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GOODPUT ANALYSIS OF A MODIFIED CUMULATIVE ARQ IN IEEE 802.16M NETWORKS

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Summary. *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. According to the advantages for reliability and high data rate transmission of the IEEE 802.16m networks, the performance of cumulative ARQ in IEEE 802.16m is proposed.An analysis model is developed for parameter manipulation in the proposed framework, where an important performance metrics, goodput, is investigated.*

Key words: *cumulative ARQ, sequence confirmed feedback, goodput, IEEE 802.16m.*

1. 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.

2. Modified cumulative ARQ. IEEE 802.16m standard defines four different types of feedback: cumulative ACK, cumulative with selective ACK, cumulative with sequence ACK. Four types of feedback have the same format but with different construction method, different way of feedback, different resource of feedback in the same situation. So feedback unit must be compressed in IEEE 802.16m to save channel resources and reduce the error probability. This paper studies the cumulative with sequence ACK ARQ on the basis of traditional 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. 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.

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.

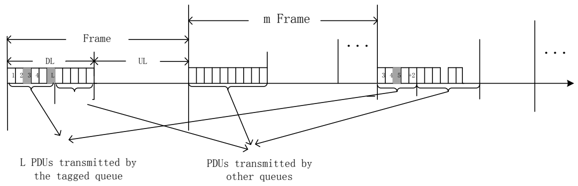

Fig.1 The illustration of the cumulative ARQ

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.

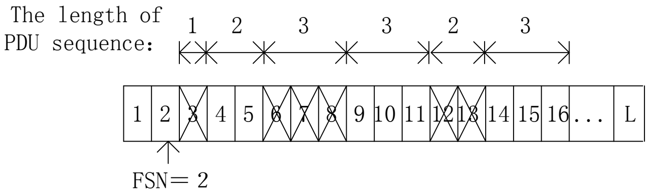

Fig.2 The division of PDU sequence

The purpose of the improvement of cumulative ARQ is to increase throughput, reduce delivery delay. The research is discussed at the following subsections.

3. 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 .

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 μ denote the number of PDUs successfully launched by the tagged queue during a transmission opportunity. The probability mass function of μ is given as

$$pr[\mu = i] = C_L^i (1-p)^i p^{L-i} \tag{1}$$

where p 163st he error probability of transmitting each PDU, L 163st he number of PDUs transmitted by the tagged queue during a DL sub-frame. The mean of μ is given by

$$E[\mu] = \sum_{i=0}^{L} i C_L^i (1-p)^i p^{L-i} = L(1-p) \tag{2}$$

$E[m]$ 163st he mean 163st he inter-service time 163st he163 tagged queue, which is given in (2). Here we consider the delay of feedback 163st he mechanism. Let Δt denote feedback delay once, and it is a fixed value. Due 163st he modified cumulative ARQ mechanism only feed back information 163st he whole successful or lost sequence, the mean feedback delay of PDUs in the model is less than $E[\mu]\cdot\Delta t$. We suppose it to $k\cdot\Delta t$, where k 163st he number of feedback sequence. Thus, the goodput achieved by the tagged SS is given by

$$G = \frac{E[\mu] \cdot B}{T \cdot (E[m] + 1 + k \cdot \Delta t)} \quad (3)$$

Let $E[m]$ denote the mean of the inter- service time for the tagged queue, $E[\mu]$ is derived from (3), T is the time duration of a MAC frame, and B is the size of a PDU in unit of bits.

References

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КЛИНИЧЕСКИЕ АСПЕКТЫ ПРИМЕНЕНИЯ ЧИСТОГО ТИТАНА В РЕКОНСТРУКТИВНОЙ ХИРУРГИИ ТРАВМАТИЧЕСКИХ ДЕФЕКТОВ КОСТЕЙ ЛИЦЕВОГО И МОЗГОВОГО ЧЕРЕПА

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Summary. *In recent decades, a trend of annually growth in the number of patients with defects of facial skull and cerebral cranium as a result of serious concomitant craniofacial injuries has been emerged. Clinical material is presented by 53 patients in the period of 1985-2008.*

A technology of fixation of perforated implants of clear titanium by titanium screws was used during reconstructive surgery for traumatic defects of the bones of facial skull and cerebral cranium. A special form has been developed for studying long-term results and classification of the obtained data.

The researches objectively show that the traumatic defects of the bones of facial skull and cerebral cranium which are complicated by its architectonics and severity of defects of functional esthetic condition of the patient the facial bones and the cranium can be virtually eliminated with the help of perforated plates of clear titanium. Scientifically grounded advantages of titanium implant give real prospects for widespread clinical use.

The presented clinical aspects should be considered as optimization of osteogenic properties and increase of regenerative capacity of the bones of facial skull and cerebral cranium, stimulating the process of osseointegration in "bone-implant" system.

Реконструктивная хирургия дефектов костей лицевого и мозгового черепа остаётся одной из наиболее актуальных современных нерешенных проблем практической черепно-челюстно-лицевой хирургии. В последние десятилетия наметилась четкая тенденция ежегодного роста числа пациентов с дефектами лицевого и мозгового черепа в результате тяжелых сочетанных черепно-лицевых травм (в республике Беларусь частота ЧЧЛТ составляет 4,0 пациента на 1000 человек, заболеваемость в 2008 году составила 390 на 100000). С одной стороны это связано с увеличением удельного веса тяжёлой черепно-лицевой травмы, с другой стороны ростом хирургической активности челюстно-лицевой и нейрохирургии в оказании специализированной хирургической помощи пострадавшим.