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THE DUAL CLOCKS THREE-DIMENSION PROBABILITY RANDOM MULTI-CHANNEL ACCESS PROTOCOL WITH ACK MECHANISM

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ABSTRACT

Ad hoc network is a multi-hop, no center, and self-organizing wireless network. The network has no fixed infrastructure, each node is mobile, and can be in any way to keep in touch with other nodes dynamically. Each node is a router at the same time; they can find and maintain complete routing functions to other nodes. Due to the use of wireless communication and therefore more vulnerable than wired network interference enemy, eavesdropping and attack. To confirm the information transmitted process, reduce system idle time, improve the system controllability, this paper proposed a dual clocks three-dimension probability random multi-channel access protocol with ACK 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. Use three-dimension probability to control the system throughput. With ACK mechanism, confirm the process of transmitting information.

INTRODUCTION

Ad hoc network is a multi-hop, no center, and self-organizing wireless network, also known as multi-hop network (Multi-hop Network), no infrastructure network (Infrastructureless Network) or a self-organizing network (Self-organizing Network) (Zhao Dongfeng, 1999). The network has no fixed infrastructure, each node is mobile, and can be in any way to keep in touch with other nodes dynamically. In such a network, because the terminal radio coverage of the limited value range, the two cannot communicate directly with a user terminal can use other nodes packet forwarding. Each node is a router at the same time, they can find and maintain complete routing functions to other nodes (Hongwei Ding *et al*., 2015). This work was supported by the National Natural Science Foundation of China (61461053, 61461054, 61072079); Natural Science Foundation of Yunnan Province (2010CD023); The Financial Support of Yunnan University (No.XT412004). Ad hoc network with its IP-based packet switching technology, can provide high-speed (existing mobile cellular network for speeds up to 2 Mbit / s, while the Ad hoc network on 2 ~ 6 GHz band can provide 2 ~ 50 Mbit / s data rate) data services and multimedia services, thus becoming an important complement to the third generation global mobile communications system; on the other hand, Ad hoc networks can also serve as a wireless extension of Internet network (Shengjie Zhou, 2015). A typical network structure of Ad hoc network is showed in Fig. 1.

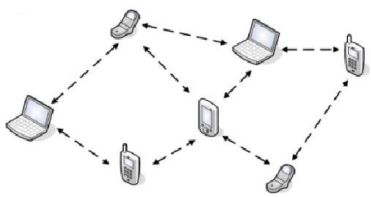

Fig. 1. A typical network structure of Ad hoc network.

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The main characteristics of Ad hoc network are the following.

- Minimize infrastructure support.
- Self-organization and self-management. Since the network infrastructure is non-availability of these nodes must be through their own organization and maintenance of networks (autonomous distributed control required). Node can detect the presence of other nodes, and, and they join the network (Zhao Dongfeng *et al*., 1997).
- Most or all nodes in the mobile and the network topology dynamically. When a node moves, network topology changes, a new node is added, some of the nodes to leave, or some routing interruption. Often frequent, temporary, sudden loss of network connectivity.
- Wireless link. Since most nodes are mobile, it means that only the wireless communication (Yi Shang *et al*., 2007).
- Node is both a host and a router. A node may want to connect to another node beyond the one-hop distance away, then the case of each node, the routing function is required because there is no substructure support network, the node does not have to be the same type (either phone, PDA, knee On computers, sensors, etc.).
- Multi-hop. Since each node can send information to another node, multi-hop are possible. In Ad hoc network capability in multi-hop is desirable, because the single-hop Ad hoc networks where space is not scaled up, it limits the communication between nodes.
- Energy limited. Since the node can move, they cannot rely on supply lines, but only powered by battery (Liu Binbin, 2006).
- Heterogeneity. Each node can have different properties. In order to be able to connect a network based on the substructure (forming a mixed network), and some of the nodes capable of more than one type of network traffic.
- Limited security. Ad hoc networks is due to the use of wireless communication, and therefore more vulnerable than wired network interference enemy, eavesdropping and attack.

To confirm the information transmitted process, we introduce the ACK mechanism. ACK (Acknowledgement), confirms that character, in data communications, station sent a transmission station transmission control character class. Representation of the data has been sent to acknowledge receipt of correct (Ma Zuchang *et al*., 2004).

In the TCP / IP protocol, if the recipient successfully receives the data, it will return an ACK. ACK signals usually have their own fixed format, length size, reply to the sender by the recipient. The format depends on the network protocol taken. When the sender receives the ACK signal, it can send the next data. If the sender does not receive a signal, then the sender may retransmit the current data package, data transfer may stop. Depending on the network protocol used. TCP packet format control bits from the six flag bits, one of which is ACK, ACK 1 indicates confirmation number is valid, 0 indicates packet does not contain confirmation, confirmation number field is ignored.

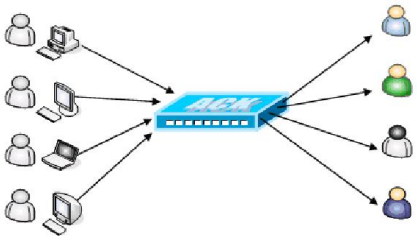

Fig. 2. The process model of ACK mechanism

ACK can also be used in AT24cxx this series for EEPROM. And in the USB transmission, ACK packet for the transaction to host / device reporting package correct transmission. So we introduce dual clocks three-dimension probability random multi-channel access protocol with ACK mechanism.

The Model

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. The model of dual clocks three-dimension probability random multi-channel access protocol with ACK mechanism is showed as Fig. 3.

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

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

According to the new protocol, if the channel is idle, then the user decides to send an information packet probability $P1$; in the transportation period, if the channel is the first idle following the CU events, then the user listens to the channel at probability $P2$;

in the "3a" time of TP, the user listens to the channel at probability $P3$ (Yi Shang *et al*., 2007). This control strategy, $P1$, $P2$ and $P3$ by three-dimensional selection enables the system under different load utilization and throughput is guaranteed.

Analysis of the Model

We use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above. Before analyze the system performance, first do the following assumptions:

- The channel is ideal with no noise and interference;
- 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 (Huang Jiancheng *et al*., 1983);
- The channel propagation delay is a, the packet length is unit length and is an integral multiple of a;
- The access method of channel is timeslot three-dimension probability random multi-channel access protocol, and the arrival process of channel satisfy the Poisson process whose independent parameter is G (Zhao Dongfeng, 1999);
- 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;
- 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 (Zhao Dongfeng, 1997):

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

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:

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:

$$E(U_1) = E(N_U) \times 1 = \frac{ap_1 G e^{-ap_1 G}}{1 - e^{-ap_1 G}} \quad (2)$$

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:

$$q_0 = \sum_{k=0}^{\infty} P(A_k) \times (1-p)^k = e^{-(3ap_3 + p_2)G} \quad (3)$$

In the transmission period $(1+3a)$, if there is only one information packet to be sent, its possibility is:

$$\begin{aligned} q_1 &= \sum_{k=1}^{\infty} P(A_k) C_k^1 p(1-p)^{k-1} \\ &= (3ap_3 + p_2) G e^{-(3ap_3 + p_2)G} \end{aligned} \quad (4)$$

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

$$E(U_2) = \frac{q_1}{q_0} = (3ap_3 + p_2)G \quad (5)$$

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

$$\begin{aligned} E(U) &= E(U_1) + E(U_2) \\ &= \frac{ap_1 G e^{-ap_1 G}}{1 - e^{-ap_1 G}} + (3ap_3 + p_2)G \end{aligned} \quad (6)$$

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

$$\begin{aligned} E(B) &= E(N_B)(1+3a) \\ &= \frac{1}{q_0}(1+3a) \\ &= \frac{1+3a}{e^{-(3ap_3+p_2)G}} \end{aligned} \tag{7}$$

Finally, solve average length $E(I)$ during the idle period.

Since the number of idle slots I within the geometric distribution with the mean: $E[N]=\frac{1}{1-e^{-Gp_1a}}$, an information packet arrive in a time slot with normalized probability: $p_{I1}=\frac{Gp_1ae^{-Gp_1a}}{1-e^{-Gp_1a}}$, more than an information packet arrives in a time slot with the normalized probability: $p_{I2}=\frac{1-Gp_1ae^{-Gp_1a}-e^{-Gp_1a}}{1-e^{-Gp_1a}}$.

Then we get:

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

The throughput of the new protocol is:

$$\begin{aligned} S &= \frac{E(U)}{E(B)+E(I)} \\ &= [\frac{ap_1Ge^{-ap_1G}}{1-e^{-ap_1G}}+(3ap_3+p_2)G] \\ &/[\frac{1+3a}{e^{-(3ap_3+p_2)G}}+(\frac{1}{1-e^{-Gp_1a}}-1)a \\ &+\frac{Gp_1a^2e^{-Gp_1a}}{2(1-e^{-Gp_1a})}+\frac{(1-Gp_1ae^{-Gp_1a}-e^{-Gp_1a})a}{1-e^{-Gp_1a}}] \end{aligned} \tag{9}$$

Simulation and Results

From the above analysis, the expression of the system throughput under the dual clocks three-dimension probability random multi-channel access protocol with ACK 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: $a=0.1$.

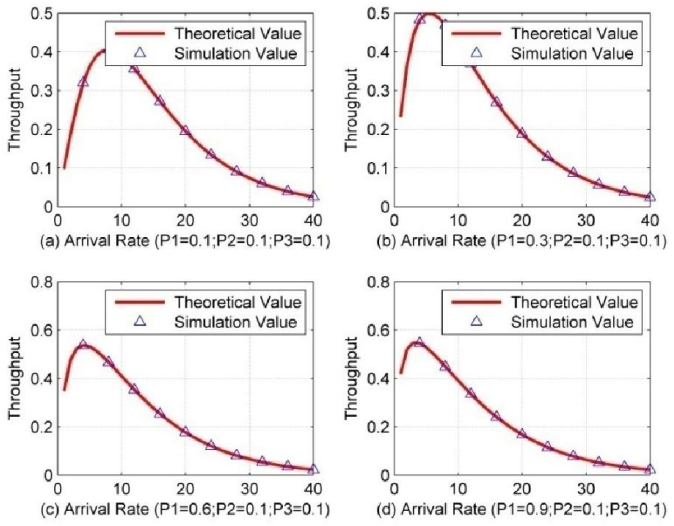

Fig. 4. The throughput of the new protocol with different $P1$.

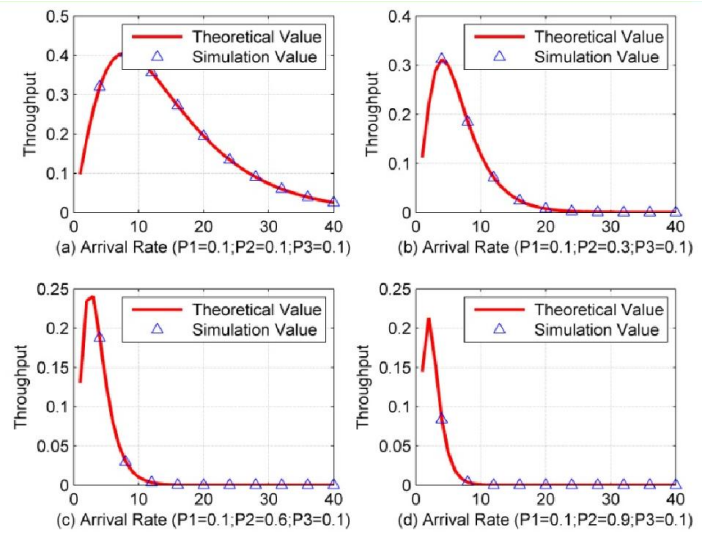

Fig. 5. The throughput of the new protocol with different $P2$

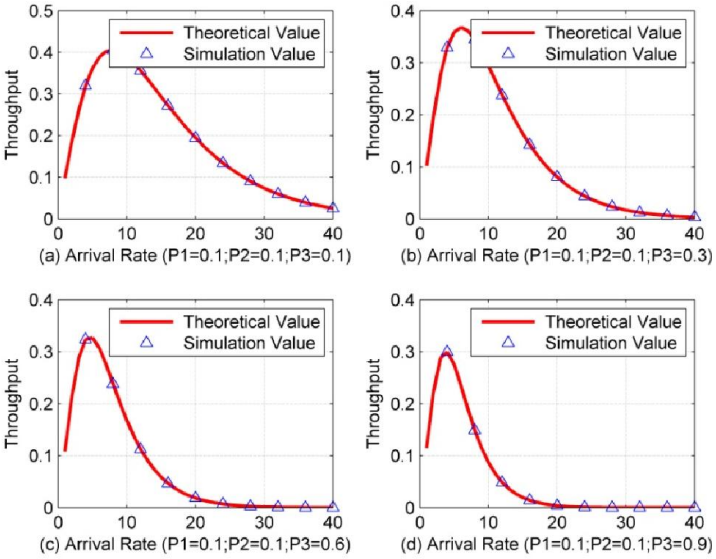

Fig. 6. The throughput of the new protocol with different $P3$

From Fig. 4 to Fig. 6, we are able to control the system throughput by change the probability of $P1$, $P2$, $P3$. 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.

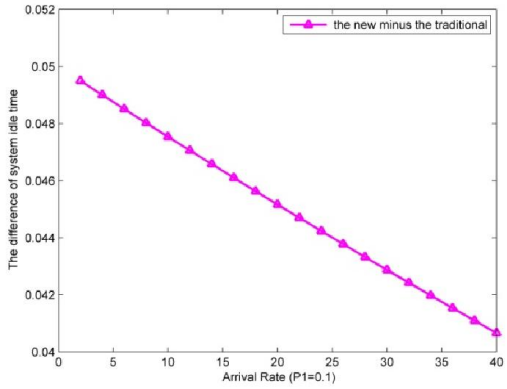

Fig.7. The difference of system idle time between the new protocol and the traditional one

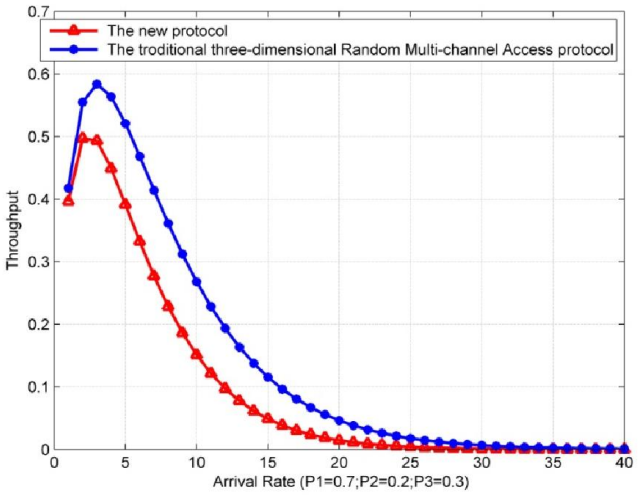

Fig. 8. The throughput of the new protocol and the traditional one

In the Fig. 7, the system idle time under the new protocol is lower than the traditional three-dimension probability random multi-channel access protocol, proven that by the dual clocks mechanism we can reduce system idle time. Know from the Fig. 8, the system throughput under the new protocol is lower than the traditional three-dimension probability random multi-channel access protocol. This is because the information of ACK occupancy information section in the packets transmitted. But, through the ACK mechanism, we confirm the process of transmitting information and make the system more stable.

Conclusions

Ad hoc network is a multi-hop, no center, and self-organizing wireless network. The network has no fixed infrastructure, each node is mobile, and can be in any way to keep in touch with other nodes dynamically. Each node is a router at the same time; they can find and maintain complete routing functions to other nodes. Due to the use of wireless communication and therefore more vulnerable than wired network interference enemy, eavesdropping and attack. To confirm the information transmitted process, reduce system idle time, improve the system controllability, this paper proposed a dual clocks three-dimension probability random multi-channel access protocol with ACK 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. Use three-dimension probability to control the system throughput. With ACK mechanism, confirm the process of transmitting information. Then use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above, results show that the theoretical analysis and simulation experiments are consistent and the system performance is improved.

Acknowledgment

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