Research on Asymmetry of Two-Queue Cycle Query Threshold Service Polling System

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***Abstract*—Based on establishing the mathematical model of the system provided system parameters, using the discrete-time Markov chain and a function set by a non-negative integer random variable as Probabilistic methods, discrete time variable, two-queue different gated polling system has been fully analyzed, the low- and higher-order properties and cycle period of the system are deduced, and average queue pair length and average waiting delay for message packets are calculated accurately. The simulation experiments agree well with the theoretical calculations. The analysis further deepens the cognition of the asymmetric threshold polling system, lays a foundation for researches on the asymmetric threshold polling system, and has positive significance for a better and more flexible control periodic query polling work system.**

Keywords—Discrete time query; asymmetric two-queue; threshold service; second-order characteristic quantity; information packets average delay

I. Introduction

Due to the difficulty of researches on asymmetric threshold service polling system [1], it generally begins by studying an asymmetric threshold service polling system with two queues. Therefore, the performance [2] of the two-queue asymmetric threshold service system is deeply analyzed and studied in this paper, whose purpose is to further explore the inherent laws [3] of the multi-queue threshold service polling system. As is known to all, the periodic [4] query queuing service system has been widely used in industrial process control [5], communication network technology [6], and computer network technology. However, for the periodic query queuing service system, parameters [7] such as the number of packets of information entering the network system at each moment, the time of packet service and the transfer time are all random variables, so the analysis of its related performance has considerable complexity [8]. Especially in the study of asymmetric systems [9], because there are still some problems in the analysis method [10], the results are local results obtained under certain limited conditions, and some precise parsing is given in the literature [11]. Based on the literature [12], This article uses the discrete-time Markov chain and a function [13] set by a non-negative integer random variable to parse the asymmetric threshold service system of discrete-time type and the double queue of periodic query type, deduces the low- and higher-order characteristic quantities [14] of the system, calculates the average length and cycle time of message grouping, and the mathematical reasoning of the average waiting delay [15]. The simulation experiments are in good agreement with the theoretical numerical calculations [16]. This topic discusses a deeper understanding of the multi-queue asymmetric threshold service polling system, which has positive significance for a more flexible control polling system. The content and scope of this paper further expand the research space of polling system.

II. Theoretical Model of the Asymmetric Threshold Service

A. Physical Model of the Asymmetric Threshold Service

The dual-queue asymmetric [17] threshold service receives service on a first-in, first-out basis in the same queue. Both Queue one and Queue two are running in threshold service policy mode [18]. In the first queue, until the current threshold information packet is serviced, the newly added information packets in the service process should be accumulated until the next polling cycle before service is performed, transition to queue two service after a transition time, and the service of queue two only serves the current threshold information packet until the service [19] is complete. And then, after a transition time, it is switched to another queue for the next round of service. The physical structure [20] of the asymmetric threshold service is shown in Fig. 1.

Buffer queue for any input, the numbers of information packets arriving in the buffer in each unit slot are independent of each other and have the same probability distribution [21]. The probabilities generating function, mean and variance of the distribution of the number of information groups in the queue are $A_i(z_i)$ 、 $\lambda_i = A_i^{'}(1)$ 、 $\sigma_{\lambda_i}^2 = A_i^{''}(1) + \lambda_i - \lambda_i^2$. The probabilities generating function, mean and variance of the transformation time distribution are $R_j(z_j)$ 、 $r_j = R_j^{'}(1)$ 、 $\sigma_{\beta_k}^2 = R_k^{''}(1) + r_k - r_k^2$. The probabilities generating function, mean and variance of service time distribution are $B_k(z_k)$ 、 $\beta_k = B_k^{'}(1)$ 、 $\sigma_{\beta_k}^2 = B_k^{''}(1) + \beta_k - \beta_k^2$. The above $i, j, k = 1,2$. Large buffer storage capacity for each group of queues is enough not to cause packet loss. Services in each queue are done on a first-come, first-served basis.

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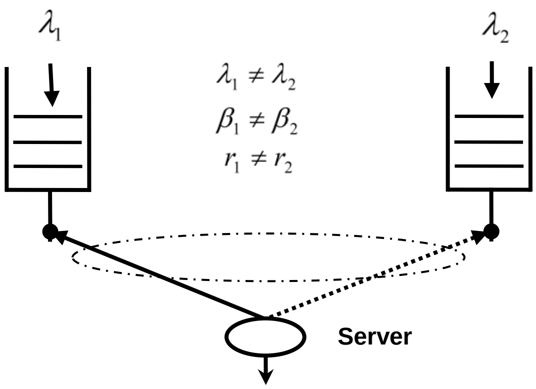

Fig. 1. Physical model of the asymmetric dual-queue threshold service

In order to facilitate the analysis of the queuing system [22], it is necessary to define the following random variables. $u_i(n)$ is defined as the query conversion while for waiter from service site i to service site $i+1$ at t_n. $v_i(n)$ is defined as the waiter starts serving while for the service site i at t_n. The number of information packets[23] entered by the waiter in the 3rd column of the queue is within 3 times。 $\mu_j(u_i)$ is defined as the number of information packets entered by the waiter in the j Queue at u_i. $\eta_j(v_i)$ is defined as the number of information packets entered by the waiter in the service site j within v_i. $\xi_i(n)$ is the number of information packets queued in the service object i at the t_n. For asymmetric two-queues $i, j = 1,2$.

B. State Variable Expression [24]

For a two-queue asymmetric threshold service polling system, when querying the threshold service queue at the t_{n+1}, the relation [25] is as follows:

$$\xi_1(n+1) = 0 + \eta_1(v_1) + \mu_1(u_1) \quad (1)$$

$$\xi_2(n+1) = \xi_2(n) + \eta_2(v_1) + \mu_2(u_1) \quad (2)$$

C. A Function set by a Non-Negative Integer Random Variable of State Variable Distribution [26]

For a two-queue asymmetric threshold service polling system, systematic probability generating function expression is as follows:

$$G_{i+1}(z_1, z_2) = \lim_{n\to\infty} E\left[\prod_{j=1}^{2} z_j^{\xi_j^{(n+1)}}\right] \quad (3)$$

Bring (1), (2) into (3), a function set by a non-negative integer random variable [27] is as follows

$$G_1(z_1,z_2) = R_2\big(A_1(z_1)A_2(z_2)\big)G_2\big(z_1, B_2(A_1(z_1)A_2(z_2))\big) \quad (4)$$

$$G_2(z_1,z_2) = R_1\big(A_1(z_1)A_2(z_2)\big)G_1\big(B_1(A_1(z_1)A_2(z_2)), z_2\big) \quad (5)$$

This $G_1(z_1,z_2)$ in (4) is a function set by a non-negative integer random variable of state variable probability distribution of information packet in threshold 1st Queue. This $G_2(z_1,z_2)$ in (5) is a function set by a non-negative integer random variable of state distribution of information packet in threshold 2nd Queue.

III. Theoretical Analysis of System Performance Indicators

A. Parse Low-Order Characteristic Quantities Expression [28]:

$$g_i(j) = \lim_{z_1,z_2\to 1} \frac{\partial G_i(z_1,z_2)}{\partial z_j} \quad i=1,2;\ j=1,2 \quad (6)$$

The following expression [29] can be obtained by parsing (4), (5) and (6).

$$g_1(1) = r_2\lambda_1 + g_2(1) + g_2(2)\beta_2\lambda_1 \quad (7)$$

$$g_1(2) = r_2\lambda_2 + g_2(2)\beta_2\lambda_2 \quad (8)$$

$$g_2(1) = r_1\lambda_1 + g_1(1)\beta_1\lambda_1 \quad (9)$$

$$g_2(2) = r_1\lambda_2 + g_1(2) + g_1(1)\beta_1\lambda_2 \quad (10)$$

The following expression can be obtained by parsing (8) and (9).

$$g_1(2) = \frac{(r_2 - \rho_1 r_2 + \rho_2 r_1)\lambda_2}{1-\rho_1-\rho_2} \quad (11)$$

$$g_2(1) = \frac{(r_1 - \rho_2 r_1 + \rho_1 r_2)\lambda_1}{1-\rho_1-\rho_2} \quad (12)$$

The following expression is average length of queue by bringing (11) and (12) into (7) and (10).

$$g_1(1) = \frac{(r_1 + r_2)\lambda_1}{1-\rho_1-\rho_2} \quad (13)$$

$$g_2(2) = \frac{(r_1 + r_2)\lambda_2}{1-\rho_1-\rho_2} \quad (14)$$

B. Resolve Two-Order Characteristics [30] Define:

$$g_i(j,k) = \lim_{z_1,z_2\to 1} \frac{\partial^2 G_i(z_1,z_2)}{\partial z_j z_k} \quad i=1,2;\ j=1,2;\ k=1,2 \quad (15)$$

The equation can be obtained by reduction and resolving (4) and (5) according to (15).

$$g_1(1,1) = \lambda_1^2 R_2''(1) + \left(r_2 + \beta_2 g_2(2)\right)A_1''(1) + \lambda_1^2 g_2(2)B_2''(1) + 2r_2\lambda_1 g_2(1) + 2\beta_2 r_2 \lambda_1^2 g_2(2) + g_2(1,1) + 2\beta_2\lambda_1 g_2(1,2) + \beta_2^2\lambda_1^2 g_2(2,2) \quad (16)$$

$$g_2(2,2) = \lambda_2^2 R_1''(1) + \left(r_1 + \beta_1 g_1(1)\right)A_2''(1) + \lambda_2^2 g_1(1)B_1''(1) + 2r_1\lambda_2 g_1(2) + 2\beta_1 r_1 \lambda_2^2 g_1(1) + g_1(2,2) + 2\beta_1\lambda_2 g_1(1,2) + \beta_1^2\lambda_2^2 g_1(1,1) \quad (17)$$

$$g_1(1,2) = g_1(2,1) = \lambda_1\lambda_2 R_2''(1) + \lambda_1\lambda_2 g_2(2)B_2''(1) + r_2\lambda_1\lambda_2 + r_2\lambda_2 g_2(1) + \left(2r_2 + 1\right)\rho_2\lambda_1 g_2(2) + \rho_2 g_2(1,2) + \rho_2\beta_2\lambda_1 g_2(2,2) \quad (18)$$

$$g_2(2,1) = g_2(1,2) = \lambda_1\lambda_2 R_1''(1) + \lambda_1\lambda_2 g_1(1)B_1''(1) + r_1\lambda_1\lambda_2 + r_1\lambda_1 g_1(2) + \left(2r_1 + 1\right)\rho_1\lambda_2 g_1(1) + \rho_1 g_1(2,1) + \rho_1\beta_1\lambda_2 g_1(1,1) \quad (19)$$

$$g_1(2,2) = \lambda_2^2 R_2''(1) + \left(r_2 + \beta_2 g_2(2)\right)A_2''(1) + \lambda_2^2 B_2''(1) + 2\rho_2 r_2\lambda_2 g_2(2) + \rho_2^2 g_2(2,2) \quad (20)$$

$$g_2(1,1) = \lambda_1^2 R_1''(1) + \left(r_1 + \beta_1 g_1(1)\right)A_1''(1) + \lambda_1^2 B_1''(1) + 2\rho_1 r_1\lambda_1 g_1(1) + \rho_1^2 g_1(1,1) \quad (21)$$

The higher-order feature [31] can be obtained by solving (16), (17), (18), (19), (20) and (21).

$$\begin{aligned} g_1(1,1) = \Big\{ & \lambda_1^2 \Big[(1 + 2\rho_2 - 2\rho_1\rho_2 - 2\rho_2^3 - 4\rho_1\rho_2^2 + \rho_1^2\rho_2^2 + 2\rho_1\rho_2^4 + 2\rho_1^2\rho_2^3)R_1''(1) + (1 - \\ & \rho_1^2\rho_2^2)R_2''(1)\Big] + \frac{(1-\rho_1\rho_2)(r_1+r_2)}{1-\rho_1-\rho_2}\Big[(1 - \rho_2^2 - \rho_1\rho_2 - 2\rho_1\rho_2^2 + \rho_1\rho_2^3)A_1''(1) + (1 + \\ & \rho_1\rho_2)\beta_2^2\lambda_1^2 A_2''(1)\Big] + \frac{(r_1+r_2)\lambda_1^2}{1-\rho_1-\rho_2}\Big[(1 + 2\rho_2 - 2\rho_1\rho_2 - 2\rho_2^3 - 4\rho_1\rho_2^2 + \rho_1^2\rho_2^2 + \\ & 2\rho_1\rho_2^4 + 2\rho_1^2\rho_2^3)\lambda_1 B_1''(1) + (1 - \rho_1^2\rho_2^2)\lambda_2 B_2''(1)\Big] + \frac{2\lambda_1^2}{1-\rho_1-\rho_2}\Big\{\Big[(1 - \rho_2^2 - \rho_1\rho_2 - \\ & 2\rho_1\rho_2^2 + \rho_1\rho_2^3)\Big] \times \Big[\rho_1(1 + 2\rho_2 - \rho_1\rho_2)r_1(r_1 + r_2) + \rho_2 r_1(r_2 - \rho_1 r_2 + \rho_2 r_1) + \\ & r_2(r_1 - \rho_2 r_1 + \rho_1 r_2) + \rho_2(1 + \rho_1\rho_2)r_2(r_1 + r_2)\Big] + \rho_2^2(1 + \rho_1\rho_2)\Big[\rho_1(1 + \rho_1\rho_2) \times \\ & r_1(r_1 + r_2) + r_1(r_2 - \rho_1 r_2 + \rho_2 r_1) + \rho_1 r_2(r_1 - \rho_2 r_1 + \rho_1 r_2) + \rho_2(1 + 2\rho_1 - \rho_1\rho_2) \times \\ & r_2(r_1 + r_2)\Big]\Big\} + \frac{2\rho_2\lambda_1^2}{1-\rho_1-\rho_2}\Big\{\Big[(1 - \rho_2^2 - \rho_1\rho_2 - 2\rho_1\rho_2^2 + \rho_1\rho_2^3)\Big] \times \Big[(1 - \rho_1 - \rho_2) \times \\ & (r_1 + \rho_1 r_2) + \rho_1(1 + \rho_2)(r_1 + r_2)\Big] + \rho_1\rho_2(1 + \rho_1\rho_2)\Big[(1 - \rho_1 - \rho_2)(r_2 + \rho_2 r_1) + \\ & \rho_2(1 + \rho_1)(r_1 + r_2)\Big]\Big\}\Big\} \Big/ \Big[(1 - \rho_1^2 - \rho_1\rho_2 - 2\rho_1^2\rho_2 + \rho_1^3\rho_2)(1 - \rho_2^2 - \rho_1\rho_2 - \\ & 2\rho_1\rho_2^2 + \rho_1\rho_2^3) - \rho_1^2\rho_2^2(1 + \rho_1\rho_2)^2\Big] \end{aligned} \quad (22)$$

$$g_2(2,2) = \{\lambda_2^2[(1-\rho_1^2\rho_2^2)R_1''(1) + (1+2\rho_1 - 2\rho_1\rho_2 - 2\rho_1^3 - 4\rho_1^2\rho_2 + \rho_1^2\rho_2^2 + 2\rho_1^4\rho_2 + 2\rho_1^3\rho_2^2)R_2''(1)] + \frac{(1-\rho_1\rho_2)(r_1+r_2)}{1-\rho_1-\rho_2}[(1+\rho_1\rho_2)\beta_1^2\lambda_2^2A_1''(1) + (1-\rho_1^2-\rho_1\rho_2-2\rho_1^2\rho_2+\rho_1^3\rho_2)A_2''(1)] + \frac{(r_1+r_2)\lambda_2^2}{1-\rho_1-\rho_2}[(1-\rho_1^2\rho_2^2)\lambda_1B_1''(1) + (1+2\rho_1-2\rho_1\rho_2-2\rho_1^3-4\rho_1^2\rho_2+\rho_1^2\rho_2^2+2\rho_1^4\rho_2+2\rho_1^3\rho_2^2)\lambda_2B_2''(1)] + \frac{2\lambda_2^2}{1-\rho_1-\rho_2}\{[(1-\rho_1^2-\rho_1\rho_2-2\rho_1^2\rho_2+\rho_1^3\rho_2)]\times[\rho_2(1+2\rho_1-\rho_1\rho_2)r_2(r_1+r_2)+\rho_1r_2(r_1-\rho_2r_1+\rho_1r_2)+r_1(r_2-\rho_1r_2+\rho_2r_1)+\rho_1(1+\rho_1\rho_2)r_1(r_1+r_2)] + \rho_1^2(1+\rho_1\rho_2)[\rho_2(1+\rho_1\rho_2)r_2(r_1+r_2)+r_2(r_1-\rho_2r_1+\rho_1r_2)+\rho_2r_1(r_2-\rho_1r_2+\rho_2r_1)+\rho_1(1+2\rho_2-\rho_1\rho_2)r_1(r_1+r_2)]\} + \frac{2\rho_1\lambda_2^2}{1-\rho_1-\rho_2}\{[(1-\rho_1^2-\rho_1\rho_2-2\rho_1^2\rho_2+\rho_1^3\rho_2)]\times[(1-\rho_1-\rho_2)(r_2+\rho_2r_1)+\rho_2(1+\rho_1)(r_1+r_2)]+\rho_1\rho_2(1+\rho_1\rho_2)[(1-\rho_1-\rho_2)(r_1+\rho_1r_2)+\rho_1(1+\rho_2)(r_1+r_2)]\}\}/[(1-\rho_1^2-\rho_1\rho_2-2\rho_1^2\rho_2+\rho_1^3\rho_2)(1-\rho_2^2-\rho_1\rho_2-2\rho_1\rho_2^2+\rho_1\rho_2^3)-\rho_1^2\rho_2^2(1+\rho_1\rho_2)^2] \quad (23)$$

C. The Average Waiting Time of the System

In the periodic query threshold service, the average waiting time of the service object is the average waiting time [32], of the information packet from entering the queue to the start of the service. From [33], the average waiting delay of the two queues of the gate service [34] can be obtained.

$$\overline{W}_{G1} = \frac{(1+\rho_1)g_1(1,1)}{2\lambda_1 g_1(1)} - \frac{A_1''(1)}{2\lambda_1^2} \quad (24)$$

$$\overline{W}_{G2} = \frac{(1+\rho_2)g_2(2,2)}{2\lambda_1 g_2(2)} - \frac{A_2''(1)}{2\lambda_2^2} \quad (25)$$

IV. Numerical Calculation and Experimental Simulation

Numerical calculations from theoretical analysis, it is time to carry out programming and simulation experiments according to the operating mechanism of the system. Let the arrival process of each queue in any time slot obey the Poisson distribution. The channel rate is 54Mbit/s; the message packet length is 2700 bit; the query conversion time is 10μs; the slot width is 10μs. And the numerical calculation is consistent with the simulation experimental parameters. Set polling number $M=10^6$. When $r_1=r_2=1$, $\lambda_1=0.01$, $\lambda_2=0.04$ the average-length and average waiting time of the first and second queue changes with service rate is in Tables I and II. If you set the number of cycles $M=3\times10^6$. Under $r_1=r_2=1, \beta_1=1, \beta_2=3$ conditions, the average-length and average waiting time of the first and second queue will change with arrival rate in Tables III and IV. If you set the number of cycles $M=5\times10^7$ under $\beta_1=\beta_2=10$, $\lambda_1=0.01, \lambda_2=0.04$ conditions, the average waiting time will change with shifting-time, which is shown in Tables V and VI. If the first and second queue is exactly the same, running the number of polling cycles $M=5\times10^7$ the average-length and average waiting time of the first and second queue changes will change with the variation-load, which is shown in Fig. 2 and Fig. 3.

TABLE I. THE AVERAGE QUEUE-LENGTH AND AVERAGE WAITING-TIME OF QUEUE ONE CHANGES WITH SERVICE RATE

β_{1i}	$g_1(1)$ Numeral Calculations	$g_1(1)$ Simulation results	$\overline{W}_{G1}$ Numeral Calculations / slot	$\overline{W}_{G1}$ Simulation results / slot
1	0.0209	0.0208	0.5888	0.5586
2	0.0223	0.0225	0.7372	0.7402
3	0.0236	0.0235	0.9598	0.9530
4	0.0251	0.0249	1.2597	1.2578
5	0.0266	0.0263	1.6536	1.6550
6	0.0285	0.0285	2.1565	2.1966
7	0.0309	0.0310	2.7938	2.7039
8	0.0334	0.0336	3.5954	3.7181
9	0.0362	0.0355	4.6048	4.8738
10	0.0399	0.0390	5.8625	5.4977

TABLE II. THE AVERAGE QUEUE-LENGTH AND AVERAGE WAITING-TIME OF QUEUE TWO CHANGES WITH SERVICE RATE

β_{2i}	$g_2(2)$ Numeral Calculations	$g_2(2)$ Simulation results	$\overline{W}_{G2}$ Numeral Calculations / slot	$\overline{W}_{G2}$ Simulation results / slot
1	0.0843	0.0843	0.6209	0.6194
2	0.0888	0.0882	0.8125	0.8144
3	0.0946	0.0950	1.0863	1.0769
4	0.1001	0.1002	1.4598	1.4344
5	0.1066	0.1066	1.9529	1.9254
6	0.1139	0.1129	2.5930	2.5883
7	0.1238	0.1220	3.4172	3.4498
8	0.1331	0.1329	4.4598	4.4635
9	0.1452	0.1436	5.7832	6.1967
10	0.1601	0.1560	7.4961	7.0018

TABLE III. THE AVERAGE QUEUE-LENGTH AND AVERAGE WAITING-TIME OF QUEUE ONE CHANGES WITH ARRIVAL RATE

λ_{1i}	$g_1(1)$ theory	$g_1(1)$ experiment	$\overline{W}_{G1}$ Theory / slot	$\overline{W}_{G1}$ Experiment / slot
0.010	0.0207	0.0207	0.6308	0.6041
0.025	0.0555	0.0552	0.7711	0.7802
0.040	0.0953	0.0954	0.9561	0.9488
0.055	0.1409	0.1410	1.1672	1.1567
0.070	0.1942	0.1935	1.4101	1.4006
0.085	0.2574	0.2571	1.6928	1.7012
0.100	0.3338	0.3351	2.0323	2.0523
0.115	0.4256	0.4249	2.4409	2.4518
0.130	0.5412	0.5409	2.9506	2.9511
0.145	0.6912	0.6941	3.6053	3.6452

TABLE IV. THE AVERAGE QUEUE-LENGTH AND AVERAGE WAITING-TIME OF QUEUE TWO CHANGES WITH ARRIVAL RATE

λ_{2i}	$g_2(2)$ theory	$g_2(2)$ experiment	$\overline{W}_{G2}$ Theory / slot	$\overline{W}_{G2}$ Experiment / slot
0.010	0.0207	0.0207	0.6254	0.6234
0.025	0.0555	0.0559	0.8354	0.8451
0.040	0.0951	0.0946	1.0771	1.0822
0.055	0.1409	0.1411	1.3584	1.3311
0.070	0.1942	0.1941	1.6871	1.6642
0.085	0.2572	0.2563	2.0768	2.0662
0.100	0.3336	0.3361	2.5452	2.5758
0.115	0.4261	0.4259	3.1197	3.1301
0.130	0.5415	0.5396	3.8358	3.8472
0.145	0.6915	0.6927	4.7583	4.7846

TABLE V. THE AVERAGE QUEUE-LENGTH AND AVERAGE WAITING-TIME OF QUEUE ONE CHANGES WITH TRANSFER TIME

γ_{1i}	$g_1(1)$ theory	$g_1(1)$ experiment	$\overline{W}_{G1}$ Theory / slot	$\overline{W}_{G1}$ Experiment / slot
1	0.0400	0.0398	5.8771	5.8765
2	0.0800	0.0802	8.0773	8.0752
3	0.1200	0.1203	10.271	10.208
4	0.1600	0.1607	12.477	12.479
5	0.2000	0.2003	14.679	14.682
6	0.2400	0.2401	16.872	16.821
7	0.2800	0.2803	19.079	18.987
8	0.3200	0.3203	21.275	21.231
9	0.3600	0.3581	23.479	23.487
10	0.4000	0.4004	25.679	25.789

TABLE VI. THE AVERAGE QUEUE-LENGTH AND AVERAGE WAITING-TIME OF QUEUE TWO CHANGES WITH TRANSFER TIME

γ_{2i}	$g_2(2)$ theory	$g_2(2)$ experiment	$\overline{W}_{G2}$ Theory / slot	$\overline{W}_{G2}$ Experiment / slot
1	0.1600	0.1597	7.5051	7.5047
2	0.3200	0.3232	10.3010	10.4120
3	0.4800	0.4801	13.1009	13.0360
4	0.6400	0.6402	15.9050	15.9380
5	0.8000	0.7999	18.7040	18.7035
6	0.9600	0.9568	21.5058	21.4448
7	1.1200	1.1201	24.3069	24.2318
8	1.2800	1.2797	27.1050	27.1030
9	1.4400	1.4378	29.9050	29.9020
10	1.6000	1.6011	32.7068	32.7691

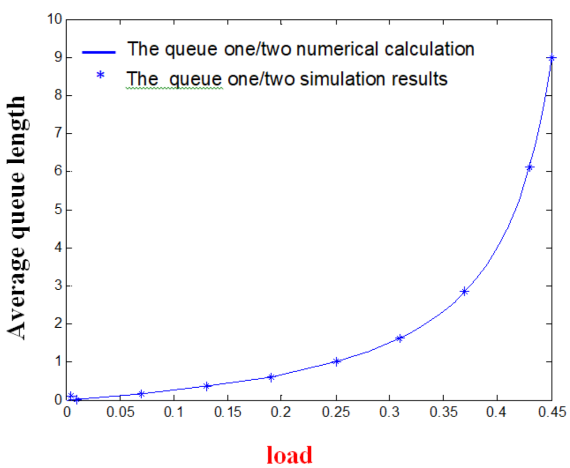

Fig. 2. The curve of the average queuing length following the load changes

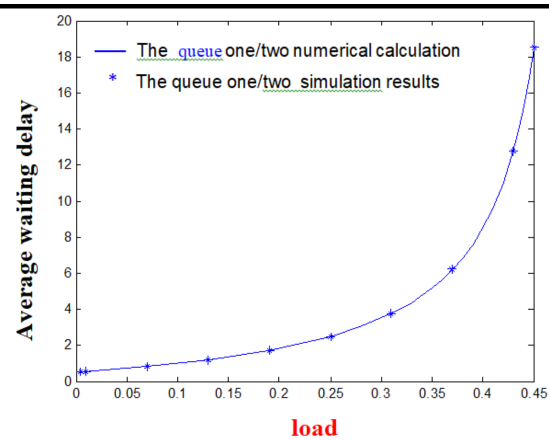

Fig. 3. The curve of the average waiting delay following the load changes

V. Discussion on Simulation Experiment And Numerical Calculation Results

Referring to Tables Ⅰ and Ⅱ, it can be seen that the average queuing length and average waiting delay changes with the variety of β_i when λ_i and γ_i remains constant. Looking at the two types of plots in Fig. 2 and 3, it can be seen that the system delay changes faster with the changing of λ_i . System delay is bigger when λ_i is bigger and when β_i remains constant. Experiment results and theoretical analysis expression (24) and (25) are consistent. In practice, the experimental results are approximately equal to the theoretical numerical calculations, there is a certain deviation. The main factor is that the number of polling statistics loops is too small, which is only $M=10^6$. If the number of polling cycle statistics is further increased, the error between the experimental value and the theoretical value will be further reduced.

By viewing Tables Ⅲ and Ⅳ, it can be seen that the average queuing length and system delay changes with the variety of λ_i when β_i and γ_i remains constant. It can be seen that the average waiting delay changes faster as β_i is variety. System delay is bigger as β_i is bigger and λ_i remains constant. Experiment results and theoretical analysis expression (24) and (25) are consistent. Experimental data are subject to minor deviations, which is because the polling statistics loop count reaches $M=3\times10^6$. If the number of polling cycle statistics is further increased, the error between the experimental value and the theoretical value will be smaller.

Referring to Tables Ⅴ and Ⅵ, It can be seen that the average queuing length and average waiting delay changes with the variety of γ_i when λ_i and β_i remains constant. It can be seen that the system delay changes faster as ρ_i is changing. System delay of the ones if lighter loads are smaller and shifting time remains constant. Experiment simulations and theoretical calculation expression (24), (25) are consistent. Experimental data are subject to minor deviations, which is because the polling statistics loop count reaches $M=3\times10^6$. If the number of polling cycle statistics is further increased, the error between the experimental value and the theoretical value will be smaller.

By viewing Fig. 2 and 3, it can be seen that the system queuing length and system waiting delay changes when the variety of ρ_i if the same γ_i under the two queues are set to be symmetrical. Experiment results and theoretical analysis expression (24) and (25) are consistent. There may be minimal deviation of experimental data because the polling statistics loop count reaches $M=5\times10^7$. If the number of polling cycle statistics is further increased, it can also improve the quality of experimental data analysis and can further reduce the uncertainty of the system.

Comparing Tables Ⅰ and Ⅱ, the load on the 10th service terminal is $\rho_{\max1,10}=0.1$, $\rho_{\max2,10}=0.4$, Comparison Table Ⅲ and Ⅳ, the maximum load on the 10th service terminal is $\rho_{\max1,10}=0.145$, $\rho_{\max2,10}=0.435$, Comparison Table Ⅴ and Ⅵ, the maximum load on the 10th service terminal is $\rho_{\max1,10}=0.1$, $\rho_{\max2,10}=0.4$. In a word, the value of the maximum load on the service terminal is $\rho_{\max}<0.5$, System service terminals are running under light load. In the following research work, it is also necessary to analyze and discuss the system under heavy load, so as to strive for the integrity of the analysis.

By comparing Tables I, Ⅱ, Ⅲ, Ⅳ, Ⅴ and Ⅵ as well as Fig. 2 and Fig. 3, it can be seen that the deviation between the simulated experimental value and the numerical calculation value is further reduced with the increase of the threshold polling times. Proven by experiment, if you take the statistical polling times $M\geq10^8$, it can prove that the error can be controlled within 1% under heavy load.

When the network system operates with symmetric parameters, Formula (24) and (25) of theoretical analysis is simplified to formula (20) in [26] under the $N=2$ condition is exactly the same.

VI. Summary

The article, using the discrete-time Markov chain and a function set by a non-negative integer random variable, Accurate Analysis of Two-Queue Asymmetric Threshold Service System, is based on the establishment of a theoretical model and the definition of system-related parameters, in which the low-order characteristic quantity, higher-order characteristic quantity and query period of the system are deduced, and the system queuing length and system waiting delay are accurately calculated. The simulation experiment comes from the operating mechanism of the system and the theoretical analysis and sample calculation are in good agreement. The article lays a foundation for the researches on the related problems of multi-queue asymmetric threshold service polling system, further deepens the cognition of the asymmetric threshold polling system, and further expands the research space of polling system.

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