Impact Analysis of Burstiness on Network Response Times for Different Traffic Sources

Changlong JI

1. Methodology

In an infinite-capacity queue traffic flow simulation, there are three distinct sources that inject packets into the queue in varying fashions. The voice source is the simplest; it emits packets of uniform size at a constant rate. The data source follows a Poisson process for packet emission, with varying packet sizes dispatched according to different probabilities. To address this, we first determine the expected packet size to ascertain the mean waiting time, and subsequently apply an exponential distribution to the inter-arrival times, aligning with the nature of a Poisson process. The video source toggles between two states, with the assumption that the conclusion of one state will invariably lead to the transition to the other, allowing us to define its transition matrix. The durations of the states are then exponentially distributed.

The experiment involves recording the response time for each packet from all three traffic sources under varying values of burstiness (b). Subsequently, we compute the average response times corresponding to different values of b, along with their confidence intervals.

When calculating the confidence intervals, the Le Gall method is preferred over the Law of Large Numbers as the response times within a single simulation are likely not independently distributed. However, post hoc, the Monte Carlo method can be employed to diminish the error margin.

2. Results

The graphical analysis indicates that as the burstiness parameter (b) increases, the response times for all three traffic sources uniformly increase, with the video traffic exhibiting a faster rate of increase in waiting time compared to the other two sources. The response times for the voice source and the data source remain closely aligned throughout, with the data source consistently exhibiting marginally higher waiting times than the voice source. However, at lower values of b, the disparity in waiting times among the three sources is less pronounced. Notably, at a burstiness value of 1 (which implies T_off =0), the waiting time for video packets is actually less than that for data packets(see in figure 1).

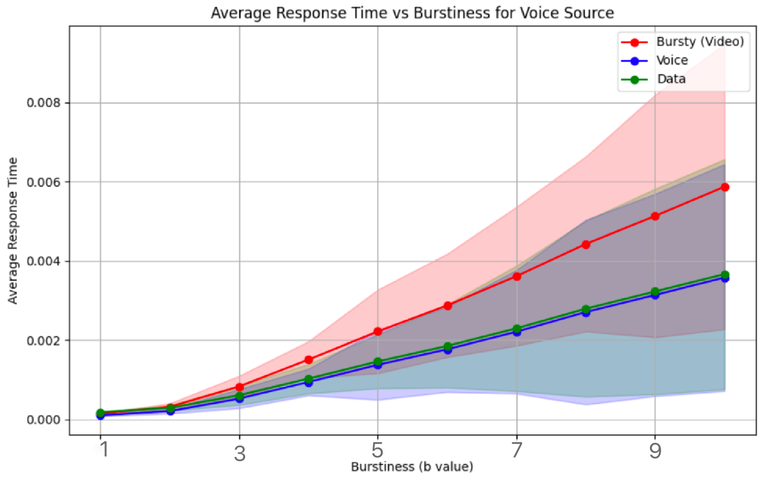

Figure 1 Average response time

The confidence intervals also widen significantly with an increase in the burstiness value, a trend that is consistently observed across all three traffic types. This expansion of the confidence intervals highlights the growing uncertainty associated with the response times as the traffic sources become more bursty.

3. Discussion

Intuitively, an increase in the burstiness parameter (b), which correlates with longer T_off durations and a higher peak rate for video, leads to a more crowded situation during the periods when video packets are emitted. Consequently, the queue becomes congested, prolonging the wait time for video packets. As the queue accrues more video packets, the waiting time for data and voice packets is also adversely affected, resulting in increased wait times for all three traffic sources. Thus, the graphical representation aligns with our intuitive expectations.

This insight suggests that for bursty resources with a constant average occupancy rate, it is advantageous to moderate their peak rates to alleviate the waiting time for all resources. For instance, in this simulation, this could be achieved by introducing a buffer zone for the video source. Packets entering this buffer zone could be emitted into the main queue at a constant rate or according to a Poisson process, thereby smoothing out the queue length and ensuring a more consistent and manageable flow.

4. Conclusion

The simulation study provided a comprehensive evaluation of the impact of burstiness on network response times across three different traffic sources: voice, data, and video. Our findings unequivocally demonstrate that an increase in burstiness parameter (b) results in a uniform rise in response times for all traffic types. Notably, video traffic, due to its bursty nature, is disproportionately affected, showing a steeper increase in waiting times compared to voice and data sources. This effect is pronounced at higher values of burstiness, whereas at lower levels of b, particularly when b equals 1, the response times of video packets are surprisingly less than those of data packets.

Future studies could focus on optimizing buffer sizes and release rates to further refine this approach. Additionally, exploring the interplay between different types of traffic and their collective impact on network performance under various burstiness scenarios could yield deeper insights, contributing to the development of more robust and efficient network systems.

5. Appendices

Code: https://github.com/CharlieChee/simulation
Raw data: https://drive.google.com/drive/folders/17iZj6EE72_VXDpjPcio5dHsnUL9eDRle