

On a Characteristic of Data Transmission with Priority Processing in Bus Network

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Abstract—Recently, in bus network each station is connected to a bus through a switching-hub which establishes a link from a sending station to a receiving station, so that the number of data collisions extremely decreased. However, in the case that the receiving buffer of a receiving station is full or the receiving station is sending or receiving data, a sending station has to wait to send data. This waiting time (stand-by time) influences an efficiency of data transmission. In this paper, a characteristic of data transmission with priority processing in bus network with the stand-by time is clarified.

Taking note of one station with two sending buffers for high priority data and low priority data, the link probability that the link from the station to a receiving station can be established is defined as a constant. The station is modeled as a priority queue with stand-by time, and then in steady state, a balance equation of the probabilities of the number of waiting data at the ready time of sending is expressed. From the equations, for each priority, probabilities of the number of waiting data mean of the number of waiting data in the sending buffer and mean waiting time which is the time from the data arrival time at the sending buffer to the beginning time of sending are derived. The calculated values are illustrated in several cases, and then the influences of the stand-by time and the link probability on data transmission with priority processing are shown.

Index Terms—Bus network, priority, link probability, mean of the number of waiting data, mean waiting time.

I. INTRODUCTION

In bus network which is a primary topology for LAN (local area network), recently, stations are connected to a bus through a switching hub which establishes a link from a sending station to a receiving station. By using a switching hub, the number of data collisions extremely decreased in comparison with the conventional protocol CSMA/CD (carrier sense multiple access / collision detection), so that a sending station did not need to almost wait to send data.

However, in this bus network with a switching hub, a sending station also has to wait for sending in the case that a receiving buffer at a receiving station is full or the receiving station is sending or receiving data.

As studies in conjunction with this paper, the proposal of MAC (media access control) protocol [1], the simulation of MAC protocol for the performance evaluation [2] and the proposal of the dynamic bandwidth allocation [3] for Ethernet PON (passive optical network) were presented. And, the time synchronization on Gb/s Ethernet [4] which is necessary for

the wide distributed system, the host configuration mechanism to network in Ethernet and wireless LAN [5] are studied. For application of Ethernet, an application method in industry [6], application to production factory [7], the performance of industrial Ethernet [8] and the performance of TDMA (Time Division Multiple Access) based network [9] are reported. And, about the Adhoc network, impact of mobility [10], [11] and routing protocol [12], [13] are studied.

However, the characteristics of data transmission (probabilities of the number of waiting data, mean of the number of waiting data and mean waiting time) were not cleared, so that I reported simulations for a bus network with CSMA/CD [14], [15] and the characteristic of data transmission in bus network with switching hub [16].

In the case of transmission of different kinds of data, such as text, sound and graphics, priority processing is necessary. In this paper, a characteristic of data transmission with priority processing in bus network is analyzed.

In this paper, the probability that a link from a sending station to a receiving station can be established (called as link probability) is defined as a constant. Taking note of one station connected to a bus, for high priority data and low priority data, probabilities of the number of waiting data, mean of the number of waiting data in the sending buffer and mean waiting time from the arrival time at the sending buffer to the beginning time of sending [16]-[18] are derived. Furthermore, some calculated values are illustrated, and then characteristics of data transmission with priority processing are considered.

II. MODELING OF BUS NETWORK WITH PRIORITY PROCESSING

The bus network shown in Fig. 1 is analyzed.

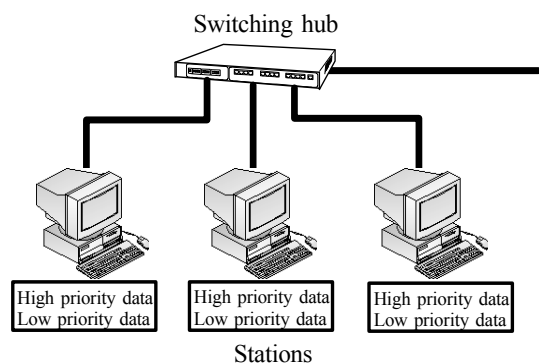


Fig. 1. Bus network with priority processing.

In the network, each station has two infinite buffers for high priority data and low priority data which are called as sending

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buffers. High priority data and low priority data arrive at each sending buffer in different Poisson process. The arrival rates of high priority data and low priority data are denoted by λ_1 and λ_2 , respectively. At the ready time of sending data, if high priority data exist in the sending buffer and a link to a receiving station is established, the station sends the first high priority datum in the sending buffer to a receiving station. If not established, the station has a little waiting time (called as stand-by time). If there is no high priority data in the sending buffer, the station checks the sending buffer for low priority data. If low priority data exist in the sending buffer and a link to a receiving station is established, the station sends the first low priority datum in the sending buffer to the receiving station. If not established, the station has stand-by time. If there is no low priority data, the station has stand-by time. Defining the link probability as q , the flowchart of sending data is shown in Fig. 2.

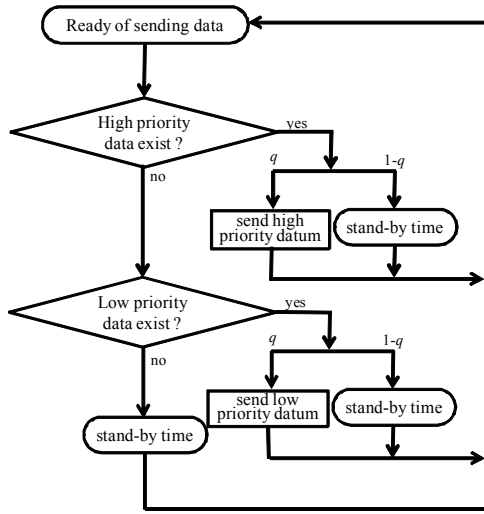


Fig. 2. Flowchart of sending data.

The sending station is modeled as a priority queue with stand-by time which is shown in Fig. 3.

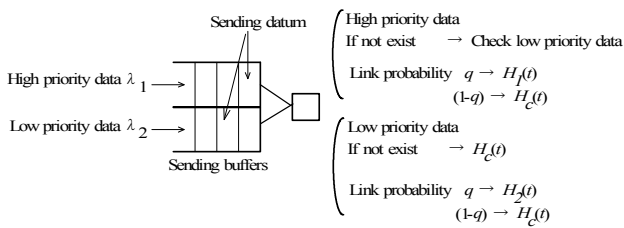


Fig. 3. Priority queue with stand-by time.

It is defined that one transmission requires arbitrary distributed transmission time. The distribution functions (DFs) of the transmission times for high priority data and low priority data are denoted by $H_1(t)$ and $H_2(t)$, respectively. The stand-by time is arbitrary distributed, and the DF of the stand-by time is denoted by $H_c(t)$.

III. PROBABILITY OF THE NUMBER OF WAITING DATA AND MEAN OF THE NUMBER OF WAITING DATA

A. Balance Equation

Let P_{n_1, n_2} be the probability that the numbers of waiting

high priority data and low priority data in the sending buffers are n_1 and n_2 at the ready time of sending. In steady state, the following balance equation is obtained.

$$\begin{aligned}
 P_{n_1', n_2'} = & q \int \sum_{n_1=1}^{\infty} \alpha_1(n_1' - n_1 + 1, t) \sum_{n_2=0}^{n_2'} \alpha_2(n_2' - n_2, t) P_{n_1, n_2} dH_1(t) \\
 & + (1-q) \int \sum_{n_1=1}^{\infty} \alpha_1(n_1' - n_1, t) \sum_{n_2=0}^{n_2'} \alpha_2(n_2' - n_2, t) P_{n_1, n_2} dH_c(t) \\
 & + q \int \sum_{n_1=0}^{\infty} \alpha_1(n_1', t) \sum_{n_2=1}^{n_2'+1} \alpha_2(n_2' - n_2 + 1, t) P_{0, n_2} dH_2(t) \\
 & + (1-q) \int \sum_{n_1=0}^{\infty} \alpha_1(n_1', t) \sum_{n_2=1}^{n_2'} \alpha_2(n_2' - n_2, t) P_{0, n_2} dH_c(t) \\
 & + \int \sum_{n_1=0}^{\infty} \alpha_1(n_1', t) \alpha_2(n_2', t) P_{0,0} dH_c(t)
 \end{aligned} \quad (1)$$

In the above equation, $\alpha_i(n, t)$ is the probability that n data arrive at the sending buffer within time t .

$$\alpha_i(n, t) = \frac{e^{-\lambda_i t} (\lambda_i t)^n}{n!} \quad (2)$$

Taking $\sum_{n_1'=0}^{\infty} \sum_{n_2'=0}^{\infty}$ after multiplying $x_1^{n_1'} x_2^{n_2'}$ in both sides of equation (1) and transforming into a generating function form, the following equation is obtained.

$$G_1(x_1, x_2) = \frac{G_2(x_2) \left\{ \frac{q}{x_2} H_2^*(z) + (1-q) H_c^*(z) - 1 \right\} + P_{0,0} \{ H_c^*(z) - 1 \}}{1 - \frac{q}{x_1} H_1^*(z) - (1-q) H_c^*(z)} \quad (3)$$

where $H_i^*(z)$ and $H_c^*(z)$ are the Laplace-Stieltjes Transformation (LST) of $H_i(t)$ and $H_c(t)$, respectively, and $z = \lambda_1(1 - x_1) + \lambda_2(1 - x_2)$.

The generating functions (GFs) of the probabilities of the number of waiting data are defined as follows.

$$G_1(x_1, x_2) = \sum_{n_1=1}^{\infty} \sum_{n_2=0}^{\infty} P_{n_1, n_2} x_1^{n_1} x_2^{n_2} \quad (4a)$$

$$G_2(x_2) = \sum_{n_2=1}^{\infty} P_{0, n_2} x_2^{n_2} \quad (4b)$$

B. Probabilities of the Number of Waiting Data

When $x_1 = x_2 = 1$ in equation (3), the following equations are obtained.

$$\begin{aligned}
 & \{q - q\lambda_1 h_1 - (1-q)\lambda_1 h_c\} G_1(1, 1) - \\
 & \{q\lambda_1 h_2 + (1-q)\lambda_1 h_c\} G_2(1) - \lambda_1 h_c P_{0,0} = 0
 \end{aligned} \quad (5a)$$

$$\begin{aligned} & \{q\lambda_2 h_1 + (1-q)\lambda_2 h_c\} G_1(1,1) - \\ & \{q - q\lambda_2 h_2 - (1-q)\lambda_2 h_c\} G_2(1) + \lambda_2 h_c P_{0,0} = 0 \end{aligned} \quad (5b)$$

In equation (5a) and (5b), h_i and h_c are mean of $H_i(t)$ and $H_c(t)$, respectively.

Because the sum of all probabilities is 1, equation (6) is obtained.

$$G_1(1,1) + G_2(1) + P_{0,0} = 1 \quad (6)$$

From equations (5a), (5b) and (6), the following probabilities are derived.

$$G_1(1,1) = \frac{\lambda_1 h_c}{q\{1 - (\lambda_1 h_1 + \lambda_2 h_2) + (\lambda_1 + \lambda_2) h_c\}} \quad (7a)$$

$$G_2(1) = \frac{\lambda_2 h_c}{q\{1 - (\lambda_1 h_1 + \lambda_2 h_2) + (\lambda_1 + \lambda_2) h_c\}} \quad (7b)$$

$$P_{0,0} = \frac{q\{1 - \lambda_1 h_1 - \lambda_2 h_2 + (\lambda_1 + \lambda_2) h_c\} - (\lambda_1 + \lambda_2) h_c}{q\{1 - (\lambda_1 h_1 + \lambda_2 h_2) + (\lambda_1 + \lambda_2) h_c\}} \quad (7c)$$

$G_1(1,1)$ is the probability that the number of high priority waiting data is 1 or more at the ready time of sending. $G_2(1)$ is the probability that the number of high priority waiting data is 0 and low priority data is 1 or more. $P_{0,0}$ is the probability that there is no waiting data.

C. Mean of the Number of High Priority Waiting Data

From equation (3), $\frac{d}{dx_1} G_1(x_1, 1)|_{x_1=1}$ which is mean of the number of high priority waiting data in the sending buffer can be derived.

From equation (3), $G_1(x_1, 1)$ is expressed by equations (8), (9a) and (9b).

$$G_1(x_1, 1) = \frac{A_1(x_1)}{B_1(x_1)} \quad (8)$$

$$\begin{aligned} A_1(x_1) = & G_2(1) \{qH_2^*(z_1) + (1-q)H_c^*(z_1) - 1\} \\ & + P_{0,0} \{H_c^*(z_1) - 1\} \end{aligned} \quad (9a)$$

$$B_1(x_1) = 1 - \frac{q}{x_1} H_1^*(z_1) - (1-q) H_c^*(z_1) \quad (9b)$$

where $z_1 = \lambda_1(1 - x_1)$.

When $x_1 = 1$ after differentiating equation (8), the following equation is obtained

$$\frac{d}{dx_1} G_1(x_1, 1)|_{x_1=1} = \frac{A_1''(1)B_1'(1) - A_1'(1)B_1''(1)}{2\{B_1'(1)\}^2} \quad (10)$$

where

$$A_1'(1) = G_2(1) \{q\lambda_1 h_2 + (1-q)\lambda_1 h_c\} + P_{0,0} \lambda_1 h_c \quad (11a)$$

$$B_1'(1) = q - q\lambda_1 h_1 - (1-q)\lambda_1 h_c \quad (11b)$$

and

$$A_1''(1) = G_2(1) \{q\lambda_1^2 h_2^{(2)} + (1-q)\lambda_1^2 h_c^{(2)}\} + P_{0,0} \lambda_1^2 h_c^{(2)} \quad (12a)$$

$$B_1''(1) = -2q + 2q\lambda_1 h_1 - q\lambda_1^2 h_1^{(2)} - (1-q)\lambda_1^2 h_c^{(2)} \quad (12b)$$

$h_i^{(2)}$ and $h_c^{(2)}$ are the second moments of the DFs of $H_i(t)$ and $H_c(t)$, respectively.

D. Mean of the Number of Low Priority Waiting Data

Using $x_1 = \delta(x_2)$ which satisfies that the denominator of equation (3) is 0, the following equation is obtained.

$$G_2(x_2) = \frac{P_{0,0} \{H_c^*(\tilde{z}) - 1\}}{1 - \frac{q}{x_2} H_2^*(\tilde{z}) + (1-q) H_c^*(\tilde{z})} \quad (13)$$

where $\tilde{z} = \lambda_1 \{1 - \delta(x_2)\} + \lambda_2 (1 - x_2)$ and $\delta(x_2)$ satisfies the following equation.

$$1 - \frac{q}{\delta(x_2)} H_1^*(\tilde{z}) - (1-q) H_c^*(\tilde{z}) = 0 \quad (14)$$

From equation (13), $\frac{d}{dx_2} G_2(x_2)|_{x_2=1}$ which is mean of the number of low priority waiting data in the case that the number of high priority waiting data is 0 can be derived. From equation (13), $G_2(x_2)$ is expressed by equations (15), (16a) and (16b).

$$G_2(x_2) = \frac{A_2(x_2)}{B_2(x_2)} \quad (15)$$

$$A_2(x_2) = P_{0,0} \{H_c^*(\tilde{z}) - 1\} \quad (16a)$$

$$B_2(x_2) = 1 - \frac{q}{x_2} H_2^*(\tilde{z}) - (1-q) H_c^*(\tilde{z}) \quad (16b)$$

When $x_2 = 1$ after differentiating equation (15), the following equation is obtained.

$$\frac{d}{dx_2} G_2(x_2)|_{x_2=1} = \frac{A_2''(1)B_2'(1) - A_2'(1)B_2''(1)}{2\{B_2'(1)\}^2} \quad (17)$$

where

$$A'_2(1) = P_{0,0}(-h_c)\tilde{z}'_0 \quad (18a)$$

$$B'_2(1) = q - q(-h_2)\tilde{z}'_0 - (1-q)(-h_c)\tilde{z}'_0 \quad (18b)$$

where $\tilde{z}'_0 = \tilde{z}' \Big|_{x_2=1}$, and

$$A''_2(1) = P_{0,0}h_c^{(2)}(\tilde{z}'_0)^2 + P_{0,0}(-h_c)(\tilde{z}''_0)^2 \quad (19a)$$

$$B''_2(1) = -2q + 2q(-h_2)\tilde{z}'_0 - qh_c^{(2)}(\tilde{z}'_0)^2 - q(-h_2)\tilde{z}''_0 - (1-q)h_c^{(2)}(\tilde{z}'_0)^2 - (1-q)(-h_c)\tilde{z}''_0 \quad (19b)$$

where $\tilde{z}''_0 = \tilde{z}'' \Big|_{x_2=1}$.

On the other hand, from $\tilde{z} = \lambda_1 \{1 - \delta(x_2)\} + \lambda_2 (1 - x_2)$ and equation (14), the following equations are obtained.

$$\tilde{z}'_0 = -\lambda_1 \delta'_0 - \lambda_2 \quad (20a)$$

$$\delta'_0 = \frac{q\lambda_2 h_1 + (1-q)\lambda_2 h_c}{q - q\lambda_1 h_1 - (1-q)\lambda_1 h_c} \quad (20b)$$

$$\tilde{z}''_0 = -\lambda_1 \delta''_0 \quad (20c)$$

$$\delta''_0 = \frac{2q(\delta'_0)^2 + 2q\delta'_0 h_1 \tilde{z}'_0 + qh_c^{(2)}(\tilde{z}'_0)^2 + (1-q)h_c^{(2)}(\tilde{z}'_0)^2}{q - q\lambda_1 h_1 - (1-q)\lambda_1 h_c} \quad (20d)$$

From these equations, \tilde{z}'_0 and \tilde{z}''_0 can be calculated.

IV. MEAN WAITING TIME

A. High Priority

The probability that the number of high priority waiting data at the end of sending data is n_1' is denoted by $R_{1n_1'}$, and then the following equation is obtained.

$$R_{1n_1'} = \frac{1}{G_1(1,1)} \int_0^\infty \sum_{n_1=1}^{n_1'+1} \alpha_1(n_1' - n_1 + 1, t) \sum_{n_2=0}^\infty P_{n_1, n_2} dH_1(t) \quad (21)$$

Taking $\sum_{n_1'=0}^\infty$ after multiplying $x_1^{n_1'}$ in both sides in equation (21), and transforming into equation of the GF, equation (22) is obtained.

$$G_{R_1}(x_1) = \frac{1}{x_1 G_1(1,1)} G_1(x_1, 1) H_1^*(z_1) \quad (22)$$

where $G_{R_1}(x_1) = \sum_{n_1'=0}^\infty R_{1n_1'} x_1^{n_1'}$.

On the other hand, the probability that the number of high priority arrival data during waiting time and sending time for high priority data is n_1' is equal to $R_{1n_1'}$, so that the following equation is obtained.

$$R_{1n_1'} = \int_0^\infty \alpha_1(n_1', t) dW_1(t) \otimes H_1(t) \quad (23)$$

where $W_1(t)$ is the DF of waiting time for high priority data and \otimes is a convolution operator.

Taking $\sum_{n_1'=0}^\infty$ after multiplying $x_1^{n_1'}$ in both sides of equation (23) and transforming into equation of the GF, equation (24) is derived.

$$G_{R_1}(x_1) = W_1^*(z_1) H_1^*(z_1) \quad (24)$$

where $W_1^*(z_1)$ is the LST of $W_1(t)$.

From equation (22) and (24), $W_1^*(z)$ is obtained as follows.

$$W_1^*(z_1) = \frac{1}{x_1 G_1(1,1)} G_1(x_1, 1) \quad (25)$$

When $z_1 = 0$ after differentiating equation (25) by z_1 , the left side of equation is obtained as follows.

$$\frac{dW_1^*(z_1)}{dz_1} \Big|_{z_1=0} = -w_1 \quad (26a)$$

where w_1 is mean of $W_1(t)$.

On the other hand, the right side is obtained as follows.

$$\begin{aligned} \frac{d}{dz_1} \frac{G_1(x_1, 1)}{x_1 G_1(1, 1)} \Big|_{z_1=0} &= \frac{d}{dx_1} \frac{G_1(x_1, 1)}{x_1 G_1(1, 1)} \frac{dx_1}{dz_1} \Big|_{x_1=1} \\ &= -\frac{1}{\lambda_1} \frac{d}{dx_1} \frac{G_1(x_1, 1)}{x_1 G_1(1, 1)} \Big|_{x_1=1} \\ &= -\frac{1}{\lambda_1 G_1(1, 1)} \frac{\frac{d}{dx_1} G_1(x_1, 1) x_1 - G_1(x_1, 1)}{x_1^2} \Big|_{x_1=1} \\ &= -\frac{1}{\lambda_1 G_1(1, 1)} \left\{ \frac{d}{dx_1} G_1(x_1, 1) \Big|_{x_1=1} - G_1(1, 1) \right\} \end{aligned} \quad (26b)$$

From equation (26a) and equation (26b), mean waiting time for high priority data w_1 is derived.

$$w_1 = \frac{1}{\lambda_1 G_1(1, 1)} \left\{ \frac{d}{dx_1} G_1(x_1, 1) \Big|_{x_1=1} - G_1(1, 1) \right\} \quad (27)$$

$G_1(1,1)$ and $\frac{d}{dx_1} G_1(x_1,1)|_{x_1=1}$ have been already derived,

so that mean waiting time w_1 can be calculated.

B. Low Priority

Similar to the analysis for high priority, the following two equations are obtained.

$$R_{2n_2'} = \frac{1}{G_2(1)} \int_0^{\infty} \sum_{n_2=1}^{n_2'+1} \alpha_2(n_2' - n_2 + 1, t) P_{0,n_2} dH_2(t) \quad (28a)$$

$$R_{2n_2'} = \int_0^{\infty} \alpha_2(n_2', t) dW_2(t) \otimes H_2(t) \quad (28b)$$

where $R_{2n_2'}$ is the probability that the number of low priority waiting data at the end of sending data is n_2' and $W_2(t)$ is the DF of waiting time for low priority data.

Taking $\sum_{n_2'=0}^{\infty}$ after multiplying $x_2^{n_2'}$ in both sides in equations (28a) and (28b), and transforming into equations of the GF, equation (29) is derived.

$$W_2^*(z_2) = \frac{1}{x_2 G_2(1)} G_2(x_2) \quad (29)$$

where $W_2^*(z_2)$ is the LST of $W_2(t)$.

From equation (29), mean waiting time for low priority w_2 is derived as follows.

$$w_2 = \frac{1}{\lambda_2 G_2(1)} \left\{ \frac{d}{dx_2} G_2(x_2) \Big|_{x_2=1} - G_2(1) \right\} \quad (30)$$

$G_2(1)$ and $\frac{d}{dx_2} G_2(x_2) \Big|_{x_2=1}$ have been already derived, so

that mean waiting time w_2 can be calculated.

C. Numerical Examples

Fig. 4 shows a relation between arrival ratio λ_1 and mean waiting time w_1 and w_2 in the case of $\lambda_1 = \lambda_2$, $q=0.1, 0.5, 0.9$, $h_1 = h_2 = 5$, $h_c = 1$ and $H(t)$ and $H_c(t)$ obey uniform distributions.

In Fig. 4, solid lines, dashed lines and chain lines are mean waiting times in the case of $q = 0.1, 0.5$ and 0.9 , respectively. In the same line, the lower line is mean waiting time w_1 and the upper line is mean waiting time w_2 . It is confirmed that the mean waiting time becomes long as the link probability q becomes low and as the arrival ratio λ becomes high. In the case of $q = 0.1$, mean waiting time w_1 and w_2 become infinite when λ_1 is over 0.0685 and 0.0335 , respectively.

This means that when $q = 0.1$ and λ_1 is over 0.0685 and 0.0335 , each sending buffer is overflow because there are more arrival data than sending data.

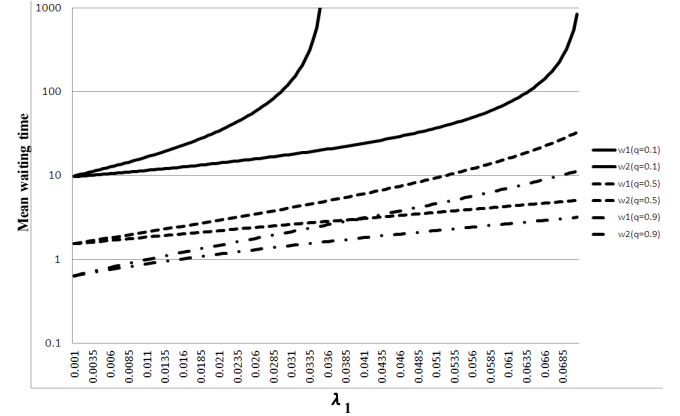


Fig. 4. Mean waiting time w_1 and w_2 ($h_1 = h_2 = 5$, $h_c = 1$, $\lambda_1 = \lambda_2$, uniform distribution).

In the case that $H(t)$ and $H_c(t)$ obey exponential distributions, Fig. 5 is illustrated.

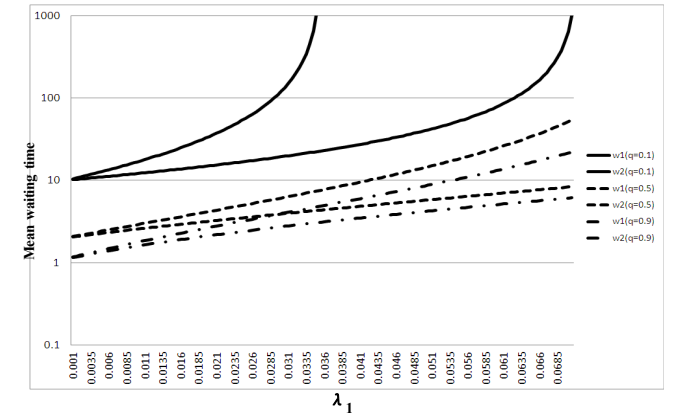


Fig. 5. Mean waiting time w_1 and w_2 ($h_1 = h_2 = 5$, $h_c = 1$, $\lambda_1 = \lambda_2$, exponential distribution).

Comparing Fig. 5 with Fig. 4, the mean waiting times become long, but Fig. 5 shows similar tendency.

Next, in the case of $q = 0.5$, $\lambda_1 = \lambda_2$ and $\lambda_2 = 3\lambda_1$, the mean waiting times are shown in Fig. 6.

Mean waiting times in the case of $\lambda_2 = 3\lambda_1$ become longer than those in the case of $\lambda_1 = \lambda_2$. Particularly, mean waiting time w_2 becomes very long. And, mean waiting time w_1 slightly becomes long in spite of same λ_1 . If an arrival rate of low priority data rises, it is natural that waiting time for low priority data becomes longer, but that for high priority data slightly becomes long. This reason is that the opportunities when low priority data are sent increase. But, there is little influence on the waiting time for high priority data.

Mean waiting times in the case of $\lambda_2 = \lambda_1/3$ become shorter than those in the case of $\lambda_1 = \lambda_2$. Particularly, mean waiting time w_1 slightly becomes short in spite of same λ_1 .

From Fig. 6 and Fig. 7, it is confirmed that mean waiting time for high priority is slightly influenced by the arrival ratio of low priority data.

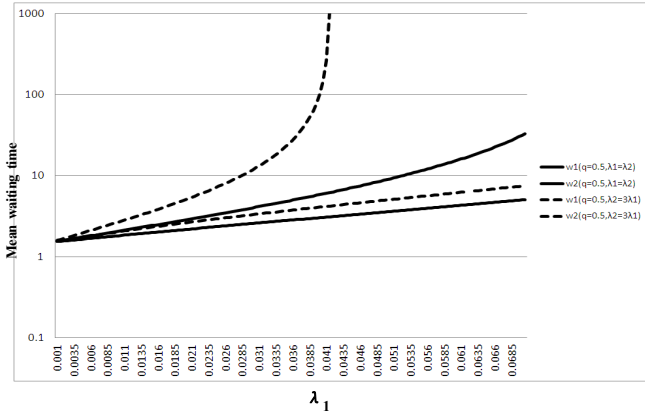


Fig. 6. Mean waiting time w_1 and w_2 ($h_1 = h_2 = 5$, $h_c = 1$, $\lambda_1 = \lambda_2$, and $\lambda_2 = 3\lambda_1$ uniform distribution).

Fig. 7 shows mean waiting times in the case of $q = 0.5$, $\lambda_1 = \lambda_2$ and $\lambda_2 = \lambda_1 / 3$.

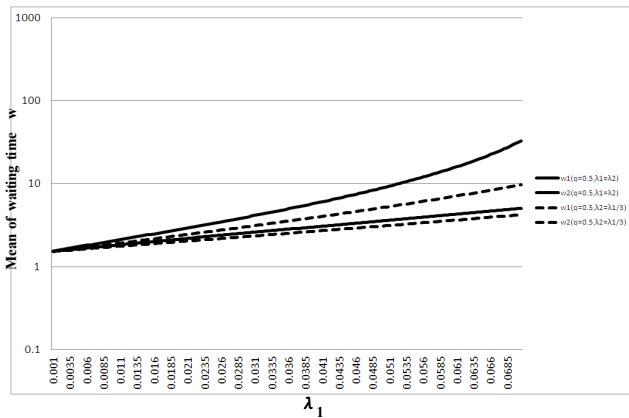


Fig. 7. Mean waiting time w_1 and w_2 ($h_1 = h_2 = 5$, $h_c = 1$, $\lambda_1 = \lambda_2$ and $\lambda_2 = \lambda_1 / 3$, uniform distribution).

V. CONCLUSION

In this paper, a characteristic of data transmission with priority processing in bus network with switching hub is clarified. In the analysis, taking note of one station connected to the bus, the link probability that the link from the station to a receiving station can be established is defined as a constant, and then for each priority data, the probabilities of the number of waiting data, the mean of the number of waiting data at the ready time of sending and the mean waiting times are derived. For the analysis of low priority, a root that the denominator of GF is equal to 0 is used.

Furthermore, some numerical examples are illustrated and the influence of the link probability and the ratio of λ_1 and λ_2 on the characteristics of data transmission are clarified.

The characteristic of data transmission with priority processing in this paper is a base of considering efficiency of bus network with priority processing. And, the analysis method in this paper may be applied to other networks.

The following considerations remain for further study:

- 1) Analyzing the bus network with more priority levels.
- 2) Clarifying a relation between the link probability and the

buffer size of a receiving station.

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