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ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 4, pp.3714-3718, April, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

THE MULTICHANNEL PD-CSMA WITH 3-WAY HANDSHAKE BASED ON CONFLICT RESOLUTION ALGORITHM IN WSN

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ARTICLE INFO

Article History:

Received 14th, March, 2015
Received in revised form 23th, March, 2015
Accepted 13th, April, 2015
Published online 28th, April, 2015

Key words:

WSN, RTS/CTS, binary tree conflict resolution, CSMA protocol.

ABSTRACT

Average cycle method is used to analyze the multichannel PD-CSMA with 3-way Handshake based on binary tree conflict resolution algorithm in WSN, getting the critical mathematical expressions of the system throughput, each priority traffic throughput, etc. The computer simulation results verify the correctness of the theory and show that the novel protocol has better performances than the anterior ones'. Compared with the multichannel PD-CSMA with 3-way handshake in WSN but without conflict resolution algorithm, the new protocol's throughput is greatly improved. On the basis of allocating the channel resource fairly, much of the resource is distributed to higher priority, realizing the better quality of service.

INTRODUCTION

Due to its dynamic network topology, WSN (wireless sensor network) can provide data, voice and video services in harsh environmental conditions, wireless transmission; therefore, whether in the military, in civil or commercial areas, there are great prospects for development for WSNs.[1] WSN radio channel access protocol has been the focus and difficulty of scholars at home and abroad on the account of the system throughput, channel utilization, system latency which depended on the protocol used. [2]

WSN is a wireless network, in which network nodes use the channel resources subjected to certain extent. Meanwhile, due to the dynamic structure of WSN, information packet during transmission has to carry more control information, occupying more channel resources. [3]

With the increasing development of information technology and frequent applications of wireless WSN, the number of transmitted gradually increases, which inevitably leads to congestion or collisions. To solve this problem and improve the performance of the system, rational conflict resolution mechanism is introduced to decompose the packet collisions and retransmit the information packet. In many conflict resolution algorithms, better one for decomposing and re-grouping the collision is the binary tree conflict resolution algorithm which can alleviate channel congestion and improve system performance to a certain extent. [4] Based on the above analysis, with the reference to domestic and foreign references, based on the analysis of the current characteristics of the wireless WSN, application requirements, Ad Hoc channel access control protocol and the main problems faced, from improving channel utilization, enhancing system security and reliability, increasing system throughput and reducing the waste of resources, such as channel perspective, the probability detection CSMA Protocol (PD-CSMA) with 3-way handshake and multichannel mechanism for WSN based on conflict resolution algorithm is introduced. [5] The proposed protocol is mainly the improved of typical PD-CSMA. First, based on the original protocol, the new protocol adds the ACK RTS / CTS control mechanism, reduces the possibility of conflict, improves the utilization of the channel resources and enhances the safety and reliability of packet transmission simply and conveniently. Secondly, the introduction of multi-channel mechanism through service priority division, making the implementation of the wireless WSN in a variety of business network load balancing effectively; different priorities make the QoS meet the different needs, in both efficiency and the principle of fairness [7]. Finally, the modified binary tree conflict resolution algorithm is applied to the multichannel PD-CSMA with 3-way handshake, in a certain extent, eases the congestion channel wireless WSN and improves system performance.

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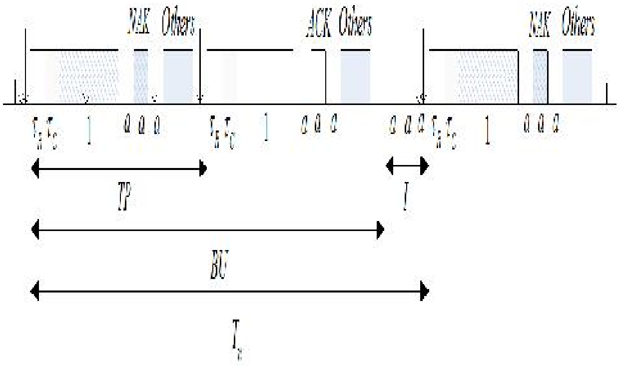
The model

The multichannel PD-CSMA with 3-way handshake and mechanism works as followed: the node listens to the channel state before sending information packet, if the channel is idle, then immediately sends the message packet. If the channel is busy, the user listens to the channel with a continuous probability p, once the channel is idle, repeat the former process. The two nodes conducted a short frame data exchange according to the new protocol, notifying the other nodes that they will occupy the channel for data transmission. Length of the transmission period is: $y=\frac{32}{23}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})$.

Under the agreement control, there will be five random events: successfully sent a packet (U), successfully sent RTS (R), successfully sent CTS (C), collision incident (B) and the channel is idle (I). These five kinds of random events reclassified as: I and BU (information packet sent successfully or collision). When the collision happens, the system model does not follow the mechanism of random back-off for some time slots after the first re-transmission of the recovery, but detects the channel state.[6] The conflict is resolved by the improved binary tree conflict decomposition mechanisms once a first idle immediately found, in this process the channel detected in a non-persistent CSMA.[7] After the packet is recovered, the model returns to normal after the transmission. The model of the i channel $(i=1,2,...,N)$ is showed as follow:



1 The model of the PD-CSMA protocol with 3-way handshake mechanism

Analysis of the model

According to the 3-way handshake mechanism, RTS signal is produced and its length of time slot is: ${}^{2}{}_{R}$; CTS signal is produced and its length of time slot is: ${}^{2}{}_{C}$; monitoring signal is produced and its length of time slot is: a, then the length of the transmission cycle is changed to: y.[8]

In a cycle period T_i, the average length of time slot the channel i occupies when it's idle is:

$$\begin{aligned}E(N_I)&=\sum_{i=1}^{\infty}\sum_{j=1}^{\infty}ip(N_I=i;N_{BU}=j)\\&=\sum_{i=1}^{\infty}\sum_{j=1}^{\infty}i(e^{-Ga})^{i-1}(1-e^{-Ga})(1-e^{-yGp})^{j-1}e^{-yGp}\\&=\frac{e^{-Ga}}{q_a^0(1-q_a^0)}\end{aligned}\qquad(1)$$

In (1), q_a^0 represents during the time slot: a, i channel has no information packet to sent, and then the next time slot is idle.[9] The number of time slot that the channel i has successfully sent information packets in a cycle period T_i is:

$$E(N_U)=\frac{q_{\frac{32}{23}}^{1}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}{q_a^0(1-q_a^0)}=\frac{yGpe^{-yGp}}{q_a^0(1-q_a^0)}\qquad(2)$$

The average length of time slot that channel i has x collisions in a cycle period is:

$$E(N_{Bx})=\frac{q_{\frac{32}{23}}^{x}(1+3a+{}^{2}{}_{R}+{}^{2}{}_{C})}{q_a^0(1-q_a^0)}=\frac{(yGp)^x e^{-yGp}}{x!q_a^0(1-q_a^0)}\qquad(3)$$

The average length of time slot that I event has occupied in a cycle period T_i is:

$$E(I)=E(N_I)a=\frac{ae^{-Ga}}{q_a^0(1-q_a^0)}\qquad(4)$$

The average length of time slot that the channel i has successfully sent information packets in a cycle period T_i is:

$$E(U)=E(N_U)\times 1=\frac{yGpe^{-yGp}}{q_a^0(1-q_a^0)}\qquad(5)$$

$$E(U^*)=E(N_U)\times y=\frac{y^2Gpe^{-yGp}}{q_a^0(1-q_a^0)}\qquad(6)$$

The average length of time slot that collisions have occupied in a cycle period T_i is:

$$\begin{aligned}E(B_x)&=\sum_{x=2}^{\infty}E(N_{Bx})x=\sum_{x=2}^{\infty}\frac{(yGp)^x e^{-yGp}}{(x-1)!q_a^0(1-q_a^0)}\\&=\frac{yGp(1-e^{-yGp})}{q_a^0(1-q_a^0)}\end{aligned}\qquad(7)$$

$$\begin{aligned}E(B_x^*)&=\sum_{x=2}^{\infty}E(N_{Bx})y(1+\overline{L_x})\\&=\frac{ye^{-yGp}}{q_a^0(1-q_a^0)}\sum_{x=2}^{\infty}\frac{(yGp)^x}{x!}(1+\overline{L_x})\end{aligned}\qquad(8)$$

In (8), $\overline{L_x}$ is the average number of time slot that successfully decomposing x collisions by the improved binary tree conflict resolution algorithm is needed.

From the formula of throughput: $S = \dfrac{E(U) + \sum_{x=2}^{\infty} E(B_x)}{E(U^*) + E(I) + \sum_{x=2}^{\infty} E(B_x^*)}$, then the throughput of the i channel by the PD-CSMA with 3-way handshake based on binary tree conflict resolution mechanism is:

$$S_i = \frac{yGp}{y(1-e^{-yGp}) + ae^{-Ga} + ye^{-yGp}\sum_{x=2}^{\infty}\frac{(yGp)^x}{x!}\overline{L_x}} \tag{9}$$

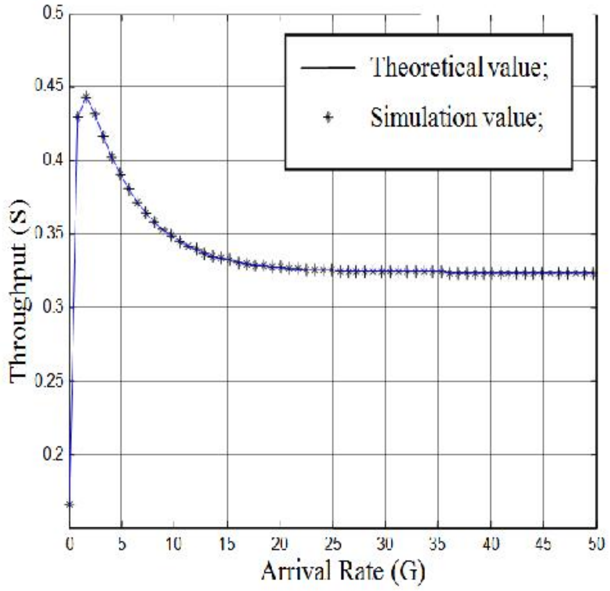
Similar to the analyses of the PD-CSMA with 3-way handshake and monitoring function, in the N channels of wireless communication system, using load balancing technology, then $G_1 = G_2 = G_3 = \dots = G_i = \dots = G_N$.[10]

The above analysis and system throughput formula: $S = \sum_{i=1}^{N} \dfrac{E[U_i]}{E[U_i^*] + E[B_i] + E[I_i]}$, then the system throughput of the new protocol is:

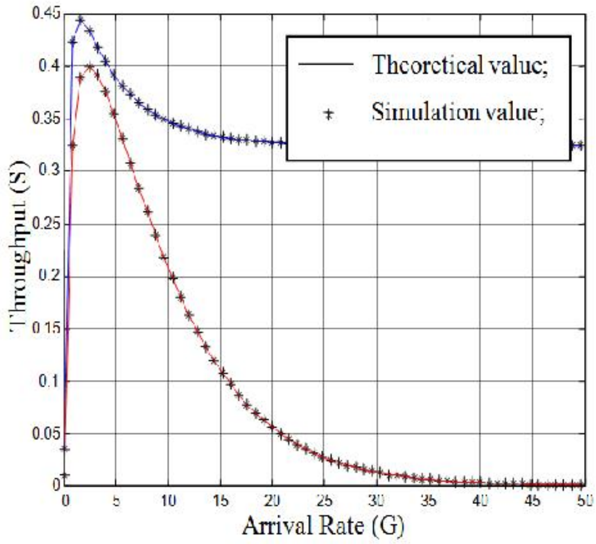
$$S = \frac{NyGp}{y(1-e^{-yGp}) + ae^{-Ga} + ye^{-yGp}\sum_{x=2}^{\infty}\frac{(yGp)^x}{x!}\overline{L_x}} \tag{10}$$

Reference to the multi-channel model and system performance parameters, according to the analysis, under the protocol, the system throughput of the l priority business is:

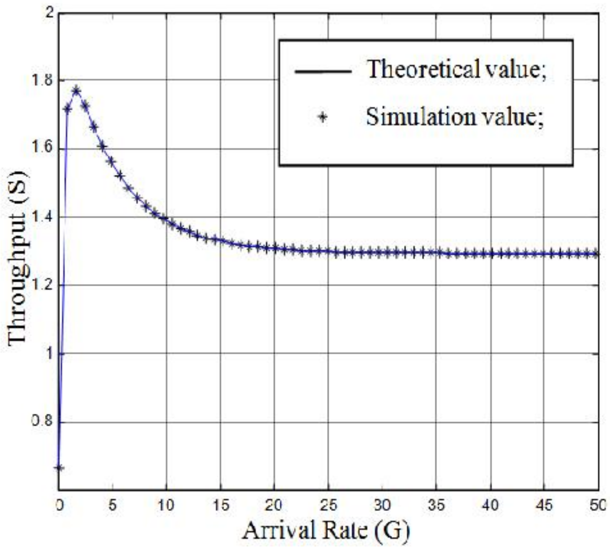
$$S_{pl} = \left(\sum_{i=1}^{l}\frac{1}{N-i+1}\right)\frac{yGp}{y(1-e^{-yGp}) + ae^{-Ga} + ye^{-yGp}\sum_{x=2}^{\infty}\frac{(yGp)^x}{x!}\overline{L_x}} \tag{11}$$



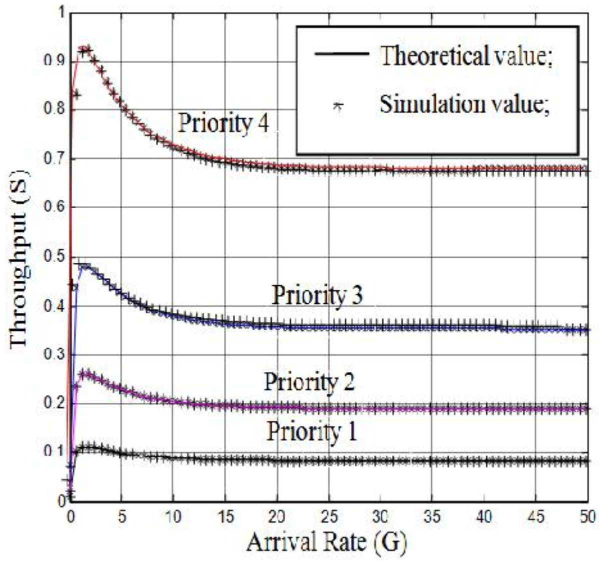
2 The comparison of the theoretical and simulation value under the new protocol



3 The comparison between the new protocol and the protocol without binary tree conflict resolution algorithm



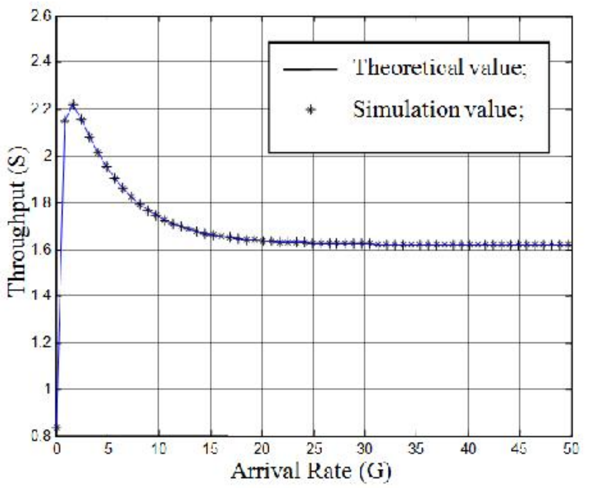
A The system throughput of 4 channels



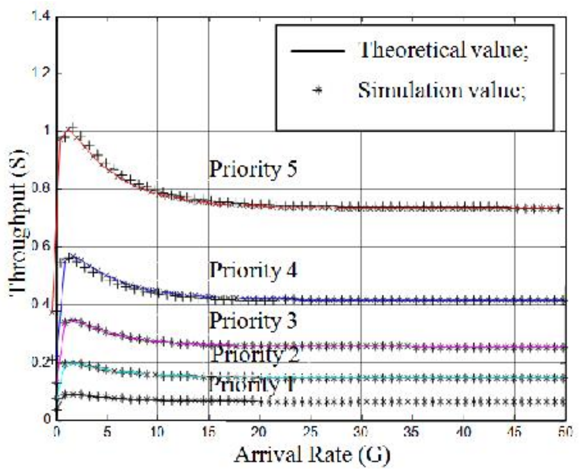
B The comparison of 4 channels with different priorities

Simulation of the model

From the above analysis, the expression of the system throughput under the multichannel PD-CSMA with 3-way handshake based on conflict resolution algorithm in WSN is got. With the simulation tool-MATLAB 7.0, system simulation and theoretical analysis are under the same working conditions. The simulation results are shown in Figure 2 to Figure 5. If not specified, the default simulation conditions is: $a = 0.1, p = 0.1, {}^2{}_R = 0.01, {}^2{}_C = 0.007$.

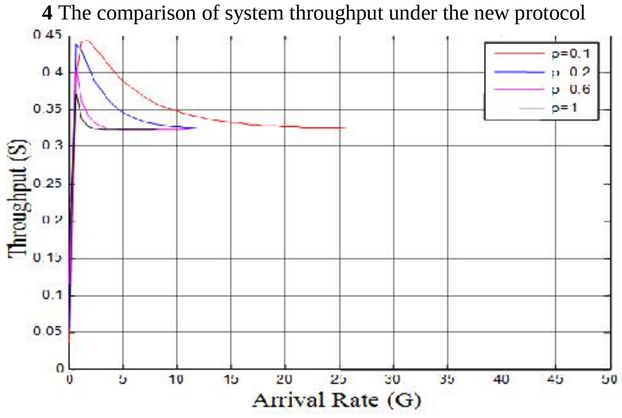


C The system throughput of 5 channels

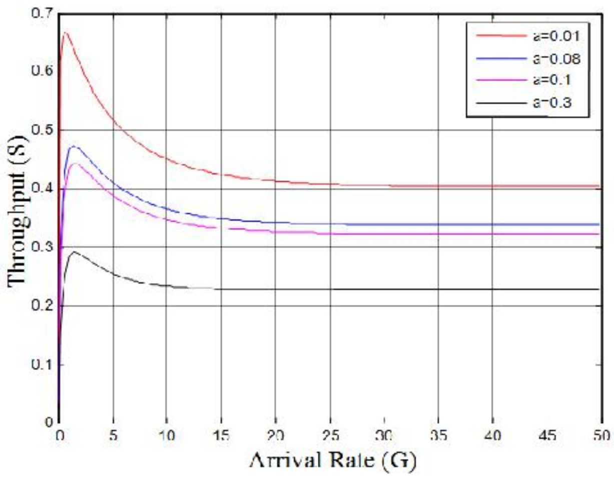


D The comparison of 5 channels with different priorities

4 The comparison of system throughput under the new protocol



A The comparison with different probability



B The comparison with different system delay

5The system throughput with different parameters

Can be found via the MATLAB simulation, under the multichannel PD-CSMA with 3-way handshake based on binary tree conflict resolution mechanism, the characteristics of the wireless CSMA protocol for WSN is:

1. In the Fig 2, under the new protocol, the theoretical and simulation value is highly consistent and the theoretical analysis is proved to be correct. The reason for this is that when the number of information packets transmitted is small, under the control of the protocol, the system can quickly perform packet processing; the processing capacity of the system can contend with the arrival rate of information packets; the system can quickly reach saturation. However, with the number of the arrival packet increasing to a certain extent, the decomposition rate of binary tree conflict resolution mechanism will reach the saturation point; the system has been completely put into the process of decomposition and retransmission so the basic channel has no idle slot so to retransmitted the newly arrived packet; the collision rate is equal with the decomposition rate and the system throughput remains stable. Compared with the PD-CSMA protocol with 3-way handshake, the throughput has been greatly improved.
2. In the Fig 3, no matter how many channels the system owns, the system load size, traffic of each priority can be assigned to a certain channel resources. The higher priority traffic can get more channel resources, while lower priority channel gains less access to resources but does not lose effectiveness, resource acquisition still able to meet its communications needs, ensuring the fairness principle of resource allocation. This system design through balancing load, distinguishing priority services, making transmission to meet the growing communication needs better.
3. In the Fig 4, detection probability p has a certain impact on the system throughput. Higher detection probability p, the faster of throughput speeds up to a maximum value, while the faster speed to fall to a stable value, with less channel load at the throughput peak. This is because when the arrival rate increases, with the

increase of detection probability p , the packets insist on detecting will accumulate when the channel is busy. The more, once the channel is idle, there may be multiple packets to be sent while the node detects the channel is idle. Then a collision occurs, resulting in reduced the throughput.

4. In the Fig 5, with the different system transmission delay, the curve of system throughput changes obviously. Smaller the system delay is, greater the throughput of the system will be; which is mainly due to the smaller transmission delay system, the number of packets detect the channel is busy during the transmission period is smaller, less packet transmission when channel is idle, reducing the possibility of collision, the throughput increasing. However, it cannot be generalized to say that the system delay is as small as possible, because the cost for reducing system delay is increasing the price.

CONCLUSION

According to the multichannel PD-CSMA with 3-way handshake based on conflict resolution algorithm in WSN, the computer simulation results verify the correctness of the theory. More channels are allocated to higher priority business, better quality of service guaranteed; though less access to resources gained to lower priority channel, the effectiveness does not lose; the access is still able to meet its communication needs, ensuring the fairness of resource allocation principles. Detection probability p has a certain impact on the system throughput. Higher detection probability p , the faster of throughput speeds up to a maximum value, while the faster speed to fall to a stable value. Smaller the system delay is, greater the throughput of the system will be.

Acknowledgements

1. This work was supported by the National Natural Science Foundation of China (61461053, 61461054); Natural Science Foundation of Yunnan Province (2010CD023); Financial support of Yunnan University (No.XT412004).

References

1. C. Siva Ram Murthy and B. S. Manoj, Ad hoc Wireless Networks: Architectures and Protocols, Prentice Hall PTR, May 2004(1)
2. Chunfen Li, Dongfeng Zhao, Hongwei Ding. Dynamic Slot Controlled Dual Probability Multiple Access MAC Protocol Analysis for WSN [J] *Journal of Communication*, 2010 (6): 14-18
3. Gribben J, Boukerche A. Location error estimation in wireless WSNs [J]. WSNs, 2014, 13: 504-515
4. Guo Y, Ding H, Zhao Y, *et al*. Study on a New Type of Discrete Random Contention
5. Jin Qu, Hao Zhang, Xiangquan Zheng. Overview of the Cellular WSNs [J] Chongqing Communication Institute, 2006, 24 (3): 27-29
6. Jinyang Li, Charles Blake, Douglas S. J. De Couto, Hu Imm Lee, and Robert Morris, Capacity of Ad Hoc Wireless Networks, in the proceedings of the 7th ACM International Conference on Mobile Computing and Networking, Rome, Italy, July 2001
7. Murad Khalid, Yufeng Wang, In-ho Ra. Two-Relay-Based Cooperative MAC Protocol for Wireless WSNs. IEEE Transactions on Vehicular Technology. 2011
8. P. Gupta and P.R. Kumar. Capacity of wireless networks. IEEE Transactions on Information Theory, Volume 46, Issue 2, March 2000
9. Peter Hyun-Jeen Lee, Udaya Parampalli, Shivaramakrishnan Narayan. Secure Communication in Mobile WSN using Efficient Certificateless Encryption [J]. *Journal of Networks*, 2009, 4(8).
10. System based on Binary Tree Conflict Resolution Algorithm [J]. 2013
11. Wang L, Wu K, Hamdi M. Attached-RTS: Eliminating an Exposed Terminal Problem in Wireless Networks [J]. Parallel and Distributed Systems, IEEE Transactions on, 2013, 24(7): 1289-1299

How to cite this article:

Hongwei Ding *et al*., The Multichannel Pd-Csma With 3-Way Handshake Based On Conflict Resolution Algorithm In Wsn. *International Journal of Recent Scientific Research Vol. 6, Issue, 4, pp.3714-3718, April, 2015*

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