Jitter approximation and QoS requirement

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Abstract—Today, one of the most important performance measures in the new burst traffic occurs to 3G and 4G systems is the End-to-End jitter. However, in order to study and analyze Jitter, many works have been devoted to estimate and evaluate this parameter.

In this paper, an analytical approximation for jitter is presented. In one node case, we found that the jitter can be approximated by the average arrival rate. We found value of the average arrival rate required to predict the expected QoS for VoIP. Finally, a very simple analytical approximation for the end-to-end jitter for a tagged flow passing through N nodes is presented. We conclude that jitter performance depends strongly on traffic correlations.

Keywords—QoS metrics; Analytical Jitter Model; VoIP; end-to-end performance; traffic correlation

I. INTRODUCTION

Nowadays, new types of services and applications supported by the 4G system as VoIP (Voice over IP), VIP (Video over IP), video conferencing and network gaming are characterized by guarantees of QoS requirements. These expectations and requirements continue to grow and evolve with variation of 4G service demand.

One of the most important performance measures for such traffics is the jitter, that is caused when the data packets are not delivered at regular intervals to the receiver. For VoIP, a typical receiver expects packets to be delivered with a well-defined rate. In there, optimization of VoIP requires complete visibility into behavior of jitter.

This paper is organized as follows:

First, we present an overview of jitter. The section II is devoted to provide an analytical approximation of jitter. Estimation of end-to-end jitter-QoS based on the proposed approximation is discussed in Section III. We found value of average arrival rate required to predict the expected QoS for VoIP.

Finally, we expose our conclusions et results in Section V.

II. JITTER APPROXIMATION

A-Jitter

Today, a main challenge for 4G system is to convey different types of traffic such as VoIP (Voice over IP), VIP (Video over IP), video conferencing and network gaming. For such applications, flexible and efficient QoS will need to be guaranteed and computed. Each of these applications requires its own QoS metrics [12].

However, there are many parameters to evaluate 4G performance such as jitter, delay, packet losses and throughput.

The most important metric of QoS is jitter. This parameter can have greater impact on the voice quality of VoIP and it can affect the other metrics.

In order to reduce these effects and maximize the jitter requirements, many works [8][2][3][4][5][7][11] have been devoted to estimate and evaluate jitter.


Jitter is defined as a variation in the delay of received packets.

So, the average end-to-end delay jitter can be expressed as [6][8]:

\[ J = E[T_{j+1} - T_j] \] (1)

Where \( T_j \) and \( T_{j+1} \) represents the delay experienced by the jth and j+1th packet going through a queue.

B-Jitter approximation: One node case

We consider the approximation of jitter given in [8] by the following formula:

\[ J = \frac{1}{\eta} \left[ j - e^{\frac{\rho - 1}{\rho}} \left( j - \frac{\rho - 1}{\rho} + e^{\frac{\rho - 1}{\rho}} \right) \right] \] (2)

We use the exponential approximation:
\[ e^x \approx 1 + x + \frac{x^2}{2} \tag{3} \]

And \[ \eta = \mu - \lambda = \mu(1 - \rho) \tag{4} \]

Based on this approximation, we show through simulation experiments that the jitter is more sensitive when \( \rho \) is large, and we see that the jitter decreases as the load increases.

If we use the exponential approximation:

\[ e^x \approx 1 + x \tag{5} \]

We obtain \[ J \approx \frac{1}{\lambda} \tag{6} \]

**C. Jitter approximation: Multiple node case**

In this section, we consider the multiple node case.

The end-to-end jitter is therefore given by the expected absolute value of the sum of inter-packet delay variations introduced by each node along the path between the source and the destination. This can be described as:

\[ J_{[1...n]} = E(\sum_{k=0}^{n} \Delta_k) \tag{7} \]

Where \( \Delta_k \) is the variation of inter-packet delay at node \( k \)

\[ \tau_k = \tau + \sum_{k=2}^{n} \Delta_k \tag{8} \]

\( \tau_k \), \( k=2,3,4,.......,n \) is the time between arrivals at node \( k \)

The load at node \( k \) can be approximated as:

\[ \rho^{(k)} = \frac{\lambda_k}{\mu_k} \tag{9} \]

Where \[ \lambda_k = \frac{1}{\tau_k} \tag{10} \]

\( \mu_k \) is the service rate of node \( k \)

The end-to-end jitter introduced by nodes 1, 2, 3, ..., \( n \) can be approximated by [1]:

\[ J_{[1...n]} = E(\sum_{k=0}^{n} \Delta_k) \approx \sum_{k=0}^{n} K_k^{(k)}(\lambda_k, \eta_k) J_k(\rho^{(k)}) \tag{11} \]

Where \[ \eta_k = \mu_k - \lambda_k \tag{12} \]

And \( K_k^{(k)}(\lambda, \eta) \) parameters depend on the delay correlation of the other nodes.

\[ J_k(\rho^{(k)}) \] is the jitter introduced by node \( k \) approximated as follows:

\[ J_k(\rho^{(k)}) = \frac{1}{\eta_k} \left[ 1 - e^{-\frac{\rho^{(k)}-1}{\eta_k}} \left( 1 - e^{-\frac{\rho^{(k)}}{\eta_k}} + e^{-\frac{\rho^{(k)}-1}{\eta_k}} \right) \right] \tag{13} \]

**III. JITTER-QoS BASED ON EXPONENTIAL APPROXIMATION**

In order to satisfy QoS requirements of real-time and interactive services, we consider the criteria of jitter for VoIP and VIP (Video over IP) [10] that the mean jitter must be less than \( J_{\text{max}} = 30 \) ms.

We use the exponential approximation given in Eq. 5 and Eq. 6.

So, to guarantee a jitter-QoS you must have

\[ J \approx \frac{1}{\lambda} \leq J_{\text{max}} \]

i.e.

\[ \lambda \geq \frac{1}{J_{\text{max}}} \tag{14} \]

We get that the average arrival rate to predict the expected QoS is

i.e.

\[ \lambda \geq 33 \text{ packets/s} \]

For Multiple node case, We consider Eq. 11. And we obtain

\[ J_k(\rho^{(k)}) \approx \frac{1}{\lambda_k} \tag{15} \]

The end-to-end jitter approximation passing through \( n \) network nodes is approximated by:

\[ J_{[1...n]} \approx \sum_{k=0}^{n} K_k^{(k)}(\lambda_k, \eta_k) \frac{1}{\lambda_k} \tag{16} \]

Showing this results, we conclude that the jitter depend strongly on \( K_k^{(k)}(\lambda_k, \eta_k) \) parameters, which confirms the result already found in [9]. Where it is shown that the jitter performance depend on traffic correlations.
IV. CONCLUSION

The behavior of QoS parameters impact performance and Quality of service in 4G system. The main finding of this work is the jitter approximation, we found value of average arrival rate required to provide QoS guarantees for real time sources. The proposed approximation of end-to-end jitter through N nodes confirm the effect of the correlation of the delay on jitter-QoS

In our future work, more complicated system models and traffic models will be considered by analysis and approximation. We will focus on metrics to provide QoS guarantee.

REFERENCES


