

Analysis of Queue Performance of n GBN-ARQ and Its Improved Protocol Based on TDD Channel

Suoping Li, Jun Yu, and Yongkui Tie, *Member, IACSIT*

Abstract—Considering Time Division Duplex (TDD) channel with susceptible environment and high packet error rate, this paper mainly analyzes delay performance of the data transmission system taking the n -copy GBN-ARQ protocol. First, combining the transmission characteristics of SR-ARQ based on n GBN-ARQ, we put forward an improved n -copy GBN-ARQ protocol which reduces the packet costs effectively. Next, we derive the mean delay indexes of the two systems by solving the M/G/1 queuing model with vacations according to the method of equivalent delay. We also discuss the effect of the delay performance affected by window length, packet error rate and copy number of the two systems in detail. The theoretical analysis and simulation indicate: the improved n GBN-ARQ protocol can still work normally when it is applied to the TDD wireless data transmission with high channel error rate and the improved n GBN-ARQ can cut down the packet cost and delay effectively, and improve the data transmission efficiency without changing the original arithmetic and increasing system complexity.

Index Terms—Queuing model, n GBN-ARQ, TDD, delay performance, equivalent service delay, mean packet delay.

I. INTRODUCTION

With the wide development and application of wireless network technology, more and more communication equipment, such as all kinds of remote controls, bluetooth headset, playstation and wireless printer etc., make use of wireless transmission to realize intelligent control. These devices make our life become convenient. But because of the cost and the characteristics of them, complex mechanisms or components are not used in these devices. The data are transmitted along the two directions in these small communication systems, but the transmission on a channel is only one-way at the same moment. Usually this way of transmission is called Time Division Duplex communication (TDD) [1]. In addition, some special channels such as underwater acoustic channels can only use the TDD communication because of the channel's complexity, noise interference and delay performance. At present, research on various data transmission control protocols is mostly limited to the full duplex communication system, and it seldom involves the TDD communication. Besides, the characteristics of the wireless channel such as time-variation and unstable transmission often lead to the decline in performance of all kinds of ARQ retransmission mechanism

in the full duplex link. So it is significant to find a new kind of data transmission control protocol which is more suitable for wireless TDD communication.

Now error control protocols of Automatic Repeat request (ARQ) are used frequently. The delay performances of wireless data transmission between GBN-ARQ and SR-ARQ systems with full-duplex are compared in [2]. In [3], the authors also researched a GBN-ARQ system and obtained the general expression of mean packet waiting delay and mean packet service delay. The performance of the half-duplex SW-ARQ protocol based on water acoustic communication network was studied in [4]. But the above studies are based on the condition of full-duplex without considering high noise channel. Authors of [5] and [6] did the research on the delay performance in half-duplex within infrared-ray communication systems, and got the general expression of mean packet waiting delay and mean packet service delay. Actually, they did the research on the continuous ARQ (CGBN-ARQ) which is one of the GBN-ARQ protocols, and didn't consider the influence of feedback delay. As an improvement of standard GBN-ARQ, n -copy GBN-ARQ (n GBN-ARQ) protocol is barely used or studied because of the increased packet number and cost. But n GBN-ARQ has its own advantage such as the higher efficiency in transmission. In [7] and [8], it was proved that n GBN-ARQ had the higher throughput in high error rate of packet, but the analysis was not based on TDD channel.

Considering that the wireless environment of TDD is easy to be disturbed and its data transmission is easy to be suspended which leads to a high packet loss rate, and the n GBN-ARQ has better transmission accuracy on high error rate channel, in this paper we mainly investigate the performance of n GBN-ARQ system under TDD with high channel noise. We first propose a new n GBN-ARQ system by making appropriate improvement on the original protocol based on combining with the characteristic of SR-ARQ, which does not increase the complexity and technical requirements of the system but decreases the packet overhead effectively. Our analysis shows that this improvement can reduce the probability of packet retransmission by the speed of geometric growth. Then we model the improved n GBN-ARQ system as an M/G/1 queue with vacation and respectively analyze the delay performances of the original and improved n GBN-ARQ system in terms of the thought of equivalent service delay. At last, by simulation analysis in MATLAB, we discuss how the delay performance is affected by the window length, packet error rate and copy number of the two systems. Based on the analysis and the conclusion of this paper, it is easy to see that the improved n GBN-ARQ system has obvious superiority in the wireless data transmission under TDD.

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The authors are with the School of Science, Lanzhou University of Technology, Lanzhou 730050, China (e-mail: lsuop@163.com).

II. *N*-COPY GBN-ARQ PROTOCOL AND ITS IMPROVEMENT BASED ON TDD

A. Features of TDD Communication with *N*-Copy GBN-ARQ Protocol

TDD transmission means that sending and accepting share the same carrier channel, and transmission mechanism is only one lane for two-way traffic that one node sends while the other node receives at the same moment. Take infrared communication devices for example, its transceiver is on the same carrier, so the light from sender and receiver is not isolated, and sending signals can interfere with the received input signals. When the emitter sends a light signal, and the receiver is in the state of receiving, it will lead to the result that signals from other devices are destroyed by the light. Therefore, the infrared data link is a TDD mode, which does not allow for sending and receiving data simultaneously [7]. Generally, most small wireless transmission devices transmit a little data, and only need the receiver to give a response for the message from sender. So, the devices should be as simple as possible as long as they can work normally, and mostly take the TDD mode. Most of the current research is on complex equipment which has large information capacity by using the full duplex channel. So, the study of the transmission protocol with TDD in small device is very practical and significant.

GBN-ARQ is one of the most widely used ARQ protocols. It has been applied to HDLC, SDLC, ADCCP and LAPB in DLC protocol. There are three types of GBN-ARQ: standard GBN-ARQ, *n*-copy GBN-ARQ, and continuous GBN-ARQ. The basic principle of GBN-ARQ is as follows: if the sender doesn't receive the acknowledgements from the receiver, it can send *N* packets successively. When a NAK (negative acknowledgment) is received by sender, the transmitting of any new packet will be stopped, and the negatively acknowledged packet and its subsequent *N*-1 packets will be retransmitted. *N* is an important parameter which is called (sliding) window width. Here, the receiver only accepts the correct order packets. RN is the received sequence number embedded in the acknowledgement, and means the packets before it are all received successfully. The receiver only needs to send an ACK (positive acknowledgment) for the biggest correct RN instead of sending an ACK once a correct packet is received. On the duplex channel the standard GBN-ARQ and continuous GBN-ARQ have been introduced and researched in detail by the existing literature. This paper mainly studies *n*GBN-ARQ and revised *n*GBN-ARQ based on TDD in high noise environment.

Now, we introduce the principle of traditional *n*GBN-ARQ protocol based on the TDD channel by taking Fig. 1 with *N*=4, *n*=2. Different from the *n*GBN-ARQ based on full duplex channel, the *n*GBN-ARQ based on half duplex channel is that its sender and receiver work in turn by time division. At first, the sender sends out a set of packets according to packet window length *N*, and then retransmits them without waiting for the response to the first transmission. The response just can reach the sender after a round trip time. By this moment, the sender has sent out 2×4 packets. The sender will continue sending a new set of packets when receiving an ACK response. Once it receives

the NAK response, the sender will go back 4 steps and retransmit the wrong packet (packet 2 in Fig. 1) and its subsequent *N*-1 packets. So, the sender needs a buffer which can store *n*×*N* packets in order to retransmit the wrong packet and its subsequent packets at any time. Here for the packet which was detected faulty, its subsequent *N*-1 packets will be abandoned whether they are right or wrong. So, the receiver just needs a buffer that can store only one packet. Therefore, the premise of packet retransmission in one transmission is there is twice error for the same packet. For packet1 in Fig. 1, although packet 1 has error but its copy is right, it can be accepted and submitted in the receiver, while packet 2 needs to be retransmitted because it and its copy both have error in transmission.



Fig. 1. *n*GBN-ARQ protocol based on TDD (*N*=4, *n*=2).

B. Improved *N*-Copy GBN-ARQ Protocol Based on TDD

Now combining the SR-ARQ, the wireless equipment such as cellphone and MP4 have been equipped with high-capacity RAM and buffer device, and the performance and speed of CPU is also improved significantly. Based on the conditions above, we can improve the *n*GBN-ARQ protocol so as to fit with wireless communication of TDD channel well without changing the technology and complexity of equipment. That is to set the next transmission window sliding rule of the system: let the correct transmitted packets retain in the buffer of receiver and the new window is to be made of the packets which err at the last transmission and the new packets. So, the improved *n*GBN-ARQ is: every feedback response will be sent after *n*×*N* packets are sent; the buffer is used to preserve all the packets that are correctly accepted in the last window and no longer abandon them; the new sending window only sends the packets that have errors in the last transmission and new packets, as Fig. 2 shows.

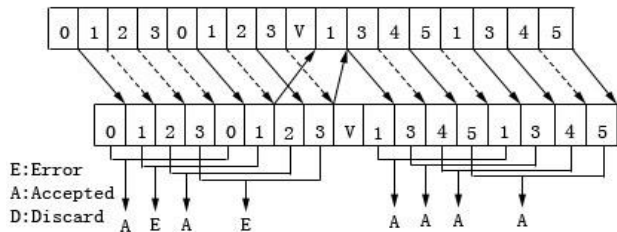


Fig. 2. The improved GBN-ARQ protocol based on TDD (*N*=4, *n*=2).

Errors occurred in packet 1 and packet 3 in Fig. 2, so in the next window transmission, packet 1 and packet 3 are automatically inserted into the window for retransmission. The packet 2 is accepted correctly and stored in the buffer of receiver, and has no need to be retransmitted. Through the calculation and analysis of the following, we can see this simple improvement can effectively reduce the system service delay.

III. PERFORMANCE ANALYSIS OF N -COPY GBN-ARQ AND IMPROVED N -COPY GBN-ARQ ON TDD TRANSMISSION

A. Performance Analysis of N -Copy GBN-ARQ Based on TDD

Through the analysis on the n GBN-ARQ system of TDD transmission channel above, we know that the sender has been in the idle state after the first window finishes sending packets and is waiting for the response. The receiver is also in the idle state after sending response. The idle time can be seen as a vacation with length V . So a packet service delay is an interval from the beginning of transmission in the data link to the time that the packet is successfully accepted by the receiver, which includes not only the first transmission delay t_b but also the retransmission delay t_f (that includes propagation delay, procession delay, and feedback delay in the data link layer). Therefore, a packet service delay can be considered as an equivalent service delay, which follows a general distribution and can be described as an $M/G/1$ queuing model with vacations.

First, some analysis assumptions and symbols are given as follows: all the packets arrive at the queue independently according to the Poisson process with rate λ ; the packet service delay is generally distributed and independent of each other; the feedback channel is error-free; the length of every packet is m units; the wrong transmission probability of one packet is p ; and under the steady state, the procession delay of a packet is t_b in the data link, and the receiver feedback delay is t_f . In addition, let X_k be the equivalent service delay of successful transmission after k times retransmission for one packet, and V_k be the k -th vacation length. X_k and V_k ($k=1, 2, \dots$) are variable sequences of independent and identical distribution respectively. Thus, according to [2] and [6], the expression of mean waiting delay W in an $M/G/1$ queuing model with vacations is as follows:

$$W = \lambda E[X^2] / 2(1 - \rho) + E[V^2] / 2E[V] \quad (1)$$

where $\rho = \lambda E[X]$ is the system service intensity, and $E[X]$, $E[X^2]$, $E[V]$ and $E[V^2]$ are the various moments of X_k and V_k respectively.

In n GBN-ARQ system, a retransmission packet is equiprobably located in each sliding window with the probability $1/nN$. So, the mean packet service delay at the first transmission, which means the receiver is busy, can be calculated as:

$$T_0 = \frac{1}{nN} m [nN + (nN - 1) + \dots + 2 + 1] = \frac{m(nN + 1)}{2}$$

The mean equivalent service delay of the k times retransmission for one packet is

$$T_k = \frac{m(nN + 1)}{2} + mnNk + (k + 1)(t_b + t_f) \quad (k \geq 1)$$

The equivalent service delay of successful transmission for one packet is

$$X_k = T_0 + T_k = \frac{m(nN + 1)}{2} + mnNk + (k + 1)(t_b + t_f)$$

Because a successful transmission for one packet of

n -copy means that there is at least one right transmission for the packet, the probability of wrong transmission for the packet is $p_i = p^n$. So the probability of right transmission for one packet is $p_r = 1 - p_i = 1 - p^n$; the probability of k times retransmission for one packet, which means one right transmission and k times wrong transmissions, is given by $p_k = p_i^k p_r = (p^n)^k (1 - p^n)$. Then, the probability of successful transmission for one packet (which means one right transmission and k times wrong transmission too) is

$$P \left\{ X_k = \frac{m(nN + 1)}{2} + mnNk + (k + 1)(t_b + t_f) \right\} = (p^n)^k (1 - p^n) \quad k = 0, 1, 2, \dots \quad (2)$$

The 1st order moment of X_k and 2nd order moment of X_k can be respectively calculated as

$$\begin{aligned} E[X] &= \sum_{k=0}^{\infty} \left[\frac{m(nN + 1)}{2} + mnNk + (k + 1)(t_b + t_f) \right] (p^n)^k (1 - p^n) \\ &= \frac{m(nN + 1)}{2} (1 - p^n) \sum_{k=0}^{\infty} (p^n)^k + mnN(1 - p^n) \sum_{k=0}^{\infty} k (p^n)^k \\ &\quad + (t_b + t_f)(1 - p^n) \sum_{k=0}^{\infty} (k + 1)(p^n)^k \\ &= \frac{m(nN + 1)}{2} + \frac{mnNp^n + t_b + t_f}{1 - p^n} \end{aligned} \quad (3)$$

$$\begin{aligned} E[X^2] &= \sum_{k=0}^{\infty} \left[\frac{m(nN + 1)}{2} + mnNk + (k + 1)(t_b + t_f) \right]^2 (p^n)^k (1 - p^n) \\ &= \sum_{k=0}^{\infty} \left[\frac{m(nN + 1)}{2} + t_b + t_f \right]^2 (p^n)^k (1 - p^n) \\ &\quad + \sum_{k=0}^{\infty} [m(nN + 1) + 2(t_b + t_f)] \\ &\quad [t_b + t_f + mnN] k (p^n)^k (1 - p^n) \\ &\quad + \sum_{k=0}^{\infty} [mnN + t_b + t_f]^2 (p^n)^k k^2 (1 - p^n) \\ &= \left[\frac{m(nN + 1)}{2} + t_b + t_f \right]^2 \\ &\quad + \frac{[2(t_b + t_f) + m(nN + 1)][t_b + t_f + mnN] p^n}{1 - p^n} \\ &\quad + \frac{[mnN + t_b + t_f]^2 p^n (1 + p^n)}{(1 - p^n)^2} \end{aligned} \quad (4)$$

In addition, we take the slots in a sending window as the vacation length, that is $V_k = mN$. Then, 1st order moment of V_k and 2nd order moment of V_k can be respectively given by

$$E[V] = \sum_{k=0}^{\infty} [mN] p^n (1 - p^n)^k = mN \quad (5)$$

$$E[V^2] = \sum_{k=0}^{\infty} [mN]^2 p^n (1-p^n)^k = (mN)^2 \quad (6)$$

Putting (3), (4), (5) and (6) into (1), the packet mean waiting delay in traditional n GBN-ARQ system of TDD can be obtained as

$$W = \frac{\lambda E[X^2]}{2(1-\rho)} + \frac{E[V^2]}{2E[V]}$$

$$= \frac{\lambda \left[k_1 + \frac{k_2 p^n}{1-p^n} + \frac{k_3 p^n (1+p^n)}{(1-p^n)^2} \right]}{2 \left\{ 1 - \lambda \left[\frac{m(nN+1)}{2} + \frac{mnNp^n + t_b + t_f}{1-p^n} \right] \right\}} + \frac{mN}{2}$$

where

$$k_1 = \left[\frac{m(nN+1)}{2} + t_b + t_f \right]^2$$

$$k_2 = \left[2(t_b + t_f) + m(nN+1) \right] \left[t_b + t_f + mnN \right]$$

$$k_3 = \left[mnN + t_b + t_f \right]^2$$

Therefore, the packet mean service delay in traditional n GBN-ARQ system based on TDD is given by $T = E[X] + W$, that is

$$T = \frac{m(nN+1)}{2} + \frac{mnNp^n + t_b + t_f}{1-p^n}$$

$$+ \frac{\lambda \left[k_1 + \frac{k_2 p^n}{1-p^n} + \frac{k_3 p^n (1+p^n)}{(1-p^n)^2} \right]}{2 \left\{ 1 - \lambda \left[\frac{m(nN+1)}{2} + \frac{mnNp^n + t_b + t_f}{1-p^n} \right] \right\}} + \frac{mN}{2} \quad (7)$$

The throughput of the system can be given by [9]

$$\eta_i = \frac{1}{T} \quad (8)$$

B. Performance Analysis of the N -Copy Improved GBN-ARQ

Next, we calculate the delay of the n -copy GBN-ARQ protocol improved in Section II.B on TDD channel. From the analysis in Section II, we know that the traditional n GBN-ARQ and the improved system have the similar transmission principle. The main difference is that if the wrong packet requires retransmission, the improved system will not retransmit all packets behind this packet but only retransmit the wrong packet of this window, and the packet which has been transmitted correctly will be stored in the buffer. It is not only reducing the packet costs, but also reducing the delay and improving the throughput of the system effectively. Similarly, based on the equivalent delay, the improved n GBN-ARQ can be described as an $M/G/1$ queuing model with vacations. The equivalent service delay of successful transmission after k times retransmission for

one packet is

$$X_k = \frac{m(nN+1)}{2} + nmk + (k+1)(t_b + t_f) \quad (9)$$

Because the probability of successful transmission for one packet still is $p_k = p_r^k p_r = (p^n)^k (1-p^n)$, this means one right transmission and k times wrong transmissions. So we have the probability distribution and the moments of X_k as follows

$$P \left\{ X_k = \frac{m(nN+1)}{2} + nmk + (k+1)(t_b + t_f) \right\} \quad (10)$$

$$= (p^n)^k (1-p^n) \quad (k = 0, 1, 2, \dots)$$

$$E[X] = \sum_{k=0}^{\infty} \left[\frac{m(nN+1)}{2} + nmk + (k+1)(t_b + t_f) \right] (p^n)^k (1-p^n)$$

$$= \frac{m(nN+1)}{2} (1-p^n) \sum_{k=0}^{\infty} (p^n)^k + nm(1-p^n) \sum_{k=0}^{\infty} (p^n)^k + (t_b + t_f)(1-p^n) \sum_{k=0}^{\infty} (k+1)(p^n)^k$$

$$= \frac{m(nN+1)}{2} + \frac{nm p^n + t_b + t_f}{1-p^n} \quad (11)$$

$$E[X^2] = \sum_{k=0}^{\infty} \left[\frac{m(nN+1)}{2} + nmk + (k+1)(t_b + t_f) \right]^2 (p^n)^k (1-p^n)$$

$$= \sum_{k=0}^{\infty} \left[\frac{m(nN+1)}{2} + t_b + t_f \right]^2 (p^n)^k (1-p^n)$$

$$+ \sum_{k=0}^{\infty} \left[m(nN+1) + 2(t_b + t_f) \right] [t_b + t_f + nm] k (p^n)^k (1-p^n)$$

$$+ \sum_{k=0}^{\infty} \left[mn + t_b + t_f \right]^2 (p^n)^k k^2 (1-p^n)$$

$$= \left[\frac{m(nN+1)}{2} + t_b + t_f \right]^2 + \frac{\left[2(t_b + t_f) + m(nN+1) \right] \left[t_b + t_f + nm \right] p^n}{1-p^n} + \frac{\left[nm + t_b + t_f \right]^2 p^n (1+p^n)}{(1-p^n)^2} \quad (12)$$

The slots in a sending window are still taken as the vacation length, i.e. $V_k = mN$. Then $E[V] = mN$, $E[V^2] = (mN)^2$. By putting the various moments into (1), the packet mean waiting delay in the improved n GBN-ARQ is:

$$W = \frac{\lambda E[X^2]}{2(1-\rho)} + \frac{E[V^2]}{2E[V]}$$

$$= \frac{\lambda \left[k_1^\Delta + \frac{k_2^\Delta p^n}{1-p^n} + \frac{k_3^\Delta p^n (1+p^n)}{(1-p^n)^2} \right]}{2 \left\{ 1 - \lambda \left[\frac{m(nN+1)}{2} + \frac{2mp^n(t_b+t_f)}{1-p^n} \right] \right\}} + \frac{mN}{2}$$

where

$$k_1^\Delta = \left[\frac{m(nN+1)}{2} + t_b + t_f \right]^2$$

$$k_2^\Delta = \left[2(t_b + t_f) + m(nN+1) \right] \left[t_b + t_f + nm \right]$$

$$k_3^\Delta = \left[nm + t_b + t_f \right]^2$$

The mean service delay of the improved *n*GBN-ARQ system based on TDD is

$$\tilde{T} = E[X] + W$$

$$= \frac{m(nN+1)}{2} + \frac{npm^n + t_b + t_f}{1-p^n}$$

$$+ \frac{\lambda \left[k_1^\Delta + \frac{k_2^\Delta p^n}{1-p^n} + \frac{k_3^\Delta p^n (1+p^n)}{(1-p^n)^2} \right]}{2 \left\{ 1 - \lambda \left[\frac{m(nN+1)}{2} + \frac{2mp^n(t_b+t_f)}{1-p^n} \right] \right\}} + \frac{mN}{2} \quad (13)$$

The throughput of the improved *n*GBN-ARQ system is [9]

$$\eta_2 = \frac{1}{\tilde{T}}$$

IV. NUMERICAL ANALYSIS

The TDD wireless communication can not transmit data steadily like the wired channel. It is easily affected by surroundings and has high data loss rate, so sometimes, it does not offer service normally or effectively. Most researchers have studied the wireless data transmission based on duplex channel or supposing the ideal circumstance and ideal error rate for transmission without considering other factors which influence the systematic delay nonnegligibly, such as error rate over the channel, packet length, and window length etc. So some simulation analysis usually falls short of the practical application. Considering TDD channel, we further make the numerical analysis for the *n*GBN-ARQ system and improved *n*GBN-ARQ system in MATLAB, which are more suitable for high error rate environments. When the influences of copy number, window length and packet length on the system delay were comprehensively taken into account, we compared the performances of the two systems by numerical analysis based on the results of (8) and (13) with $t_b=t_f=1$, $\lambda=0.02$. Fig. 3-Fig. 5 give the simulation results which agree with the parameter practical meaning and the conditions of the system steady state.

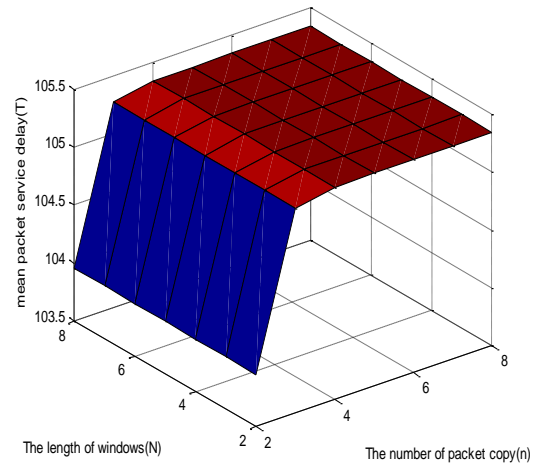


Fig. 3. The length of windows and the number of packet copy versus the mean packet service delay of the *n*GBN-ARQ.

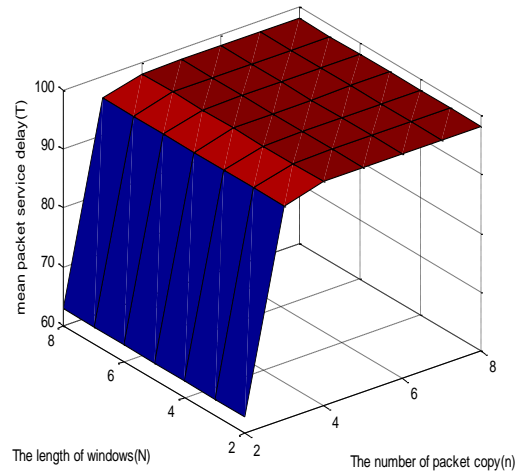


Fig. 4. The length of windows and the number of packet copy versus the mean packet service delay of the *n*GBN-ARQ.

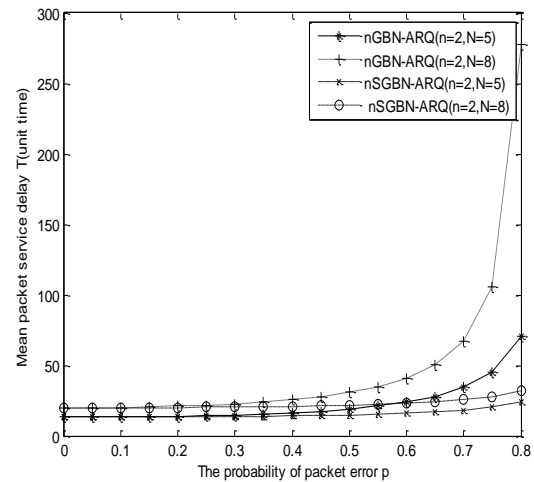


Fig. 5. Mean packet service delay versus packet error probability.

The comparison between the Fig. 3 and the Fig. 4 shows: when the system is in the steady state and the packet transmission error rate is fixed, the window length and the copy number have the same effect trend to the delay of the two systems on condition that the packet arrival rate, data link transmission delay, feedback delay and vacation length are equal respectively. The packet mean service delay is getting larger as the window length and the copy number are

getting larger. On the other hand, when the window length and copy number are getting smaller, the delay of improved n GBN-ARQ mechanism is far smaller than the n GBN-ARQ's; when the window length and copy number are getting larger, the delay increasing rate of the improved n GBN-ARQ is far smaller than the n GBN-ARQ's. Besides, the sensitivity of the throughput of the improved n GBN-ARQ system to the window length and the copy number is smaller than the n GBN-ARQ's. Compared to the improved n GBN-ARQ, the n GBN-ARQ mechanism has to cut down its sliding window length and packet number to attain the same system throughput, but this will lower the data transmission efficiency. So we can get the following conclusion: considering the fixed packet length and the packet arrival rate, the best error-control solution to raise the system transmission capacity without increasing the system complexity is taking the improved n GBN-ARQ protocol in wireless transmission based on TDD.

According to the packet mean service delay in Fig. 5, the n GBN-ARQ mechanism and the improved n GBN-ARQ mechanism have no obvious difference under the same simulation circumstance when the error rate is lower. As the packet transmission error rate p increases, the mean service delay of the two systems also increases yet and the increasing rate of the n GBN-ARQ is far larger than the improved n GBN-ARQ's. That is to say: the improved n GBN-ARQ mechanism can still be applied to data transmission normally when system is in the bad channel environment and the packet error rate is high. Next, the variance on the packet service delay to the n GBN-ARQ is larger under the conditions of the copy number $n=2$ and the window length $N=5$ and $N=8$, and the delay variance of the improved n GBN-ARQ is very small. This illustrates that the improved n GBN-ARQ mechanism is more suitable for engineering application because it can effectively eliminate the consumption of system throughput which is caused by increasing packet costs in the n GBN-ARQ system.

On the other hand, because the optimal window length and copy number can be determined from (7) and (13) considering the objective of optimal mean service delay, by comprehensively analyzing on Fig. 3, Fig. 4 and Fig. 5, we can get the changing rule of the optimal sliding window and copy number under condition of given transmission parameter, that is the optimal sliding window length and copy number will increase with the raise of transmission accuracy rate of channel and the system delay. Hence, the improved n GBN-ARQ protocol can not only be applied in bad wireless channel but also achieves a kind of adaptive control to system delay by selecting window length and copy number.

V. CONCLUSION

Considering small wireless transmission devices being used widely without complex mechanism, this paper establishes an M/G/1 queuing model with vacation for the n GBN-ARQ protocol and its improved protocol based on TDD transmission and the thought of equivalent service delay. We analyze the performance characteristics of the two systems theoretically, derive their mean service delay and throughput by solving M/G/1 queuing model with vacation,

and make a computer numerical analysis on the delay influence factors such as channel error rate, packet length, and window length etc. in MATLAB. The theoretical analysis and simulation indicate: the improved n GBN-ARQ protocol can still work normally when it is applied to the TDD wireless data transmission with high channel error rate. Meanwhile, the improved n GBN-ARQ can cut down the packet cost and delay effectively, and improve the data transmission efficiency without changing the original arithmetic and increasing system complexity. Moreover, by the analysis results of this paper, the wireless communication system can achieve automatically adjusting its transmission pattern by means of detecting channel circumstance, window length and packet copy number in engineering. So, the research can provide with some theoretical basis and approach for designing the optimal wireless communication states.

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Suoping Li is with the School of Science at Lanzhou University of Technology, China. He received the Ph.D. degree in signal and information processing from Beijing Jiaotong University, China, in 2004. He also got a M.Sc. degree in stochastic model with applications from Lanzhou University in 1996, and B.Sc. degree in mathematics from Northwest Normal University in 1986. He was a visiting scholar at the Swiss Federal Institute of Technology Zurich from May 2007 to May 2008. He also is a visiting professor at East Texas Baptist University from Aug. to Dec. 2011. His primary research interests include stochastic control theory and stochastic process; error control theory and data communication protocol; hybrid dynamic systems modeling, control and simulation.



Jun Yu is with the School of Science at Lanzhou University of Technology. His major is operational research and cybernetics. He received the BS degree in applied mathematics from Zhoukou Normal University in 2009. His research interests are in the areas of stochastic modeling analysis of wireless communication systems and hybrid dynamic systems modeling, control and simulation.



Yongkui Tie is with the School of Science at Lanzhou University of Technology. His major is operational research and cybernetics. He received the BS degree in applied mathematics from Beifang University of Nationality. His research interests are in the areas of stochastic modeling analysis of wireless communication systems and hybrid dynamic systems modeling, control and simulation.