Implementation of AP Selection System in a Heterogeneous Wireless Network

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***Abstract*—In recent years, the increasing amount of data arisen from mobile terminals has deteriorated the response speed felt by users especially in a crowded place. Our previous studies have proposed a method of identifying an application being used by each terminal and selecting the optimum access point. However, there are some considerations in an actualizing the system. In order to compose a more realistic environment, this research developed a prototype system with an Android application on each mobile terminal and a control server. Some network performances are evaluated from the perspective of assignment status and computation time.**

***Keywords*–Wi-Fi service, Round-Trip Time, assignment problem, Android.**

I. INTRODUCTION

While the Long Term Evolution (LTE) has been in widespread use and the line speed for data communications has also been improved, the exploding data traffic that evolving applications require lead to increase the utilization factor of public WiFi services from now on. However, the response speed that users feel might become longer due to throughput degradation on a public WiFi station because of increasing network load in a crowded place such as a railroad station and a classroom in an academic campus. Particularly, Japanese train stations are congested during commuting rush hours.

One of the above causes is considered that there are some mismatches between users and Access Points (APs). Therefore, it is essential to associate with an appropriate AP to improve the Quality of Experience (QoE). A problem to lead a user to an appropriate AP is named an AP selection problem. The current association policies are mostly based on a selfish user's behavior maximizing its own throughput [1][2]. However, it should be realized that different users have different needs since running applications have their particular Quality of Service (QoS) requirements [3]. Our previous studies [4] have proposed a method of identifying an application being used by each terminal and selecting the optimum AP.

II. PREVIOUS RESEARCH

A. System Model

Our proposed system includes a control server, plural APs, and mobile terminals in Figure 1. Each AP is constantly associated with a Measuring Terminal (MT) that is dedicated to measuring the response speed. MTs regularly obtain RTT and throughput by using ping and PathQuick, and send the information to the control server. PathQuick is a systematic approach to estimate the throughput in brief time [5].

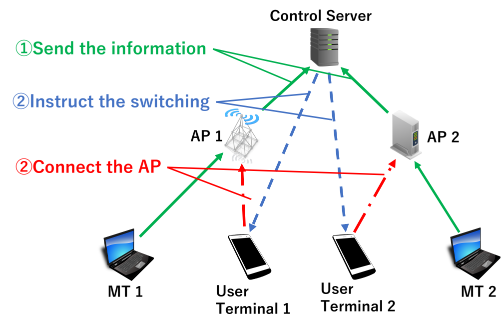

Figure 1. System Model

The control server solves an assignment problem by the Hungarian method to find the optimum AP for each user based on the information acquired from the MTs and the running applications on user terminals. Then, the server sends the suitable AP information to terminals.

Finally, according to the information sent from the control server, all user terminals switchover to the optimal AP.

B. Problem Formulation

There are some real-time applications, which require more strict RTT between a user terminal and a destination server, and others which might strongly demand throughput. The former applications belong to a group G_{RTT} and the latter ones belong to a group G_{TP}. Therefore, the needed RTT (RTT_{need}) and throughput (TP_{need}) are defined by four different types of applications shown in TABLE I.

TABLE I. $RTT_{need} \cdot TP_{need}$

Application	*Group*	RTT_{need}	TP_{need}
Call Application	G_{RTT}	200ms	-
Browser	G_{TP}	-	6Mbps
Video Application	G_{TP}	-	2Mbps
Others	-	-	-

$$S_i = \begin{cases} \frac{RTT_{need}}{RTT_{link}} & (APP_i \in G_{RTT}) \\ \frac{TP_{link}}{TP_{need}} & (APP_i \in G_{TP}) \end{cases} \quad (1)$$

Equation (1) expresses a satisfaction degree S_i of each mobile user. APP_i indicates an application running on terminal i. RTT_{link} and TP_{link} indicate RTT and throughput provided when connecting to the AP i. The objective is to maximize the harmonic mean for all S_i.

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C. Research Tasks

In the previous research, the system was evaluated by simulating only an assignment algorithm in a control server. However, it is needed to consider the detailed communication contexts and a practical network environment to develop an implementation plan for a real case. This paper explains a system with actual devices, such as user terminals and a control server, and evaluates the validity of the assignment results and computing time by constructing the system.

III. Development and Implementation

The software on a user device includes the five main functions, "Obtain the available AP informations.", "Switch the connection automatically.", "Measure the response speeds.", "Identify the running application.", and "Communicate with the control server.". The system used an Android application which is relatively easy for implementation.

The software on a control server includes the four main functions, "Communicate with the user device.", "Decide the needed response speed.", "Calculate the assignment problem.", and "Store the virtual terminal informations.". Also, because of fairness, the control server must be located on a different network, and be able to access the Internet.

IV. Simulations and Evaluations

A. Definition of Satisfaction Degree

TABLE II. RTT_{need}

Application	RTT_{need}
Call Application	200ms
Browser	85ms
Video Application	256ms
Others	-

In this paper, the response speed considered is only RTT at this stage, for that reason the applications included in G_{TP} need to be redefined. The redefined RTT_{need} is shown in TABLE II. Instead of using (1), the satisfaction degree RTT_{gap} is derived by subtracting RTT_{need} from RTT_{link}. If the RTT_{gap} is a negative value, it is set to 0. The objective in this paper is to minimize the total amount of the RTT_{gap}.

B. Conditions

In the experiment, the number of APs is set to 3, the number of terminals is set to 50 (pattern 1) and 70 (pattern 2), and the terminal capacities of AP are set to 20, 25, 30 in pattern 1 and 30, 40, 50 in pattern 2. The RTT_{link} is set to increase by 3ms or 4ms for each connected terminal. This research also verified the greedy method and the random method. The greedy method prioritizes assignment in order from the terminals with the shortest response speed required, and the random method assigns the terminals in a random manner.

C. Results and Discussions

The results are shown in TABLE IV. The experimental results have demonstrated that the Hungarian method gains the highest satisfaction degree compared with two other methods. The satisfaction degree by the Greedy method does not increase because a terminal judges an appropriate AP according to a transient response speed.

TABLE III. CONDITIONS

Case	RTT_{link} increase(ms)	AP capacity
case1-1	3	20
case1-2	3	25
case1-3	3	30
case2-1	4	20
case2-2	4	25
case2-3	4	30
case3-1	3	30
case3-2	3	40
case3-3	3	50
case4-1	4	30
case4-2	4	40
case4-3	4	50

TABLE IV. RESULT

Case	*Average of* RTT_{gap}(ms)		
	Hungarian	greedy	random
case1-1	0	0	0
case1-2	0	1.36	0
case1-3	0	4.96	0.07
case2-1	0	2.54	0.58
case2-2	0	7.36	1.52
case2-3	0	12.16	1.88
case3-1	0	6.2	1.8
case3-2	0	12.39	1.64
case3-3	0	19.67	1.37
case4-1	1.22	15.2	7.85
case4-2	0	22.1	7.03
case4-3	0	35.47	6.4

This research defines computing time as a processing interval from identifying an application to establishing a connection to an assigned AP. The greedy method and the random method finish the calculation within below 1 second in every case. However, the Hungarian method finishes that within around 12 seconds in the most frequent processes. This processing time leaves room for improvement on the effectiveness.

V. Conclusion

This research implemented the previously proposed system with actual devices and showed the higher satisfaction degree by using Hungarian method. The developed system has to be extended with considering TP in order to improve the effectiveness, since the experiments consider only RTT. The processing time in our proposed system has been found to be longer for users in a certain case. The future tasks include devising a simpler approximate method for rapidity.

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