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RESEARCH ARTICLE

DOUBLE CLOCKS THREE-DIMENSION PROBABILITY RANDOM MULTI-CHANNEL ACCESS PROTOCOL FOR IOT WITH THREE- WAY HANDSHAKE MECHANISM

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A B S T R A C T

Generation of information technology. IoT will be the next "significant productivity" to promote the world in rapid development. To truly establis h an effective IoT, there are two important factors: first, the scale; second, liquidity. But due to relatively high mobility and application environment is more complex, how to enhance controllability and the accuracy of information transmission is particularly important when design the transmission protocol. To solve the problems : safety of information transmission, the hidden terminal and exposed terminal, this paper introduces double clocks three-dimension probability random multi-channel access protocol with three-way handshake mechanism. Make the transfer of information more securable, solve the problem of the hidden terminal and exposed terminal, and improve the performance of the system by the introduction of three-way handshake mechanism. Improve the system controllability by the three -dimension probability mechanism. And use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above. Shorter the system idle time by the double clocks mechanism and improve the utilization of channel resources.

INTRODUCTION

Things is an important part of a new generation of information technology. Its English name is "The Internet of things" (IoT). Thus, by definition, "things that material objects connected to the Internet". There are two meanings: First, the core and foundation of things is still the Internet, the Internet is based on the extension and expansion of the network; second, to extend and expand its client to any goods and items of information exchange and communication [1]. Therefore, the definition of IoT is through radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners and other information sensing device, according to the agreed protocol, to any article connected to the Internet, information exchange and communication, in order to achieve the objects of the intelligent identify, locate, track, monitor and manage a network [2].

IoT are seen as extensions of the Internet application, the application of innovation is the core of the development of IoT and the user experience as the core of the innovation is the soul of the development of IoT [3]. According to its actual use it can be attributed to three basic application modes: smart label object, environmental monitoring and object tracking, intelligent control object. IoT industry characteristics mainly reflected in their applications, currently green agriculture, industrial monitoring, public safety, urban management, telemedicine, smar thome, intelligent transportation, and environmental monitoring and other industries have to try things networking applications, some industry has accumulated some successful cases [4].

A typical communication infrastructure of IoT is showed as Fig. 1

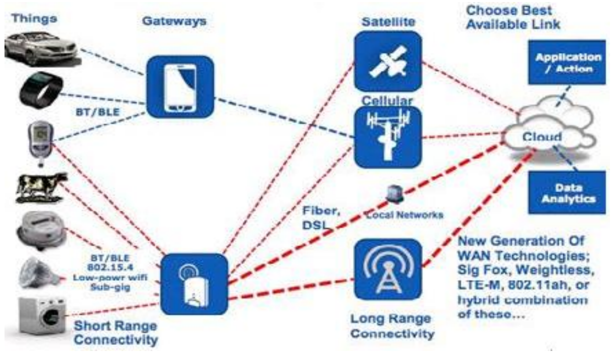

Figure 1 The typical communication infrastructure of IoT

To truly establish an effective IoT, there are two important factors. First, the scale, only with the scale, in order to make intelligent materials play a role. Second, liquidity, items are usually not static, but in a state of movement, items must be kept in motion, even under high speed motion state can be ready for dialogue [5].

Industry experts believe that IoT can improve economic efficiency on the one hand, significant cost savings; on the other hand can provide technical impetus to global economic recovery. Currently, the US, the EU invested so heavily in-depth study and explore IoT. China is also highly concerned about the emphasis on study of IoT, the Ministry of Industry and Information Technology together with relevant departments, the new generation of information technology, ongoing research to form policy measures to support the next generation of information technology development [6]. American authority advisory body FORRESTER predicts that by 2020, Internet of Things business in the world, compared with the business people to communicate, to reach 30 to 1, so the "Internet of Things" is known to be the next one trillion communication services [7]. IoT will be the next significant productivity" to promote the world in rapid development. Due to relatively high mobility and application environment is more complex, how to enhance controllability and the accuracy of information transmission is particularly important when design the transmission protocol. To solve the problems mentioned above, we introduce double clocks three-dimension probability random multi channel access protocol with three-way handshake 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. According to the new protocol, if the channel is idle, then the user decides to send an information packet probability $P1$; in the " 1" time of TP, the user listens to the channel at probability $P2$; in the " 32/23（9/32+3a+τ_R+τ_C) "time of TP, the user listens to the channel at probability $P3$. This control strategy, $P1$, $P2$ and $P3$ by three-dimensional selection enables the system under different load utilization and through putisguaranteed.The model of double clocks three-dimension probabilityrandom multi-channel access protocol with three-way handshake mechanism is showed as Fig. 2**.**

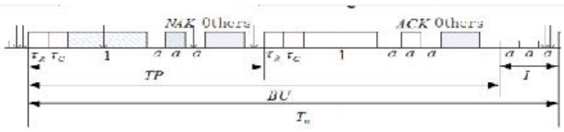

Figure 2 The model of double clocks three-dimension probability random multi-channel access protocol with three-way handshake mechanism.

In the proposed protocol, there will be three random events: 1, U events, information packets are sent successfully. 2, C events, information packets collide with each other (the collision appears). 3, I events, there is no information packets in the channel arrive, the channel is idle. In the model of double clocks three-dimension probability random multi-channel access protocol with three-way handshake mechanism, the total length of a transmission periodis:32/23(1+ 3 +τ_R + τ_C), where the total length of the data field is:（1+3a + τ_o + τ）, the total length of other field is:9/23 （1+3 a +τ_o + τ）

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 threedimension probability random multi-channel access protocol, and the arrival process of channel satisfy thePoisson 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.

And we use the averaging cycle period conduct analytical and simulation experiment with the control strategy mentioned above.

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

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

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:

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

(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:

$$q_0 = \sum_{k=0}^{\infty} P(A_k) \times (1-p)^k = e^{-G[p_2 + \frac{32}{23} p_3 (3a + \tau_R + \tau_C + \frac{9}{32})]} \qquad (3)$$

In the transmission period 32 /23 （1+3 a + τ_R +τ C） if there is only

One information packet to be sent, its possibility is:

$$q_1 = \sum_{k=1}^{\infty} P(A_k) C_k^1 p(1-p)^{k-1}$$
$$= G[p_2 + \frac{32}{23} p_3 (3a + \tau_R + \tau_C + \frac{9}{32})\ ] \times e^{-G[p_2 + \frac{32}{23} p_3 (3a+\tau_R+\tau_C+\frac{9}{32})\ ]} \quad (4)$$

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

$$E(U_2) = \frac{q_1}{q_0} = G[p_2 + \frac{32}{23} p_3 (3a + \tau_R + \tau_C + \frac{9}{32})\ ] \quad (5)$$

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

$$E(U) = E(U_1) + E(U_2) = \frac{p_1 G a e^{-p_1 G a}}{1 - e^{-p_1 G a}} + G[p_2 + \frac{32}{23} p_3 (3a + \tau_R + \tau_C + \frac{9}{32})\ ] \quad (6)$$

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

$$E(B) = E(N_B) \times \frac{32}{23}(1 + 3a + \tau_R + \tau_C) = \frac{1}{q_0} \times \frac{32}{23}(1 + 3a + \tau_R + \tau_C) = \frac{\frac{32}{23}(1 + 3a + \tau_R + \tau_C)}{e^{-G[p_2 + \frac{32}{23} p_3 (3a+\tau_R+\tau_C+\frac{9}{32})\ ]}} \quad (7)$$

Finally, solve average length E (I) during the idle period. Since the number of idle slots I within the geometric distribution with the mean: 1 E [N]= 1– £–d®:~:,

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

Since the number of idle slots I within the geometric distribution with the mean: $E[N] = \frac{1}{1-e^{-Gp_1 a}}$, an information packet arrive in a time slot with normalized probability: $p_{I1} = \frac{Gp_1 a e^{-Gp_1 a}}{1 - e^{-Gp_1 a}}$, more than an information packet arrives in a time slot with the normalized probability $p_{I2} = \frac{1 - Gp_1 a e^{-Gp_1 a} - e^{-Gp_1 a}}{1 - e^{-Gp_1 a}}$
Then we get:

$$E(I) = (\frac{1}{1 - e^{-Gp_1 a}} - 1)a + \frac{Gp_1 a^2 e^{-Gp_1 a}}{2(1 - e^{-Gp_1 a})} + \frac{(1 - Gp_1 a e^{-Gp_1 a} - e^{-Gp_1 a})a}{1 - e^{-Gp_1 a}} \quad (8)$$

The throughput of the new protocol is

$$S = \frac{E(U)}{E(B) + E(I)}$$
$$= \{\frac{p_1 G a e^{-p_1 G a}}{1 - e^{-p_1 G a}} + G[p_2 + \frac{32}{23} p_3 (3a + \tau_R + \tau_C + \frac{9}{32})\ ]\} \quad (9)$$
$$/[\frac{\frac{32}{23}(1 + 3a + \tau_R + \tau_C)}{e^{-G[p_2 + \frac{32}{23} p_3 (3a+\tau_R+\tau_C+\frac{9}{32})\ ]}} + (\frac{1}{1 - e^{-Gp_1 a}} - 1)a + \frac{Gp_1 a^2 e^{-Gp_1 a}}{2(1 - e^{-Gp_1 a})} + \frac{(1 - Gp_1 a e^{-Gp_1 a} - e^{-Gp_1 a})a}{1 - e^{-Gp_1 a}}]$$

SIMULATION AND RESULTS

From the above analysis, the expression of the system throughput under the double clocks Three-dimension probability 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: $a = 0.1$, $\tau^R = \tau_C = 0.1$.

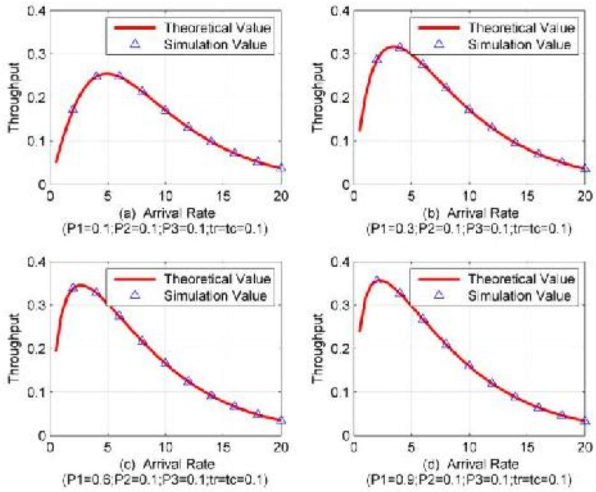

Fig. 3 The throughput of the new protocol with different P1

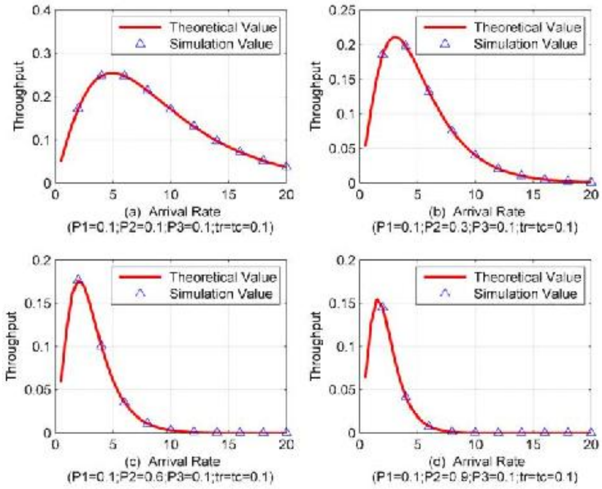

Fig. 4 The throughput of the new protocol with different P2

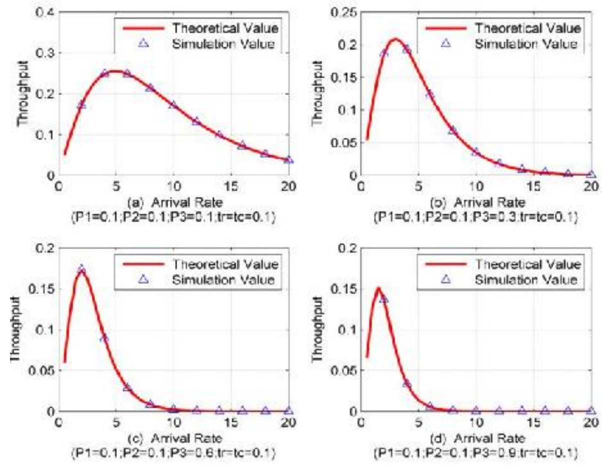

Fig. 5 The throughput of the new protocol with different P3

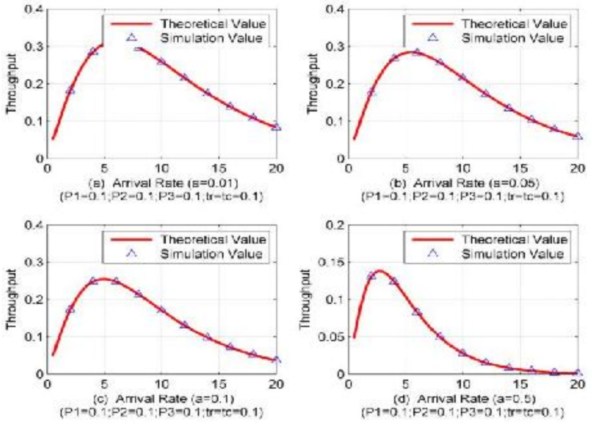

Fig. 6 The throughput of the new protocol with different a

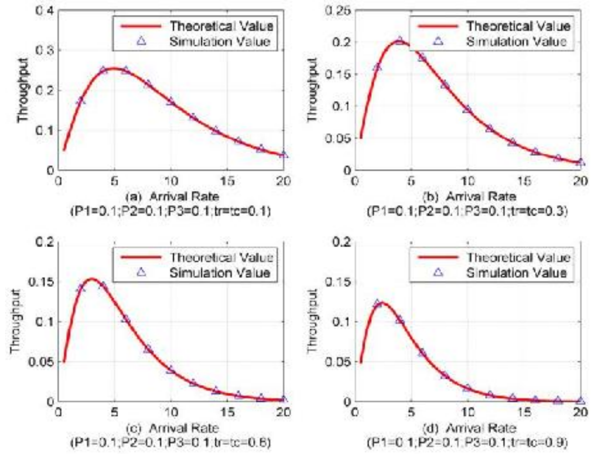

Fig. 7 The throughput of the new protocol with different τ_R, τ_C

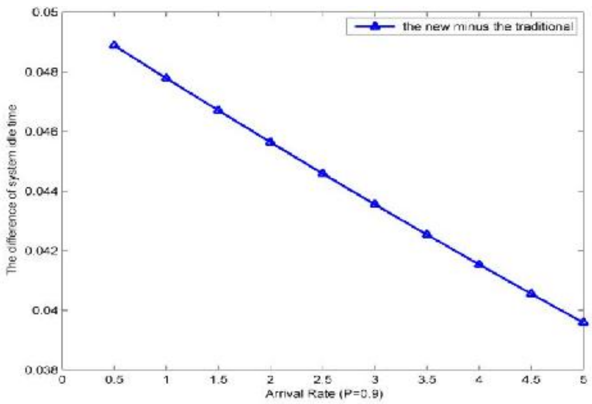

Fig. 8 The difference of system idle time between the new protocol and the traditional one.

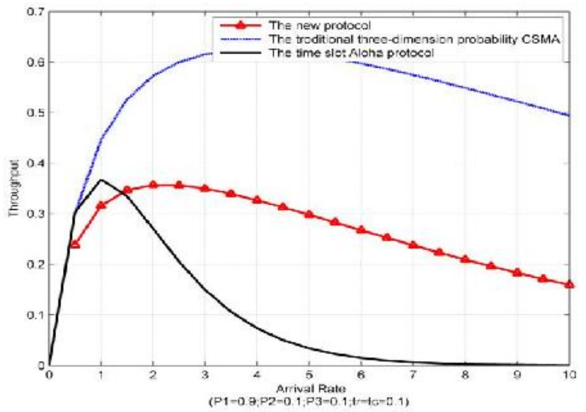

Fig. 9 The system throughput under different protocols

From the results, we know that the double clocks three-dimension probability random multi-channel access protocol with three-way handshake mechanism has the following characteristics

1. The theoretical value and simulations are highly unified, and also show that the correctness of above analysis. Meanwhile, the throughput of double clocks three-dimension probability random multi-channel access protocol with three- way handshake mechanism has decreased due to the join of inquire response mechanism, but system delay has increased.

This is because when the system functions become relatively complex, communication packets to be transmitted will carry more other control information, the channel resources occupied by communication system will be more, which leads to the increase of system delay. However, such system ensures the safety and reliability of the communication system to reduce the collision probability and increase the throughput, especially when the system is in light load, so the system has an excellent throughput performance.

2. Whether the detecting probability P1, or listening probability P2, P3, the impact on system throughput is particularly evident.

The selection of P1 and mainly depends on the system load, when the load is light, we can choose larger value of and P1, then the system throughput and utilization are high. But when the system is heavily loaded, we can select smaller value of P2 and P3 to reduce the collision probability and improve the system throughput.

So we can control the system throughput by the three-dimension probability mechanism.

3. The smaller the system delay a and $\tau_R = \tau_C$, system throughput, but in actual communication system, the larger the throughput is going to pay a higher price.

And 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.

4 Shorter the system idle time by the double clocks mechanism and improve the utilization of channel resources.

CONCLUSIONS

IoT is an important part of a new generation of information technology. IoT will be the next "significant productivity" to promote the world in rapid development. To truly establish an effective IoT, there are two important factors: first, the scale; second, liquidity. But due to relatively high mobility and application environment is more complex, how to enhance controllability and the accuracy of information transmission is particularly important when design the transmission protocol. To solve the problems: safety of information transmission, the hidden terminal and exposed terminal, this paper introduces double clocks three-dimension probability random multi- channel access protocol with three-way handshake mechanism. 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. Make the transfer of information more securable, solve the problem of the hidden terminal and exposed terminal, and improve the performance of the system by the introduction of three-way handshake mechanism. Improve the system controllability by the three-dimension probability mechanism. Shorter the system idle time by the double clocks mechanism.

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