Performance Analysis and Experimentation of Maximum Transmission Rate Control for Autonomous User Movement

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Abstract- **In this paper, we propose a dynamic control of maximum transmission rate for ID/Locator separation networks. In the proposed method, the maximum transmission rate decreases as the utilization time of corresponding communication session increases. Moreover, the maximum transmission rate increases and a sampling interval for decreasing the maximum transmission rate becomes large when the corresponding locator changes. By using the proposed method, the network utilization is expected to be improved while promoting users to regularly change the access points. In order to investigate the performance of the proposed method, we construct an analytical model where users arrive at an access point according to a Poisson process. In this analysis, we utilize the probability with which a user moves to other access point in order to improve the maximum transmission rate. We also investigate the validity of the proposed method experimentally. From the experimental results, we show the validity of the proposed method. Moreover, we found how the total bandwidth changes by using the proposed method.**

I. INTRODUCTION

For transmitting data flexibly in future networks, ID/Locator separation networks such as LISP and HIMALIS are expected to be utilized [1]. In such ID/Locator separation networks, mobility, multihoming, security, and heterogeneous network layer protocol can be supported by separating ID and locator of each host. Even when a mobile host moves from an access point to another access point and its locator changes, a communication session for the host is not terminated. This is because each communication session is established by using ID of the host.

In this paper, we propose a dynamic control of maximum transmission rate for ID/Locator separation networks. In the proposed method, the maximum transmission rate decreases as the utilization time of corresponding communication session increases. Moreover, the maximum transmission rate increases and sampling interval for decreasing the maximum transmission rate becomes large when the corresponding locator changes. By using the proposed method, the network utilization is expected to be improved while promoting users to regularly change the access points. In order to investigate the performance of the proposed method, we construct an analytical model where users arrive at an access point according to a Poisson process. In this analysis, we utilize the probability with which a user moves to other access point in order to improve the maximum transmission rate. We also investigate the validity of the proposed method experimentally.

The rest of this paper is organized as follows. Section II explains ID/Locator separation networks and Section III describes our proposed maximum transmission rate control. Section IV shows the detail of our performance analysis of the maximum transmission rate. Section V shows some numerical examples, and finally we conclude this paper in Section VI.

II. ID/LOCATOR SEPERATION NETWORKS

In this section, we explain ID/Locator separation networks. Especially, as one of the network architectures for ID/Locator separation networks, we introduce Heterogeneity Inclusion and Mobility Adaptation through Locator ID Separation (HIMALIS) architecture, that has been proposed in National Institute of Information and Communications Technology (NICT) [1].

In the HIMALIS architecture, each host is identified by both host names and IDs. Because the network layer protocols can change a locator of each host directly and its location is also updated quickly, this architecture can support mobility management.

The HIMALIS architecture consists of edge networks, global transit network, and name registries logical network. HIMALIS gateway is utilized in the boundary between an edge network and the global transmission network, and it stores ID and locator of each host. Two hosts can communicate with each other by using the ID and locator that are in the HIMALIS gateway. If a host moves to another edge network and its locator changes, a new locator is stored in each HIMALIS gateway. Thus the communication session is not terminated.

III. PROPOSED MAXIMUM TRAMSISSION RATE CONTROL

In this section, we propose a dynamic control of maximum transmission rate that can be used in ID/Locator separation networks. This method extends the maximum transmission rate control that has been proposed in [2].

In the proposed method, the maximum transmission rate decreases as the utilization time of corresponding communication session increases. Moreover, the maximum transmission rate increases and sampling interval for decreasing the maximum transmission rate becomes large when the corresponding locator changes due to the host's movement. In the following, for a sending host, let $b(t)$ denote the maximum transmission rate at time t. Moreover, let b^{high} and b^{low} be the upper bound and the lower bound of $b(t)$, respectively. When the utilization time of corresponding communications session increases, the transmission rate $b(t)$ changes as follows:

$$b(t) = max\left(b^{low}, b^{high} - \alpha \left\lfloor \frac{t - t_{i-1}}{\Delta_{i-1}} \right\rfloor\right), t_{i-1} \leq t \leq t_i. \quad (1)$$

In this equation, t_{i-1} means the time at which the $(i$-1)th change of the host's locator occurs and Δ_{i-1} represents a sampling interval of the maximum transmission rate. In addition, α is larger than 0 for decreasing $b(t)$.

Moreover, when the ith change of the host's locator occurs at time t_i due to the host's movement, the ith sampling time Δ_i is derived from Δ_{i-1} as follows:

$$\Delta_i = \gamma_i \Delta_{i-1}. \quad (2)$$

In this equation (2), γ_i is equal to or larger than 1.0. Because the maximum transmission rate increases and the sampling interval becomes large when a locator changes, it is expected that hosts move to other access points regularly.

IV. PERFORMANCE ANALYSIS

In this section, we construct an analytical model in order to evaluate the performance of the proposed method.

At first, we derive the probability with which a user moves from an access point to other access point for increasing the maximum transmission rate. Now, when the transmission rate is $b(t)$ for a user at time t, the user would like to pay a cost $c(b) = 1211 \times b^{0.228}$[2]. Moreover, the transmission rate has decreased from b^{high} to $b(t)$, and hence the user would like to continue the transmission at the access point with probability

$$\rho\big(b(t)\big) = -28.7 \times log_e\left(\frac{c(b^{high})}{c(b(t))} - 1\right) - 0.604. \quad (3)$$

From the probability $\rho(b(t))$, the expected transmission rate $B(t)$ that the user can utilize from time 0 to time t is given by

$$B(t) = \int_0^t b(\tau) \cdot \rho(b(\tau))d\tau. \quad (4)$$

Here, we assume that users arrive at the access point according to a Poisson process with rate λ. Therefore, from time 0 to time T, the nth arriving user utilize the access point during time that follows Erlang-k distribution. When the arrival time of the i user is t_i, the total transmission rate that n users can utilize is derived from the following equation.

$$B_n = \sum_{i=1}^{n} \int_0^T B(T - t_i) \times \frac{\lambda^i}{(i-1)!} t_i^{i-1} e^{-\lambda t_i} dt_i. \quad (5)$$

Finally, from the assumption of Poisson arrivals, the expected total transmission rate is given by

$$\overline{B} = \frac{1}{T} \sum_{n=1}^{\infty} B_n \times \frac{(\lambda T)^n}{n!} e^{-\lambda T}. \quad (6)$$

V. NUMERICAL EXAMPLES

In this section, at first, we investigate how the sending throughput changes by using the proposed method. In our experimental environment, HIMALIS architecture has been implemented in a desktop PC. Figure 1 shows how the sending throughput changes by changing the size of sending buffer dynamically according to the proposed method. From this figure, we find that our proposed method can be implemented with the sending buffer.

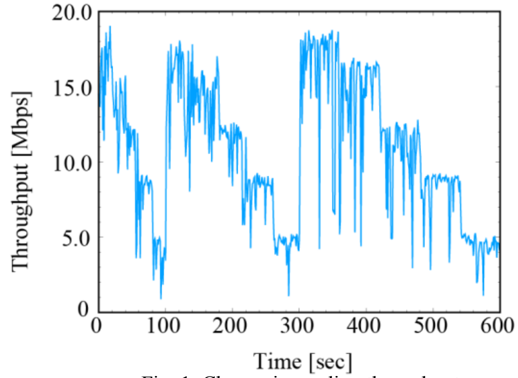

Fig. 1. Change in sending throughput.

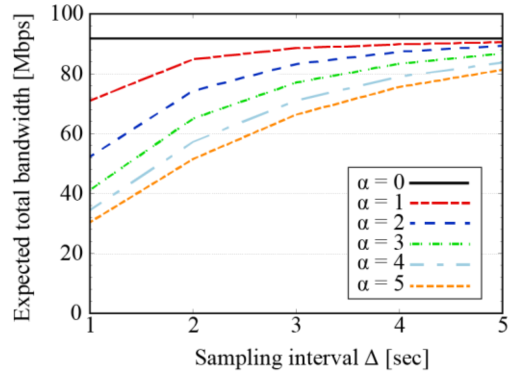

Fig. 2. Expected total bandwidth against sampling interval.

Next, we analyze how the total bandwidth changes by using the proposed method. Figure 2 shows that the total bandwidth against the sampling interval $\Delta_i = \Delta$. From this figure, we find that the total bandwidth decreases as α becomes large. Moreover, we find that the total bandwidth increases as Δ becomes large. By using our proposed method, it is expected that users move to other access point to utilize a large bandwidth.

VI. CONCLUSION

In this paper, we proposed the maximum transmission rate control method and constructed an analytical model for the proposed method. We evaluated the performance of the proposed method experimentally and analytically. From the experimental results, we found that the validity of the proposed method. Moreover, we found how the total bandwidth changes by using the proposed method.

REFERENCE

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