's process to Markovov Modulated processes. We have wanted to create the parameters estimation methodology for examined processes. We have used Effective Bandwidth for the estimation of parameters in the case of Markov Modulated Bernoulli process. We have showed, it is possible to obtain relevant results although without the accordance of examined process and MMBP processes using this approach. The main of future research is to identify and analyse complicated MMP process with two Bernoilli's floes or Poisson's processes.

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