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An improved routing method using transmission memory information for wireless communication networks

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Abstract—Recently, a drastic increase in mobile users leads to packet congestion on the wireless communication network. Many researchers then try to propose efficient routing methods that remove the packet congestion even if the flowing packets increase. As one of the effective routing methods for the wireless communication networks, an effective routing method using transmission memory information has already been proposed. However, the method used fixed parameters at each node to route the packet. In this study, we improve the routing method [1] using dynamic parameter adjustment method to apply our method to various topologies of the computer networks.

1. Introduction

Traffic control of the computer networks is one of the most important problems for reliable communication. Therefore, many researchers propose various routing methods for communication networks. For example, the routing method using distance between nodes and transmission memory information in wired communication networks has been proposed in Ref. [2]. Yang *et al.*[3] proposed the routing method using geographical distance between nodes and the number of holding packets. This approach improves the packet congestion by using the information of congestion status of neighbor nodes. The effectiveness of routing method using transmission memory information for the wireless communication network model has been proposed in Ref. [1]. The routing method [1] alleviates the packet congestion using the diversification of selecting paths of packets which is realized by memory information. However, this method used the fixed parameter at each node. These parameter settings make it harder to apply the routing method to various topologies of the networks. To overcome this problem, we introduce a dynamic parameter adjustment method to the routing method [1] in this study. From the results of the numerical experiments, the improved routing method using transmission memory information transmits the packets more quickly than the conventional routing method [1].

2. Mobile communication network model

We use the weighted and undirected graphs $G = (V, E)$ to construct the mobile communication network model, where V is the set of nodes and E is the set of links. Each node represents a wireless agent and each link represents a connection between two nodes. $N = |V|$ expresses the total number of nodes and these N nodes are placed in the square-shaped cell of size L. The ith node updates its position using the following equations:

$$\begin{aligned} x_i(t+1) &= x_i(t) + v\cos\theta_i(t), & (1)\\ y_i(t+1) &= y_i(t) + v\sin\theta_i(t), & (2)\\ \theta_i(t) &= \phi_i, & (3) \end{aligned}$$

where $x_i(t)$ and $y_i(t)$ are coordinates of the ith node at the tth time. In addition, we define v is the moving speed of the node and $\phi_i (i = 1, \ldots, N)$ is the phase position of the ith node. ϕ_i is randomly determined using the uniformly distributed random numbers from $-\pi$ to π. If the ith node exceeds the range of the square-shaped cell size L, the position of the ith node is updated again not to move beyond the area of network. In addition, the distance between the ith node and the jth node at the tth iteration is defined as follows:

$$D_{ij}(t) = \sqrt{[x_i(t) - x_j(t)]^2 + [y_i(t) - y_j(t)]^2}. \quad (4)$$

If the distance of two nodes (the ith node and the jth node) is smaller than communication radius, C_r, the jth node becomes neighbor node of the ith node or connected to the ith node. Then, the node selects one of the neighbor nodes within its communication range as a transmitting node. The packets are transmitted to the next node based on the First-In First-Out basis; a packet at the head of the buffer of the node is transmitted to its neighbor node, and the packet is store at the tail of the neighbor node. Sources and destinations of packets are randomly selected using uniformly distributed random numbers. If the buffer of a transmitting node is full, the transmission of the packet to node is canceled. These packets wait for the next opportunity for transmission.

3. Packet routing using transmission memory information

In this study, if the distance between the ith and the jth nodes at the tth iteration is less than or equal to its communication range, namely $D_{ij}(t) \leq C_r$, we set the distance between these nodes to 1. On the other hand, we set the distance of the nodes to ∞. Each node determines the transmitting node using following equations.

$$y_{ij}(t+1) = \xi_{ij}(t+1) + \zeta_{ij}(t+1), \tag{5}$$

where $\xi_{ij}(t+1)$ is the distance information and $\zeta_{ij}(t+1)$ is the transmission memory information of the ith node at the tth iteration. The distance information is defined as follows:

$$\xi_{ij}(t+1) = \frac{d_{jg(p_i(t))}(t)}{C_r}, j \in N_i(t), \tag{6}$$

where $p_i(t)$ is a transmitting packet from the ith node at the tth time, $g(p_i(t))$ is destination of $p_i(t)$, $N_i(t)$ is the number of the neighbor nodes of the ith node at the tth time, $d_{jg(p_i(t))}(t)$ is the distance between the jth neighbor node and $g(p_i(t))$.

The transmission memory information of the ith node is defined as follows:

$$\begin{aligned} \zeta_{ij}(t+1) &= \alpha \sum_{\gamma=0}^{t} k_r^{\gamma} x_{ij}(t-\gamma) \\ &= \alpha x_{ij}(t) + k_r \zeta_{ij}(t-1), \end{aligned} \tag{7}$$

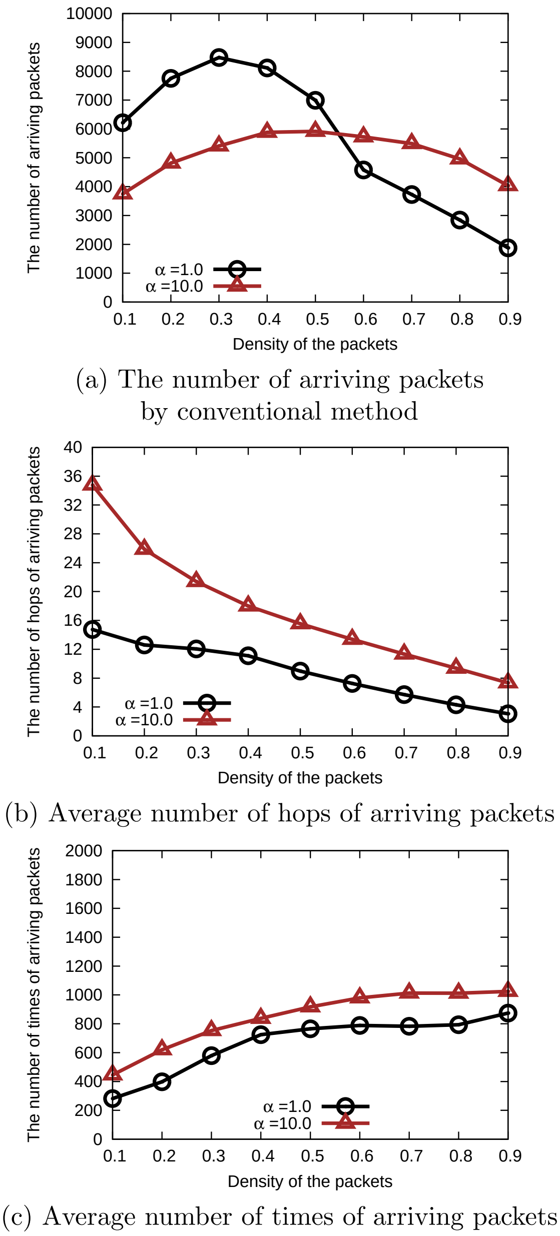
where α is parameter that determines the strength of transmission memory information, and k_r is decay parameter. $x_{ij}(t)$ is the packet transmission history of the jth node at the tth time and defined by,

$$x_{ij}(t) = \begin{cases} 1 & (\min(y_{ij}(t+1)), \\ 0 & (\text{otherwise}). \end{cases} \tag{8}$$

In Eq. (8), the ith node transmits a packet to the jth neighbor node if $y_{ij}(t+1)$ is the smallest among the neighbor nodes.

We first evaluate the performance of conventional method. These experiments are conducted as follows. First, packets are generated in the network whose sources and destinations are randomly assigned. Then, the density of the packets $D = \rho \cdot N \cdot B$, is set to between $0 < \rho \leq 1$, where ρ is the packet generating rate, N is the number of nodes, and B is the buffer size of each node. The square-shaped cell size, L, is set to 4. The number of nodes, N, is set to 100 and the buffer size of each node, B, is set to 100. In addition, the moving speed of node, v, is set to 0.01 and the communication radius, C_r, to 0.6. The parameters in Eqs. (7) are set as follows: $\alpha = 6.0$ and $k_r = 0.9$.

The number of iterations I, is set to $3,000$. Here, we defined a single iteration as the determinations of the transmitting nodes and the transmissions of packets to those nodes.



(a) The number of arriving packets by conventional method

(b) Average number of hops of arriving packets

(c) Average number of times of arriving packets

Figure 1: Results by the conventional method for the mobile communication networks

Figure 1 shows the total number of arriving packets, an average number of hops of arriving packets, and an average times of the arriving packets by the conventional method. In Fig .1(a), the number of arriving packets by $\alpha = 1$ increases in comparison to those by $\alpha = 10$ if the density of packet D is less than 0.5. On the other hand, the number of arriving packets increases if α is set to 10 as D becomes large. In Figs. 1(b) and(c), the average number of hops and the average number of times increase as α becomes large. From these results, the performance of the conventional method is varied depending on the state of the networks; a small α setting is better for lower D case and a high α setting is better for high D case. Then, if each node can automatically adjust the value of α depending on the state of the network, we expect that the performance of our routing method will be enhanced.

4. A proposed method with improved transmission memory information

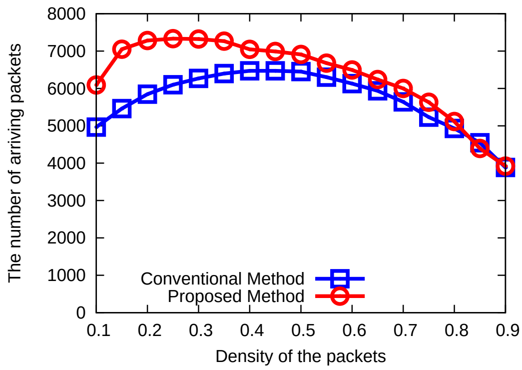
From the previous results, we confirmed that the routing method might be enhanced if the parameter α automatically changes depending on the state of the networks. To realize this functionality, we change the transmission memory information as follows:

$$\begin{aligned} \zeta_{ij}(t+1) &= \beta n_i(t) \sum_{\gamma=0}^{t} k_r^{\gamma} e_{ij}(t-\gamma), \\ &= \beta n_i(t) x_{ij}(t) + k_r \zeta_{ij}(t-1), \end{aligned} \tag{9}$$

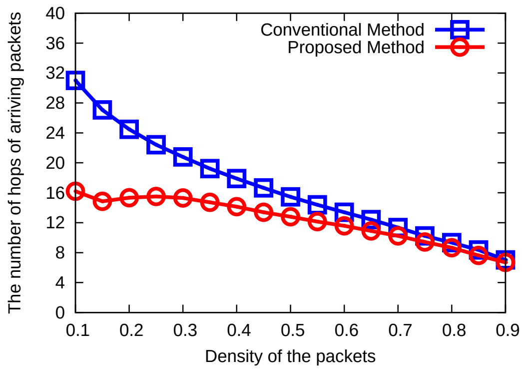
where $n_i(t)$ is the number of holding packets of the ith node, β is a controlling parameter.

We compared the performance of the proposed with that of the conventional method. We apply the same experimental conditions used in the previous experiments. In addition, the parameter α in Eq. (7) is set to 6.0 and β in Eq. (9) is set to 0.05.

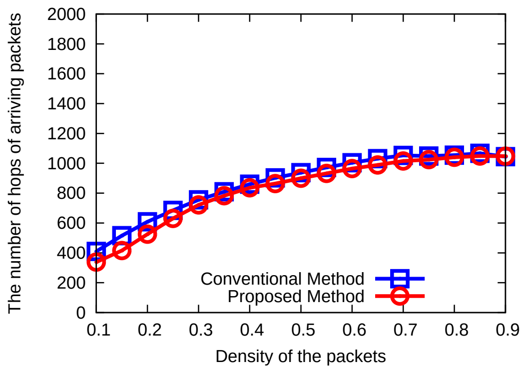
Figure 2 shows the number of arriving packets, the average number of arriving packets, and the average times of arriving packets by the conventional method and the proposed method. In Fig. 2(a), the number of arriving packets by the proposed method is larger than that by the conventional method. In addition, in Fig. 2(b), the average hops of the arriving packets by the proposed method is smaller than that by the conventional method. Further, in Fig. 2(c), the packets by the proposed method are transmitted to their destinations more quickly than the conventional method. From the results of the numerical experiments, the proposed method transmits the packets by effectively adjusting the strength of the transmission memory in comparison to the conventional routing method.



(a) The number of arriving packets



(b) Average number of hops of arriving packets



(c) Average number of times of arriving packets

Figure 2: Performance evaluation for the conventional and the proposed method

5. Conclusions

In this study, the performance of the routing method using transmission memory information has been evaluated for the mobile communication networks. The conventional method used fixed parameter for every node to route packets. We then improved the routing method by using the dynamic adjusting method for determining the strength of transmission memory at each node. As a result, we confirmed that the performance of the proposed method is enhanced in comparison to the conventional method.

Evaluation of our method using the realistic network will be conducted for the future works.

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