SIMULATION OF SELECTIVE REPEAT AUTOMATIC RETRANSMISSION REQUEST SCHEME

Valentin Hristov

Department of Computer Systems and Technology at South West University
66, Iv. Mihajlov, 2700 Blagoevgrad, Bulgaria
E-mail: v_hristov@swu.bg

Abstract

The present paper presents a simulator to evaluate the impact of burstness both in the channel errors and in the arrival process on the SR ARQ statistics. The simulations then used to show and discuss some results which are explained. In this investigation GPSS- General Purpose Simulation System is used to create the simulation model

Keywords – Selective Repeat Automatic Retransmission Request, GPSS Simulations.

1. INTRODUCTION

The Selective Repeat Automatic Repeat reQuest (SR ARQ) protocol is a general strategy for handling frame transmission errors when the round-trip time for frame transmission and reception of the acknowledgment is comparable to or larger than frame transmission time, e.g. TCP. In this protocol, the transmitter groups the frames into windows so that each window contains N frames. When the sender sends frames within a window, the receiver stores the frames of the current window and checks for errors. After a complete window has been received, or after the proper timeout period, the receiver instructs the transmitter to resend only the frames that contained errors.

The investigations of delay performance and other related issues of different ARQ schemes has been subject of many papers [1]–[7].

In [1], Badia presents an extended analysis, with two Markov chains describing arrival and channel error processes. However, he assumes error-free ACK/NACKs and unlimited transmitter and receiver buffers as well as omits the constant propagation delay term.

Seo et al., in [4], derive the delay statistics of Hybrid ARQ also through Markov chains.

A matrix geometric approach [7] has been used by Le et al. to evaluate the performance of ARQ schemes in a radio link with adaptive modulation and coding. To derive the queueing statistics it is observed that the process is Quasi-Birth and Death (QBD), which holds also for the system studied in [5]. Finally, in [6], Luo et al. discuss the ARQ delivery delay by focusing on the impact of the link layer ARQ on the performance of upper layers, i.e., the service data unit (SDU) delay. Though their focus is different, they obtain some results by means of simulation, which in what follows will be derived analytically.

The purpose of present paper is to present a simulator to evaluate the impact of burstness both in the channel errors and in the arrival process on the SR ARQ statistics. The simulations then used to show and discuss some results which emerge in the statistics and which are non intuitive.

2. SIMULATION MODEL

Figure 1 shows the delay between the first transmission of a frame and its release from the receiver buffer, we will call delivery delay- T_D. Total delay- T_t experienced by a frame also comprises the time spent in the transmitter's queue, which we denote as queueing delay- T_Q. Because round-trip delay is larger than the frame transmission time, frames are not always transmitted in numerical increasing order, and this forces the receiver to keep the received frames in a buffer, from where they can be released only when all frames with lower identifiers have been acknowledged. The delay between the first transmission of a frame and its release from the receiver buffer can not be computed trivially [1], since it also depends on the outcome of the transmission of all frames with lower identifiers. In this paper General Purpose Simulation System (GPSS) is used to create the simulation model and to estimate the delay terms. Q- system of this model is depicted on fig. 2.

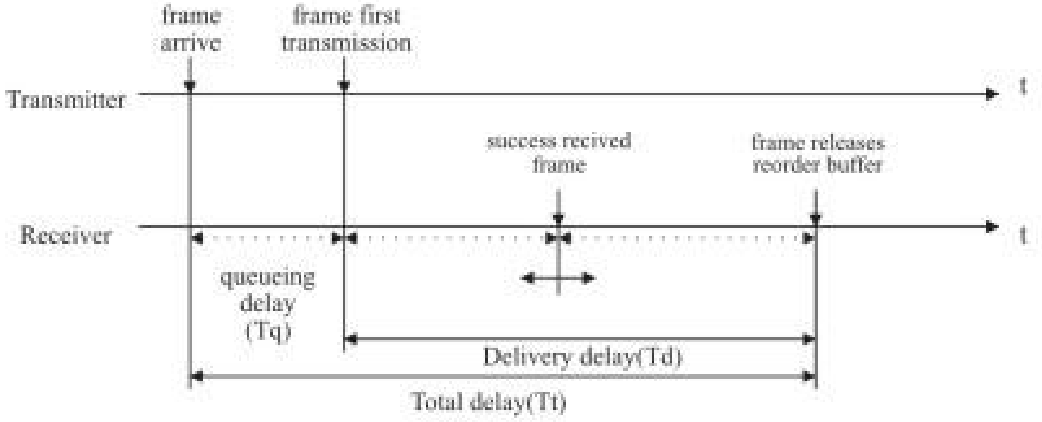

Fig. 1. Frames delivery in Selective Repeat Automatic Retransmission Request Scheme

The transmitter transfers frames after that receiver answers with positive or negative acknowledgement (ACK/NACK) according to the correct/erroneous reception of these frames, respectively. After a full round-trip time ACK/NACKs arrive at the transmitter's side, and either a new frame or a retransmission is sent over the channel. We assume that the value of the ARQ window size is m, i.e. the round-trip time equals m transmitted frames. Frames arrive at the transmitter's queuing buffer from an ON- OFF source with two states, referred in the following as "OFF"=no frame arrival and "ON"=frame arrival.

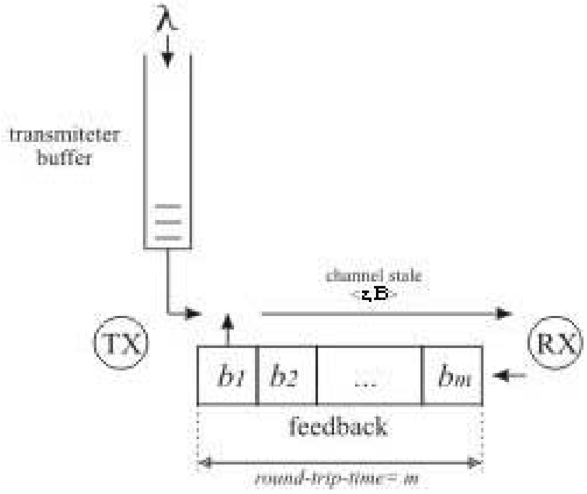

Fig. 2. Q- system of simulation model

The ON- OFF source is characterized by means of two independent parameters, the average arrival rate- λ, and the average arrival burst length- A.

The data sent from the transmitter's queue arrive at the receiver through a noisy channel. This is modeled through "good" state corresponding to error-free transmission and "bad" state where the frame is always in error.

The channel in proposed model is characterized again by two parameters, the error probability ε, and the average error burst length B.

3. SIMULATION RESULTS

In this section we present some interesting results given from the proposed above GPSS Simulator. For all of the reported results, m and ε are taken to be equal to 10 and 0.1, respectively, even though other values have been tested and the results agree with the ones shown here.

Fig. 3 shows the queueing delay and the delivery delay as functions of A in the case B = 3 (a mildly correlated channel), m=10, and ε=0.1, for various values of λ = {0.4, 0.6}. The delivery delay curves show that the value of T_D does not significantly change when λ and/or A varies. The queueing delay, instead, is shown to increase with λ, which maybe somehow expected, but also it exhibits a linearly increasing behavior in A.

This can be explained by considering that the frames arrive in bursts and therefore are likely to find many other frames ahead in the queue, which results in a higher T_Q and total delay.

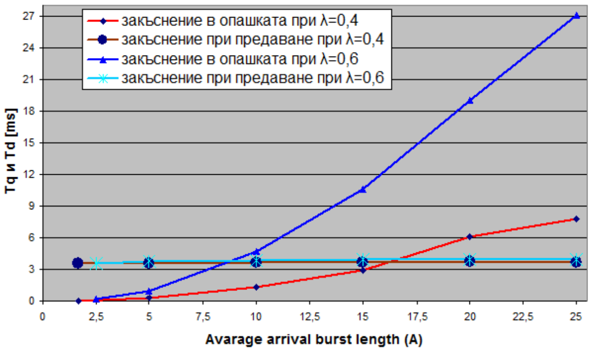

Fig. 3. Queueing and delivery delay vs. A, for various values of λ

Fig. 4 shows average values of the delivery delay for m=10, ε=0.1, A=2.5 as a function of arrival rate λ, for various values of B.

In this figure, a counterintuitive behavior is emphasized: one might expect that the delay increases with λ, since the system is more heavily loaded. This reasoning is correct for the queuing delay, but not for the delivery delay.

However, for more realistic cases where the average burst length is moderate or higher, the delivery delay is almost independent of the frame arrival rate or may decrease with increasing λ. This phenomenon can be explained by appearance of long sequences of slots where the channel is in a good state, thus it is easier to solve an entire sequence of frames directly. It is more acute for large values of burst error length B.

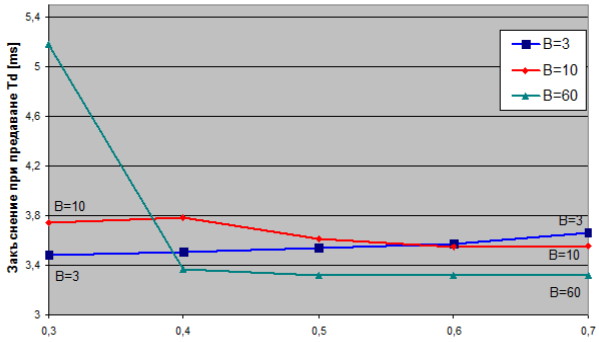

Fig. 4. Delivery delay vs. λ, for various values of B

Fig. 5 shows average values of the total delay for m=10, ε=0.1, λ= 0.6 as a function of burst error length B, for various values of arrival burst length A={2.5, 7}.

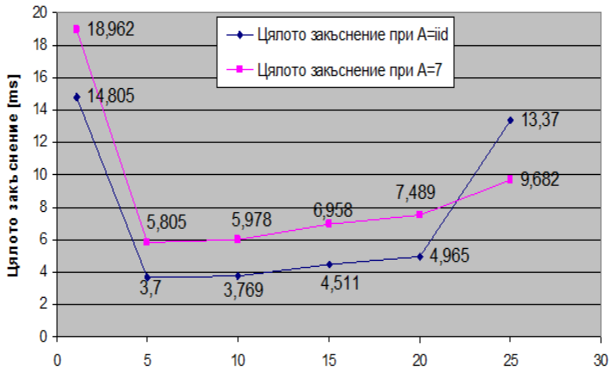

Fig. 5. Total delay vs. B, for various values of A={2.5, 7}.

As can to see total delay decreases at first and then increases linearly, i.e. the moderate channel burstiness achieves lower delay than one at the lower or higher channel burstiness.

Finally, comparison between the queueing delay, the delivery delay, and the total delay for m=10, ε=0.1, λ=0.6, as a function of B, for A=2.5 is shown in Fig. 6. This figure explains the fact that moderate channel burstiness achieves a lower total delay than one at the lower or higher channel burstiness: By looking at the figure, we are now able to recognize that total delay depends on the dominant delay term being either the delivery or the queueing delay. In fact, while T_D is decreasing when the channel burstiness increases around moderate values, T_Q is linearly increasing, which becomes the prominent term for high B.

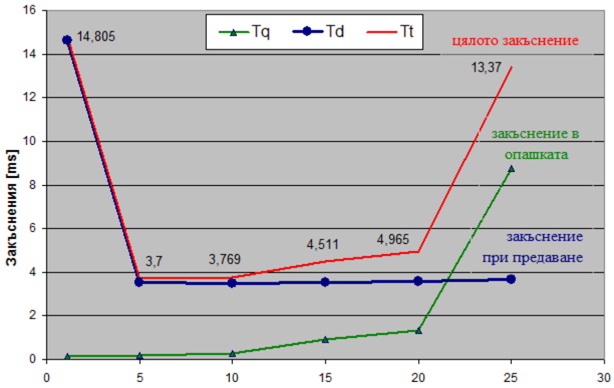

Fig. 6. Queueing, delivery, and total delay vs. error length B

Similar curves have been given in [1], which are derived analytically, and this fact can be presented as the kind of verification of proposed in present paper simulation model and results.

4. CONCLUSION

In present paper, we compare the SR ARQ delays with various intensities of the arrival rate and the arrival burstnesss at the transmitter's queue as well as investigate the effect of the error burstness in the channel. We show that the delivery delay may actually decrease for an increasing arrival rate when the channel is moderately burst, and in certain cases error burstness may imply a general decrease of the total delay. These aspects are remarkable to achieve correct delay estimation in real time multimedia services over wireless channels, e.g. video-streaming applications.

5. ACKNOWLEDGEMENTS

This paper is sponsored by Research project No SRP-B4 at South West University- Blagoevgrad, Bulgaria.

References

[1] Badia, L. On the Impact of Correlated Arrivals and Errors on ARQ Delay Terms, IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. 57, NO. 2, FEBRUARY 2009, pp.334-337.

[2] Hristov, V., SIMULATION OF TRANSPORT LAYER PROTOCOLS, Proc. of the Conference Computer Science'2006, Instambul, Turkey, 30 September – 2 October, 2005, Part I, pp. 114- 119.

[3] J. G. Kim and M. M. Krunz, "Delay analysis of selective repeat ARQ for a Markovian source over a wireless channel," IEEE Trans. Veh. Technol. , vol. 49, no. 5, 2000, pp. 1968-1981.

[4] J.-B. Seo, Y.-S. Choi, S.-Q. Lee, N.-H. Park, and H.-W. Lee, "Performance analysis of a type-II hybrid-ARQ in a TDMA system with correlated arrival over a non-stationary channel," in Proc. ISWCS,Siena, Italy, 2005, pp. 59-63.

[5] L. B. Le, E. Hossain, and A. S. Alfa, "Radio link level performance evaluation in wireless networks using multi-rate transmission with ARQ– based error control," IEEE Trans. Wireless Commun.,vol.5,no.10, Oct. 2006, pp. 2647-2653.

[6] W. Luo, K. Balachandran, S. Nanda, and K. Chang, "Delay analysis of selective-repeat ARQ with applications to link adaptation in wireless frame data systems," IEEE Trans. Wireless Commun., vol. 4, no. 3, May 2005, pp. 1017-1029.

[7] M. F. Neuts,Matrix-Geometric Solutions in Stochastic Models.New