THE DOUBLE CLOCKS TWO-DIMENSIONAL PROBABILITY CSMA WITH THREE-WAY HANDSHAKE MECHANISM

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INTRODUCTION
Wireless sensor networks (WSN, wireless sensor networks) is the current international concern, involving many points and hot research field [1]. It combines sensor technology, embedded computing technology, modern network and wireless communication technology and more highly cross-disciplinary knowledge, highly integrated information and distributed processing technology frontier [2]. It is possible through various integrated of micro-sensors collaborate the object or the island by monitoring, sensing and collection of environmental information in real-time. The network structure of WSN is showed in the Fig. (1). Information is transmitted wirelessly, and ad hoc multi-hop transmission network approach to the observer. Sensors, sensing target and observer composition are the three elements in the wide sensor network [3]. Wireless sensor network is a new information acquisition and processing technology [4].

The key to ensure wireless sensor network communications media (MAC) protocol in wireless sensor network protocol just bottom part, for a fair and effective sharing of communication medium between the sensor nodes have a greater impact on the performance of the sensor network, is one network protocols. Performance of wireless sensor networks such as throughput, latency performance depends entirely on the dry MAC protocol used [5]. Therefore, the design of a superior performance of MAC protocol algorithm has become a hot issue in WSN research [6].

![Network structure of WSN](http://www.recentscientific.com)

Fig (1) The network structure of WSN.

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This paper proposed a double clocks two-dimensional probability CSMA with three-way handshake mechanism, set the probability of sending packet and the probability of sensing channel, improves the controllability of the system, the channel utilization, system security, and reliability of packet transmission. By introduction of the three-way handshake mechanism increases the reliability and stability of the system, reducing the collision possibility of the information packets to a certain extent, solves the problem of the hidden terminal and exposed terminal, improves the channel utilization. Using the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above. By modeling analysis, the analytical results and simulation results show that the theoretical analysis is consistent with the simulation experiments.

The model

The model of two-dimensional probability CSMA protocol with three-way handshake mechanism is showed as Fig. (2).

Fig (2) The model of double clocks two-dimensional probability CSMA with three-way handshake mechanism.

In the proposed protocol, there will be three random events:

a. U events: Event that information packets are sent successfully.

b. C events: Event that information packets collide with each other (the collision appears).

c. I events: Event that there is no information packets in the channel arrive, the channel is idle.

In the model of double clocks two-dimensional probability CSMA with three-way handshake mechanism, and the total length of a transmission period is: \( \frac{22}{23} + (1 + 3a + \tau_g + \tau_c) \), where the total length of the data field is: \( \frac{9}{23} + (1 + 3a + \tau_g + \tau_c) \).

Analysis of The System Throughput

Before analyze the system performance, first do the following assumptions:

a. The channel is ideal with no noise and interference;

b. The basic unit of the system control clock is \( \alpha \), the information packets arrived at time \( \alpha \) will transmit at the starting time of the next slot [7];

c. The channel propagation delay is \( \alpha \), the packet length is unit length and is an integral multiple of \( \alpha \);

d. The arrival process of channel satisfy the Poisson process whose independent parameter is \( G \) [8];

e. The channel using the new protocol, the information packets need to be sent at the first slot in the transmission period can always detecting the state of the channel at last moment [9];

f. During the transmission of information packets, the phenomenon of packet collisions occur inevitably, and continues to be sent after a random time delay, it sends will not produce any adverse effects on the arrival process channel [10].

The arrival process of channel satisfies the Poisson process:

\[
P(n) = \frac{(aG)^n e^{-aG}}{n!} \quad (1)
\]

In Equation (1), \( P(n) \) is the event of \( n \) packets arriving during time of \( a \).

First, solve the average length \( E(U) \) of packet successfully sent in the event of U.

Packet successfully sent into the following two cases:

1. If packets arrive during the last slot of idle period, namely packet arrives at the continuous clock control, and in the next slot time, no one but it adhere to send it, then it is sent successfully, the record for the event is \( U_1 \).

The average length of \( U_1 \) is:

\[
E(U_1) = E(N_{U1}) \times \frac{1}{p} \frac{apG}{1 - e^{-apG}} \quad (2)
\]

2. If the packet arrives at the busy period, and the packet is the only packet adhere to send at the current TP period, then the packet will be successfully transmitted within the next TP period, referred to as an event of \( U_2 \).

At the transmission period, if there is no information packets to be sent, its possibility is:

\[
q_0 = e^{-p, p, G} \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} \quad (3)
\]

In the transmission period \( \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} \), if there is only one information packet to be sent, its possibility is:

\[
q_i = p, p, G \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} e^{-p, p, G} \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} \quad (4)
\]

In a cycle, the average length of information packets transmitted successfully at the \( U_2 \) is:

\[
E(U_2) = \frac{q_i}{q_0} = p, p, G \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} \quad (5)
\]

Then the average length \( E(U) \) is:

\[
E(U) = E(U_1) + E(U_2) = \frac{p, G}{1 - e^{-apG}} \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} \quad (6)
\]

Secondly, the average length \( E(B) \) during the busy period:

\[
E(B) = E(N_B) \times \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)}
\]

\[
= \frac{1}{q_0} \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)}
\]

\[
= \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)} e^{-p, p, G} \frac{22}{23} \frac{1 + 3a + \tau_g + \tau_c}{(1 + 3a + \tau_g + \tau_c)}
\]

Finally, the average length \( E(I) \) during the idle period:

Since the number of idle slots \( I \) within the geometric distribution with the mean: \( E(N) = \frac{1}{1 - e^{-apG}} \), an information
packet arrive in a time slot with normalized probability:

\( P_{n1} = \frac{Gp_1ae^{-Gp_1}}{1-e^{-Gp_1}} \), more than an information packet arrives in a
time slot with the normalized probability:

\( P_{i2} = \frac{1-Gp_1ae^{-Gp_1}-e^{-Gp_1}}{1-e^{-Gp_1}} \).

Then we get:

\[
E(I) = (-\frac{1}{1-e^{-Gp_1}} - 1) + \frac{Gp_1ae^{-Gp_1}}{2(1-e^{-Gp_1})} + \frac{(1-Gp_1ae^{-Gp_1}-e^{-Gp_1})a}{1-e^{-Gp_1}} \]  

Besides, we know that the average length \( E(I) \) during the idle
period under the traditional two-dimensional probability is:

\[
E(I) = \frac{a}{1-e^{-Gp_1}} \]  

The throughput of the new protocol is:

\[
S = \frac{E(U)}{E(B) + E(I)} = \left[ \frac{pGae^{-Gp_1}}{1-e^{-Gp_1}} + p_1p_2G \frac{32}{23}(1+3a + \tau_R + \tau_c) \right]
\]

\[
\frac{32}{23}(1+3a + \tau_R + \tau_c) + \left( \frac{1}{1-e^{-Gp_1}} - 1 \right) + \frac{Gp_1ae^{-Gp_1}}{2(1-e^{-Gp_1})}
\]

\[
+ \frac{(1-Gp_1ae^{-Gp_1}-e^{-Gp_1})a}{1-e^{-Gp_1}} \]

(10)

Simulation

From the above analysis, the expression of the system
throughput under the double clocks two-dimensional
probability CSMA with three-way handshake mechanism is

got. 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:

\( a = 0.1, \tau_R = \tau_c = 0.1 \).

Fig (3) The throughput of the new protocol with different P1.

Fig (4) The throughput of the new protocol with different P2.

Fig (5) The throughput of the new protocol and the traditional one.

Fig (6) The throughput of the new protocol with different a.
From the above MATLAB simulation can be found, the double clocks two-dimensional probability CSMA with three-way handshake mechanism has the following characteristics: From Fig. (3) to Fig. (4), we can see that we are able to control the system throughput by change the probability of sending packet or the probability of sensing channel. Also we can change both of them at the same time too. So the new protocol can perform better than other protocols on the controllability. Through the Fig. (5) to Fig. (7), we know the system throughput under the new protocol is lower than the traditional two-dimensional probability CSMA protocol. This is because the information of RTS-CTS takes some resources of the packets transmitted. But the little system throughput we fail to gain, we realize three-way handshake mechanism of the total system. Therefore we lose a little but get more security. On the surface, the smaller the delay \( \alpha \), the greater system throughput, but in actual communication system, the larger the throughput is going to pay a higher price. The smaller the \( r_s, r_c \) parameter, the greater the system through put. This is because when the frame length of inquire-answering signal reduced, the effective data contained in a data frame will be more, the greater the throughput of the system.

In the Fig. (8), we know the system idle time under the new protocol is lower than the traditional two-dimensional probability CSMA protocol. And the channel resource is use more highly than the usually ones.

**CONCLUSIONS**

By setting the probability of sending packet and the probability of sensing channel, this paper apply the theory of double clocks control to the CSMA protocols, decreasing the system idle time, making the channel resource highly use and improving the system performance. By the introduction of the three-way handshake mechanism increases the reliability and stability of the system, reducing the collision possibility of the information packets to a certain extent, solves the problem of the hidden terminal and exposed terminal, improves the channel utilization. By the modeling analysis and computer simulation-MATLAB, the analytical results and simulation results show that the theoretical analysis are consistent with the simulation experiments. At last, the computer simulation experiments show that the choice of detecting probability, listening probability and system delay has a great influence on the system throughput, so, no matter what the values are necessary to the actual system as a precondition to considering the realized possibility, the costs and gains of actual system.

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