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## Review Article

# DOUBLE CLOCKS MULTI-CHANNEL P-PERSISTENT RANDOM MULTIPLE ACCESS PROTOCOL WITH THREE-WAY HANDSHAKE MECHANISM

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**ABSTRACT**

The paper proposed a double clocks multi-channel p-persistent random multiple access protocol based on three-way handshake mechanism. By introduction of the inquire response three-way handshake mechanism increases the reliability and stability of the system, improves the channel utilization; by the use of the multi-channel mechanism, not only improve the system throughput, but also realize that different business with different throughput and make the system meet the different priorities with different QoS both efficiently fairly; To shorter the system idle time, we adopt the double clocks mechanism which basic principle is that the channel is the continuous clock manner during channel is idle; the channel is the slot time manner during channel is busy.



## INTRODUCTION

To increase the reliability and stability of the system, improves the channel utilization, we introduce the three-way handshake mechanism; to improve the system throughput, realize that different business with different throughput and make the system meet the different priorities with different QoS both efficiently fairly, and we use the multi-channel mechanism (Jing Qu *et al*., 2006). The paper proposed a double clocks multi-channel p-persistent random multiple access protocol based on three-way handshake mechanism.

### The analysis of the proposed protocol

### The analysis of the protocol model

Upon sensing the channel is idle, at the beginning of the next slot, the nodes send the information packet with probability p, with probability (1-p) abandon send; when the packet idle period that is continuous clock arrives, sent at the same probability p, with probability (1-p) abandon sent (Xuming *et al*., 2003). The channel model of p-persistent CSMA protocol based on three-way handshake mechanism is shown in Fig.1.

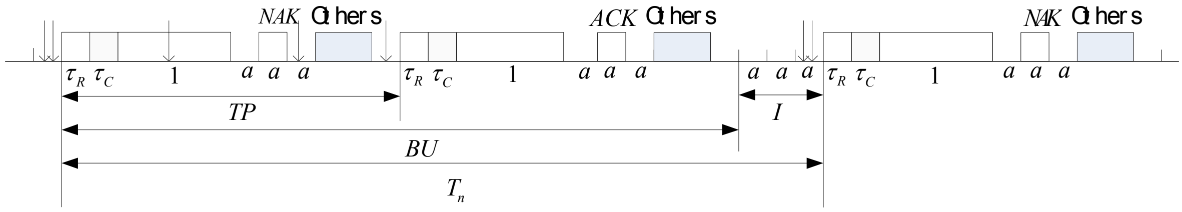


**Fig.1 The channel model of p-persistent CSMA protocol based on three-way handshake mechanism**

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**In this model, there will be three random events**

- Event that information packets are sent successfully (U events).
- Event that information packets collide with each other (the collision appears, C events).
- Event that there are no information packets in the channel arrive, the channel is idle (I events).

Force the C events and the U events into B events (Conti and Giordano, 2014). In the model of p-persistent probability CSMA protocol based on three-way handshake mechanism, and the total length of a transmission period is: $\frac{32}{23}(1+3a+\tau_R+\tau_C)$, where the total length of the data field is: $(1+3a+\tau_R+\tau_C)$, the total length of other field is: $\frac{9}{23}(1+3a+\tau_R+\tau_C)$ (Gandhi and Arya, 2014).

Assuming that nodes have different service requirement have different priorities, setting N traffic channels in the system, the node occupies the channel according to their business priorities (Xiaoping Wu, 2006). Assume that each priority unlimited the number of users, the priority from low to high in order is priority 1, priority 2… priority N (Jayasuriya *et al*., 2004). Priority 1 occupies the channel 1, priority 2 occupies channel 1 and channel 2… priority $i$ occupies channel 1 to channel $i$, and so on, as shown in Fig.2.

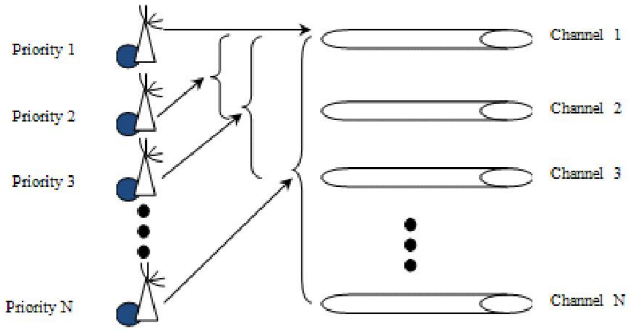


**Fig.2. The multichannel mechanism owning N channels**

**The analysis of the protocol throughput**

When there are n information packets arriving, the process of channel satisfying the Poisson process, the probability is：

$$P(n)=\frac{(aG)^n e^{-aG}}{n!} \tag{1}$$

In I events, at idle time slot $a$, if there is no information packets to be sent in channel $r$, its possibility is:

$$q_1^0=e^{-apG_r} \tag{2}$$

In I events, at idle time slot $a$, if there is only one information packet to be sent in channel $r$, its possibility is:

$$q_1^1=apG_r e^{-apG_r} \tag{3}$$

At the transmission period: $\frac{32}{23}(1+3a+\tau_R+\tau_C)$, if there is no information packets to be sent in channel $r$, its possibility is:

$$q_2^0=e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \tag{4}$$

In the transmission period: $\frac{32}{23}(1+3a+\tau_R+\tau_C)$, if there is only one information packet to be sent in channel $r$, its possibility is:

$$q_2^1=p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \tag{5}$$

In a cycle $T_n$, the possibility of continuous $i$ idle events in channel $r$ is:

$$P(N_{I_r} = i) = (e^{-apG_r})^{i-1} e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \tag{6}$$

In a cycle $T_n$, the possibility of continuous $j$ B events in channel $r$ is:

$$P(N_{B_r} = j) = (1-e^{-apG_r})(1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r})^{j-1} \tag{7}$$

In a cycle $T_n$, the possibility of continuous $i$ I events and $j$ B events in channel $r$ is:

$$\begin{aligned} P(N_{I_r} = i, N_{B_r} = j) &= (e^{-apG_r})^{i-1}(1-e^{-apG_r}) \\ &(1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r})^{j-1} e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \end{aligned} \tag{8}$$

The average number of $i$ continuous I events in a cycle $T_n$ in channel $r$ is:

$$\begin{aligned} E(N_{I_r}) &= \sum_{i=1}^{\infty}\sum_{j=1}^{\infty} iP(N_I = i, N_B = j) \\ &= \sum_{i=1}^{\infty}\sum_{j=1}^{\infty} i(e^{-apG_r})^{i-1}(1-e^{-apG_r}) \\ &(1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r})^{j-1} e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \\ &= \frac{1}{1-e^{-apG_r}} \end{aligned} \tag{9}$$

The average number of $j$ continuous B events in a cycle $T_n$ in channel $r$ is:

$$\begin{aligned} E(N_{B_r}) &= \sum_{i=1}^{\infty}\sum_{j=1}^{\infty} jP(N_I = i, N_B = j) \\ &= \sum_{i=1}^{\infty}\sum_{j=1}^{\infty} j(e^{-apG_r})^{i-1}(1-e^{-apG_r}) \\ &(1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r})^{j-1} e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \\ &= \frac{1}{1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r}} \end{aligned} \tag{10}$$

To the discrete time multichannel p-persistent random multiple access protocol with three-way handshake mechanism, the information packets are sent successfully in two cases (Wang *et al*., 2013).
Firstly the number of information packet transmitted successfully in I events in channel $r$ are:

$$E(N_{U_{r1}}) = \frac{q_1^1}{1-q_1^0} = \frac{apG_r e^{-apG_r}}{1-e^{-apG_r}} \tag{11}$$

The average length of information packet transmitted successfully in I events in channel $r$ is:

$$E(U_{r1}) = E(N_{U_{r1}}) \times 1 = \frac{apG_r e^{-apG_r}}{1-e^{-apG_r}} \tag{12}$$

Secondly the average length of continuous $K$ U events in the TP time in a cycle in channel $r$ is:

$$E(U_{r2})=\sum_{i=1}^{\infty}\sum_{j=1}^{\infty}\sum_{K=0}^{i-1}KP(N_I=i,N_B=j)\times 1$$
$$=\sum_{i=1}^{\infty}\sum_{j=1}^{\infty}\sum_{K=0}^{i-1}K(e^{-apG_r})^{i-1}(1-e^{-apG_r})$$
$$(1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r})^{j-1}e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r} \tag{13}$$
$$=p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r$$

In a cycle $T_n$, the average length of time slot that information packet has been successfully sent in channel $r$ is:

$$E(U_r)=E(U_{r1})+E(U_{r2})$$
$$=\frac{apG_r e^{-apG_r}}{1-e^{-apG_r}}+p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r \tag{14}$$

The average length of B event in channel $r$ is:

$$E(B_r)=E(N_{B_r})\times\frac{32}{23}(1+3a+\tau_R+\tau_C)=\frac{\frac{32}{23}(1+3a+\tau_R+\tau_C)}{1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r}} \tag{15}$$

The average length of I event in channel $r$ is:

$$E(I_r)=E(N_{I_r})\times a=\frac{a}{1-e^{-apG_r}} \tag{16}$$

The throughput of the p-persistent random multiple access protocol in channel $r$ is:

$$S_r=\frac{E(U_r)}{E(B_r)+E(I_r)}$$
$$=\frac{\frac{apG_r e^{-apG_r}}{1-e^{-apG_r}}+p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r}{\frac{\frac{32}{23}(1+3a+\tau_R+\tau_C)}{1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G_r}}+\frac{a}{1-e^{-apG_r}}} \tag{17}$$

In the $N$ channels of wireless communication system, because this channel model is a load equilibrium model, so the arrival probabilities of each channel are the same (Dongfeng Zhao, 1999), that is to say:

$$G_1=G_2=G_3=\cdots=G_i=\cdots=G_N=G \tag{18}$$

Basing on the above analysis and computational formula of the systemic throughput, the system total throughput is:

$$S'=NS_j=N\frac{\frac{apGe^{-apG}}{1-e^{-apG}}+p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G}{\frac{\frac{32}{23}(1+3a+\tau_R+\tau_C)}{1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G}}+\frac{a}{1-e^{-apG}}} \tag{19}$$

Assuming that the length of information packet sent by the business with priority $l$ successfully in average cycle period of channel $j$ is: $E(U_j^{(pl)})(j \le l)$ (Dongfeng Zhao *et al.*, 1997). Then according to the above analysis, we can get the throughput with the priority $l$:

$$
\begin{aligned}
S_{pl} &= (\sum_{i=1}^{l} \frac{1}{N-i+1}) S_j \\
&= (\sum_{i=1}^{l} \frac{1}{N-i+1}) \frac{\frac{apGe^{-apG}}{1-e^{-apG}} + p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G}{\frac{\frac{32}{23}(1+3a+\tau_R+\tau_C)}{1-e^{-p\frac{32}{23}(1+3a+\tau_R+\tau_C)\ G}} + \frac{a}{1-e^{-apG}}}
\end{aligned}
\tag{20}
$$

**Experimental Classification Results and Analysis**

Based on the above analysis, with the use of simulation tool: MATLAB R2010a, the simulation results are shown as following. During the simulation, transmission delay time: $a = 0.01$, $\tau_R = \tau_C = 0.01$ ,packet length is: $\frac{32}{23}(1+3a+\tau_R+\tau_C)$.

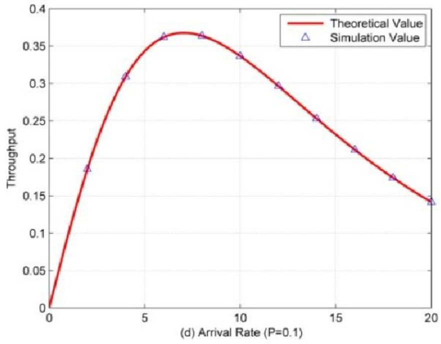


**Fig. 3. The throughput of the proposed protocol for channel $r$**

In the Fig. 3, the simulation results are consistent with the theoretical ones which shows the correction of our model and analysis.

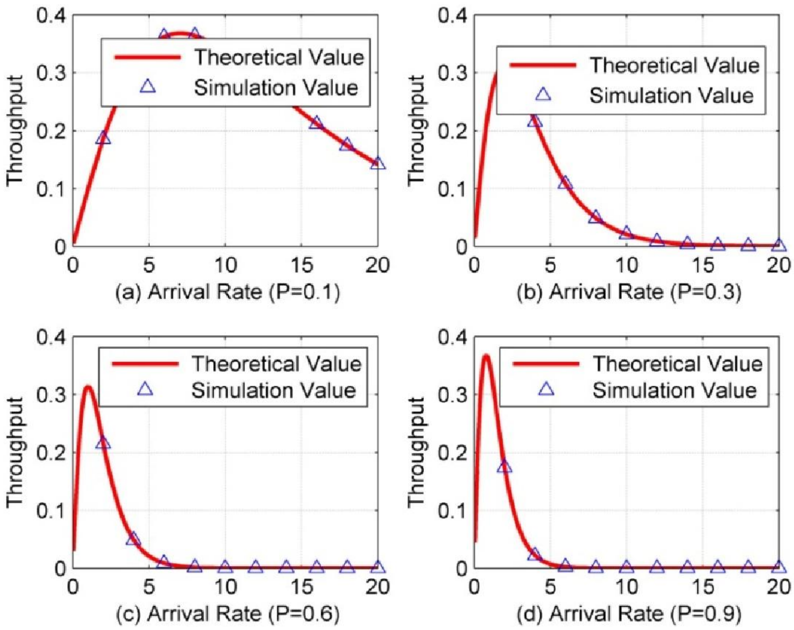


**Fig. 4 The throughput of the protocol with variable parameter P**

From the Fig. 4, we see that the value of P can change the system throughput. Therefore, we can improve the efficiency of channel resources and increase the value of the system throughput.

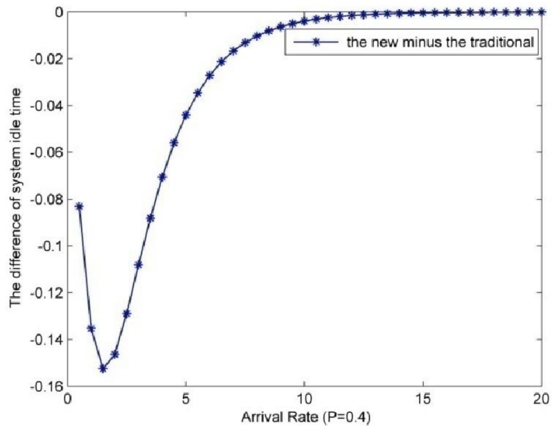


**Fig. 5 The difference of system idle time between the new and the traditional one**

In the Fig. 5, we can see the double clocks mechanism can reduce the system idle time especially when G is around 2 under P=0.4. Therefore, the system channel resource is more highly used than before when the arrival rate is light.

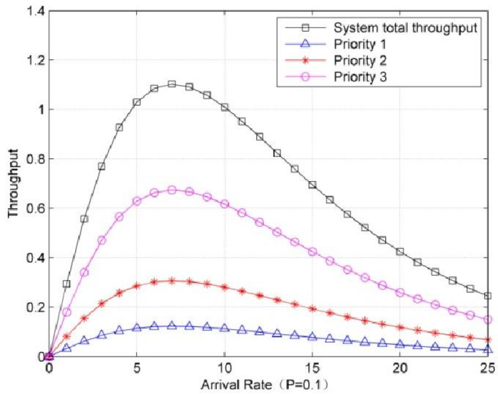


**Fig. 6. The throughput of the protocol with 3 channels**

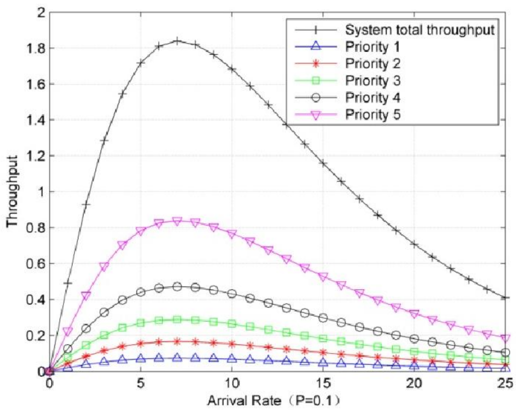


**Fig. 7. The throughput of the protocol with 5 channels**

From Fig.6 to Fig. 7, with the total number of channels increases, the value of the protocol's total system throughput will increases; the channel resources can distribute to every channel according to their priority according to their own priority separately; when the priority is higher, the corresponding single channel will get more network resources than the lower priorities.

## Conclusion

The paper proposed a double clocks multi-channel p-persistent random multiple access protocol based on three-way handshake mechanism. By introduction of the inquire response three-way handshake mechanism increases the reliability and stability of the system, improves the channel utilization; by the use of the multi-channel mechanism, not only improve the system throughput, but also realize that different business with different throughput and make the system meet the different priorities with different QoS both efficiently fairly; To shorter the system idle time, we adopt the double clocks mechanism which basic principle is that the channel is the continuous clock manner during channel is idle; the channel is the slot time manner during channel is busy.

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