Goodput Analysis of a Modified Cumulative ARQ

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Abstract. For the wireless channel characteristics, this paper modifies the cumulative ARQ in order to improve the performance of the traditional cumulative ARQ. We put in sequence confirmed feedback to satisfy the demands of the new generation cellular mobile communication. An analysis model is developed for parameter manipulation in the proposed framework, where an important performance metrics, goodput, is investigated. Finally, the simulation results show that the performance of modified cumulative ARQ is better than traditional mechanism.

Introduction

Because of the widely used of computer and Internet network, the users' demand for data service continues to improve, and they also put forward high request to the reliability of data transmission. Error control technology is one of the most efficient methods to improve the reliability of data transmission. At present, one of the efficient error control technology is ARQ which plays important roles in broadband wireless communication such as 4G, WiFi and UWB, so it has been catching many researchers' attention over the years. A modified form of the ARQ selective repeat protocol with timer control is studied in [1]. A discrete-time Geom/G/1/ queue model is established by analyzing the transmission mechanism of SR-ARQ in [2]. P.Latkoski, etc. discussed the delay and throughput of IEEE 802.16 ARQ mechanism in [3].In order to improve the channel utilization and keep the advantages of cumulative ARQ, F.Hou, etc. studied the performance of cumulative ARQ in IEEE 802.16 networks, and developed an analytical model to investigate some important performance in [4].

In this paper, we modify the transmission mechanism of cumulative ARQ and study its performance such as goodput.

Modified Cumulative ARQ

Without loss of generality, the following discussions are for downlink traffic.

At first, we introduce the general cumulative ARQ mechanism which can be got in [4]. The transmission mechanism is proposed as follows.

Transmission principle of cumulative ARQ can be seen in figure 1. The general scheduling scheme proposed in [5] is considered in the mechaism, which is briefly described as follows. It is characterized by two parameters: h and L, where h is the number of SSs selected at each MAC frame, while L is the number of PDUs granted to an SS when it is served. Differentiated services among traffic flows in the system can be achieved by using different values of h and L for satisfying their QoS requirements in terms of goodput and delivery delay. From figure 1, we can see that in the first frame, since the PDU with sequence number 3 has been lost and identified by the receiver, the largest sequence number among all successfully received PDUs is 2. Therefore, in the feedback information, the FSN is 2, and all the PDUs with a sequence number from 3 to L need to be retransmitted. Then, the tagged queue waits for another m frames until it obtains the transmission opportunity again, where m is a random variable in unit of frame sand its probability density function is based on channel conditions of all SSs under the consideration. When the tagged queue obtains the transmission opportunity, L PDUs with sequence number from 3 to $L+2$ are retransmitted/transmitted. The BS will adjust FSN according to feedback information.

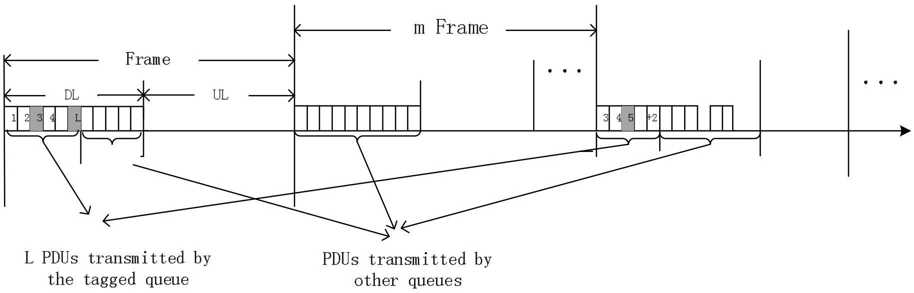

Fig.1 The illustration of the cumulative ARQ

In the process of the traditional cumulative ARQ mechanism transmission, when the first lost PDU appears, the successful received PDU before the first lost PDU will be fed back. This PDU and the PDU after it will wait to the next transmission opportunity to retransmit. In this way, the transmission causes large delivery delay and waste of channel. So on the basis of the discussion, we propose a modified scheme which adds to the sequence ACK in the traditional cumulative ARQ.

For simplicity, a queue under consideration is referred to as the tagged queue. The modified mechanism is described as follows. In the first frame, since the PDU with sequence number 3 has been lost and identified by the receiver, the largest sequence number among all successfully received PDUs is 2, which is shown in figure 2. The received PDUs with continuous lost state or continuous successful state are divided into a sequence and we need contain the number of PDUs in each sequence. In this way, we just need to know the information of sequence feedback and retransmit the lost sequence.

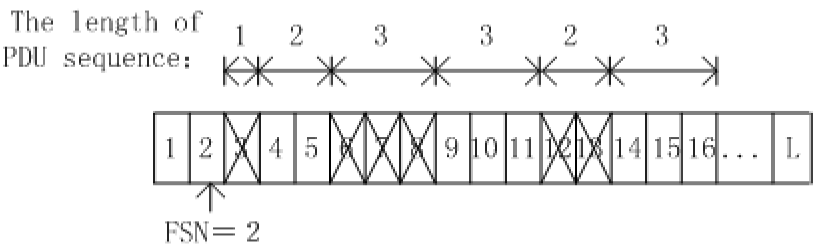

Fig.2 The division of PDU sequence

The purpose of the improvement of cumulative ARQ is to increase throughput, reduce delivery delay. In this paper, when calculate the delivery delay, we simplify the modified cumulative ARQ. We just study the condition that appear one lost sequence, namely, when it comes second lost sequence, the PDUs in first lost sequence and the PDUs with the number from the second lost number to L need to be retransmitted. Aim at this mechanism, an absorbing Markov model is developed for providing a simple and efficient approach to investigate the performance of the mechanism. The research is discussed at the following subsections.

Goodput Analysis of Modified Cumulative ARQ

As mentioned above, a queue under consideration is referred to as the tagged queue, and the SS to which the PDUs buffered at the tagged queue are destined is referred to as the tagged SS. The proposed analytical model is based on the following assumptions:

(1) in the link layer, each SDU is fragmented to F PDUs with equal size of B bits;

(2) feedback information of PDUs launched in a DL sub-frame will be sent back to the BS in the following UL sub-frame using the UL-ACK channel;

(3) Denote the number of PDUs which are transmitted when the tagged queue obtains the transmission opportunity by L .

Wireless channels suffer from deep fading that occurs randomly in the time span with a random duration and depth. Numerous studies have shown that such channels can be described by a Markov model to capture such burst error nature. In this paper, a finite state Markov channel (FSMC) model, which has been widely adopted in various related research [6, 7], is adopted to model the time-varying wireless channel of each SS.

Goodput achieved at the tagged queue is defined as the average data rate (in unit of bit/second) successfully launched by the tagged queue. Let m denote the number of PDUs successfully launched by the tagged queue during a transmission opportunity. The probability mass function of m is given as

$$pr[m=i]=C_L^i\left(1-p\right)^i p^{L-i} \tag{4}$$

where p is the error probability of transmitting each PDU, L is the number of PDUs transmitted by the tagged queue during a DL sub-frame. The mean of m is given by

$$E[m]=\sum_{i=0}^{L} iC_L^i\left(1-p\right)^i p^{L-i}=L\left(1-p\right) \tag{5}$$

$E\left[m\right]$ is the mean of the inter-service time for the tagged queue, which is given in (3). Here we consider the delay of feedback of the mechanism. Let Δt denote feedback delay once, and it is a fixed value. Due to the modified cumulative ARQ mechanism only feed back information of the whole successful or lost sequence, the mean feedback delay of PDUs in the model is less than $E\left[m\right]\cdot\Delta t$. We suppose it to $k\cdot\Delta t$, where k is the number of feedback sequence. Thus, the goodput achieved by the tagged SS is given by

$$G=\frac{E\left[m\right]\cdot B}{T\cdot\left(E\left[m\right]+1+k\cdot\Delta t\right)} \tag{6}$$

Let $E\left[m\right]$ denote the mean of the inter- service time for the tagged queue, $E[m]$ is derived from (5), T is the time duration of a MAC frame, and B is the size of a PDU in unit of bits.

Numerical Results and Simulation Analysis

In this Section, the performance of the modified cumulative ARQ scheme is evaluated by using both numerical and simulation results. We compared the modified and traditional cumulative ARQ performance. Extensive simulations are conducted to demonstrate the efficiency of the proposed framework and illustrate the impacts of three parameters, L, h and p.

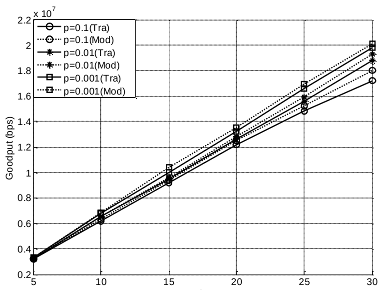

Fig.3 Goodput versus L for different p

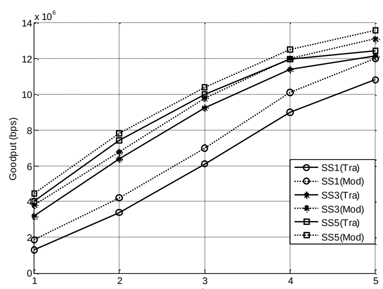

Fig.4 Goodput versus h

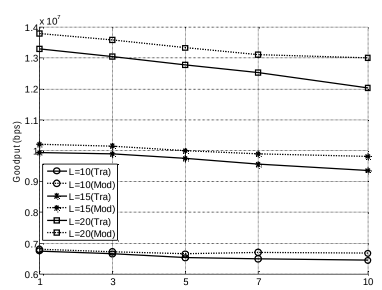

Fig.5 Goodput versus p

It is observed from Fig.3 that the goodput requirement can be achieved by manipulating a proper L. With the increasing of L, the achieved goodputs of SSs increase accordingly. In addition, the modified system achieves higher goodputs than traditional mechanism. With the larger p, the more the goodput increases. In another words, the improvement of goodput in the modified mechanism is better with the bigger loss probability and poor channel condition. Figure 4 shows the relationship between the obtained goodput and h for different SSs. When h increases, the goodput increases accordingly. And the goodput decreases with the worse channel condition. Compared with the two mechanisms, the goodput in modified mechanism is larger than that in original mechanism. And the worse the channel condition is, the more goodput increases. With the increase of h, inter-service time of each SS decreases. It leads to a higher throughput if each SS obtains more chances of transmission. Fig. 16 shows the relation between the achieved goodput and p. It is observed that goodput changes by the different p. With the increase of p, the achieved goodputs of SSs decrease accordingly. With a fixed p, an SS with larger bandwidth achieves a lower throughput since it has more lost PDU in a transmission. Compared the two mechanisms, with the longer L, the more the reduction of the goodput increases accordingly. At the same time, with the larger p, the more the reduction of the goodput increases similarly.

Conclusion

A modified cumulative ARQ is surveyed in this paper. On the basis of the traditional cumulative ARQ, we put in the sequence ACK feedback in the transmission. We have studied the goodput of the modified mechanism by building the Markov model and contrast the performance of the new mechanism with the traditional mechanism. From the simulation and numerical results, we can find that the modified cumulative ARQ has larger goodput than the original cumulative ARQ. The improvement is important to adapt to the environment with wireless channel. Our further research on the cumulative with several sequences feedback is under way.

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