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RESEARCH ARTICLE

A TIME DIVISION P-PERSISTENT RANDOM MULTI-CHANNEL ACCESS PROTOCOL WITH THREE-WAY HANDSHAKE MECHANISM

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ABSTRACT

Wireless LANs are now widely used in the business district, universities, airports and other public areas. The most common standard for wireless local area network is defined by IEEE 802.11 family of standards. To solve the problems of safety and the hidden terminal and exposed terminal, this paper introduces time division P-persistent random multi-channel access protocol with three-way handshake mechanism, its basic principle is that the channel is the continuous clock manner during channel is idle and the channel is the slot time manner during channel is busy. By the introduction of three-way handshake mechanism, we make the transfer of information more securable, solve the problem of the hidden terminal and exposed terminal, and improve the performance of the system. Use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above, the analytical results and simulation results show that the theoretical analysis and simulation experiments are consistent, prove the feasibility and validity of the proposed protocol.

INTRODUCTION

Wireless LAN (Wireless Local Area Networks, WLAN) use the radio waves as a data transmission medium, and its transmission distance is generally only tens of meters. Wireless LAN backbone network typically use a wired cable, wireless LAN users through one or more wireless access points to access the wireless LAN [1]. Wireless LANs are now widely used in the business district, universities, airports and other public areas. The most common standard for wireless local area network is defined by IEEE 802.11 family of standards. A typical network structure of WLAN is showed as Fig. 1.

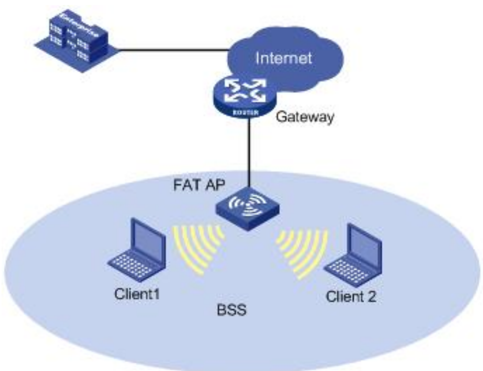

Fig. 1 Example of a figure caption.

Overview of Wireless LAN topology: wireless LAN based on the IEEE802.11 standard which is may not necessarily be allowed to authorize the use of ISM band of 2.4GHz or 5GHz radio band for wireless LAN connection environment. They are widely used, and then a hot Internet access from home to business [2].

Advantages of wireless LANs

1. ***Flexibility and mobility;*** in a wired network, network equipment placement restricted network location, and wireless LAN any position within the wireless coverage area can access the network. Another big advantage of wireless LANs in its mobility, users connected to a wireless LAN and can be moved while maintaining a connection with the network [3].
2. ***Easy to install;*** wireless LAN can be removed or minimize the workload of network cabling, generally as long as the installation of one or more access point device, you can establish a local area network covering the entire region [4].
3. ***Easy for network planning and adjustment;*** for wired networks, office location or network topology change usually means re-building network. Rewiring is an expensive, time-consuming, wasteful and trivial process, the wireless LAN to avoid or reduce the occurrence of the above circumstances [5].

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4. ***Fault location easily;*** once wired network physical failure, especially due to weak line connection network disruptions, it is often difficult to identify, and repair lines need to pay a high price. Wi-Fi is very easy to locate the fault, simply replace the faulty equipment to restore the network connection.
5. ***Easy to expand;*** wireless LANs have a variety of configurations can be quickly expanded from just a few users to thousands of small local area network users to large networks, and can provide inter-node "roaming" and other cable networks cannot be implemented features. As wireless LANs have more advantages, so its development is very rapid. In recent years, wireless LANs have been in business, hospitals, shops, factories and schools and other occasions been widely used [6].

But there are some deficiencies of wireless LAN: Wireless LAN can bring convenience and utility to network users at the same time, there are some drawbacks, for example: safety. Radio waves are not required to establish the nature of the physical connection channels, the wireless signal is divergent. Theoretically, it is easy to listen to any broadcast signals in the radio wave range, resulting in leakage of communication information. Also, there is a problem of the hidden terminal and exposed terminal.

To solve the problems mentioned above, we introduce time division P-persistent random multi-channel access protocol with three-way handshake mechanism; its 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 [7]. And we use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above.

The Model

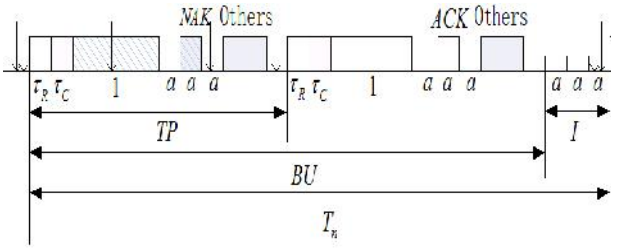

Fig. 2 The model of time division P-persistent random multi-channel access protocol with three-way handshake mechanism.

The model of time division P-persistent random multi-channel access protocol with three-way handshake mechanism is showed as Fig. 2.

In the proposed protocol, there will be three random events

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

In the model of time division P-persistent random multi-channel access protocol with three-way handshake mechanism, the total length of a transmission period is: $\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})$, where the total length of the data field is: $(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})$, the total length of other field is: $\frac{9}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})$.

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.

Analysis of the Model

Before analyze the system performance, first do the following assumptions

1. The channel is ideal with no noise and interference;
2. The basic unit of the system control clock is a, the information packets arrived at time a will transmit at the starting time of the next slot [8];
3. The channel propagation delay is a, the packet length is unit length and is an integral multiple of a;
4. The access method of channel is timeslot P-persistent CSMA protocol, and the arrival process of channel satisfy the Poisson process whose independent parameter is G [9];
5. 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;
6. 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.

The arrival process of channel satisfies the Poisson process [10]

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

In (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:

$$E(U_1)=E(N_U)\times 1=\frac{apGe^{-apG}}{1-e^{-apG}}=\gamma \tag{2}$$

(2) If the packet arrives at the busy period, and the packet is the only packet adhere to sent 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:

$$q_0=\sum_{k=0}^{\infty}P(A_k)\times(1-p)^k=e^{-pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}=\gamma \tag{3}$$

In the transmission period $\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})$, if there is only one information packet to be sent, its possibility is:

$$\begin{aligned}q_1&=\sum_{k=1}^{\infty}P(A_k)C_k^1p(1-p)^{k-1}\\&=pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})\;e^{-pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}\end{aligned} \tag{4}$$

In a cycle, the average length of information packets transmitted successfully at the U_2 is

$$E(U_2)=\frac{q_1}{q_0}=pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C}) \tag{5}$$

Then the average length $E(U)$ is

$$\begin{aligned}E(U)&=E(U_1)+E(U_2)\\&=\frac{pGae^{-pGa}}{1-e^{-pGa}}+pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})\end{aligned} \tag{6}$$

Secondly, solve average length $E(B)$ during the busy period.

$$\begin{aligned}E(B)&=E(N_B)\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})\\&=\frac{1}{q_0}\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})\\&=\frac{\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}{e^{-pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}}\end{aligned} \tag{7}$$

Finally, solve average length $E(I)$ during the idle period.
Since the number of idle slots I within the geometric distribution with the mean: $E[N]=\frac{1}{1-e^{-Gpa}}$, an information packet arrive in a time slot with normalized probability: $p_{I1}=\frac{Gpae^{-Gpa}}{1-e^{-Gpa}}$, more than an information packet arrives in a time slot with the normalized probability: $p_{I2}=\frac{1-Gpae^{-Gpa}-e^{-Gpa}}{1-e^{-Gpa}}$.
Then we get:

$$\begin{aligned}E(I)=&\left(\frac{1}{1-e^{-Gpa}}-1\right)a+\frac{Gpa^2e^{-Gpa}}{2(1-e^{-Gpa})}\\&+\frac{(1-Gpae^{-Gpa}-e^{-Gpa})a}{1-e^{-Gpa}}\end{aligned} \tag{8}$$

The throughput of the new protocol is:

$$\begin{aligned}S&=\frac{E(U)}{E(B)+E(I)}\\&=\left[\frac{pGae^{-pGa}}{1-e^{-pGa}}+pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})\right]\\&/\left[\frac{\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}{e^{-pG\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}}+\left(\frac{1}{1-e^{-Gpa}}-1\right)a\right.\\&\left.+\frac{Gpa^2e^{-Gpa}}{2(1-e^{-Gpa})}+\frac{(1-Gpae^{-Gpa}-e^{-Gpa})a}{1-e^{-Gpa}}\right]\end{aligned} \tag{9}$$

Simulation and Results

From the above analysis, the expression of the system throughput under the time division P-persistent random multi-channel access protocol 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: $a=0.1$, ${}^{2}{}_{R}={}^{2}{}_{C}=0.1$.

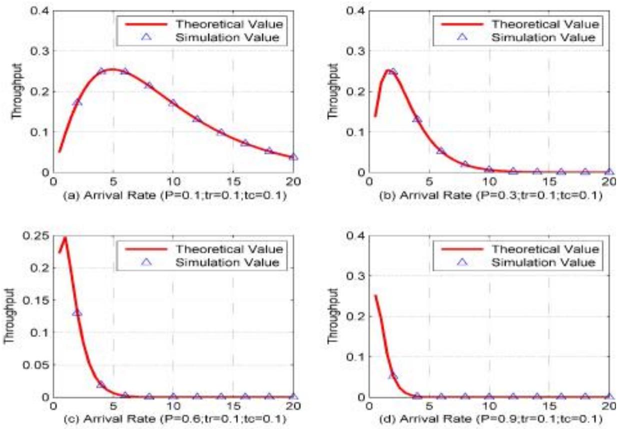

Fig. 3 The throughput of the new protocol with different P

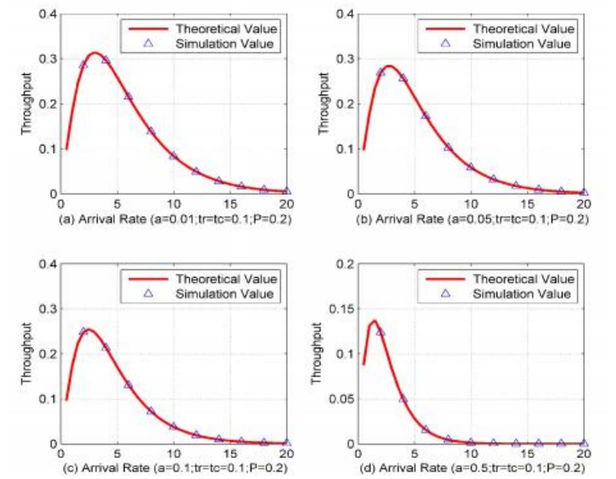

Fig. 4 The throughput of the new protocol with different a

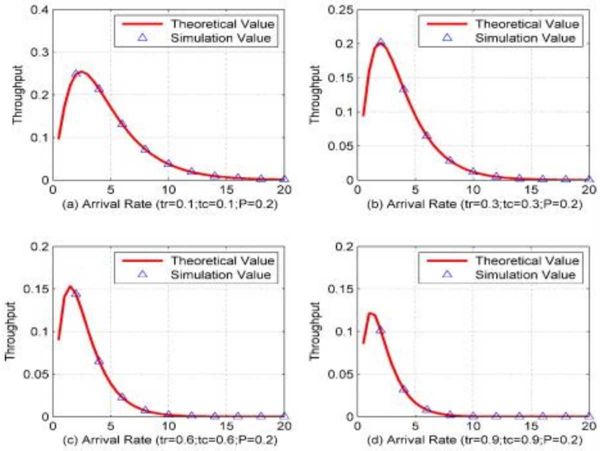

Fig. 5 The throughput of the new protocol with different $^{2}_{R},^{2}_{C}$

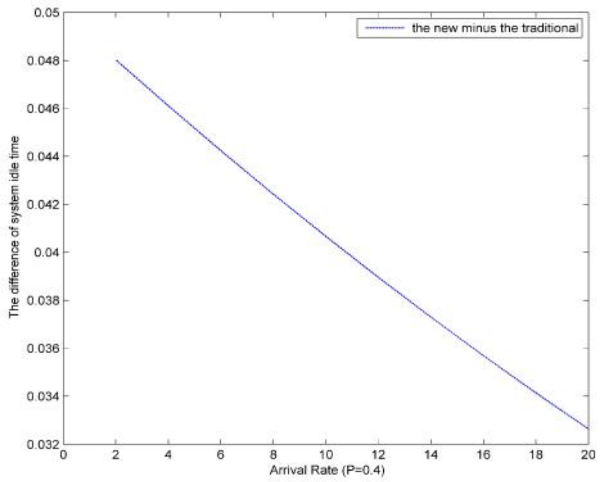

Fig. 6 The difference of system idle time between the new protocol and the traditional one

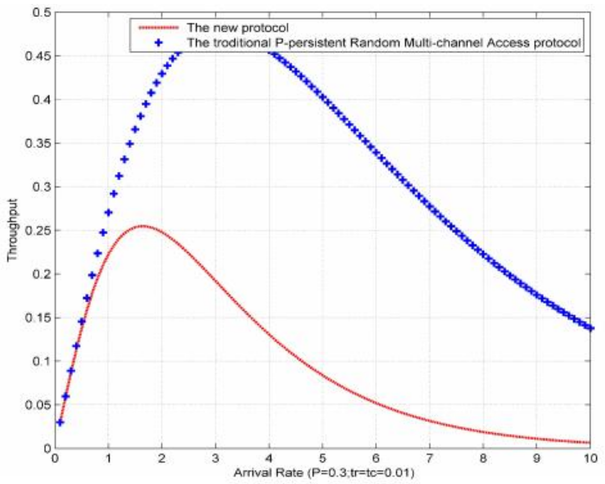

Fig. 7 The throughput of the new protocol and the traditional one

From the above MATLAB simulation can be found, the time division P-persistent random multi-channel access protocol with three-way handshake mechanism has the following characteristics:

From Fig. 3 to Fig. 5, 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. Because we can see that when a, P or $^{2}_{R},^{2}_{C}$ become bigger, the system throughput become smaller.

In the Fig. 6, the system idle time under the new protocol is lower than the traditional P-persistent random multi-channel access protocol. It is proven we can reduce system idle time by the time division mechanism.

From the Fig. 7, the system throughput under the new protocol is lower than the traditional P-persistent random multi-channel access protocol. This is because the information of $^{2}_{R},^{2}_{C}$ and other information occupancy information section in the packets transmitted. However, through this mechanism, we can solve the problem of the hidden terminal and exposed terminal and information safety, makes the system more stable, and better performance on robust.

CONCLUSIONS

WLANs are now widely used in the business district, universities, airports and other public areas. The most common standard for wireless local area network is defined by IEEE 802.11 family of standards. To solve the problems of safety and the hidden terminal and exposed terminal, this paper introduces time division P-persistent random multi-channel access protocol with three-way handshake mechanism, its basic principle is that the channel is the continuous clock manner during channel is idle and the channel is the slot time manner during channel is busy. By the introduction of three-way handshake mechanism, we make the transfer of information more securable, solve the problem of the hidden terminal and exposed terminal, and improve the performance of the system. Use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above, the analytical results and simulation results show that the theoretical analysis and simulation experiments are consistent, prove the feasibility and validity of the proposed protocol, and makes the system more stable, and better performance on robust..

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